50-320 THREE MILE ISLAND #2

STEAM LINE BREAK ENVIRONMENTAL QUALIF.

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RJB

7/13/79

This set of documents had been pulled out of the docket file, prior to processing the file, for proprietary information determinations. These can now be released to the public

C. H. Reed

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Technical

Report

Final Report
F-C4350-2

TESTS OF ELECTRICAL CABLES SUBJECTED TO THERMAL AGING, GAMMA RADIATION AND A LOSS-OF-COOLANT ACCIDENT SIMULATION

Prepared for

The Anaconda Company
Marion, Indiana

July 1976

POOR ORIGINAL

512 023

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

Technical

Report

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TESTS OF ELECTRICAL CABLES SUBJECTED TO THERMAL AGING, GAMMA RADIATION AND A LOSS-OF-COOLANT ACCIDENT SIMULATION

Prepared for

The Anaconda Company
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512 024

July 1976

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
THE BENJAMIN FRANKLIN PARKWAY · PHILADELPHIA, PENNSYLVANIA 19103

CONTENTS

512 025

1. INTRODUCTION

A group of electrical cables submitted by The Anaconda Company Wire and Cable Division were subjected to an environmental test program based on the guidelines of IEEE Standards 323-1974[1] and 383-1974[2] to determine their suitability for service within the containment of nuclear power generating stations. This report deals specifically with eleven cables, identified as single conductor FREP low voltage power cable, FREP/CPE control and instrumentation cable.

All of the cables were thermally aged for seven days (9 of them at 150°C, 1 at 136°C and 1 at 121°C) then subjected to 200 megarads of gamma radiation from a cobalt-60 source at an average dose rate of 0.35 megarads per hour.

Following the thermal and radiation aging, the cables were subjected to a 30-day exposure of steam and chemical spray (S/C) which simulated the in-containment environmental conditions resulting from a postulated loss-of-coolant accident (LOCA), and those occurring during the cooldown after the LOCA. The temperature/pressure profile of this exposure was as follows:

1. A rapid rise to [illegible]6°F at a steam pressure > 110 psig with an 8-hour dwell at this temperature and pressure
2. A 3-hour dwell at 335°F/96 psig, a 4-hour dwell at 315°F/ 69 psig, and an 81 hour dwell at 265°F/28 psig
3. A 26-day dwell at 212°F at a steam/air pressure of approximately 4 psig.

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1. IEEE Std 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations, The Institute of Electrical and Electronics Engineers, Inc., New York, N. Y., 1974.

2. IEEE Std 383-1974, IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations, The Institute of Electrical and Electronics Engineers, Inc., New York, N. Y., 1974.

512 026

2. TEST SPECIMENS

A description of the cable specimens is presented below. The descriptions were provided by The Anaconda Company. Table 1 lists the cable specimens tested and shows their energizing voltage and current levels.

A. Low Voltage Power Cable Specimens: 18.31, 18.32, 18.33, 18.34,* 18.35* 1/C No. 12 AWG 7/W Tinned Copper Conductor, 30-mil Flame Resistant Cross-Linked Ethylene Propylene Rubber Insulation (FREP)

   * No. 14 AWG

B. Control Cable Specimens. 20.12, 20.16
   7/C No. 12 AWG 7/W Tinned Copper Conductor, 30-mil Flame Resistant Cross-Linked Ethylene Propylene Rubber Insulation (FREP), Cabled, Asbestos-Mylar Tape, 60-mil Chlorinated Polyethylene Jacket (CPE)

C. Instrumentation Cable Specimens: 20.25, 20.26, 20.27, 20.28
   2/C No. 16 AWG 7/W Tinned Copper Conductor, 25-mil Flame Resistant Cross-Linked Ethylene Propylene Rubber Insulation (FREP), Twist, Silicone/glass Tape, Tinned Copper Drain Wire, Aluminum/Mylar Tape, 30-mil Chlorinated Polyethylene Jacket (CPE)

512 027

3. TEST PROGRAM

3.1 PRETEST INSPECTION AND PREPARATIONS

The specimens were visually inspected upon receipt for defects, damage or sharp bends and identified with numbered stainless steel tags, then wound around two concentric stainless steel mandrels (each consisting of 8 stainless steel tubes in a circular array) as shown in Figure 1. The cables on the inner mandrel (OD = 16 inches) were wrapped with three turns and those on the outer mandrel (OD = 20 inches) were wrapped with two turns. The double mandrel was immersed in a tank of tap water at room temperature and insulation resistance (IR) measurements were made after applying a potential of 500 Vdc for one minute. For the 7/C cables, the measurements were made between conductors 2, 4 and 6 connected together versus conductors 1, 3, 5 and 7 connected together at ground potential; for the 2/C cables, measurements were made between conductors; and for the 1/C cables measurements were made between the conductor and the mandrel at ground potential. Following the IR measurements, the double mandrel was removed from the water and allowed to air dry.

3.2 THERMAL AND RADIATION AGING

While still on the mandrel, the cables were placed in a forced-convection, air oven and thermally aged for 7 days at 150°C (302°F), after which the cables were visually inspected for obvious changes in physical appearance.

Three additional cables (20.16, 20.27 and 20.28) were wrapped around a second mandrel and thermally aged for seven days at 150°C. Two other cables were reported by Anaconda to have been aged for 7 days at two temperature levels; cable 20.25 at 136°C and cable 20.26 at 121°C. All five of these cables were subsequently added to the original double mandrel.

The double mandrel was attached to the flanged head of the pressure vessel and the ends of the cables were passed up through the central volume temperature, was applied at the rate of 0.15 gpm per square foot (100 ml per second per square meter) of spray area. Fresh spray solution was used until the temperature was reduced to 315°F (elapsed time = 11.5 hrs). Thereafter, the spray solution was recirculated from the reservoir at the bottom of the chamber. The pH was monitored periodically, and was maintained within the range of 9 to 11 by addition of fresh solution.

During the exposure the cables were energized with the 60 Hz rms potentials and currents listed in Table 1. The energizing potentials were applied to the cables as shown in Figure 3. Ampere loading and voltages were set at the specified values prior to the start of the exposure; thereafter, the potentials and currents were recorded periodically and readjusted, if required, to the specified levels after each reading.

Chamber temperature and pressure was monitored continuously on strip-chart and multipoint recorders.

A list of the data acquisition instruments used in the test program is included as Appendix A.

3.4 MANDREL WRAP AND HIGH-POTENTIAL WITHSTAND TESTS

Following the 30-day S/C exposure, the mandrel was lifted out of the pressure vessel. The cables were severed immediately below the penetrations in the flanged head to facilitate cable removal; and each cable was slowly unwound from the double mandrel, straightened, then rewound around a mandrel whose diameter was approximately 40 times the cable diameter. The specimens (still coiled) were immersed in a tank of tap water at room temperature and subjected to a high-potential withstand test for five minutes using a potential of 80 Vac rms 60 Hz per mil of insulation. At the end of the five-minute period, the charging/leakage current was measured.

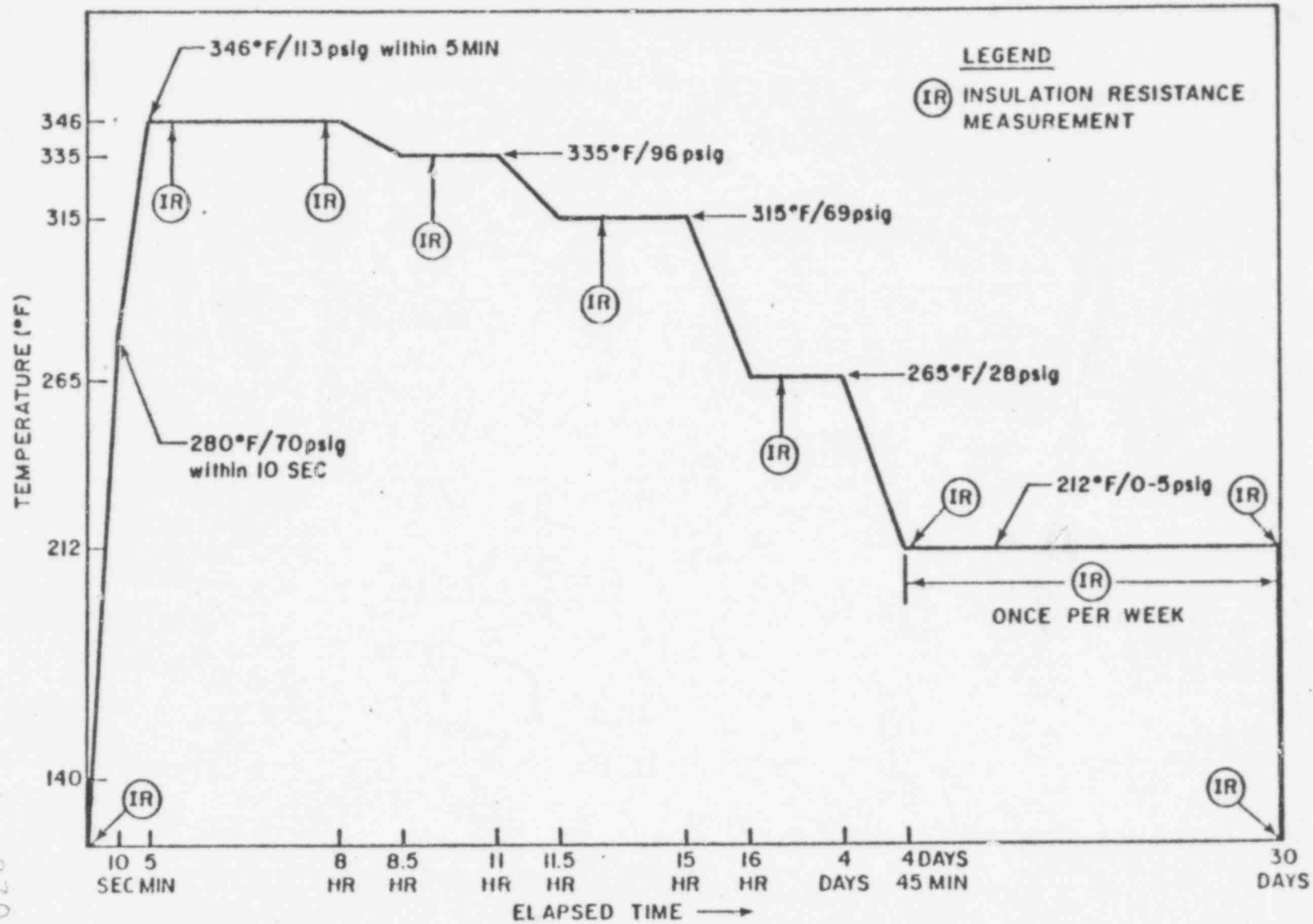


Figure 2. Temperature/Pressure Profile for Simulation of Loss-of-Coolant Accident (LOCA) Environment

F-C4350-2

512 030

4. TEST RESULTS

4.1 PRETEST INSPECTION AND ELECTRICAL MEASUREMENTS

The results of insulation resistance (IR) measurements are presented in Table 3. A visual inspection revealed no signs of damage or defects in any of the cable samples.

4.2 THERMAL AND RADIATION AGING

Visual inspection of the cables after thermal aging revealed that one of the cables contained indentations in the jacket material where the cables were supported by metal clips on the mandrel or where the cable lead ends had lain across the top of the mandrel. The condition of individual cables as observed after thermal aging and the radiation exposure is provided in Appendix B.

A certification of the radiation exposure is included as Appendix C.

4.3 LOCA ENVIRONMENT EXPOSURE

The specimens were exposed to a steam and chemical-spray environment in general accordance with Figure 2. Some deviations from the profile occurred during the first 3 hours of the dwell at 265°F/28 psig due to intermittent failure of electric heaters and attempts to restabilize using steam. A summary of the deviations following the initial stabilization at 265°F/28 psig is as follows:

a) A 14-min period during which the temperature and pressure varied between 199-290°F and 22-54 psig.

b) A 47-min period during which the temperature and pressure varied between 239-275°F and 44.5-68.5 psig. During most of this period the temperature remained between 260 and 272°F.

c) A 13-min period during which the temperature and pressure slowly fell from 270°F/47 psig to 164°F/25 psig.

512 031

Table 2. Summary of Insulation Resistance Measurements[(a)] (ohms)

Elapsed Time	Temperature (°F)	Chamber Pressure (psig)	Specimen Number 18.31	18.32	18.33	18.34	18.35	20.12	20.16	20.25	20.26	20.27	20.28
As Received	Room Ambient	0	2.6×10^{12}	4.0×10^{12}	4.0×10^{12}	7.4×10^{12}	6.0×10^{12}	1.3×10^{12}	1.2×10^{13}	8.2×10^{12}	4.0×10^{12}	1.9×10^{12}	2.0×10^{12}
Pre-LOCA	80	0	2.0×10^{10}	2.2×10^{10}	1.7×10^{10}	1.3×10^{10}	9.4×10^{9}	2.4×10^{9}	2.6×10^{9}	7.6×10^{9}	1.0×10^{10}	1.0×10^{10}	1.3×10^{10}
0.3 hr	347	120	$<5.0 \times 10^{4}$ @ 10 Vdc	1.8×10^{7}	2.2×10^{7}	4.0×10^{7}	4.0×10^{7}	2.8×10^{6}	2.2×10^{6}	6.8×10^{7}	6.0×10^{7}	5.0×10^{7}	3.5×10^{7}
6.5 hr	347	116	$<5.0 \times 10^{4}$ @ 10 Vdc	3.5×10^{7}	3.5×10^{7}	5.1×10^{7}	5.3×10^{7}	2.2×10^{6}	2.4×10^{6}	8.6×10^{7}	4.5×10^{7}	8.6×10^{7}	5.0×10^{7}
8.9 hr	335	98	$<5.0 \times 10^{4}$ @ 10 Vdc	5.3×10^{7}	5.1×10^{7}	7.8×10^{7}	7.8×10^{7}	3.5×10^{6}	3.5×10^{6}	1.1×10^{8}	6.3×10^{7}	1.1×10^{8}	6.8×10^{7}
13.7 hr	315	70	$<5.0 \times 10^{4}$ @ 10 Vdc	1.1×10^{8}	1.1×10^{8}	1.7×10^{8}	1.6×10^{8}	8.4×10^{6}	7.0×10^{6}	2.8×10^{8}	1.3×10^{8}	2.2×10^{8}	1.7×10^{8}
0.6 d	265	25	$<5.0 \times 10^{4}$ @ 10 Vdc	5.5×10^{8}	6.0×10^{8}	9.1×10^{8}	6.9×10^{8}	6.2×10^{7}	4.0×10^{7}	8.5×10^{8}	6.6×10^{8}	1.1×10^{9}	7.6×10^{8}
4.1 d	212	5	$<5.0 \times 10^{4}$ @ 10 Vdc	6.0×10^{9}	5.8×10^{9}	5.8×10^{9}	4.0×10^{9}	1.2×10^{9}	6.4×10^{8}	6.2×10^{9}	5.5×10^{9}	7.6×10^{9}	6.4×10^{9}
11.8 d	212	3	$<5.0 \times 10^{4}$ @ 10 Vdc	5.8×10^{9}	6.6×10^{9}	6.6×10^{9}	3.0×10^{9}	1.6×10^{9}	7.4×10^{8}	4.0×10^{9}	6.4×10^{9}	8.2×10^{9}	6.6×10^{9}
18.8 d	212	3	$<5.0 \times 10^{4}$ @ 10 Vdc	4.9×10^{9}	5.0×10^{9}	5.3×10^{9}	2.2×10^{9}	1.7×10^{9}	8.4×10^{8}	5.6×10^{9}	5.5×10^{9}	9.4×10^{9}	8.2×10^{9}
27.1 d	210	4	$<5.0 \times 10^{4}$ @ 10 Vdc	4.5×10^{9}	4.5×10^{9}	5.8×10^{9}	3.0×10^{9}	1.8×10^{9}	9.8×10^{8}	8.0×10^{9}	7.8×10^{9}	1.4×10^{10}	1.6×10^{10}
29.5 d	210	4	$<5.0 \times 10^{4}$ @ 10 Vdc	5.2×10^{9}	4.5×10^{9}	6.8×10^{9}	3.0×10^{9}	1.9×10^{9}	1.0×10^{9}	1.2×10^{10}	7.4×10^{9}	1.4×10^{10}	1.1×10^{10}
Post-LOCA	Room Ambient	0	$<5.0 \times 10^{4}$ @ 10 Vdc	2.9×10^{10}	6.2×10^{10}	5.0×10^{10}	2.4×10^{10}	3.0×10^{9}	3.5×10^{9}	8.8×10^{9}	8.6×10^{9}	9.8×10^{9}	1.3×10^{10}

NOTE: (a) Measurements made at 500 Vdc held for one minute unless otherwise noted.

POOR ORIGINAL

Table 3. Results of Post-LOCA High-Potential Withstand Tests

CABLE NO.	POTENTIAL kVac	LEAKAGE/CHARGING CURRENT (mA)	REMARKS*
18.31	2.4	1.1	4 turns around mandrel - damaged area at one end held out of water**
18.32	2.4	1.2	6 turns around mandrel
18.33	2.4	1.4	5 turns around mandrel
18.34	2.4	<1	5 turns around mandrel
18.35	2.4	1.1	5 turns around mandrel
20.12	2.4	4.7	Conductors 2, 4, 6 versus 1, 3, 5, 7 then 3, 5, 7 versus 1, 2, 4, 6. Leakage current identical for both readings. 6 in. section cut from one end of cable 20.16 after first test resulted in tracking.
20.16	2.4	4.1	
20.25	2.0	<1	Black conductor versus white and drain wire then white conductor versus black and drain wire. Leakage current identical for both readings.
20.26	2.0	1.1	
20.27	2.0	<1	
20.28	2.0	1.2	

*Except as may be noted, all cables withstood the applied potentials for 5 min while immersed in tap water at room temperature.
**See Section 4.3.

5. CONCLUSIONS

Eleven electrical cables submitted by The Anaconda Company were subjected to a test program based on the guidelines of IEEE Standards 323-1974 and 383-1974. The program was designed to simulate normal service, a loss-of-coolant accident (LOCA) and the cooldown following the LOCA.

All of the cables were thermally aged,* exposed to 200 megarads of gamma radiation from a cobalt-60 source and then subjected to a steam and chemical spray environment for 30 days, simulating a loss-of-coolant accident (LOCA). All of the cables were energized at the start of the LOCA with potentials and currents simulating service use, and 10 remained energized throughout the 30-day exposure. At the conclusion of the above sequence of exposures, all of the specimens were subjected to a mandrel bend/high-potential withstand test.

Ten cables demonstrated satisfactory performance during the exposures simulating normal service, a LOCA and subsequent cooldown; and all of these appeared to have a substantial margin of life remaining by withstanding post-LOCA bends at diameters forty times the cable diameters and high-potential tests at 80 Vac per mil of insulation.

Cable 18.31, which did not maintain its electrical load during the LOCA simulation, also appeared to be capable of demonstrating satisfactory performance. A post-test inspection revealed an isolated fault which may have been caused by the mode of support; the rest of the cable withstood a post-LOCA high-potential test.** This conclusion is further supported by the fact that the cable was identical in construction to two other cables (18.32 and 18.33) which maintained their electrical loads for 30 days and withstood a post-LOCA high-potential test.

*Two cables, 20.25 and 20.26, were aged by The Anaconda Company.
**See Section 4.3.

6. CERTIFICATION

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

L. E. Witcher
Test Engineer

W. M. Denny
Project Leader

D. V. Paulson, Chief
Environmental Test Section

APPROVED:

Zenons Zudans, Vice President
Engineering

S. P. Carfagno, Manager
Performance Qualification Laboratory

512 035

F-C4350-2

Appendix

A

LIST OF DATA ACQUISITION INSTRUMENTS

512 036

INSTRUMENT NUMBER	4217507
INSTR AND MFR	BECKMAN INST., INS. AND BREAKDOWN TEST SET
TYPE/MODEL NUMBER	1600-AC/DC ITS
SERIAL NUMBER	77145
RANGE/FEATURES	10 KV AC/DC 10 MA AC/DC
DATE CALIBRATED	07 12 76
INSTRUMENT NUMBER	18037
INSTR AND MFR	NORDEN KETAY, PRESSURE GAGE
TYPE/MODEL NUMBER	ACRAGAGE AISI 316 TUBE
SERIAL NUMBER	A6
RANGE/FEATURES	0-200 PSIG 1 PSI/DIV
DATE CALIBRATED	01 27 76
INSTRUMENT NUMBER	18062
INSTR AND MFR	AMETEK, PRESSURE TRANSDUCER
TYPE/MODEL NUMBER	50G0200BC2X24
SERIAL NUMBER	20583-1 R3081-1
RANGE/FEATURES	0-50, 100, 200 PSIG
DATE CALIBRATED	01 27 76
INSTRUMENT NUMBER	18117
INSTR AND MFR	WESTON, AMMETER
TYPE/MODEL NUMBER	1934
SERIAL NUMBER	NONE
RANGE/FEATURES	0-100 A AC
DATE CALIBRATED	06 09 76
INSTRUMENT NUMBER	18178
INSTR AND MFR	HONEYWELL-BROWN, MULTIPOINT TEMP.RECORDER
TYPE/MODEL NUMBER	ELECTRONIK 16,1630 3856
SERIAL NUMBER	S0355 779001
RANGE/FEATURES	0-500 DEGREES F TYPE T T/C 0.125-1.0 IN/MIN
DATE CALIBRATED	04 13 76
INSTRUMENT NUMBER	18183
INSTR AND MFR	BARTON INSTRUMENT, PRESSURE GAGE
TYPE/MODEL NUMBER	STAINLESS STEEL
SERIAL NUMBER	227-19714
RANGE/FEATURES	0-100 IN. WATER 6000 PSIG STATIC
DATE CALIBRATED	05 27 76
INSTRUMENT NUMBER	18193
INSTR AND MFR	SIMPSON VOLTMETER
TYPE/MODEL NUMBER	NONE
SERIAL NUMBER	NONE
RANGE/FEATURES	0-750 VAC 10V/DIV
DATE CALIBRATED	03 30 76

512 037

INSTRUMENT NUMBER	18264
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	CURRENT TRANSFORMER
SERIAL NUMBER	NONE
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	04 02 76
INSTRUMENT NUMBER	18265
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	CURRENT TRANSFORMER
SERIAL NUMBER	NONE
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	04 02 76
INSTRUMENT NUMBER	18266
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	CURRENT TRANSFORMER
SERIAL NUMBER	NONE
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	04 02 76
INSTRUMENT NUMBER	18267
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	CURRENT TRANSFORMER
SERIAL NUMBER	NONE
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	04 02 76
INSTRUMENT NUMBER	18289
INSTR AND MFR	HIPOTRONICS HI-POT POWER SUPPLY
TYPE/MODEL NUMBER	705-2 CS14-750
SERIAL NUMBER	75-21623
RANGE/FEATURES	0 - 5 KV 0 - 400 MA
DATE CALIBRATED	01 30 76

F-C4350-2

Appendix

B

VISUAL INSPECTION RESULTS

512 039

APPENDIX B

A. Visual Inspection of Cables after Thermal Aging

A visual inspection of the cables on the double mandrel was made after thermal aging to determine if any obvious physical deterioration has occurred. The comments below are general in nature since the cables were not removed from the mandrel for a detailed inspection.

1. Cable 20.12 contained deep indentations in the outer jacket at both ends and at a point approximately 35 inches from the top of the mandrel. At the request of the client, sections of heat shrinkable tubing about 2 inches long were placed over the indentations at the ends of the cable after thermal aging.

2. No apparent defects were found in the remaining cables.

B. Visual Inspection of Cables after Radiation Exposure

Following the radiation exposure, another visual inspection was conducted of the cables on the double mandrel.

No apparent defects were found in any of the cables.

C. Visual Inspection of Cables after LOCA Exposure

Following the LOCA exposure, the cables on the mandrel were inspected before they were removed for the mandrel bend and high-potential withstand test. It was noted that chemical deposits from the spray solution covered the surfaces of all the cables.

No apparent defects were found in any of the cables.

F-C4350-2

Appendix

C

CERTIFICATION OF RADIATION

512 041

50-320

ANACONDA

Wire and Cable Division

FLAME-GUARD FR-EP CABLE

512 042

ENGINEERING DATA SHEET

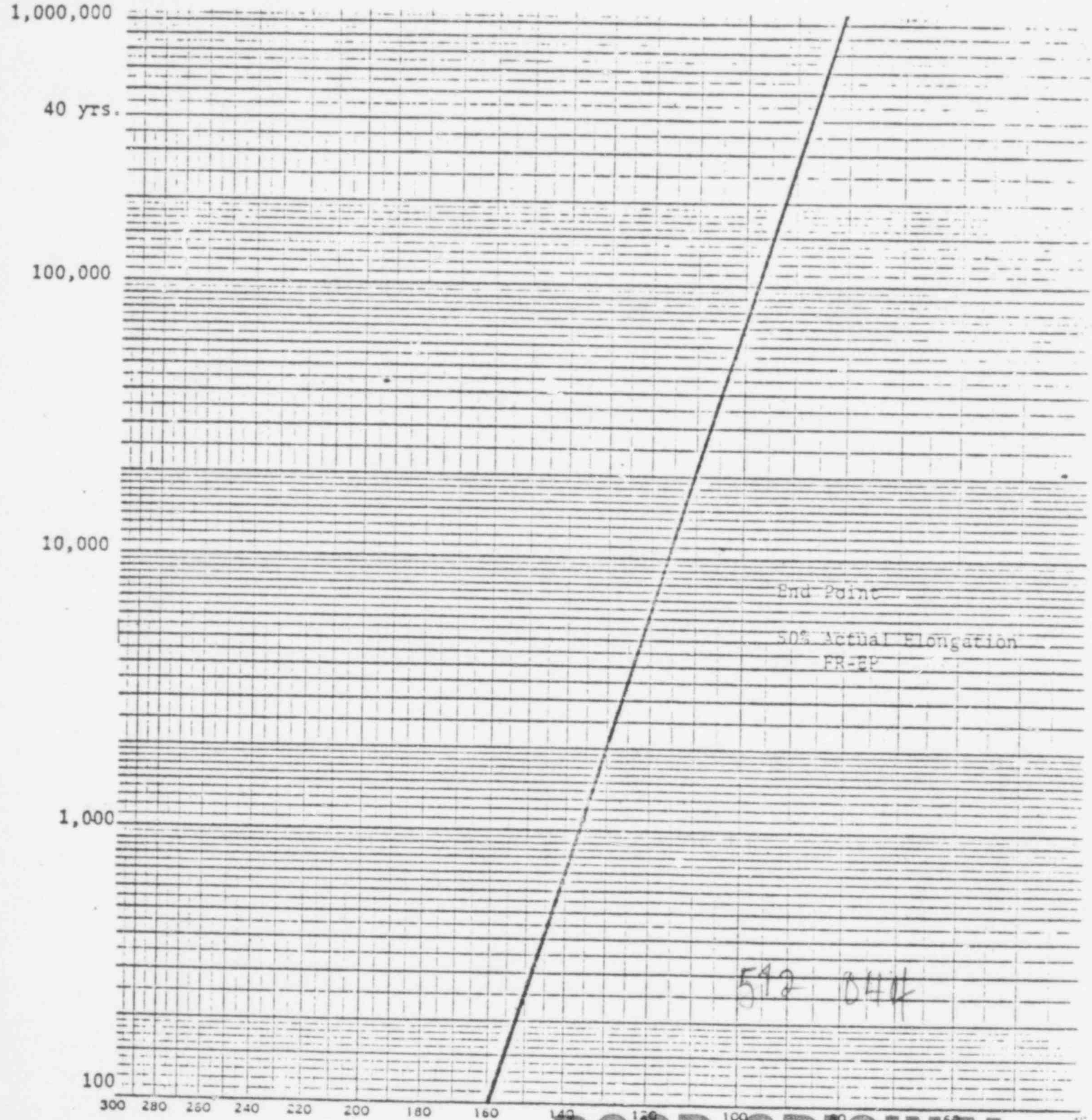
a. Arrenhenius Plot

b. Qualification Test Report From FIRL

512 043

ANACONDA

a. Arrehenius Plot



50-320

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

512 045

F-C2232-01

JANUARY 2, 1969

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 non-metallic 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

512 046

1. Preliminary heat tests on component parts.
2. Preliminary heat tests on actuator.
3. 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 conditions.

6. 150 life cycle test of actuator producing approximately 16,500 po' .ds of thrust.

7. Test of Limitorque valve operator and electric brake motor under a simulated reactor containment post-accident steam and chemical env:ronment.

512 047

1. PRELIMINARY HEAT TESTS ON COMPONENT PARTS

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.

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.

512 049

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. 150 LIFE CYCLE TEST OF LIMITORQUE OPERATOR PRODUCING APPROXIMATELY 16,500 POUNDS THRUST

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 OPERATOR 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-

512 051

mental condition.

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 steam 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 switch 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.

512 052

Test Report No. 2120-4594

REPORT OF TEST
on

PHILADELPHIA GEAR CORPORATION

SMBO-15 LIMITORQUE

Report Writer: B. F. Soltis

Test Engineer: W. A. Black

LOCKHEED ELECTRONICS COMPANY

MILITARY SYSTEMS DIVISION ······· PLAINFIELD, NEW JERSEY

Date: July 31, 1968

Approved by: N. Johnson, Supervisor
Environmental Laboratory

LEC

POOR ORIGINAL

LEC 197P

512 053

T t Report No. 2120-4594

PURPOSE OF TEST:	To subject the test specimen to the Vibration Test referenced in Philadelphia Gear Corporation Purchase Order No. 600198.
MANUFACTURER:	Philadelphia Gear Corporation King of Prussia, Pa.
SPECIMENS TESTED:	SMBO-15 Limitorque (Reliance Motor S/N 435571-MS)
APPLICABLE DOCUMENTS:	Philadelphia Gear Corporation Purchase Order No. 600198
CASE NUMBER:	24-8041-0594
QUANTITY OF SPECIMENS TESTED:	One (1)
SECURITY CLASSIFICATION OF SPECIMENS TESTED:	Unclassified
DATE TEST COMPLETED:	7/30/68
TEST CONDUCTED BY:	LOCKHEED ELECTRONICS COMPANY ENVIRONMENTAL LABORATORY
DISPOSITION OF SPECIMENS TESTED:	Returned to Franklin Institute, Applied Mechanics Laboratory per the request of Philadelphia Gear Corporation per Lockheed 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, MB Company Model M-6, S/N 539 Vibration Pickups, MB Company Type 120, S/N 14187 (vert'cal) and S/N 11263 (horizontal)
TEST PROCEDURE:	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.

POOR ORIGINAL

Form LEC 197F

TEST PROCEDURE: (Cont'd)

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.

TEST RESULTS:

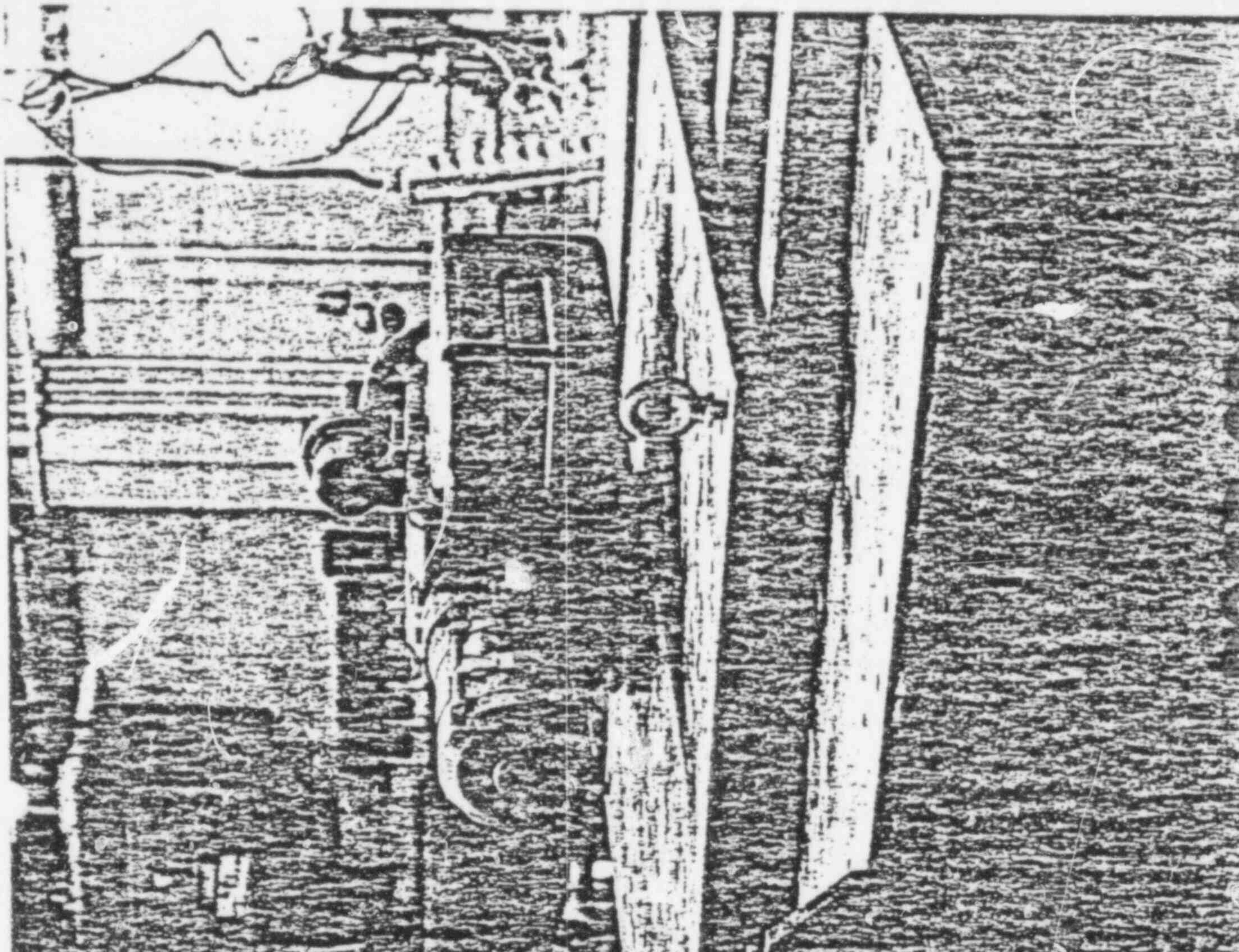
The Vibration Test was completed with no visible evidence of any external physical damage.

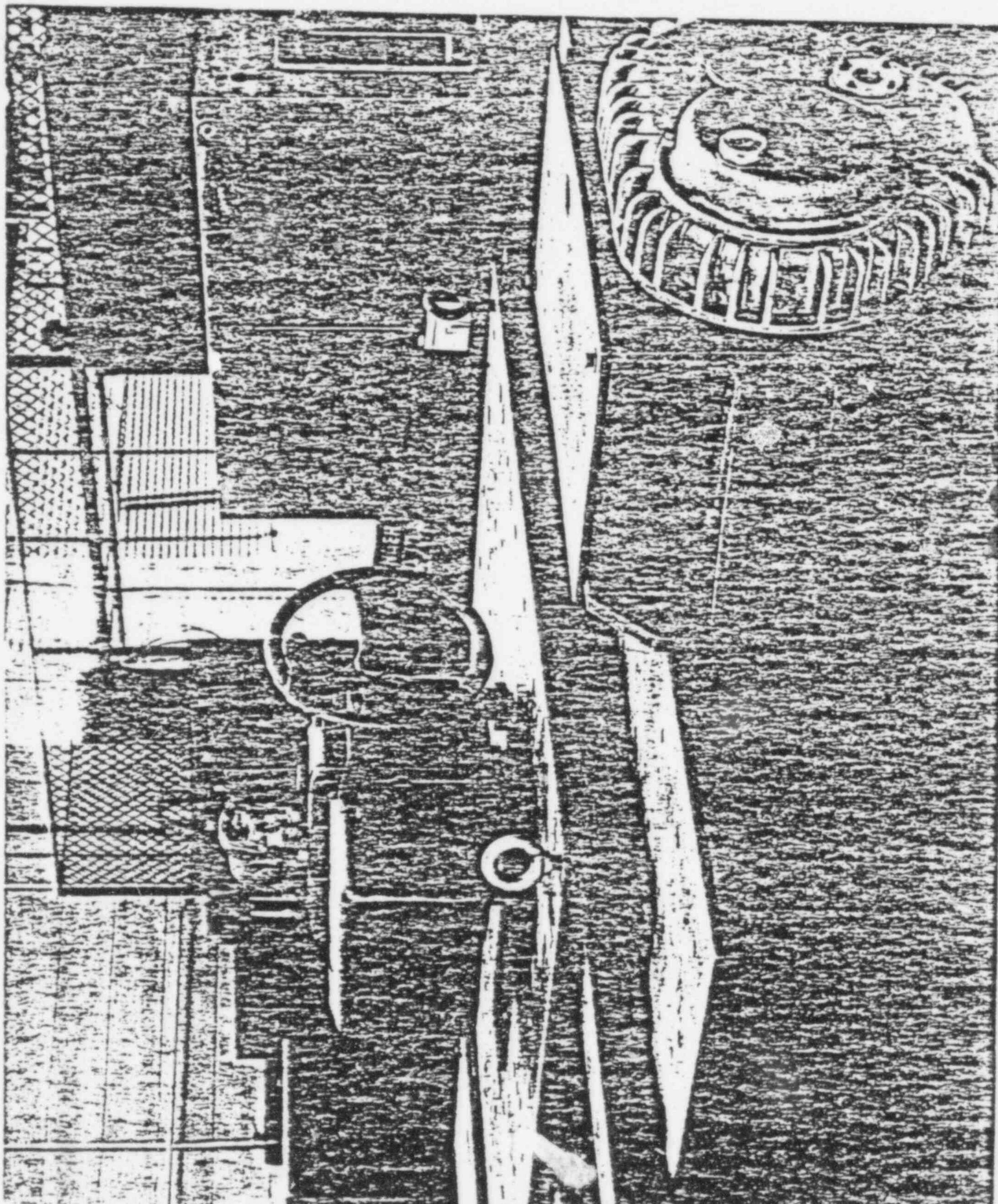
RECOMMENDATIONS:

None. Data merely submitted.

Test Engineer: W. A. Black

512 055

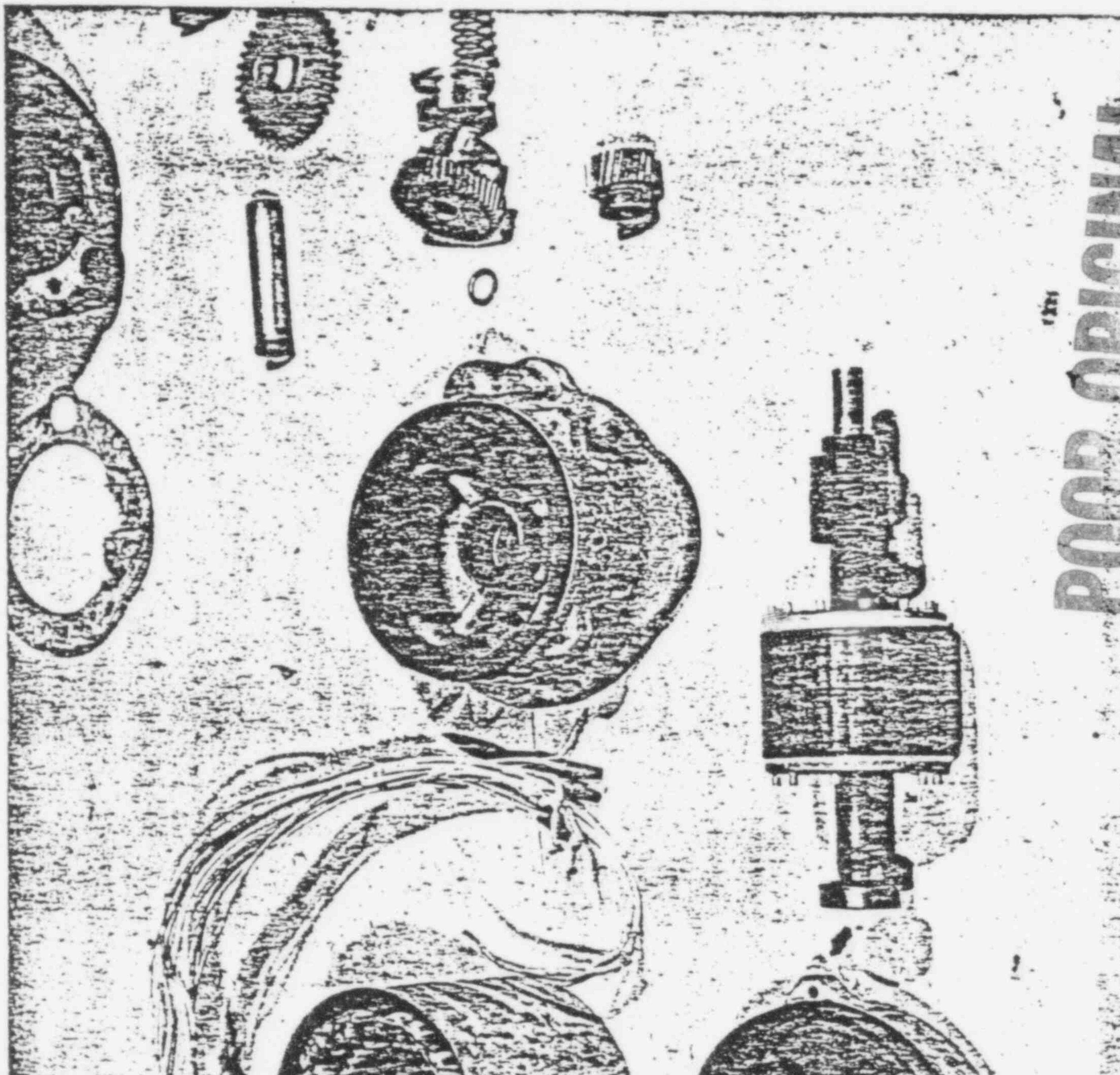


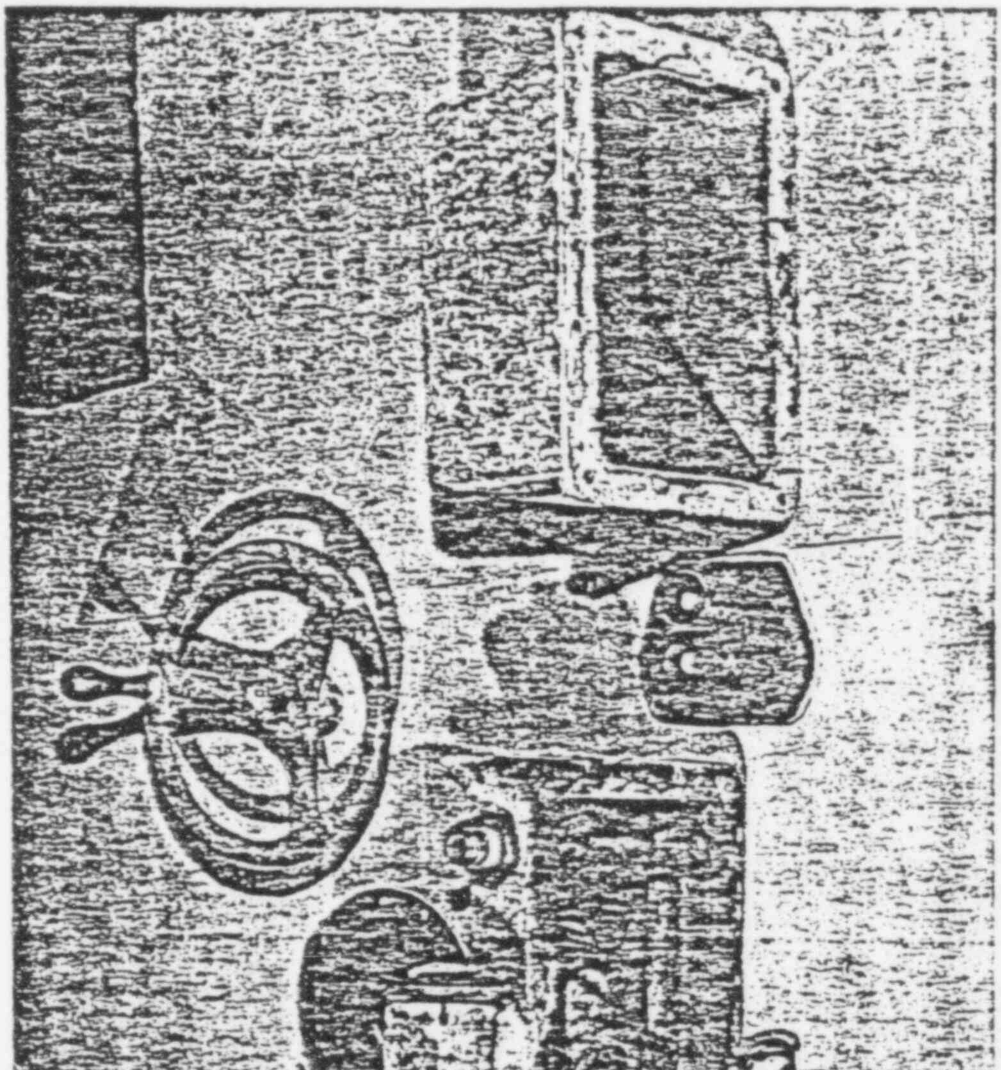


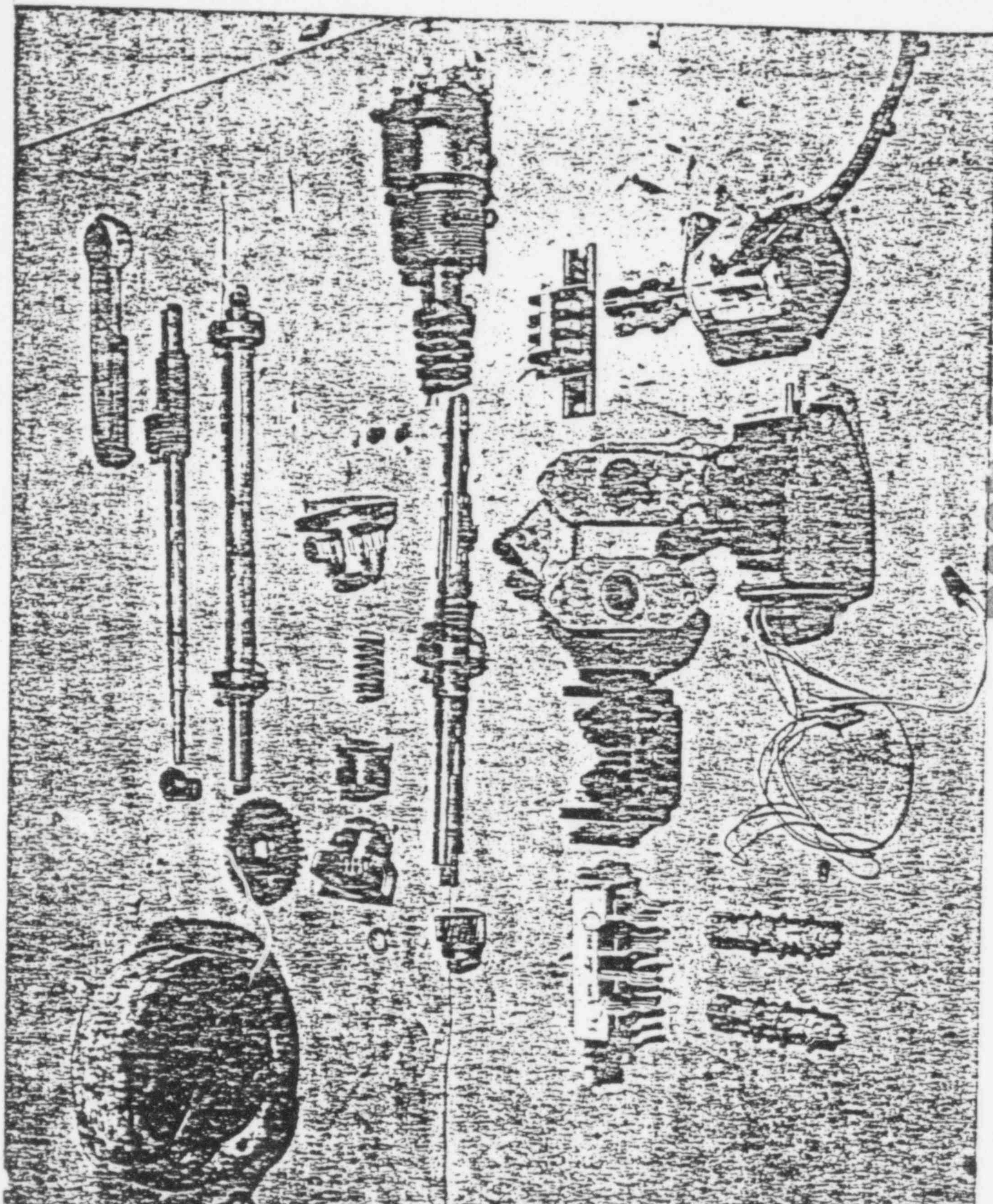
512 057

PHOTOGRAPHS
OF
LIMITORQUE OPERATOR PARTS

DISASSEMBLED AFTER ENVIRONMENTAL TEST







512 061

50-320

ADDENDUM #1

512 062

PHILADELPHIA GEAR CORPORATION
KING OF PRUSSIA, PENNA. 19406

LIMITORQUE VALVE CONTROL

ADDENDUM NUMBER #I
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

APRIL 29, 1969

512 063

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.

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 Laboratories in Philadelphia, Pennsylvania 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 and 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

512 066

5.3 G's, 35 Hz.

512 067

PHILADELPHIA GEAR CORPORATION

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

Main Office:
Schuylkill Expressway, Suburban Phila.
KING OF PRUSSIA, PA. 19406
TELEPHONE: 265-3000

SUBJECT: REPORT OF TEST ON LIMITORQUE VALVE CONTROL

SHOCK & VIBRATION UP TO 5.3 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 a 4-train geared limit switch installed and all contacts not being 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 each 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

512 068

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, upon starting the second run, the hardware holding the geared limit 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 and vibration at 10 G's and 49 Hz.

The enclosed Test Report #2539A-4723 of Lockheed Test Lab. is submitted for your information.

Very truly yours,

PHILADELPHIA GEAR CORPORATION

E. F. Lawson

Edward F. Lawson, Sales Manager
Limitorque Division

ak
enc.

512 069

50-320

Test Report No. 2538A-4723

Issue 2

REPORT OF TEST
on

LIMITORQUE CORPORATION
SMB-0-25
VALVE OPERATOR

Report Writer: R F Soltis
R. F. Soltis

Test Engineer: W. A. Black
W. A. Black

LOCKHEED ELECTRONICS COMPANY

PLAINFIELD, NEW JERSEY

Date: September 23, 1970

Approved by: Nat Johnson
N. Johnson, Supervisor
Environmental Laboratory

LEC 197P-1

POOR ORIGINAL

512 070

LEC

Test Report No. 2533A-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:	SMB-0-25 Valve Operator
APPLICABLE DOCUMENTS:	Limitorque Corporation Purchase Order Number 348572, dated 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 BY:	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 completed 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 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 35 Hz in two (2) axes. The exploratory scans were followed by three (3) cycles of vibration in each axis. Each cycle consisted of two (2) minutes of vibration at a frequency of 35 Hz and an acceleration level of 5.3G'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 additional 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 G's.

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

TEST RESULTS:

The 5.3 G portion of testing was completed with no evidence of any discrepancies noted during either axis 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 limi switch mounting hardware.

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

RECOMMENDATIONS:

None. Data merely submitted.

Test Engineer: W. A. Black GB
W. A. Black

Form LEC 197F

512 072

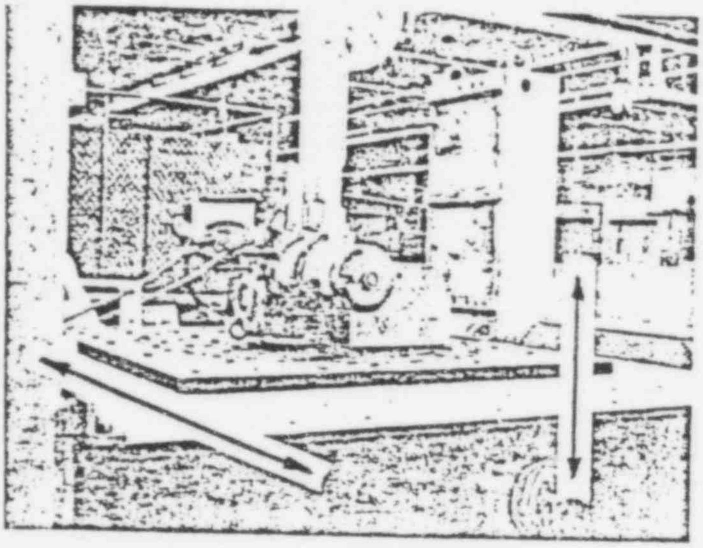


FIGURE 1

VIBRATION TEST SETUP
(HORIZONTAL AND VERTICAL)

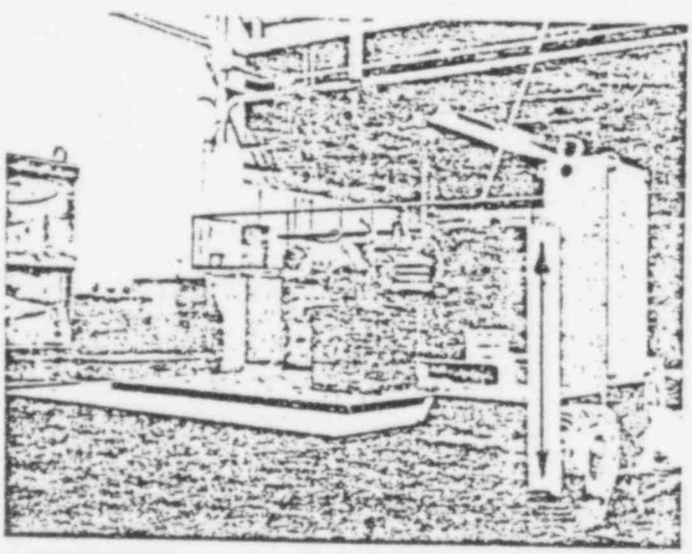


FIGURE 2

VIBRATION TEST SETUP
(VERTICAL)

LOCKHEED ELECTRONICS
ENVIRONMENTAL LABORATORY DATA SHEET Issue 2

Date: 8-20-76

Case: 34

Specimen Description

SMB-00-25 VALVE OPERATOR
PHILA GEAR

Technician

Test Condition EXPLORATORY SCAN

SCAN 5-33 CPS. VERTICAL EARTHQUAKE VIB. TEST

Test Engineer

	VERTICAL				
HZ	"DA	HZ	"DA		
5	.076	32	.067		TOTAL SCAN TIME = 5 MIN.
6	.076	33	.066		
7	.076	34	.066		
8	.076	35	.066	4 G's	
9	.075				
10	.075				
11	.072				
12	.072				
13	.071				
14	.071				
15	.070				
16	.069				
17	.069				
18	.069				
19	.063				
20	.063				
21	.064				
22	.064				
23	.068				
24	.068				
25	.068				
26	.068				
27	.068				
28	.067				
29	.067				
30	.067				
31	.067				

512 074

POOR ORIGINAL

LEC 376C

[illegible]KHEED ELECTRONICS
ENVIRONMENTAL LABORATORY DATA SHEET, ISSUE [illegible]

Date: [illegible] 30-70

Specimen Description
SMB-0-25 VALVE OPERATOR
PHILI GEAR . .

Case: 34
5041-1783

Technician
[illegible]

Test Condition EXPLORATORY SCAN
HORIZONTAL
5-35 CPS. EARTH QUAKE
VIB. TEST.

Test Engineer
[illegible]

HZ	" DA.	HZ.	" DA.	
5	.098	32	.084	Total SCAN TIME = 5 MIN.
6	.098	33	.084	
7	.096	34	.084	
8	.094	35	.084	5.3 G's
9	.092			
10	.092			
11	.092			
12	.090			
13	.090			
14	.090			
15	.090			
16	.088			
17	.090			
18	.090			
19	.088			
20	.088			
21	.088			
22	.088			
23	.088			
24	.088			
25	.088			
26	.088			
27	.088			
28	.086			
29	.086			
30	.086			
31	.086			

512 075

LEDEED ELECTRONICS
ENVIRONMENTAL LABORATORY DATA SHEET ISSUE 2

Specimen Description SMD-0-25 VALVE OPERATOR RHLI GEAR	Case: 3?
	Technician
Test Condition EXPLORATORY SCAN VERTICAL WITH UNIT STANDING. EARTH QUAKE VIB. TEST.	Test Engineer

HZ	"D/A							Remarks
								TOTAL SCAN TIME = 3 MIN.
5	.1							
6	.1							
7	.1							
8	.1							
9	.093							
10	.086							
11	.071							
12	.078							
13	[illegible]							
14	[illegible]							
15	[illegible]							
16	[illegible]							
17	.090							
18	.090							
19	.090							
20	.090							
21	.090							
22	.088							
23	.088							
24	.088							
25	.088							
26	.085							
27	.084							
28	.085							
29	.058							
30	.056							
31	.056							
32	.056							
33	.056							
34	.056							
35	.056	5.3 G's						

512 076

LEC 3768

LOCKHEED ELECTRONICS
ENVIRONMENTAL LABORATORY DATA SHEET

ISSUE 2

Date: 8 ...

Specimen Description: SMB-0-25 VALVE OPERATOR. PHILL. GEAR.

Case: ...

Technician: [illegible]

Test Condition: EXPLORATORY SCAN VERTICAL WITH UNIT STANDING. EARTH QUAKE VIB. TEST.

Test Engineer: [illegible]

Hz	g/A		Hz	g/A					Remarks
5	1		38	.056					TOTAL SCAN TIME = 7 MIN.
6	.1		39	.056					
7	.1		40	.056					
8	.075		41	.056					
9	.095		42	.056					
10	.096		43	.056					
11	.095		44	.056					
12	.094		45	.056					
13	.094		46	.056					
14	.056		47	.056					
15	.055		48	.056	10 g's				
16	.054		49	.056	10 g's				
17	.054		50						
18	.054								
19	.054								
20	.054								
21	.052								
22	.052								
23	.052								
24	.052								
25	.052								
26	.055								
27	.052								
28	.055								
29	.061								
30	.056								
31	.056								
32	.056								
33	.057								
34	.057								
35	.057								
36	.056								
37	.056								

512 077

LOCKHEED ELECTRONICS
ENVIRONMENTAL LABORATORY DATA SHEET

Date: [illegible]-70

Case: DY-80[illegible]1-0723

Specimen Description

SHB-0-25
VALVE OPERATOR

Technician: R. Solte

Test Condition

CYCLING TEST

Test Engineer: [illegible]

AXIS NO.	CYCLE NO.	VIBRATION INPUT g's	TIME MINUTES
1	1	5.3	2
		0	1
	2	5.3	2
		0	1
	3	5.3	2
		0	1
2	1	5.3	2
		0	1
	2	5.3	2
		0	1
	3	5.3	2
		0	1
3	1	5.3	2
		0	1
	2	5.3	2
		0	1
	3	5.3	2
		0	1
3	1	10.0	2
		0	1
	2	10.0	1 *

AXIS #1 = VERTICAL VIBRATION AS SHOWN IN FIGURE 1

AXIS #2 = HORIZONTAL VIBRATION AS SHOWN IN FIGURE [illegible] (PARALLEL TO SHAFT)

AXIS #3 = VERTICAL VIBRATION AS SHOWN IN FIGURE 2

5 g INPUTS WERE APPLIED AT 35 HZ, 10 g INPUTS WERE APPLIED AT 43 HZ

*TEST STOPPED AT THIS TIME DUE TO FATIGUING OF MOUNTING HARDWARE

512 078

APPENDIX D

Seismic Qualification - Lockheed Test Report

512 079

TEST REPORT NO. 3521-4811

REPORT OF TEST

ON

LIMITORQUE CORPORATION
SMB0 OPERATOR W/MOTOR (40 FT. LB.)
AND
MOTOR (25 FT. LB.)

REPORT WRITER: R. F. Soltis

TEST ENGINEER: W. A. Black

LOCKHEED ELECTRONICS COMPANY, INC.

PLAINFIELD, NEW JERSEY

DATE: June 17, 1974

APPROVED BY: N. Johnson, Manager
Environmental Laboratory

512 080

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) SM80 Operator with 40 ft. lb. motor. S/N 189835 (b) Reliance 25 ft. lb. motor
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.

512 081

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 ± 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.

512 082

POOR ORIGINAL

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

POOR ORIGINAL

512 083

FORM LEC 197A

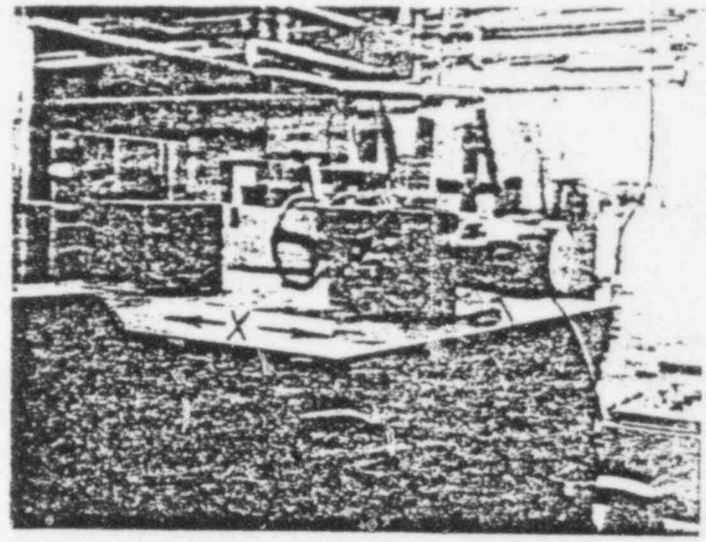


FIGURE 1

TEST SETUP - X AXIS

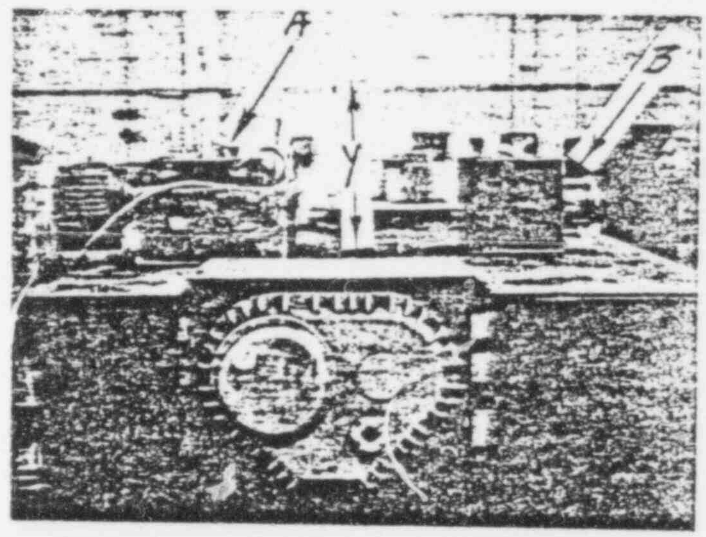


FIGURE 2

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

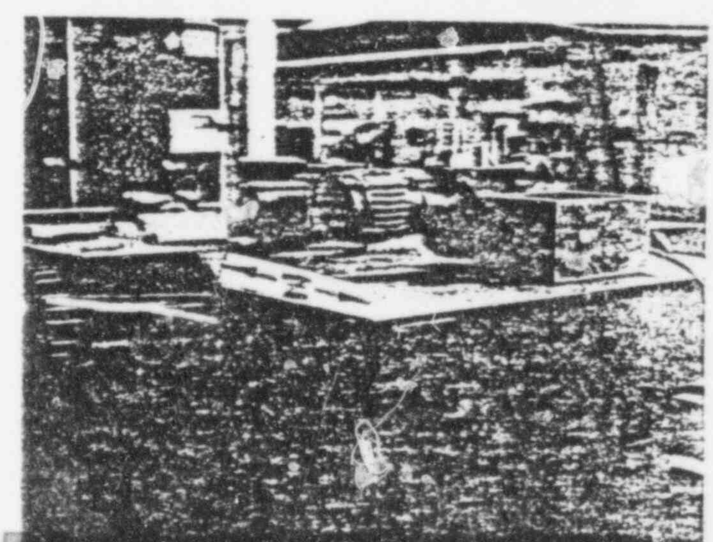


FIGURE 3

TEST SETUP - Z AXIS

VIBRATION TEST DATA SHEET

AXIS: Z Axis

Hz	EXPLORATORY (PARA. 1) INPUT	CH. 1	CH. 2	VARIABLE FREQUENCY (PARA 2.2) INPUT	CH. 1	CH. 2
4						
5	.014	.016	.013			
6	.016	.016	.014	.054	.049	.047
7	.017	.016	.016			
8	.018	.017	.017	.054	.052	.052
9	.018	.017	.018			
10	.018	.017	.0185	.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	.019	.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	.049	.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				Operator Actuation During		
41				This Portion of Test		
42						
43						
44						
45						
46						
47						
48						
49						
50						

RES. NONE Hz

REPORT NO. 3521 - 4511

DATE 6/12/74

NOTE: RECORDED DATA IS DOUBLE AMPLITUDE (INCHES)

ENDURANCE TEST (PARA 2.2) Hz	INPUT	DURATION
35	.100	10 SE.

• TEST SPECIMEN • NOMENCLATURE

1 MOTOR W/FIXTURE
1 SMBO OPERATOR W/MOTOR

SERIAL NO.

MANUFACTURER

LIMITORQUE CORP.

ACCELEROMETER LOCATIONS

CH. 1	SIDE OF MOTOR
CH. 2	TOP OF UNIT

REMARKS:

512 085

POOR ORIGINAL

TEST ENGINEER

Wm G. [signature]

SHEET 5 OF 7

FORM LEC 322B

VIBRA ON TEST DATA SHEET

AXIS: X AXIS

REPORT NO. 3521 - 4811

DATE 6/12/74

NOTE: RECORDED DATA IS DOUBLE AMPLITUDE (INCHES)

Hz	EXPLORATORY (PARA. 1) INPUT	CH. 1	CH. 2	VARIABLE 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	.0195	.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	.029	.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

ENDURANCE TEST (PARA 2.2.3)

Hz	INPUT	DURATION
35	.100	10 SEC

TEST SPECIMEN NOMENCLATURE

1 MOTOR W/FIXTURE

1 SMBC OPERATOR W/MOTOR

SERIAL NO.

MANUFACTURER

LIMITORQUE CORP.

ACCELEROMETER LOCATIONS

CH. 1	REAR OF MOTOR
CH. 2	FRONT OF HANDWHEEL

REMARKS:

512 086

POOR ORIGINAL

TEST ENGINEER

Wm H. Black

FORM LEC 922B

SHEET 6 OF 7

VIBRATION TEST DATA SHEET

AXIS: Y AXIS

REPORT NO. 3521 - 4811

DATE 6/12/74

NOTE: RECORDED DATA IS DOUBLE AMPLITUDE (INCHES)

Hz	EXPLORATORY (PARA. 1) INPUT	CH. 1	CH. 2	~~VARIABLE FREQUENCY~~ (PARA 2.2) INPUT	CH. 1	CH. 2
4						
5	.004	.016	.010			
6	.004	.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						
41				OPERATOR ACTUATED [illegible]		
42				[illegible]		
43						
44						
45						
46						
47						
48						
49						
50						

RES. NONE Hz

ENDURANCE TEST (PARA 2.2)

Hz	INPUT	DURATION
35	.100	10 SEC.

TEST SPECIMEN NOMENCLATURE

1-MOTOR W/FIXTURE

1-SMB0 OPERATOR W/MOTOR

SERIAL NO.

MANUFACTURER

LIMITORQUE CORP.

ACCELEROMETER LOCATIONS

CH. 1	TOP OF MOTOR
CH. 2	TOP FRONT OF HANDWHEEL

REMARKS:

512 087

POOR ORIGINAL

TEST ENGINEER

Wm. C. Bl[illegible]

SHEET 7 OF 7

APPENDIX E

512 088

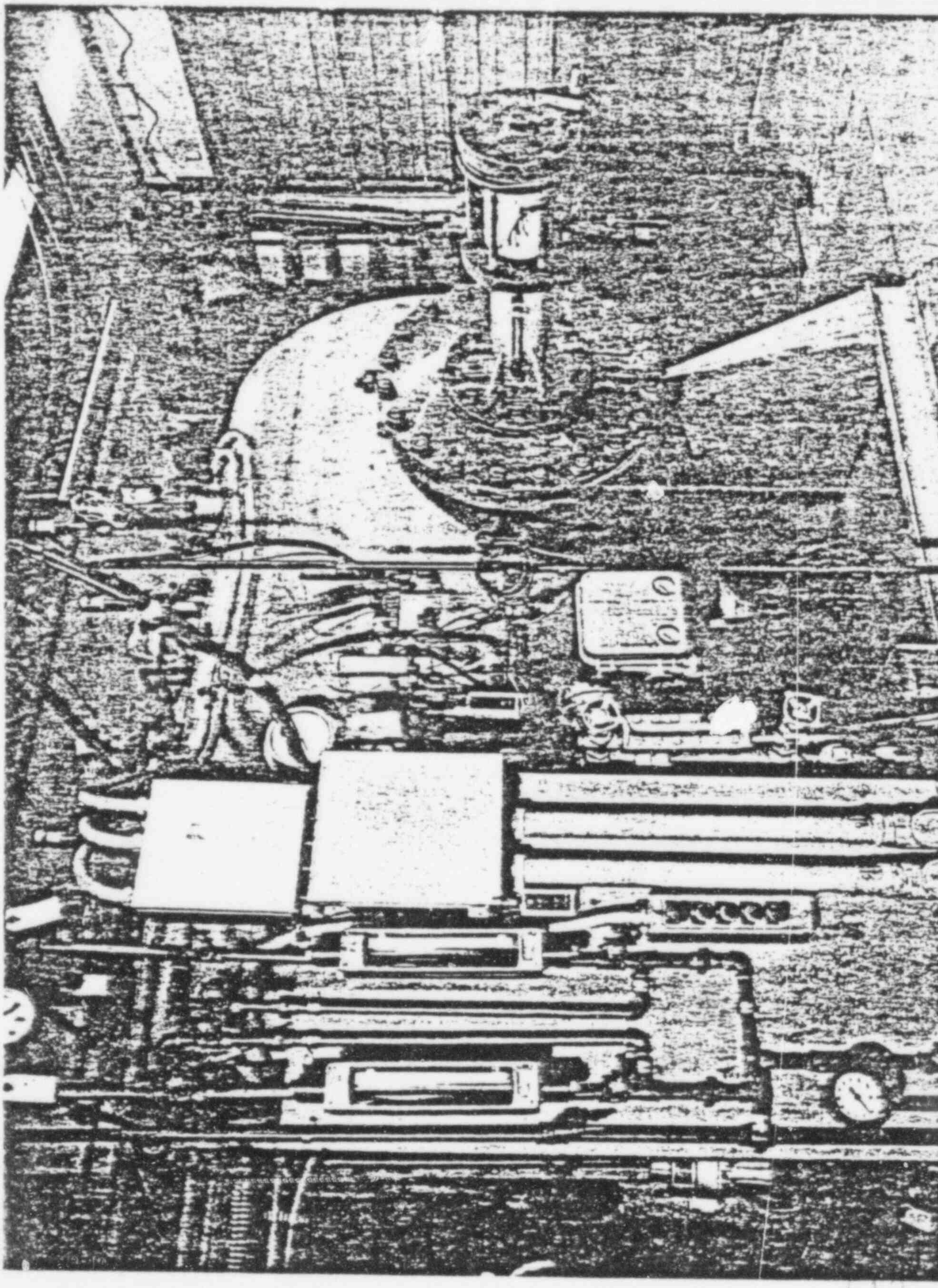


Figure 1
Test Chamber

512 089

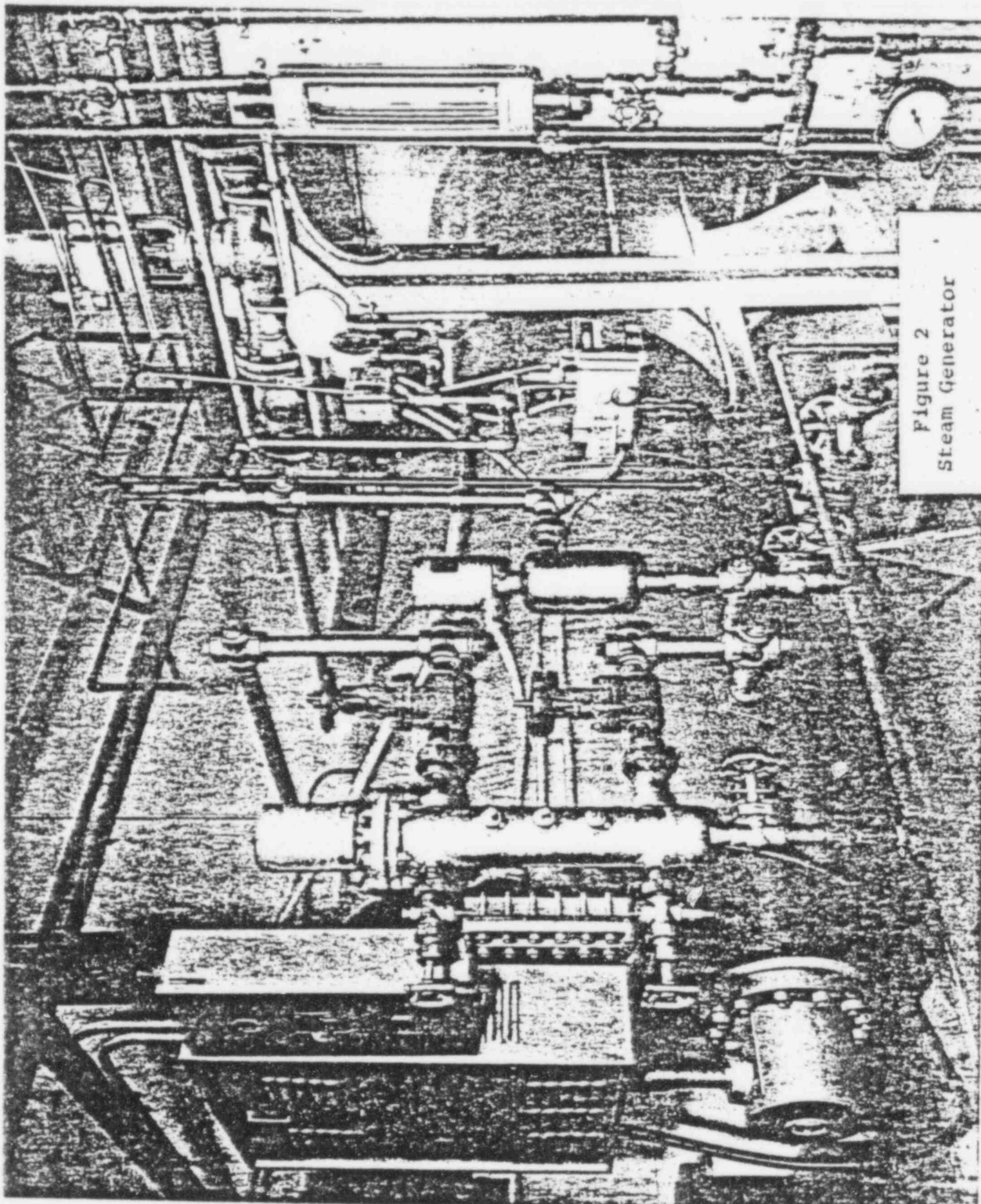


Figure 2
Steam Generator

512 090

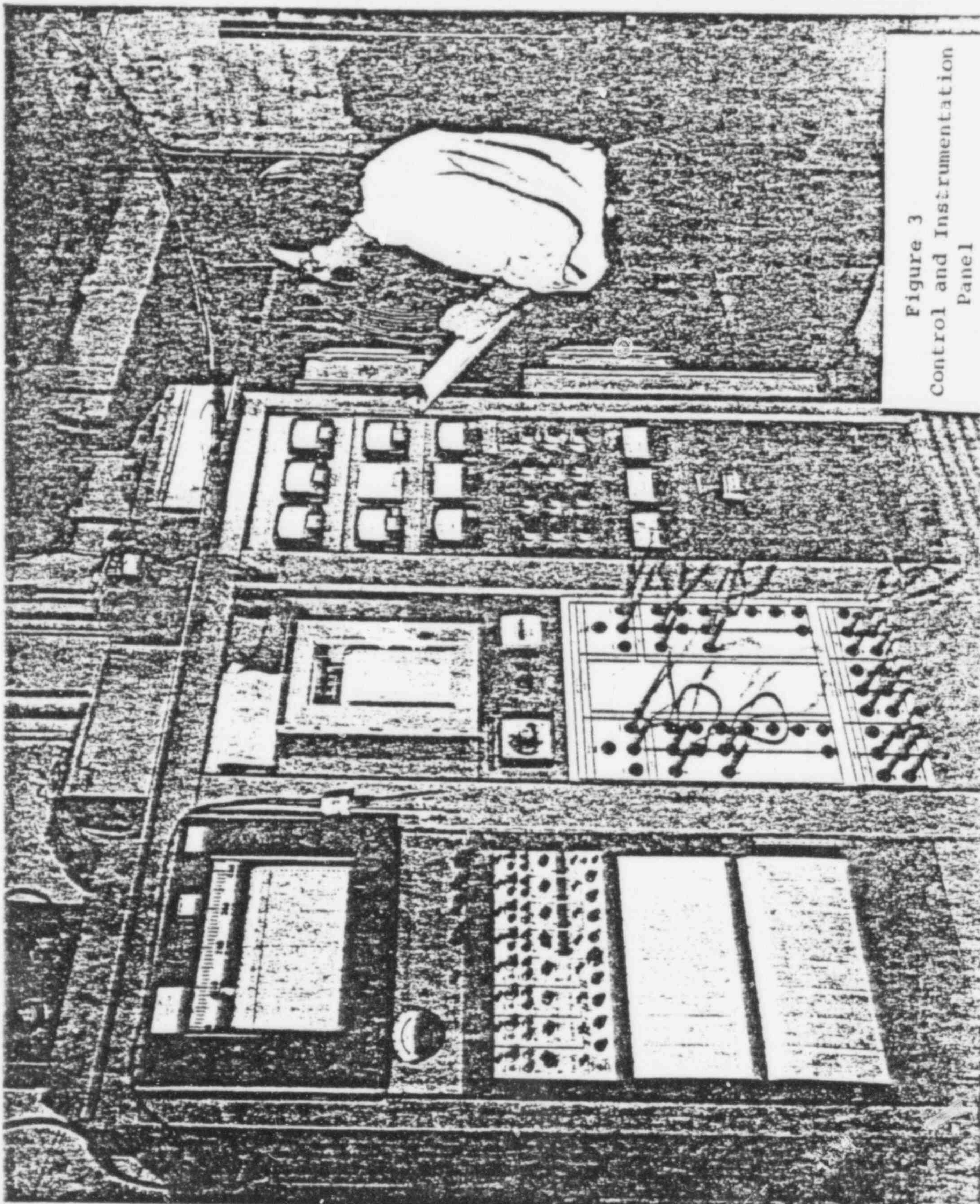


Figure 3
Control and Instrumentation
Panel

APPENDIX F

512 092

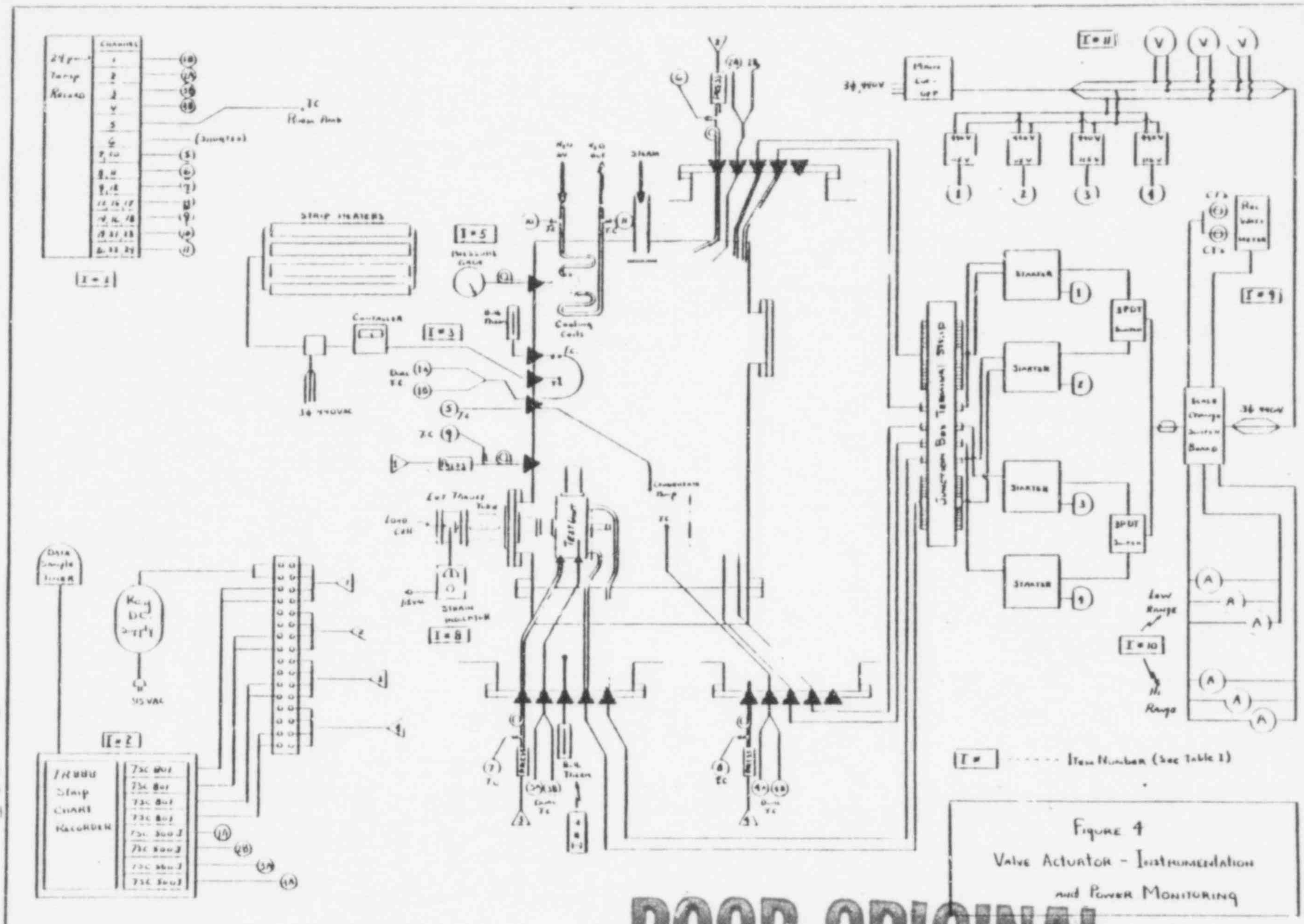


Figure 4
Valve Actuator - Instrumentation and Power Monitoring

TABLE I

SUMMARY OF DATA ACQUISITION SYSTEM

Measurement Categories IEEE Std.382 Par.4.51	PARAMETER	Item No.	MEASURING SYSTEM: Indicator	Signal Conditioner	X-Ducer	Monitoring Point	LAST CALIBRATION	NEXT CALIBRATION
I - ENVIRONMENT	TEMPERATURE	1.	Multipoint Temperature Recorder Type J T. C. Honeywell Model No. K153x80-c- II-W6-65 Serial No. T11806-83004	1 2 3 4 5 6 7,10 8,11 9,12 13,15,17 14,16,18 19,21,23 20,22,24	1B T. C.-J(2) 2A T. C.-J(2) 3B T. C.-J(2) 4B T. C.-J(2) - - - - 5 T. C.-J 6 T. C.-J 7 T. C.-J 8 T. C.-J 9 T. C.-J 10 T. C.-J 11 T. C.-J	Chamber Amb. Test Unit L.S.Comp Chamber Amb. Room Amb. Shorted Condensate Press x-D#2 Press x-D#3 Press x-D#4 Press x_D#1 H_2O input H_2O output	Feb. 1974	Feb. 1975
	TEMPERATURE & PRESSURE	2.	Strip Chart Recorder 8 Channel Gulton TR888 S/N 3042802	1 Amplif. 2 " 3 " 4 " 5 T.C. Mod. 6 " 7 " 8 "	Press x-D#1 Press x-D#2 Press x-D#3 Press x-D#4 1A T.C.-J(2) 2B T.C.-J(2) 3A T.C.-J(2) 4A T.C.-J(2)	Chamber Amb. Test Unit L.S. Comp. Chamber Amb. Chamber Amb. Test Unit L.S. Comp. Chamber Amb.	Mar. 1974	Sept. 1974

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			Monitoring Point	LAST CALIBRATION	NEXT CALIBRATION
			Indicator	Signal Conditioner	X-Ducer			
I - Environment	TEMPERATURE	3	Mercury bulb Thermometer Wexler 50-400 F			Chamber Ambient	New 2/74	2/75
I - Environment	TEMPERATURE	4	Bi-metal Dial Thermometer Wexler 50-400 F			Chamber Ambient	New 2/74	2/75
I - Environment	Pressure	5	Dial Pressure Gage Ashcroft 30 in Hg to 200 psig			Chamber Pressure	5/74	11/74
I - Environment	Time	6	Time of Day Wall-Clock			Time of Day	-	-
I - Environment	Time	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
			Indic-ator	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 2/74	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

512 096

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	[illegible]	2/75 [illegible]or
	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

512 097

50-320

Spec 24

REPORT NO. X-421

DATE May 18, 1973

JOY MANUFACTURING CO.

NEW PHILADELPHIA, OHIO

REPORT ON

MODIFIED ENVIRONMENTAL TEST

AND

LOW SPEED HEAT TEST

ON

JOY MANUFACTURING COMPANY
FAN MODEL 48-26½-1170/870 RPM
PART NO. 500722-66

FOR

JERSEY CENTRAL POWER & LIGHT COMPANY
THREE MILE ISLAND NUCLEAR STATION
UNIT NO. 2

CUSTOMER: AMERICAN AIR FILTER COMPANY
LOUISVILLE, KENTUCKY

512 098

PREPARED BY J. T. Zeigler/ J. T. Zeigler

CHECKED BY W. W. Olson/ W. W. Olson

APPROVED BY

APPROVED
G.P.U./Q.A.-TMI
NAME [illegible]
DATE 5/22/74

Rel. on NBS165 5-30-73

REVISIONS

DATE	PAGES AFFECTED	REMARKS

POOR ORIGINAL

NP22

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

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CHECKED BY W.W. Olson
DATE May 18, 1973

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NAME
DATE 5/22/74

POOR ORIGINAL

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

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PREPARED BY J.T. Zeigler
CHECKED BY W.W. Olson
DATE May 18, 1973

1.0 Test Objective

1.1 Simulated environmental test on Joy Mfg. Co. AXIVANE Fan P/N 500722-66 incorporating Reliance Electric Co. Motor Serial No. X325074AZ Rated 100/100 HP, 1170/870 RPM, 3/60/460 TEAO.

1.2 Low Speed Heat Test

To ensure that no overheating of the motor installed in Joy P/N 500722-66 would occur when the fan is delivering a low volume of air.

2.0 Test Equipment

(1) Joy Environmental Test Chamber
(2) Sellers Immersion Steam Boiler S/N 56690, 1,350,000 BTU
(3) Pressure Gauge 0-100 Pounds
(4) Two Wheatstone Bridges S/N 486646 & 1199665
(5) Rotary Switch
(6) Potentiometer S/N 1217589
(7) Weston Poly-phase Wattmeter Model 329 S/N 4461
(8) Weston Voltmeter Model 341 S/N 18677
(9) Weston Ammeter Model 433 S/N 132845
(10) Two Weston Instrument Transformers
(11) Flow Meter
(12) Chemical Water Pump
(13) Manometers
(14) Pitot Tube
(15) 48" Test Duct
(16) G.R. Sound Level Meter
(17) Stop Watch

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NAME
DATE 5/22/74

3.0 Testing

With the motor and fan rotor installed in the pressure vessel and the entire assembly mounted vertically, insulation resistance values of the motor windings were taken with a megger. These values are shown in Table I.

At the same time, resistance measurements were taken of the R.T.D.'s. These values are shown in Table II.

3.1 Pre-Heat Cycle

During a 30 minute period, the pressure vessel containing the motor was preheated by releasing steam into the vessel and maintaining a pressure of 40 psig

POOR ORIGINAL

512 100

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

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and a temperature of 287° F. At the end of the preheat cycle, the steam was shut off and the pressure reduced to 0 psig. See Tables III and IV.

3.2 Start Run Cycle

When the vessel had reached a 0 psig, steam was again released into the vessel to raise the pressure to 60 ±5 psig and 287° F. This was to be accomplished in approximately 10 seconds.

Two attempts to do this were made at the request of Mr. Vic Hawkins.

On the first attempt, the pressure reached 75 psig in 11 seconds.

On the second attempt, 60 psig was attained in 8 seconds.

At the same time the steam was released into the chamber, the motor was energized.

During the initial surge of steam, the temperature in the chamber reached 308° F. so the chamber temperature was reduced to 287° F. and allowed to stabilize at this point before the official test was begun. This stabilization required approximately twenty-five minutes. This delay in the start of the official run period was at the request of Mr. Hawkins.

At the start of the official run test, a chemical water solution having a Ph value of 7.2 and containing Hydrazine, Boric Acid, Sodium Hydroxide and Potassium Hydroxide and Sodium Thiosulphate was injected into the pressure vessel at the rate of .25 gallons per minute. This flow rate was maintained throughout the run cycle.

During the entire test period, readings of power, temperature, pressure and resistance of the RTD's were taken every five minutes.

A pressure of 60 ±5 psig and a temperature of approx. 287° F. was maintained for two hours.

Upon completion of the run cycle, the chamber pressure was gradually reduced to 0 psig while the motor continued to operate. Upon reaching 0 psig, fifteen additional minutes of motor operation was performed before shutting down for megger tests.

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POOR ORIGINAL

FORM NP53

These test results are shown in Table I.

The motor was then restarted at 0 psig and operated for one hour before shut down.

Megger readings of the insulation resistance were again taken and are shown in Table I.

During the run cycle, erratic operation of RTD #5 was noticed.

In order to eliminate the possibility of faulty instrumentation or switch, the instrumentation was changed, but no difference in readings was observed.

4.0 Post Test Inspection

After a 24 hour cool down period, the motor was again meggered and the results are shown in Table I.

The motor was then disassembled and checked for evidence of coating failure.

At this time, photographs were taken of the parts for record purposes and are on file at Joy Manufacturing Co.

Resistance readings of the RTD's were also taken at this time to see if RTD #5 was still erratic. Figure "A" shows where readings were taken and the results are tabulated on Table II.

5.0 Low Speed Heat Run

After the post test inspection, the motor was assembled into a fan unit and mounted on a 48 inch diameter duct for a low speed heat run.

The unit was operated until RTD readings had remained stable for one hour. See Table V.

6.0 Sound

512 102

During the heat run, sound pressure levels and octave band analysis were taken at distances of 3 feet and 5 ft. and at angles of 45 degrees and 90 degrees from the fan inlet.

This data is shown on Table VI.

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DATE 5/22/74

FORM HPE3

7.0 Acceleration Time

Acceleration time of the fan was checked at both low and high speeds. The results are shown below:

	Accel. Time	Volts	Amps	Watts
High Speed	7.2 Sec.	442	78.6	33,000
Low Speed	4.0 Sec.	443	60	14,100

8.0 Remarks

Inspection of the recorded data taken on the R.T.D.s shows a probable failure of R.T.D. No. 5.

This premise is based on the fact that R.T.D. No. 6 is located in an adjacent slot to R.T.D. No. 5 and the readings for R.T.D. No. 6 compare very closely to the readings taken on the remaining R.T.D.s.

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MEGGER READINGS

Lead No.	High Speed To Ground	Lead No.	Low Speed To Ground	Between Windings	Remarks
11	INF	1	INF	INF)	Before Test Amb. Temperature
12	INF	2	INF	INF)	70° F.
13	INF	3	INF	INF)	
11	150 Megs	1	125 Megs	125 Megs)	15 Minutes after
12	200 Megs	2	125 Megs	125 Megs)	cool down cycle
13	200 Megs	3	150 Megs	125 Megs)	Chamber Temp. 231° F.
11	400 Megs	1	200 Megs	325 Megs)	After 1 hour run at atmospheric
12	400 Megs	2	200 Megs	325 Megs)	conditions.
13	400 Megs	3	200 Megs	325 Megs)	Chamber temp. 182° F.
11	INF	1	INF	INF	Cold Motor
12	INF	2	INF	INF	Ambient
13	INF	3	INF		Temperature 66° F.

TABLE I

512 104

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JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

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DATE May 18, 1973

R.T.D.

RESISTANCE IN OHMS

Shaft End Brg.	Opposite Shaft End Bearing	1	2	3	4	5	6	Remarks
1106	1103	1100	1098	1100	1100	1106	1100	Before Test
		1088.5	1086	1088.5	1088	1101	1088	Measured at Point "A"
						1100.5	1087.5	Measured at Point "B"
						1099.5	1087	Leads "A" & "B" Removed

* Multiply all readings x .1

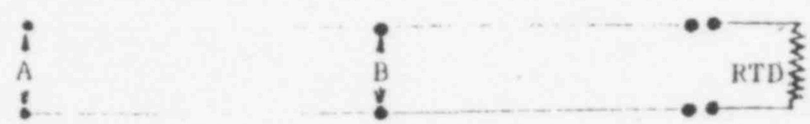

Figure "A"

512 105

TABLE II

APPROVED

JOY MANUFACTURING CO.
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DATE May 18, 1973

TABLE III, SHEET #1

ENVIRONMENTAL TEST
FAN MODEL 48-26-1/2-1170/870
JOY MANUFACTURING COMPANY, NEW PHILADELPHIA, OHIO

TIME	VOLTS	AMPS X60	WATTS X600	CHAMBER PRESS. PSIG	CHAMBER TEMP. oF.	ROOM AMB. DB	ROOM AMB. WB	REMARKS
8:15						68	56	
PREHEAT CYCLE								
9:20					82	69	56	
9:25				45	277	69	56	
9:30				40	287	69	56	
9:35				40	283	69	57	
9:40				42	287	70	57	
9:45				40	285	70	58	
9:50				40	280	70	58	
DRAINING DOWN TO 0 PSIG								
9:55				0	243	70	58	
START RUN CYCLE - FROM 0 TO 60 PSIG - 8 SECONDS								
10:02				60	308	70	58	
10:05				60	310	71	58	
10:10	430	1.97	112	63	295	71	59	
10:15	431	1.92	108	59	292	71	59	
10:20	431	1.90	107	60	290	71	59	
10:25	432	1.80	100	55	286	72	59	
10:30	430	1.90	106	57	292	71	59	
10:35	431	1.85	104	55	286	71	59	START OFF. TEST
10:40	431	1.85	102	55	288	71	59	
10:45	431	1.85	103	55	288	71	59	
10:50	431	1.87	105	56	289	71	59	
10:55	CHANGED WATT			56	290	72	60	
11:00	METER			55	290	71	59	
11:05	432	1.84	102	55	289	71	59	512 106
11:10	432	1.84	103	55	292	72	60	
11:15	432	1.87	107	55	292	72	60	
11:20	432	1.84	103	55	292	72	60	
11:25	436	1.84	102	56	296	72	60	
11:30	437	1.83	101	55	297	72	60	
11:35	438	1.83	100	55	297	72	60	
11:40	440	1.85	103	57	296	72	60	
11:45	440	1.80	99	55	298	71	59	
11:50	440	1.80	100	55	295	71	59	
11:55	440	1.85	103	55	294	71	59	
12:00	439	1.80	100	55	290	72	60	

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NAME [signature]
DATE 05/22/74

JOY MANUFACTURING CO
NEW PHILADELPHIA, OHIO

REPORT NO. X-421
PREPARED BY [illegible] Zeigler
CHECKED BY W.W. Olson
DATE May 18, 197[illegible]

TABLE III, SHEET #2

ENVIRONMENTAL TEST, CONTINUED

TIME	VOLTS	AMPS X60	WATTS X300	CHAMBER PRESS. PSIG	CHAMBER TEMP. °F.	ROOM AMB. DB	ROOM AMB. WB	REMARKS
12:05	437	1.80	103	56	291	73	60	
12:10	[illegible]	[illegible]	103	57	293	72	60	
12:15	432	1.85	103	56	293	72	60	
12:20	431	1.84	102	56	293	72	60	
12:25	431	1.84	101	56	292	72	60	
12:30	436	1.87	105	56	292	73	60	
12:35	431	1.82	100	55	293	73	60	
12:40	431	1.83	100	55	292	73	60	
12:45	430	1.82	100	55	292	73	60	
12:50	430	1.83	100	55	292	73	60	
12:55	431	1.83	100	55	293	73	60	
1:00	431	1.82	100	55	292	73	60	
BRING CHAMBER PRESSURE TO 0 PSIG								
1:05	430	1.70	90	47	290	73	60	
1:10	431	1.68	89	45	286	72	59	
1:15	432	1.65	83	40	272	73	60	
1:20	428	1.62	78	35	266	73	60	
1:25	430	1.43	65	25	244	73	60	
1:30	432	1.45	68	25	237	74	61	
1:35	432	1.37	60	18	229	73	60	
1:40	432	1.35	60	18	213	72	60	
1:45	432	1.20	40	5	207	73	60	
1:50	430	1.20	37	5	206	72	60	
1:55	430	1.10	26	0	205	73	60	
2:00	430	1.09	24	0	221	73	60	
2:00 "0" PRESSURE								
2:05	430	1.08	23	0	229	73	60	
2:10	436	1.07	23	0	234	74	60	
2:15	436	1.09	23	0	239	73	60	
FAN SHUT OFF								
2:40	-	-	-	0	228	73	60	
2:45	-	-	-	0	227	73	60	
START MOTOR @ 0 PSIG FOR 1 HOUR TEST								
2:45				0	227	73	60	
2:47	440	1.09	25	0	216	73	60	
2:50	440	1.10	24	0	212	74	60	
2:55	439	1.10	21	0	208	73	61	
3:00	439	1.10	22	0	205	73	61	

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[illegible]WED

J. [illegible] 5/22/7[illegible]

TABLE III, SHEET #3

ENVIRONMENTAL TEST, CONTINUED

TIME	VOLTS	AMPS X60	WATTS X100	CHAMBER PRESS. PSIG	CHAMBER TEMP. °F.	ROOM AMB. DB	ROOM AMB. WB	REMARKS
3:05	441	1.10	22	0	202	73	61	
3:10	442	1.10	22	0	198	73	61	
3:15	433	1.10	21	0	194	73	61	
3:20	440	1.11	25	0	194	71	60	
3:25	444	1.15	29	0	190	73	61	
3:30	444	1.15	29	0	189	72	60	
3:35	444	1.15	20	0	186	71	60	
3:40	444	1.15	20	0	184	71	60	
3:45	443	1.16	30	0	183	71	60	
3:47	443	1.15	30	0	182	71	60	

FINISHED TEST

512 108

APPROVED
G.P.U. / Q.A. TMI
NAME J. Fowler
DATE 5/22/74

FORM 1221

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

PAGE 10 OF
REPORT NO. X-421
PREPARED BY J. T. Zeigler
CHECKED BY K.W. Olson
DATE May 18, 1973

FAN MODEL 48-26½-1170/870

JOY MFG. CO. NEW PHILADELPHIA, OHIO

TIME A.M.	SHAFT #8 End Brg. (Res.OHMS)	OPP.SHAFT #7 End Brg. (Res.OHMS)	RTD's RESISTANCE IN OHMS # 1	# 2	# 3	# 4	# 5	# 6
8:15	1106X.1	1103X.1	1100X.1	1098X.1	1100X.1	1100X.1	1106X.1	1100X.1
9:20		30 MIN. PREHEAT CYCLE						
9:30	1397X.1	1344X.1	1233X.1	1216X.1	1139X.1	1142X.1	1163X.1	1162X.1
9:40	1550	1507	1524	1515	1473	1476	1492	1484
9:50	1544	1521	1542	1538	1537	1536	1543	1546
10:00	1549	1513	1564	1547	1544	1541	1548	1537
10:05	1584	1576	1588	1583	1589	1585	1597	1589
10:10	1579	1579	1587	1584	1589	1576	1595	1587
10:15	1576	1578	1587	1584	1589	1583	1593	1587
10:20	1575	1576	1587	1583	1587	1577	1591	1583
10:25	1573	1572	1583	1582	1584	1580	1589	1583
10:30	1573	1573	1587	1584	1587	1581	1592	1585
		START OF OFFICIAL TEST						
10:35	1573	1570	1589	1588	1589	1583	1596	1587
10:40	1573	1567	1591	1589	1590	1585	1600	1591
10:45	1574	1566	1595	1593	1595	1592	1611	1596
10:50	1575	1566	1601	1598	1601	1593	1626	1600
10:55	1577	1568	1604	1601	1604	1600	1642	1605
11:00	1580	1567	1609	1606	1609	1609	1644	1608
11:05	1583	1569	1610	1611	1614	1614	1647	1613
11:15	1587	1570	1620	1617	1620	1620	1709	1619
11:25	1592	1575	1627	1723	1627	1627	1723	1627
11:30	1595	1577	1631	1628	1631	1632	1732	1631
11:35	1597	1578	1634	1631	1633	1634	1752	1633
11:40	1599	1580	1637	1634	1637	1638	1758	1636
11:45	1601	1580	1640	1636	1640	1640	1759	1639
11:50	1603	1579	1641	1638	1642	1642	1755	1641
11:55	1606	1582	1643	1639	1643	1643	1748	1642
12:00	1607	1583	1644	1641	1644	1644	1747	1642

SEE CALIB CURVE FOR CONVERSION TO TEMP °F

APPROVED G.P.U. TMI
NAME
DATE

FAN MODEL 48-26½-1170/870

JOY MFG. CO. NEW PHILADELPHIA, OHIO

TIME	SHAFT#8 End Brg. (Res. OHMS)	OPP. SHAFT#7 End Brg. (Res. OHMS)	RTD's RESISTANCE IN OHMS # 1	# 2	# 3	# 4	# 5	# 6
12:05	1607	1584	1644	1641	1644	1644	1741	[illegible]
12:10	1607	1586	1645	1641	1644	1644	1738	1643
12:15	1608	1587	1645	1642	1645	1645	1739	1643
12:20	1608	1589	1645	1642	1645	1645	1738	1644
12:25	1609	1589	1646	1643	1647	1646	1734	1646
12:30	1610	1591	1647	1643	1646	1646	1733	1645
12:35	1610	1589	1646	1643	1646	1646	1734	1645
12:40	1610	1589	1646	1643	1646	1646	1734	1645
12:45	1610	1589	1646	1643	1647	1647	1730	1645
12:50	1611	1590	1647	1644	1647	1647	1729	1645
12:55	1611	1590	1647	1644	1647	1647	1731	1645
1:00	1610	1590	1647	1644	1647	1647	1732	1646
1:00	START COOL DOWN CYCLE							
1:05	1610	1580	1647	1643	1648	1647	1742	1646
1:10	1609	1577	1645	1642	1646	1646	1708	1644
1:15	1607	1572	1639	1635	1639	1639	1674	1638
1:20	1602	1574	1637	1633	1636	1637	1688	1635
1:25	1596	1569	1631	1628	1631	1631	1685	1630
1:30	1592	1565	1627	1624	1626	1626	1673	1625
1:35	1582	1558	1618	1615	1617	1617	1658	1617
1:40	1570	1547	1609	1605	1607	1607	1640	1606
1:45	1562	1538	1599	1596	1598	1598	1629	1598
1:50	1553	1526	1591	1588	1589	1589	1620	1590
1:55	1540	1507	1576	1572	1572	1573	1604	1575
2:00	1534	1497	1567	1565	1564	1566	1596	1567
2:00	"0" PRESSURE							
2:05	1528	1490	1559	1557	1556	1558	1589	1560
2:10	1524	1485	1553	1552	1552	1553	1585	1556
2:15	1520	1485	1551	1548	1549	1550	1582	1554

SEE CALIB CURVE FOR CONVERSION TO TEMP °F

FAN MODEL 48-26½-1170/870

JOY MFG. CO. NEW PHILADELPHIA, OHIO

TIME	SHAFT#8 End Brg. (Res. OHMS)	OPP. SHAFT#7 End Brg. (Res. OHMS)	RTD'S RESISTANCE IN OHMS #1	#2	#3	#4	#5	#6
	WITH FAN SHUT DOWN 25 MINUTES							
2:45	1506	1476	1524	1521	1522	1522	1556	1528
2:47	RESTART MOTOR "0" PRESSURE							
2:50	1504	1478	1535	1532	1534	1535	1558	1537
2:55	1500	1474	1528	1526	1526	1528	1545	1527
3:00	1496	1467	1517	1516	1516	1518	1537	1517
3:05	1491	1459	1509	1507	1506	1508	1531	1507
3:10	1483	1449	1497	1495	1494	1496	1517	1495
3:15	1475	1443	1484	1484	1482	1484	1504	1483
3:20	1469	1432	1477	1476	1473	1475	1494	1474
3:25	1460	1422	1469	1466	1463	1465	1482	1462
3:30	1453	1415	1460	1458	1456	1457	1471	1455
3:35	1445	1404	1451	1448	1446	1448	1463	1444
3:40	1436	1395	1442	1440	1438	1439	1454	1435
3:45	1429	1388	1434	1432	1431	1432	1447	1428
3:47	1425	1384	1430	1428	1427	1429	1445	1424
	SHUT DOWN							

SEE CALIB CURVE FOR CONVERSION TO TEMP ^{O}F

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

REPORT NO. Y-421
PREPARED BY J.T. Zeigler
CHECKED BY W.W. Olson
DATE May 18, 1973

LOW SPEED HEAT RUN

FAN MODEL 48-26½-1170/870

JOY MFG. CO. NEW PHILADELPHIA, OHIO

TIME	SHAFT End Brg. (Res. OHMS)	OPP. SHAFT End Brg. (Res. OHMS)	RTD'S RESISTANCE IN OHMS #1	#2	#3	#4	#5	#6
9:50			1083X.1	1081X.1	1082.5X.1	1082X.1	1098X.1	1083X.1
10:00	AMB.TEMP. INCREASE		1097	1099	1098	1099	1113X.1	1099
10:05			1105	1104.5	1106	1106.5	1126.5	1107
10:10			1112	1112	1112	1112	1132	1112
10:15			1116	1115	1116.5	1116.5	1138	1116.5
10:20			1122.0	1120	1121	1121	1141	1121
10:25			1124	1123.5	1125.5	*1127	1148	1126
10:30			1127	1127	1128	1128	1149	1128
10:35			1131.5	1130.5	1131.5	1131.5	1154	1131.5
10:40			1133	1132.5	1134	1134	1155.5	1134
10:45			1138.5	1138.5	1139	1139	1162	1139
10:50			1141.5	1141	1142.5	1142.5	1164	1142.5
10:55	AMB TEMP 72DB 56°WB		1144.5	1144	1145	*1148	1168.5	1145.5
11:00			1147	1146.5	1149	1148	1176.5	1148
11:05			1149	1149	1150	1150	1173.4	1150
11:15			1152	1152.5	1152.5	1152.5	1178	1152.5
11:20			1153	1152.5	1154	1154	1177.5	1154.5
11:25			1155	1155	1155	1155.5	1179.5	1158
11:30			1157	1157	1157	1160.5	1182	1158.5
11:35			1159	1159	1160.5	1160.5	1185	1161
11:40	AMB TEMP 72DB 57 WB		1160.5	1160	1160	1161.5	1186.5	1162.5
11:45			1163	1163	1164	1164	1189.5	1165
12:00	AMB TEMP 73DB 57 WB		1165	1165	1165.5	1166	1191.5	1167
12:10			1167.5	1167	1167	1167.5	1193	1168
12:20			1168	1167.5	1168	1168	1194.5	1169.5
12:30			1169	1168.5	1169.5	1169.5	1196	1171
12:40			1170	1169.5	1170.5	1171	1197	1172
12:50			1172	1171.5	1171.5	1171.5	1198	1173

APPROVED G.P.U. NAME DATE 5/2?/7?

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* SEE CALIB CURVE FOR CONVERSION TO TEMP °F

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

PAGE 1? OF
REPORT NO. X-421
PREPARED BY J.T. Zeigler
CHECKED BY W.W. Olson
DATE May 18, 1973

JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

LOW SPEED HEAT RUN
FAN MODEL 48-26½-1170/870

JOY MFG. CO. NEW PHILADELPHIA, OHIO

TIME	SHAFT End Brg. (Res. OHMS)	OPP.SHAFT End. Brg. (Res. OHMS)	RTD'S RESISTANCE IN OHMS					
1:00	AMB TEMP 74DB 58WB		1172	1172	1172	1173.5	1199.5	1174
1:10			1173	1173	1173	1173.5	1201	1174.[illegible]
1:20			1173.5	1173.5	1173.5	1174.5	1201.5	1175.5
1:30			1174	1174	1174	1174	1201.5	1176
1:40			1174.5	1174	1174.5	1175	1202.5	1176.5
1:45			1175	1174.5	1175	1175	1203	1177
1:55			1175	1174.5	1175	1175.5	1203	1177
2:00	AMB TEMP 76DB 57WB		1175	1175	1175.5	1175.5	1203.5	1177
2:05			1175	1175.5	1175.5	1176.5	1203.5	1177
2:15			1175	1175.5	1175.5	1176.0	1203	1177
2:25			1175.5	1175.5	1175.5	1176.5	1203.5	1177.5
2:35	AMB TEMP 74DB 57WB		1175.5	1175.5	1175.5	1176.5	1204	1177.5
2:45			1176	1176	1176	1177	1204	1177.5

SEE CALIB CURVE FOR CONVERSION TO TEMP °F

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PAGE [illegible] OF
REPORT NO. X-421
PREPARED BY J.T. Zeigler
CHECKED BY W.W. Olson
DATE May 19, 1973

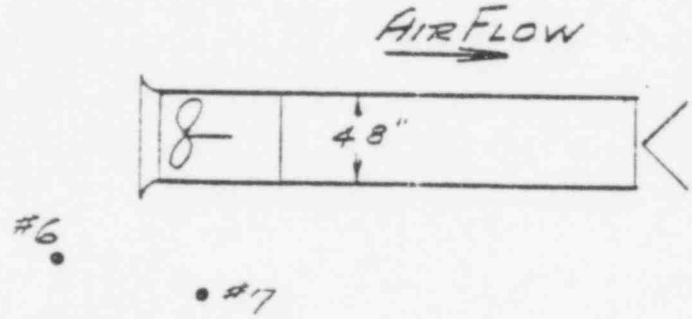
JOY MANUFACTURING CO.
NEW PHILADELPHIA, OHIO

PAGE 15 OF
REPORT NO. X-421
PREPARED BY J.T. Zeigler
CHECKED BY W.W. Olson
DATE May 18, 1973

TABLE VI

SOUND LEVELS

POSITION	Ps	O.A.	63	125	250	500	1000	2000	4000	8000
#6 @ 3'	2.5	89.5	74	84	85	84	80	73.5	65	55
#6 @ 5'	2.5	89.5	73.5	83.5	84	83.5	79.5	72.5	64	54
#7 @ 3'	2.5	92.5	74	86	87.5	87.5	84	77	68	58.5
#7 @ 5'	2.5	91.5	73.5	82.5	84.5	87	82.5	76.5	67	59



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J. J... 5/22/74

NEW PHILADELPHIA DIVISION
JOY MANUFACTURING COMPANY
338 SOUTH BROADWAY
P. O. BOX 431
NEW PHILADELPHIA, OHIO 44663

May 31, 1973

ADDENDUM NO. 1
JOY MANUFACTURING COMPANY REPORT X-421 (5/18/73)

JERSEY CENTRAL POWER & LIGHT
THREE MILE ISLAND NUCLEAR STATION

Report on test made at Reliance Electric on RTD in Motor XC-325074A1.

Motor Application - Nuclear Containment Axial Fan

Burns & Roe Spec - 2555-24

AAF order to Joy Mfg. Co. 25-1317-1

Joy Mfg. Co. Order NPX 60768

Joy Mfg. Co. Order to Reliance Electric NU-4455

512 115

Test conducted at Reliance Electric and witnessed by representatives of GPU.

POOR ORIGINAL

APPROVED
G.P.U. Q.A. TMI
NAME
DATE 5/22/74

Short Time Overload

and

Short Circuit Current Tests

for

Low Voltage Power Electrical Penetrations

June 14, 1974

R. M. Schuster

Instrumentation Mechanical Equipment Engineering

General Electric Co.

BWRSD

INTRODUCTION

SCOPE

These qualification tests were performed to demonstrate that the low voltage power type of electrical penetration can maintain electrical and mechanical integrity during short circuit and short time overload conditions (these conditions are defined below.)

QUALIFICATION SUMMARY

By virtue of the completion of testing defined herein, the low voltage power electrical penetration is qualified for all service electrical loading. The unit subjected to these tests is a generic design and is applicable to all variations which include:

1. Number of conductors
2. Diameter of nozzle
3. Length of penetration

QUALIFICATION HARDWARE

DESCRIPTION OF HARDWARE

The low voltage power electrical penetration consisted of 10 each 4/0 cables and 72 each #16 MWG wires. Only the 4/0 cables were used for this test.

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IDENTIFICATION OF HARDWARE

Drawing No.	238x604MHG001
Serial No.	6578337
Date of Fabrication	1974

ASME Code, Class MC, Constructed to the 1971 edition of Section III

TEST FACILITY

The testing was performed at the General Electric High Current Laboratory in Bloomington, Illinois.

QUALIFICATION TEST

INTRODUCTION

The tests described below (with the exception of the qualification acceptance test) were conducted at General Electric, Bloomington, Illinois from 5/6/74 to 5/8/74. Final acceptance testing of the qualification unit test was conducted at General Electric, San Jose.

The qualification tests described below (with the exception of qualification acceptance test) were conducted by General Electric personnel of the General Purpose Control Products Department. The qualification acceptance test was conducted by General Electric Quality Control Inspection.

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SHORT TIME OVERLOAD and SHORT CIRCUIT CURRENT

TEST DESCRIPTION

TEST SETUP

The penetration assembly was instrumented with thermocouple as shown on Figure 1. The 3 phase test circuit was connected to the current source on one end and bussed together on the other end (see Figure 2). The remaining seven (7) 4/0 cables were connected in series and attached to a different current source. Each end of the penetration assembly was secured to simulate actual installed conditions. No additional supports, aside from those supplied on every penetration, were used to support the cables.

Test Procedure:

1. Apply 125 amps to 4/0 conductor connected in series for two hours before test
2. Record temperature
3. Apply overload current of 880 amps to 3ϕ circuit for 60 seconds
4. Record maximum temperature
5. Allow 30 minutes for temperature stabilization of 3ϕ circuit
6. Perform calibration short circuit test at 10,000 amps for 4 cycles
7. Allow 30 minutes for temperature stabilization of 3ϕ circuit
8. Apply short circuit curren' f 25,000 amps for 6 cycles
9. Record maximum temperature

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Upon return to San Jose

10. Leak Test

    a) Pressurize penetration to 63 psi with nitrogen for 24 hours

    b) Pressurize penetration to 63 psi using helium and ~~test~~ for leaks using a Mass Spectrometer for 15 minutes (leak rate to be less than 10^{-9} cc/sec)

11. Test all 4/0 conductors for continuity

12. Test each 4/0 conductor for dielectric breakdown by applying 2200 VRMS for 1 minute

13. Test 4/0 conductor's insulation resistance @ 500 Vdc (1×10^{-10} ohms minimum).

Test Results

Maximum Temperature °F

Test	Thermocouple										
	0	1	2	3	4	5	6	7	8	9	10
Overload	79	110	110	83	81	79	81	86	84	98	98
Short circuit	78	113	113	83	79	78	102	103	86	95	101

Overload Current

Current	Duration
880 amps	60 seconds

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Short Circuit Current

	Current Peakamps	RMS amps	Duration Cycles
Phase A	45290	25156	8
Phase B	44422	24022	8
Phase C	54404	25847	8

All tests performed at G.E., San Jose were successfully completed.

Conclusion

These tests demonstrated that the penetration assembly can withstand the overload and short circuit currents stated in this test report and still maintain the assembly's electrical and mechanical integrity.

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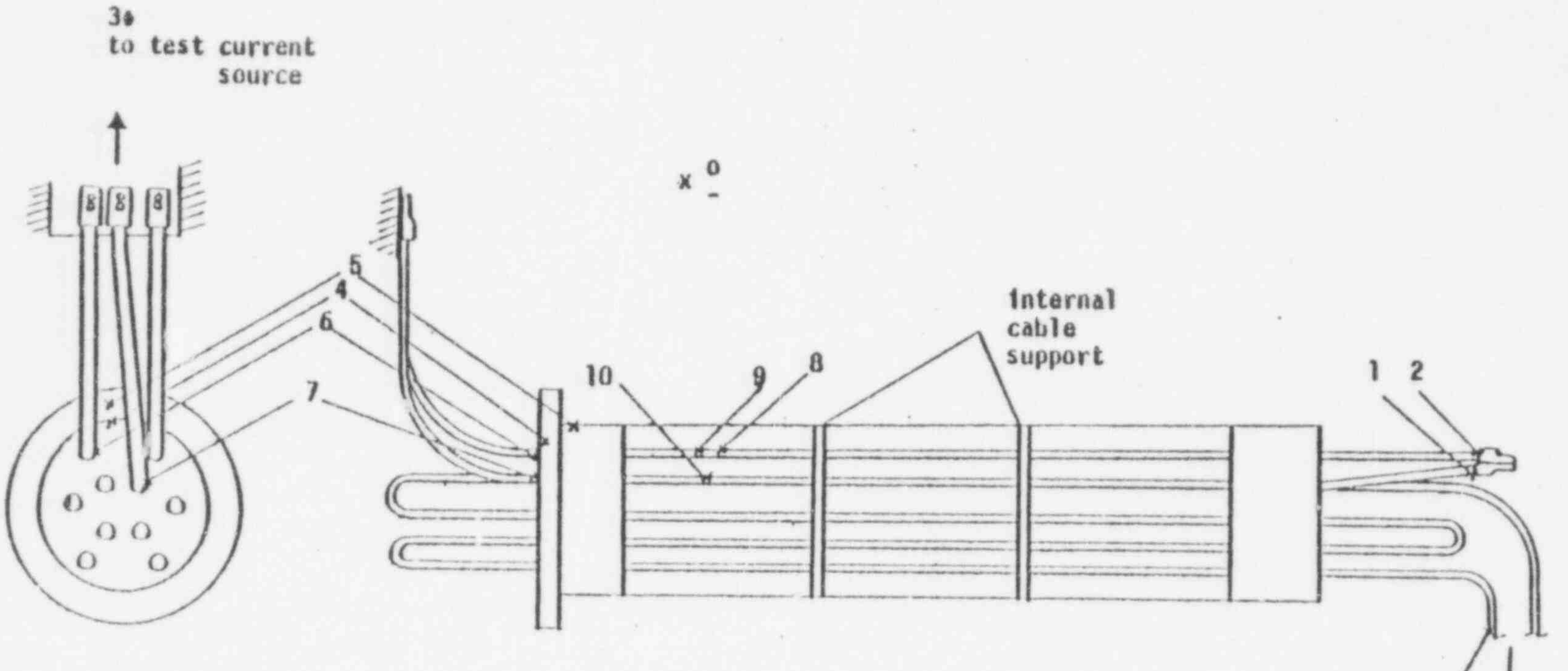
TEST CONF..URATION



Thermocouples

0. ambient temperature
1. #6 conductor on conductor
2. #1 " " "
3. series circuit on conductor
4. inside diameter of steel ring
5. outside diameter of steel ring
6. #3 conductor on insulation
7. #6 conductor on insulation
8. #1 conductor inside penetration on insulation
9. #1 " " " " "
10. #6 " " " " "

Figure 1.

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STARTUP AND SHORT CIRCUIT CURRENT TEST CIRCUIT DIAGRAM

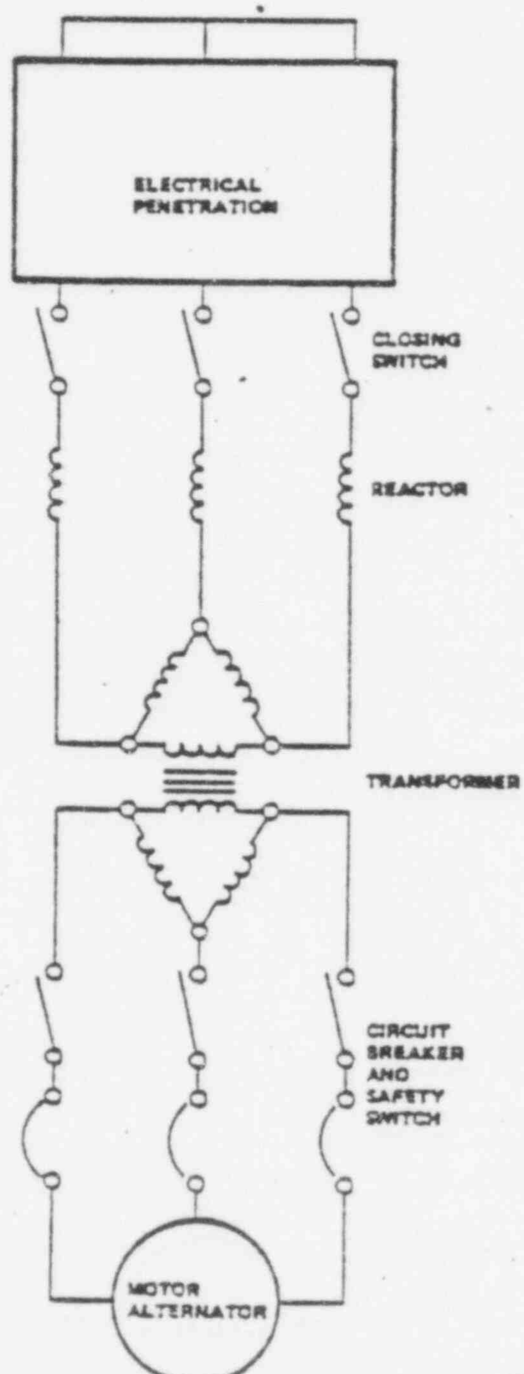

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Figure 2.

03 20

Technical

Report

Final Report

F-C4033-3

TESTS OF RAYCHEM THERMOFIT® INSULATION SYSTEMS UNDER SIMULTANEOUS EXPOSURE TO HEAT, GAMMA RADIATION, STEAM AND CHEMICAL SPRAY WHILE ELECTRICALLY ENERGIZED

Prepared for

Raychem Corporation

Menlo Park, California

January 1975

512 124

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

THE BENJAMIN FRANKLIN PARKWAY · PHILADELPHIA PENNSYLVANIA

CONTENTS

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FIGURES

512 126

®Registered Trademark Raychem Corporation

TABLES

512 127

1. INTRODUCTION

Six specimen loops containing in total two Thermofit[TM] in-containment transition field splices an[illegible] Thermofit in-line field splices submitted by Ra[illegible] were subjected to an environmental test program based on the guidelines of IEEE Standards 323-1974[1] and 383-1974[2] to determine their suitability for service within the containment of a nuclear power generating station.

The test program commenced with a seven-day combined thermal and radiation aging period at 150°C (302°F) and 5×10^7 rads gamma radiation dose while the specimens were electrically energized. The thermal and radiation period was followed by a simultaneous exposure to steam, chemical spray and gamma radiation (S/C/R). This exposure was as follows:

1. An initial dwell at >177°C (351°F) at a steam pressure of >70 psig for 10 hours.

2. 4.5 days at 135°C (275°F) at a steam pressure of 31 psig.

3. A 26 day dwell at 100°C (212°F) at a steam/air pressure of approximately 10 psig.

During the S/C/R portion of the program, the specimens were exposed to an additional gamma radiation dose of 1.5×10^8 rads. The specimens were also electrically energized during the S/C/R exposure. This exposure simulated the in-containment environmental conditions resulting from a postulated Loss-Of-Coolant Accident (LOCA) in a generating plant having a boiling water or pressurized water reactor, and those occurring during the cooldown after the postulated LOCA. The electrical integrity of the specimens was evaluated by:

1. Insulation resistance measurements

2. The ability to maintain electrical loading during the test cycle

3. By high-potential withstand tests performed after bending at the conclusion of the exposure.

The program was conducted by The Franklin Institute Research Laboratories (FIRL) during the period of December 1974 through January 1975.

2. TEST SPECIMENS

Table 1 presents a description of the specimens tested and also shows the energizing voltage and currents levels.

Table 1 Test Specimens

Specimen			Electrical Loading	
Description*	Number†	Length (ft)‡	Voltage (Vrms - 60 Hz)	Initial Current (A)#
Raychem Thermofit® In-Containment Field Splice Cable - Raychem Adverse Service Coaxial Cable, AWG 22 conductor 1st insulation layer - 8 mil wall of Alkane-imide polymer 2nd insulation layer - 49 mil wall of Rayolin R™ radiation cross-linked polyolefin Braided Copper Shield Raychem Flamtrol™ Jacket - 34 mil nominal wall Part No. 10483 Run No. J7-5-10-72-6 Splice Components for one splice Raychem Thermofit® WCSF-115-6-N Soldered connection (See Figure 1)	9X	20	600	0
Raychem Thermofit® In-Containment Field Splices Cable AWG 4 insulated with EPR-neoprene (not a Raychem product) Splice Components for six splices (Note 1) Raychem Thermofit® WCSF-200-6-N 6 each of compression connectors: Burndy Hylink YS4C-L T&B 2F-4 3M #4	13	35	2000	70
Raychem Thermofit® In-Containment Field Splices Cable AWG 6 insulated with Raychem Flamtrol™ Splice Components for six splices (Note 1) Raychem WCSF-200-6-N 6 each of compression connectors: Burndy Hylink YS6C-L	14	37	1000	65
Raychem Thermofit® In-Containment Field Splices Cable AWG 12 insulated with EPR neoprene (not a Raychem product) Splice Components for six splices (Note 1) Raychem WCSF-115-6-N 3 each of compression connectors: Burndy Hylink YSV10 T&B 2C-10	15	32	2000	25
Raychem Thermofit® In-Containment Field Splices. Six splices. Same construction as Sample #15 except that Raychem Flamtrol™ wire was used	16	33	1000	25

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Table 1 Test Specimens (continued)

Specimen			Electrical Loading	
Description*	Number†	Length (ft)‡	Voltage (Vrms - 60 Hz)	Initial Current (A)#
Raychem Thermofit® In-Containment Transition Splices Cable AWG 6 insulated with Raychem Flamtrol™, spliced to three cables of AWG 12 insulated with Raychem Flamtrol™ and reconnected to an AWG 6 cable insulated with Raychem Flamtrol™ Splice Components for two splices (Note 1) Raychem Thermofit® WCSF-200-6-N Raychem Thermofit® heat-shrinkable 3-finger cable breakout (Part Number 403A112-4/83) used to provide seal at the transition between the AWG 6 and the three AWG 12 cables. 2 each of compression connectors: Burndy Hylink YS6C-L	17	23	1000	65

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* Description of specimens provided by Raychem

† Specimens 1 thru 8 and 10 thru 12 were other test specimens supplied by Raychem. The test results on these specimens are presented in report numbers F-C4033-1 and -2.

‡ Specimens cut to lengths shown. Approximately 4 ft of the length extended outside of the test vessel (2 ft on each end of the specimen).

\# Initial currents were applied at room temperature, and allowed to drop to a lower level during combined radiation and thermal aging and simultaneous LOCA-simulation testing. See text for discussion.

Note 1 - Each in-line splice or transition was covered with tinned copper wire mesh to aid in providing a close proximity ground plane as shown in Figure 2.

Figure 1. Coaxial cable splice with Raychem Thermofit heat-shrinkable tubing splice cover.

Figure 2. View of typical metal grounding mesh over splice area.

3. TEST PROGRAM

3.1 PRETEST INSPECTION AND PREPARATIONS

The specimens were visually inspected upon receipt, identified with stainless steel tags, and wound onto two concentric mandrels (See FIRL reports F-C4033-1 and -2) as shown in Figure 3. The mandrels were assembled with the flanged head of the 24-inch diameter pressure test vessel and the cables were passed through pressure-sealing glands in the vessel head so that electrical measurements could be made and electric loads applied during the test exposure.

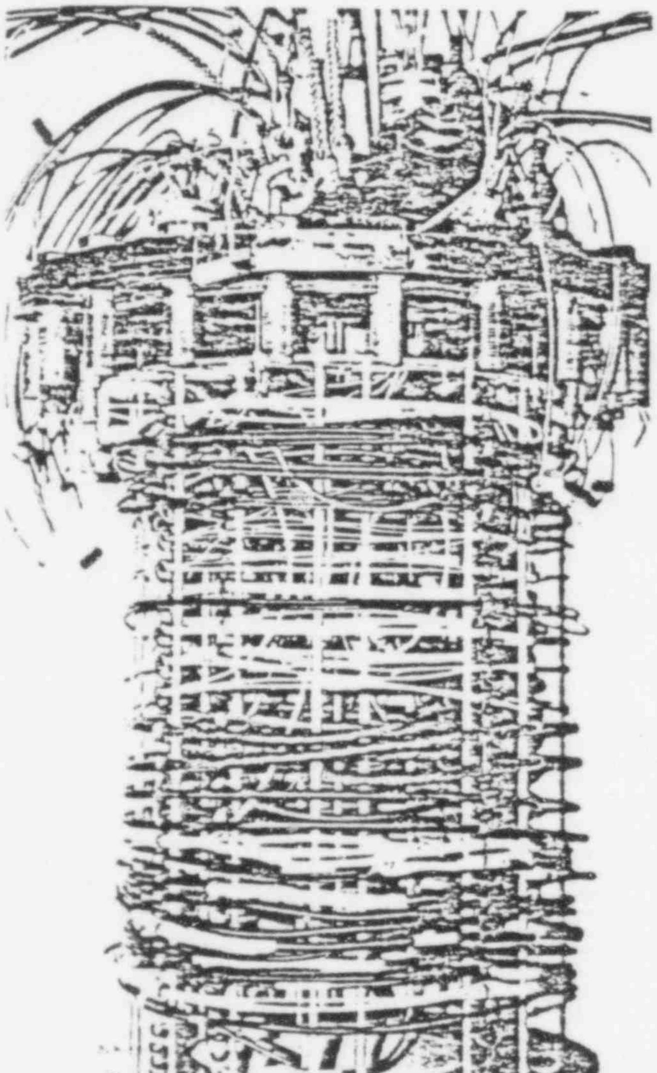

Figure 3. Pretest view of specimens on mandrels.

The insulation resistance (IR) of the specimens was measured with a megohmmeter at 500V dc applied for one minute. Then the flanged head with the mandrels and the specimens attached was installed in the vessel.

3.2 ENVIRONMENTAL TEST FACILITY

The pressure vessel for the test was a 24-inch diameter by 48-inch steel chamber with a flat flange head, in which there were penetrations for the specimens (See Figures 4 and 5). A perforated steam inlet pipe extended about 7 inches down from the center of the head flange; this was surrounded by a cylindrical baffle that prevented direct impingement of steam on the specimens.

A spray system was provided to spray the specimens uniformly at an average rate of 0.15 gallons per minute (gpm) per square foot over the cylindrical area approximately midway between the two mandrels. This was accomplished by locating four wide-angle spray nozzles at each of two locations along the axis of the mandrel. The spray was directed radially outward, part of it impinging on the specimens mounted on the inner mandrel and part of it passing through the spaces between cable turns to impinge on the specimens mounted on the outer mandrel. If it is assumed that the spray is uniformly applied to the interior of an imaginary cylinder midway between the 33-inch long inner and outer mandrels, 0.15 gpm per square foot is equivalent to a total rate of 1.94 gpm. A rate of 2.5 gpm was used to assure adequate spray formation from the eight wide-angle nozzles (approximately 0.31 gpm per nozzle).

The spray solution was collected in the bottom of the vessel and was directed to a drain or returned to the pump for recirculation, as required. The spray flow rate was measured with an orifice-plate flowmeter.

The test vessel assembly with associated components was installed inside a radiation hot cell approximately 6-feet x 11-feet x 9-feet high. The cobalt-60 source consisted of pellets packed in 62-inch long pencils and arranged into a vertical cylindrical array which was moved around the vessel during the test to achieve a uniform exposure.

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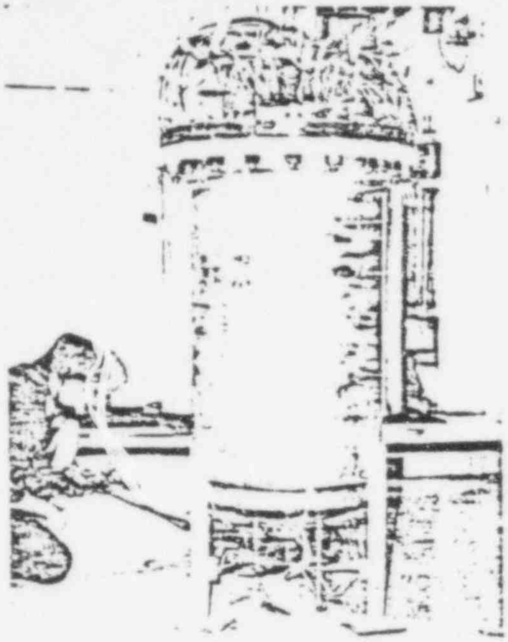


Figure 4. View of test vessel with specimens installed.

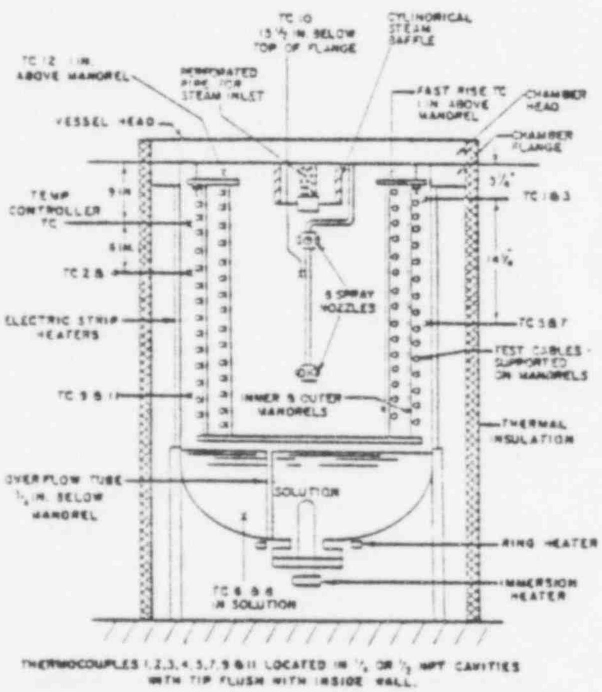


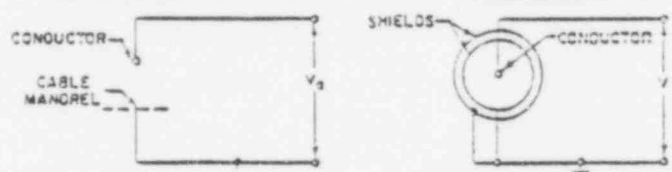
Figure 5. Diagram of test vessel showing salient features and location of thermocouples.

3.3 ELECTRICAL ENERGIZING

Shielded extension cables were run from the exterior of the hot cell to the top of the vessel; and connections were made at this point with the ends of the specimens which extended above the vessel. The shielding on the extension cables served to reduce the effects of radiation on measurements of insulation resistance.

Figure 6 is a diagram of the typical energizing circuitry. The energizing cabinets are illustrated in Figure 7. Table 1 gives the specified initial current loads. Current loads were adjusted to the initial specified values of Table 1 prior to the start of the environmental exposures. With the specified current, the voltage drops (resulting from conductor resistances) through the test cables and shielded extension cables were measured and recorded. Thereafter, the currents were adjusted as necessary to reestablish the initial voltage drop. The actual currents were recorded periodically as part of the test data.

This method was specified by Raychem to be in accordance with IEEE Standard 383-1974, Paragraph 2.4.3.1, which states, "....they should be energized at rated voltage and loaded with rated service current while under the average normal operating condition."



For 1/conductor cable, Specimens 13, 14, 15, 16 and 17. V_a and currents per Table 1.

For 1/conductor coaxial cable, Specimen 9X. V = 600V rms. Current = 0 A.

Figure 6. Electrical loading circuit for energizing specimens during environmental exposure.

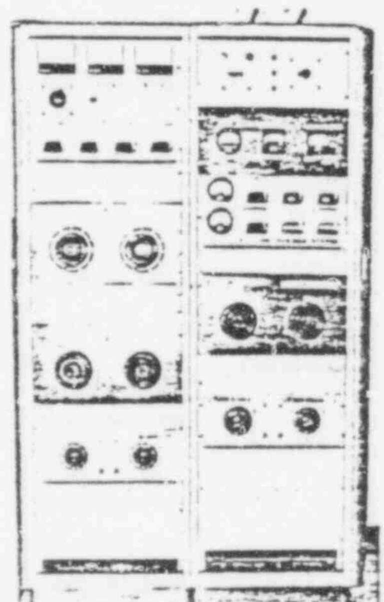


Figure 7. View of electrical energizing cabinets.

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3.4 INSTRUMENTATION

Chamber temperature and pressure were monitored continuously on strip-chart recorders. The locations of the thermocouple junctions were as shown in Figure 5.

A list of the data acquisition instruments used in the test program is included as Appendix A.

Radiation Dosimetry data are included as Appendix B.

3.5 COMBINED RADIATION AND THERMAL AGING EXPOSURE

The specimens were electrically energized as stated in Section 3.3, while simultaneously thermally aged at 150°C (302°F) and irradiated to an air-equivalent dose of 5×10^7 rads. The vessel was electrically heated. During this exposure air was circulated through the test vessel by an external blower. Insulation resistance measurements were made during and after this exposure.

Note: *An air-equivalent dose means that the volume occupied by the specimens receives an isotropic flux of gamma radiation equivalent to the radiation dose that would result if the volume contained only air.*

3.6 LOSS-OF-COOLANT ACCIDENT (LOCA) ENVIRONMENT EXPOSURE

Following the combined radiation-thermal aging exposure, the specimens were simultaneously exposed to steam, chemical-spray and gamma radiation (S/C/R) as illustrated in Figure 8.

A chemical spray consisting of 3000 ppm boron as boric acid, 0.064 molar sodium thiosulfate and adjusted with sodium hydroxide to a pH of 10.5 at room temperature, was applied at the rate of 0.15 gpm per square foot (100 ml per second per square meter) of spray area (See Section 3.2). Fresh heated spray solution was used for the first hour of the profile. Thereafter, the spray solution was recirculated from the reservoir at the bottom of the chamber. The pH was monitored periodically, and was maintained within the range of 9.5 to 11.0 by addition of fresh solution.

During the S/C/R exposure, the specimens were energized as indicated in Section 3.3.

3.7 MANDREL WRAP AND HIGH-POTENTIAL WITHSTAND TESTS

After the S/C/R exposure, before the test vessel was removed from the radiation hot cell, it was filled with tap water and insulation resistance measurements and preliminary

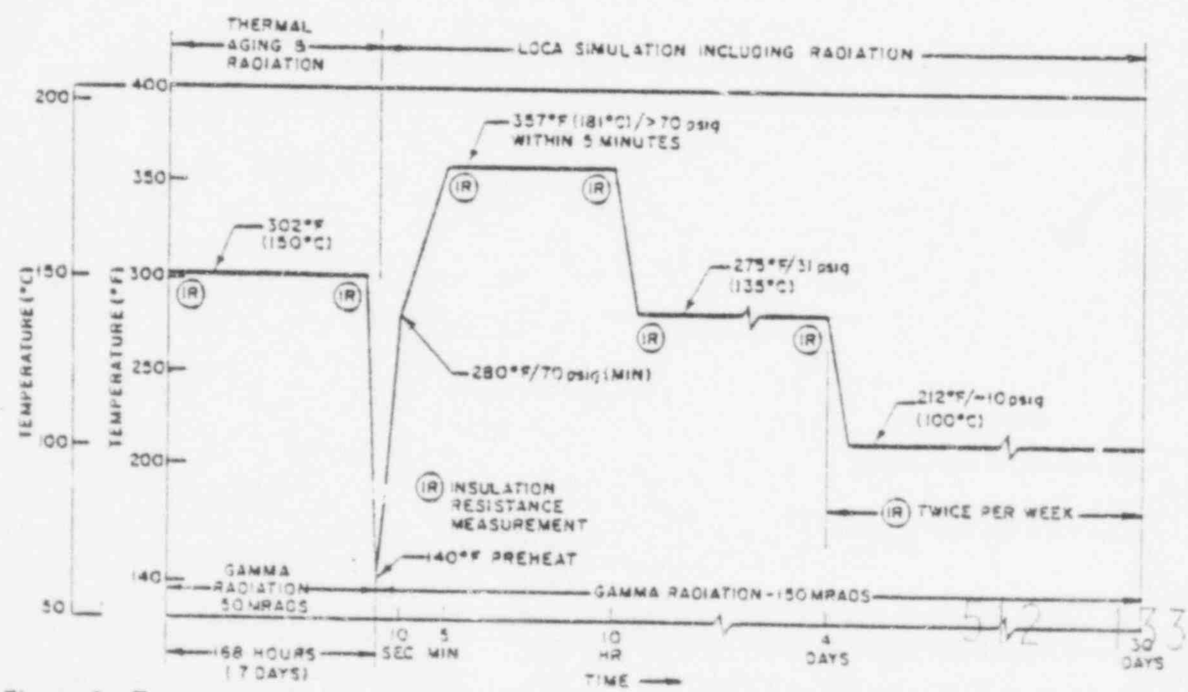

Figure 8. Temperature/pressure profile for simulation of Loss-Of-Coolant Accident environment.

high-potential withstand tests were made on all specimens at ambient temperature. The test vessel was drained, the mandrels with the specimens were removed from the vessel and the specimens were visually inspected. The specimens were then removed from the vessel mandrels and bent around test mandrels 40 times the cables' diameter. The specimens (still coiled from the test mandrel) were immersed in water and subjected to a high-potential withstand test for five minutes at the voltages shown in Section 4.4.

4. TEST RESULTS

4.1 PRETEST ELECTRICAL MEASUREMENTS

The results of insulation resistance measurements are presented in Table 2.

4.2 COMBINED RADIATION AND THERMAL AGING

The specimens were exposed to the aging environment described in Section 3.5. The average temperature near the specimens approximated or exceeded 150°C (302°F). The specimens maintained the electric loads described in Section 3.3 and Table 3. Insulation resistance measurements are included in Table 2.

4.3 LOCA ENVIRONMENT EXPOSURE

The specimens were exposed to a simultaneous steam, chemical-spray and radiation environment in general accordance with Figure 8. Minor deviations occurred as follows:

a) The temperature of 280°F was obtained in 25 seconds instead of 10 seconds.

b) The temperature drop from 357°F to 275°F was accomplished in two hours instead of one hour.

c) After nine days of the S/C/R environment, occasional clogging of the spray nozzles and filters from chemical and other deposits (possibly specimen materials) caused spray rate reductions*, which were periodically corrected by cleaning of filters and two complete replacements of the spray solutions.

Post-test inspection and performance test of the spray nozzles indicated only three of the eight nozzles were spraying†. Therefore, the spray rate was in excess of 0.15 gpm per square foot of area in front of the working nozzles. Since the three working nozzles were in the upper portion of the chamber (See Figure 5), there is reasonable assurance that the impinging spray splashed and flowed onto the lower cables.

Clogging of nozzles and filters and replacements of spray solutions are not unusual occurrences for FIRL conducted tests of this type.

†The chemical sprays tend to vaporize into steam when exiting the nozzles and leave chemical deposits leading to possible clogging of spray nozzles.

The specimen energizing data and the results of electrical tests made during the exposure are summarized in Tables 2 and 3.

4.4 FINAL INSPECTION AND ELECTRICAL TESTS

Immediately after the S/C/R exposure, the test vessel was filled with water. Insulation resistance measurements and one-minute high-potential withstand tests were made at ambient temperature before the vessel was removed from the radiation hot cell. The results indicated that all specimens except 13, 15 and 16 were capable of withstanding appropriate high-voltage test potentials.

After removal of the vessel head and specimen mandrel from the vessel, further diagnostic tests indicated the insulation on specimen 16 was faulted in the area of the chamber penetration. This specimen was severed immediately below the penetration before conducting the final inspection and electrical tests.

The results of the mandrel wrap tests and high-potential withstand tests which followed the 30-day S/C/R environment are included in Tables 2 and 4. Figure 9 shows a typical test mandrel being wrapped with a specimen. Figure 10 shows the high-

Table 2. Summary of Insulation Resistance Measurements

Elapsed LOCA Time	Temperature (°F)	Chamber Pressure (psig)	Insulation resistance (ohms)[a] of specimen number 9X	13	14	15	16	17
Pre-Test	Ambient	0	$>1.0\times10^{13}$	1.5×10^{11}	5.0×10^{11}	4.0×10^{11}	2.5×10^{12}	5.5×10^{11}
	Ambient	0	2.7×10^{11}	5.0×10^{9}	2.7×10^{11}	1.2×10^{11}	2.1×10^{10}	5.9×10^{11}
Note b	302	0	1.4×10^{8}	7.3×10^{7}	3.5×10^{8}	$<5.0\times10^{4}$[e]	$<5.0\times10^{4}$[e]	4.7×10^{8}
	262	0	6.2×10^{8}	$<5.0\times10^{4}$[e]	5.4×10^{8}	$<5.0\times10^{4}$[e]	$<5.0\times10^{4}$[e]	6.8×10^{8}
	140	0	1.5×10^{8}	$<5.0\times10^{4}$[e]	7.0×10^{7}	$<5.0\times10^{4}$[e]	$<5.0\times10^{4}$[e]	6.4×10^{7}
	120	0	1.4×10^{8}	$<5.0\times10^{4}$[f]	8.5×10^{8}	$<5.0\times10^{4}$[f]	$<5.0\times10^{4}$[f]	8.0×10^{8}
2.2 hr	353	130	1.5×10^{8}	$<1.0\times10^{4}$[f]	2.0×10^{8}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	1.0×10^{7}
9.6 hr	358	134	1.5×10^{8}	$<1.0\times10^{4}$[f]	1.2×10^{8}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	4.5×10^{8}
14.8 hr	275	31.0	1.5×10^{8}	$<1.0\times10^{4}$[f]	1.4×10^{7}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	5.0×10^{7}
4.0 da	274	31.0	1.8×10^{7}	$<1.0\times10^{4}$[f]	9.5×10^{8}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	3.3×10^{7}
4.1 da	212	6.5	1.8×10^{8}	$<1.0\times10^{4}$[f]	9.0×10^{7}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	2.2×10^{8}
7.9 da	212	11.0	1.5×10^{8}	$<1.0\times10^{4}$[f]	9.0×10^{7}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	1.9×10^{8}
13.8 da	220	10.0	1.7×10^{7}	$<1.0\times10^{4}$[f]	4.2×10^{7}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	1.2×10^{8}
17.8 da	212	12.0	1.6×10^{7}	$<1.0\times10^{4}$[f]	1.4×10^{4}[f]	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	8.9×10^{7}
21.8 da	212	12.0	1.6×10^{8}	$<1.0\times10^{4}$[f]	2.6×10^{7}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	5.5×10^{7}
24.8 da	212	15.0	1.7×10^{8}	$<1.0\times10^{4}$[f]	2.5×10^{7}	$<1.0\times10^{4}$[f]	3.5×10^{7}[f]	4.3×10^{7}
29.9 da	212	15.0	8.0×10^{8}	$<1.0\times10^{4}$[f]	2.8×10^{7}	$<1.0\times10^{4}$[f]	$<1.0\times10^{4}$[f]	4.0×10^{7}
Post Test	Ambient	0	3.0×10^{12}	Note c	1.4×10^{8}	Note d	$<1.0\times10^{4}$[f]	1.1×10^{8}

NOTES:

[a] Measurements made at 500V d-c held for one minute unless otherwise indicated. Measurements made during the combined radiation/thermal aging and S/C/R include the IR effects of the test extension leads. The IR of a dummy set of extension leads measured as low as 1.5×10^{9} ohms.

[b] During combined Thermal and Radiation aging.

[c] Measurement not made.

[d] Measurement was not made, see Table 4, Section 4.4 and 5. for post test dielectric withstand data.

[e] Measurements at 10V d-c

[f] Measurements at 50V d-c

Table 3. Electrical Loading Results

Specimen Number	Energizing Voltage (Vrms)	Conductor	Actual Energizing Current (A)* Room Temp.	At 300 °F[#]	At 355 °F	At 275 °F	At 212 °F	Ability to Hold Electric Load During S/C/R Exposure
9X	600	1	No current					Held load for 30 days
13	2000	1	70	63	0	0	0	Load removed after 5 days during combined radiation/thermal aging and before S/C/R.[†]
14	1000	1	65	51	58	60	62	Held load for 30 days.
15	2000	1	25	0	0	0	0	Load removed after 30 minutes during combined radiation/thermal aging and before S/C/R.[†]
16	1000	1	25	0	0	0	0	Load removed after 1.5 days during combined radiation/thermal aging and before S/C/R.[†]
17	1000	1	65	51	58	60	62	Held load for 30 days.

*See constant-voltage drop method discussed in Section 3.3

[#] Rated service currents are not required during the thermal aging phase[2]. Reduced currents prevented heat input (resistive heating from current loading) from exceeding heat losses.

[†] See Section 4.4 and 5 for discussion of results.

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Table 4. Results of Mandrel Wrap and High-Potential Withstand Tests.

Cable	Cable O.D. (in.)	Mandrel O.D. (in.)	Mandrel to Cable O.D. Ratio	Number of Turns on Mandrel	Visual Appearance of Cable	Withstand Potential* (Vrms)	Withstand Potential Results
9X	0.24	9.5	39.6	2.5	Cable flexible. Splice intact. Cable surface crinkled.	2000	Withstood potential for 5 min. Charging/leakage current less than 10 mA
13	0.413	Bend test not conducted.			Jacket falling off in large strips; insulation cracked through to conductor; splices apparently intact†	0	Could not be energized due to faulted cable insulation*
14	0.277	11	39.7	7.5	Cable flexible; surface pitted; surface cracks in some areas. Splices appear intact; marking sleeves intact with some surfaces crinkled.	5000	Withstood potential for 5 min. Charging/leakage current less than 10 mA
15	0.190	Bend test not conducted.			Jacket and insulation brittle and falling away from conductor; wire gauze breaking away from splices. Splices apparently intact†	0	Could not be energized due to faulted cable insulation*
16	0.188	7.5	39.9	10.5	Metal gauze over six-splices weak and breaking off; marking sleeves intact and flexible	3600	Withstood potential for 5 min. Charging/leakage current less than 10 mA
17	0.279	11	39.4	3.5	Cable flexible; metal gauze over splices weak and breaking off. No apparent damage to cable or basic splice†	3600	Withstood potential for 5 min. Charging/leakage current less than 10 mA

*Potentials were applied between the cable conductors and a 55-gal metal drum of room temperature tap water (at ground potential) in which the bent (coiled) portion of the cables was immersed. Conductor shields, if present, were at ground potential.

†See Section 4.4 for discussion.

Figure 9. Mandrel being wrapped with a specimen following removal from test.

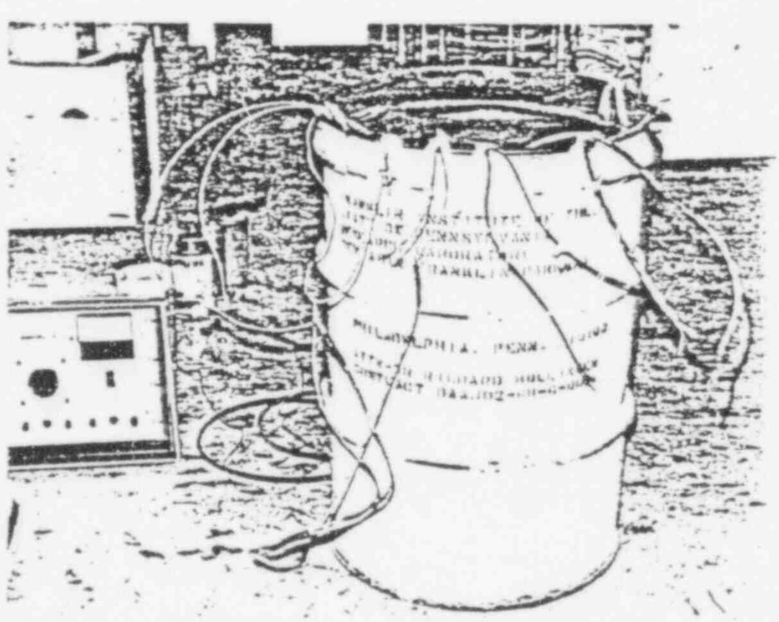

Figure 10. View of high-potential withstand testing.

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potential withstand test. Post-test photographs of the specimens are presented as Figures 11 and 12. The specimens were returned to Raychem for additional testing by Raychem.

Subsequently, specimens 13, 15, and 17 were returned to FIRL by Raychem for additional examinations and tests of the splice areas. The splice areas were cleaned. Some of the splices were flexed both with fingers, as shown in Figure 13, and around a mandrel as shown in Figure 14.

High-potential withstand testing of the splices was performed by wrapping the splice with a wet cotton cloth saturated with water as the ground electrode and then bending the splice around the curved surface of a test mandrel as shown in Figure 15. A high potential was applied between the specimen conductor and a bare copper wire wrapped around the wet cloth. The results of these examinations and tests are presented in Table 5.

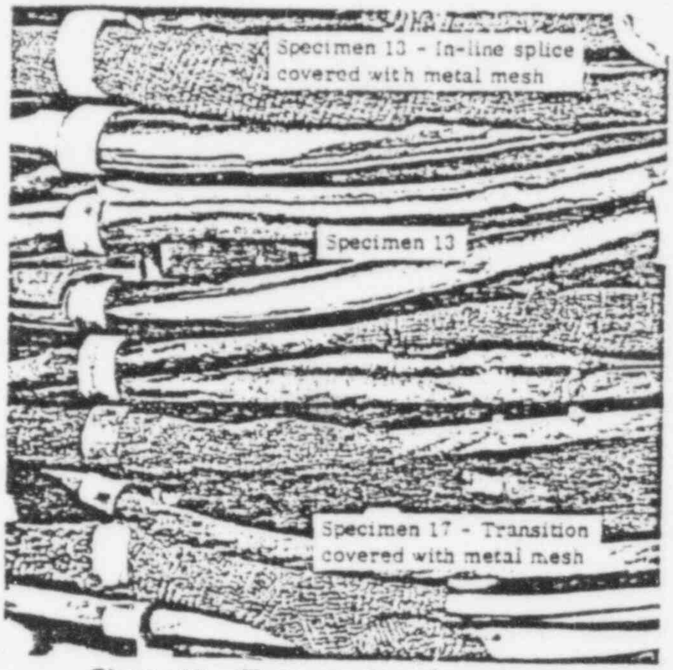

Figure 12. Close-up view of specimens on test mandrel.

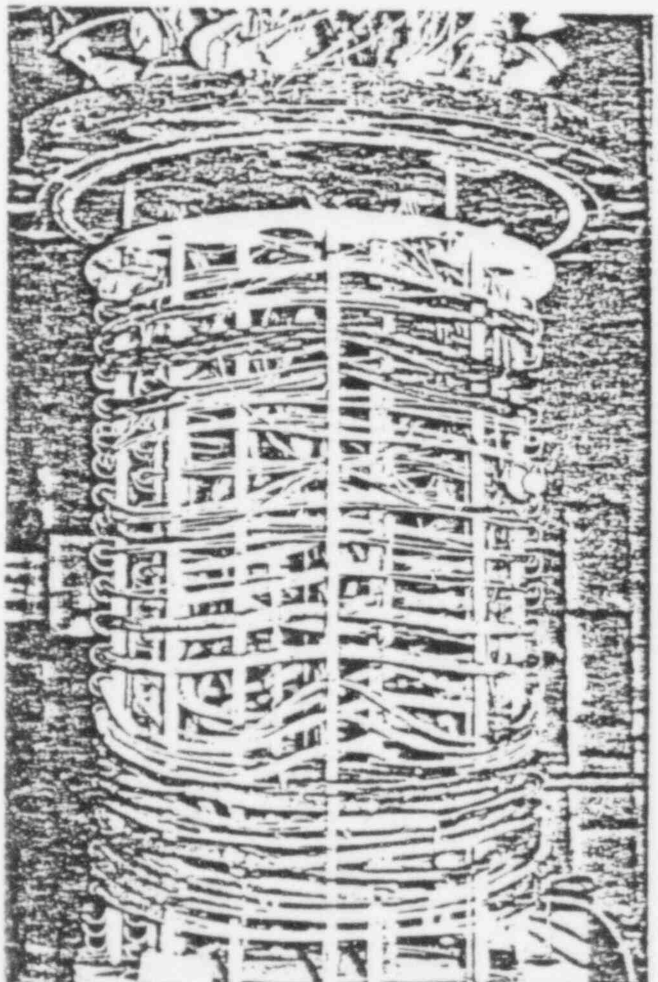
Figure 11. Post test view of specimens on vessel mandrel.

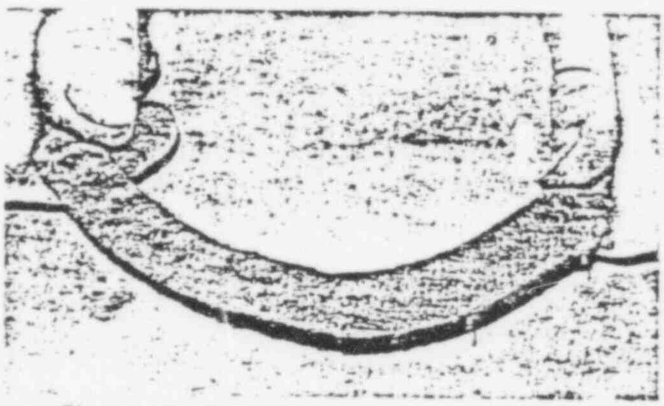
Figure 13. View of one splice in specimen 13 being flexed by fingers.

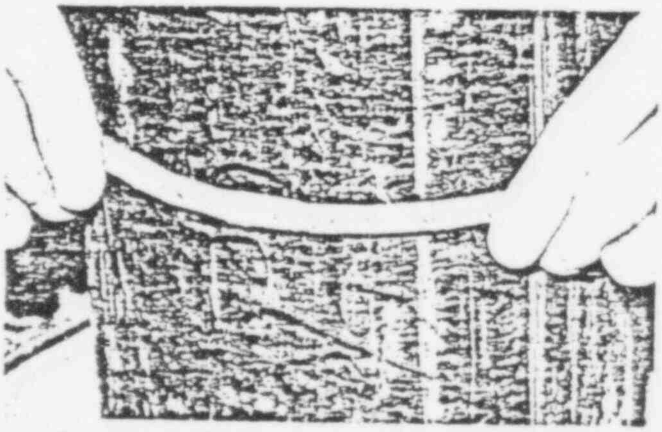
Figure 14. View of one splice in specimen 13 being flexed around mandrel.

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Table 5. Results of Additional Testing

Specimen and Splice No.[a]	Mandrel O.D. (in.)	Visual Appearance of Cable	Withstand Potential (Vrms)[b]	Withstand Potential Results
13A	17[c]	All splices appeared stiff but could be bent without evidence of cracking. One splice was bent to an included angle of 90° without evidence of cracking. (Only one splice was bent in this fashion.)	5000	All splices withstood potential for 5 min. Charging/leakage currents less than 1.0 mA
13B	17[c]		5000	
13C	17[c]		5000	
13D	17[c]		5000	
13E	17[c]		5000	
13F	17[c]		5000	
15A	6.5[d]	All splices were flexible. No evidence of cracking when bent around mandrel. Adhesive which extruded from end of splice sleeve showed separation between adhesive and end of sleeve. (Only one splice was inspected to this latter detail.)	4000	All splices withstood potential for 5 min. Charging/leakage currents less than 1.0 mA
15B	6.5[d]		4000	
15C	6.5[d]		4000	
15D	6.5[d]		4000	
15E	6.5[d]		4000	
15F	6.5[d]		4000	
17	—	Wire gauze had been removed previously. Splice material showed no evidence of cracking. Splice was not flexed again per client's direction (see Table 4 for mandrel bend test results), but there was no obvious indication that it could not be flexed again without cracking. Splice could be depressed with fingernail.	—	Cable with splices previously tested successfully. See Table 4.

[a]Splices arbitrarily identified by suffix letters A through F added to specimen numbers.

[b]See Section 4.4 for discussion of method.

[c]Mandrel diameter to cable-diameter ratio was 41; mandrel-diameter to splice-diameter ratio was much less (splice diameter not measured).

[d]Mandrel-diameter to cable-diameter ratio was 25; mandrel-diameter to splice-diameter ratio was much less (splice diameter not measured).

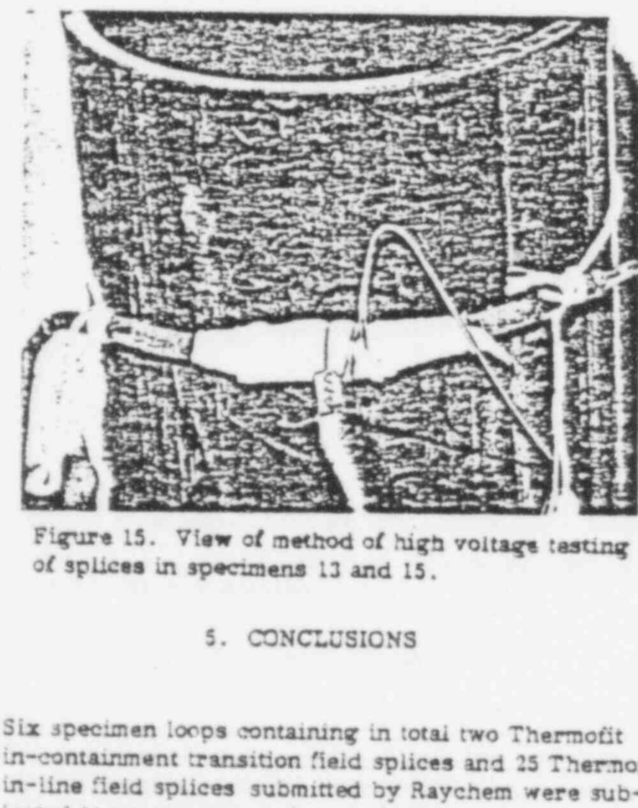

Figure 15. View of method of high voltage testing of splices in specimens 13 and 15.

5. CONCLUSIONS

Six specimen loops containing in total two Thermofit in-containment transition field splices and 25 Thermofit in-line field splices submitted by Raychem were subjected to a test program based on the guidelines of IEEE Standards 323[1] and 383[2]. The program was designed to simulate normal service, a Loss-Of-Coolant Accident (LOCA) and the cooldown following the LOCA and included combined radiation and thermal aging with 5×10^7 rads of gamma irradiation; and a subsequent simultaneous steam, chemical-spray and radiation exposure (S/C/R) with an additional 1.5×10^8 rads of irradiation. Throughout the exposures, the specimens were energized (except specimens which were removed from the circuits) with potentials and currents simulating field service use. At the conclusion of the above sequence of exposures, each specimen was subjected to a bend and high-potential withstand test.

Every specimen except 13, 15 and 16 demonstrated satisfactory performance during the exposures simulating normal service, a LOCA and associated cooldown; plus demonstrating a substantial margin of life remaining in the specimen by withstanding a post-LOCA bend and a high-potential withstand test with the specimen immersed in water.

Specimens 13 and 15 failed within 5 days of the start of the combined thermal and radiation aging. Post-test analysis indicated that the failures were probably due to the associated cable rather than failure of the splices. Further analysis of these specimens determined that the splices were capable of withstanding a high-potential test while bent around a mandrel approximately 40 times the cables' diameter. The splices on these specimens therefore also appear to be capable of demonstrating satisfactory performance during the exposures simulating normal service, a LOCA and associated cooldown; plus demonstrating a substantial margin of life remaining in the specimen by withstanding a post-LOCA bend and a high-potential withstand test with the specimen immersed in water.

Based on the discussion presented below, specimen 16 appeared to be cabable of demonstrating satisfactory performance during the exposures simulating normal service, a LOCA and associated cooldown; plus demonstrating a substantial margin of life remaining in the specimen by withstanding a post-LOCA bend and a high-potential withstand test with the specimen immersed in water.

Specimen 16 was removed from its energizing circuit after 38 hours of combined thermal and radiation aging. However, a post-test inspection and analysis indicated the specimen was faulted at the point of vessel penetration and the remaining portion of the specimen within the vessel was capable of withstanding a high-potential test after being subjected to the required test mandrel bend. In addition, the vessel penetrations probably were not representative of an actual installation in a generating station.

REFERENCES

1. IEEE Standard 323-1974, IEEE Standard for Qualifying 1E Equipment for Nuclear Power Generating Stations, *The Institute of Electrical and Electronics Engineers, Inc., New York, N.Y., 1974.*

2. IEEE Standard 383-1974, IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations, *The Institute of Electrical and Electronics Engineers, Inc., New York, N.Y., 1974.*

6. CERTIFICATION

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

L.E. Witcher
L.E. Witcher
Test Engineer

D.V. Paulson
D.V. Paulson, P.E.
Project Leader

APPROVED

Zenons Zudans
Zenons Zudans, Director
Engineering Department

W.H. Steigelmann
W.H. Steigelmann, P.E., Manager
Energy Engineering Laboratory

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Appendix

A

LIST OF DATA ACQUISITION INSTRUMENTS

512 140

INSTRUMENT NUMBER	10132
INSTR AND MFR	MEILAND STOPWATCH PLASTIC TIME METER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-9999.9 MM
DATE CALIBRATED	NOT REQUIRED
INSTRUMENT NUMBER	10260
INSTR AND MFR	SIMPSON AC VOLTMETER
TYPE/MODEL NUMBER	RECTIFIER
SERIAL NUMBER	
RANGE/FEATURES	0 TO 1.2 MVAC 20 VAC DIV
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10261
INSTR AND MFR	SIMPSON AC MILLIAMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100 MAAC 2MA DIV
DATE CALIBRATED	REFERENCE ONLY
INSTRUMENT NUMBER	10262
INSTR AND MFR	SIMPSON AC MILLIAMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100 MA AC 2MA DIV
DATE CALIBRATED	REFERENCE ONLY
INSTRUMENT NUMBER	10264
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10265
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10266
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	12 21 74

INSTRUMENT NUMBER	10267
INSTR AND MFR	MIDWEST AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A WITH CURRENT XFMR
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10196
INSTR AND MFR	SIMPSON, AMMETER
TYPE/MODEL NUMBER	7016
SERIAL NUMBER	
RANGE/FEATURES	0-1 A AC 0.02 A/DIV
DATE CALIBRATED	04 29 74
INSTRUMENT NUMBER	10027
INSTR AND MFR	SIMPSON, AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	7016
RANGE/FEATURES	0-1.0 A AC
DATE CALIBRATED	04 29 74
INSTRUMENT NUMBER	10193
INSTR AND MFR	SIMPSON VOLTMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-750 VAC 10V/DIV
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10218
INSTR AND MFR	GE AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A F.S. 2 DIV WITH CURRENT XFMR
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10118
INSTR AND MFR	WESTINGHOUSE, AMMETER
TYPE/MODEL NUMBER	NT-35
SERIAL NUMBER	
RANGE/FEATURES	0-10 A
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10271
INSTR AND MFR	GE AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A F.S. 2 DIV WITH CURRENT XFMR
DATE CALIBRATED	12 21 74

POOR ORIGINAL

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LIST OF DATA ACQUISITION INSTRUMENTS 64033-01

INSTRUMENT NUMBER	10272
INSTR AND MFR	GE AC AMMETER
TYPE/MODEL NUMBER	AD-91 FS 5A
SERIAL NUMBER	
RANGE/FEATURES	0-100A F.S. 2 DIV WITH CURRENT XFMR
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10273
INSTR AND MFR	WIDGEST AC AMMETER
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0-100A F.S. 2 DIV WITH CURRENT XFMR
DATE CALIBRATED	12 21 74
INSTRUMENT NUMBER	10174
INSTR AND MFR	ESTERLINE ANGUS 2-PEN RECORDER
TYPE/MODEL NUMBER	SPEED SERVO II E11025
SERIAL NUMBER	908424
RANGE/FEATURES	0-400 DEGREES F TYPE J T/C 0-10 MVDC 1-980 IN/HR
DATE CALIBRATED	10 11 74
INSTRUMENT NUMBER	4215152
INSTR AND MFR	DATESTROP INSTRUMENT, MULTIPOINT RECORDER
TYPE/MODEL NUMBER	6702
SERIAL NUMBER	205030
RANGE/FEATURES	0-400 DEGREES F TYPE J T/C
DATE CALIBRATED	10 11 74
INSTRUMENT NUMBER	10235
INSTR AND MFR	GENERAL RADIO MEGOHMMETER
TYPE/MODEL NUMBER	1864
SERIAL NUMBER	4368-1030
RANGE/FEATURES	50K TO 5T OHMS 10-1000 V DC
DATE CALIBRATED	11 26 74
INSTRUMENT NUMBER	10087
INSTR AND MFR	HIPOTRONICS, MEGOHMMETER
TYPE/MODEL NUMBER	M3A
SERIAL NUMBER	3930-1232 P/N 1620
RANGE/FEATURES	10 MILLION MEGOHMS 50,100,500,1000 VDC
DATE CALIBRATED	11 08 74
INSTRUMENT NUMBER	10258
INSTR AND MFR	HIPOTRONICS AC DIELECTRIC TEST SET
TYPE/MODEL NUMBER	705-2
SERIAL NUMBER	74-21046 UNIT 2
RANGE/FEATURES	0 10 KV KVA 3KVA
DATE CALIBRATED	12 21 74

LIST OF DATA ACQUISITION INSTRUMENTS 64033-01

INSTRUMENT NUMBER	10039
INSTR AND MFR	MARSH RELAY, PRESSURE GAGE
TYPE/MODEL NUMBER	ALHAMBRA AISI 316 TUBE
SERIAL NUMBER	1036
RANGE/FEATURES	0-200 PSIG 1 PSI/DIV
DATE CALIBRATED	11 19 74
INSTRUMENT NUMBER	10247
INSTR AND MFR	AMETEK PRESSURE TRANSDUCER
TYPE/MODEL NUMBER	50G0200BC2A24
SERIAL NUMBER	40227-1
RANGE/FEATURES	0-200 PSIG 0-1 V DC AT OHM LOAD
DATE CALIBRATED	08 23 74
INSTRUMENT NUMBER	10248
INSTR AND MFR	BARTON INSTRUMENTS MANOMETER
TYPE/MODEL NUMBER	227
SERIAL NUMBER	227-82467
RANGE/FEATURES	0-100 IN. WATER
DATE CALIBRATED	09 26 74
INSTRUMENT NUMBER	10249
INSTR AND MFR	DANIEL INDUSTRIES ORIFICE FLOW SECTION
TYPE/MODEL NUMBER	
SERIAL NUMBER	
RANGE/FEATURES	0.375 IN. DIA ORIFICE 0.750 IN. DIA PIPE
DATE CALIBRATED	10 07 74
INSTRUMENT NUMBER	10175
INSTR AND MFR	ASHCROFT, PRESSURE GAGE
TYPE/MODEL NUMBER	
SERIAL NUMBER	1033
RANGE/FEATURES	0-160 PSIG
DATE CALIBRATED	REFERENCE ONLY
INSTRUMENT NUMBER	10254
INSTR AND MFR	MULTI-AMP AC AMMETER
TYPE/MODEL NUMBER	105
SERIAL NUMBER	2102
RANGE/FEATURES	MULTI RANGE 10 TO 10000 MA AC
DATE CALIBRATED	11 11 74
INSTRUMENT NUMBER	10276
INSTR AND MFR	AMPROBE AC VOLT-AMMETER PROBE
TYPE/MODEL NUMBER	RS-3
SERIAL NUMBER	DU 421604
RANGE/FEATURES	0-6/15/40/100/300MAC 0-150/300/600 VAC 75 OHM RS
DATE CALIBRATED	08 16 74

POOR ORIGINAL

512 142

28 P

50-320 THREE MILE ISLAND #2

STEAM LINE BREAK ENVIRONMENTAL QUALIF.

w/letter dated 10-31-78....7811090114.

#28

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10/31/78

512 145

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October 31, 1978
GQL 1781

Director of Nuclear Reactor Regulation
Attn: S. A. Varga, Chief
Light Water Reactors Branch No. 4
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Steam Line Break Environmental Qualification

Enclosed please find the responses to the questions raised in your letter of May 8, 1978, concerning Steam Line Break Environmental Qualification of electrical components.

Also enclosed, please find copies of the TMI-2 FSAR pages which discuss these environmental qualifications. These FSAR pages have been updated to reflect the information transmitted in response to your May 8, 1978 questions, and will be included in a future FSAR amendment.

In addition, we have enclosed four (4) copies of the Environmental Qualification Test Reports for the above mentioned electrical components. Test Data Reports for two types of instrumentation cable are included in these reports. An investigation of the TMI-2 Cable Pull-slips is currently underway to determine if any other types of cable had been used. After the results of this investigation are obtained, any additional pertinent test data will be forwarded to you.

Sincerely,

Signed J. G. Herbein

J. G. Herbein
Vice President-Generation

512 144

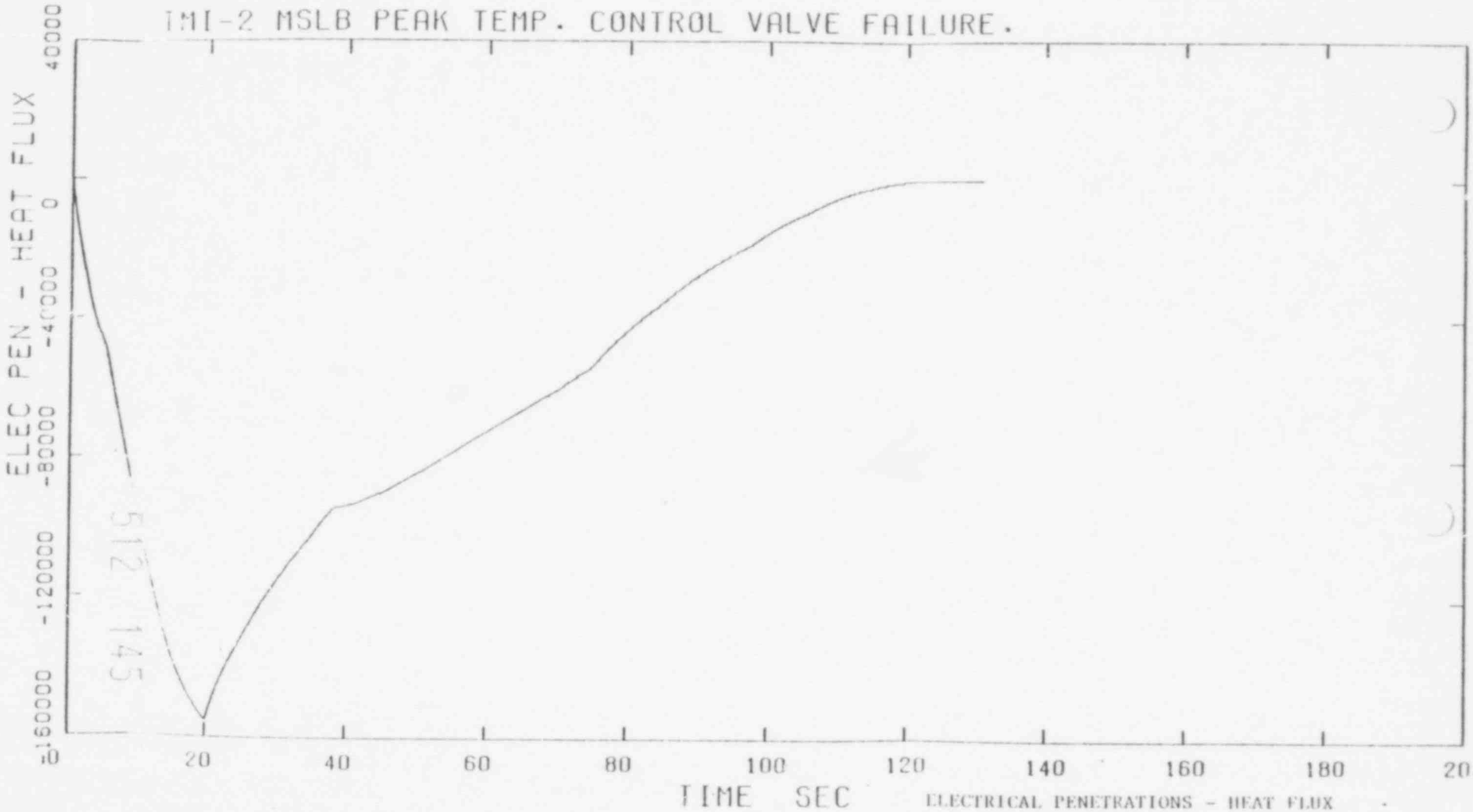
JGH:RAL:cjg

Attachment: 1. Response to May 8, 1978 Questions
2. Four copies of Environmental Qualification Test Reports (as further identified on Pages S3-42-23c and S3-42-23d of Attachment No. 1)

cc: Mr. Harley Silver (NRC)

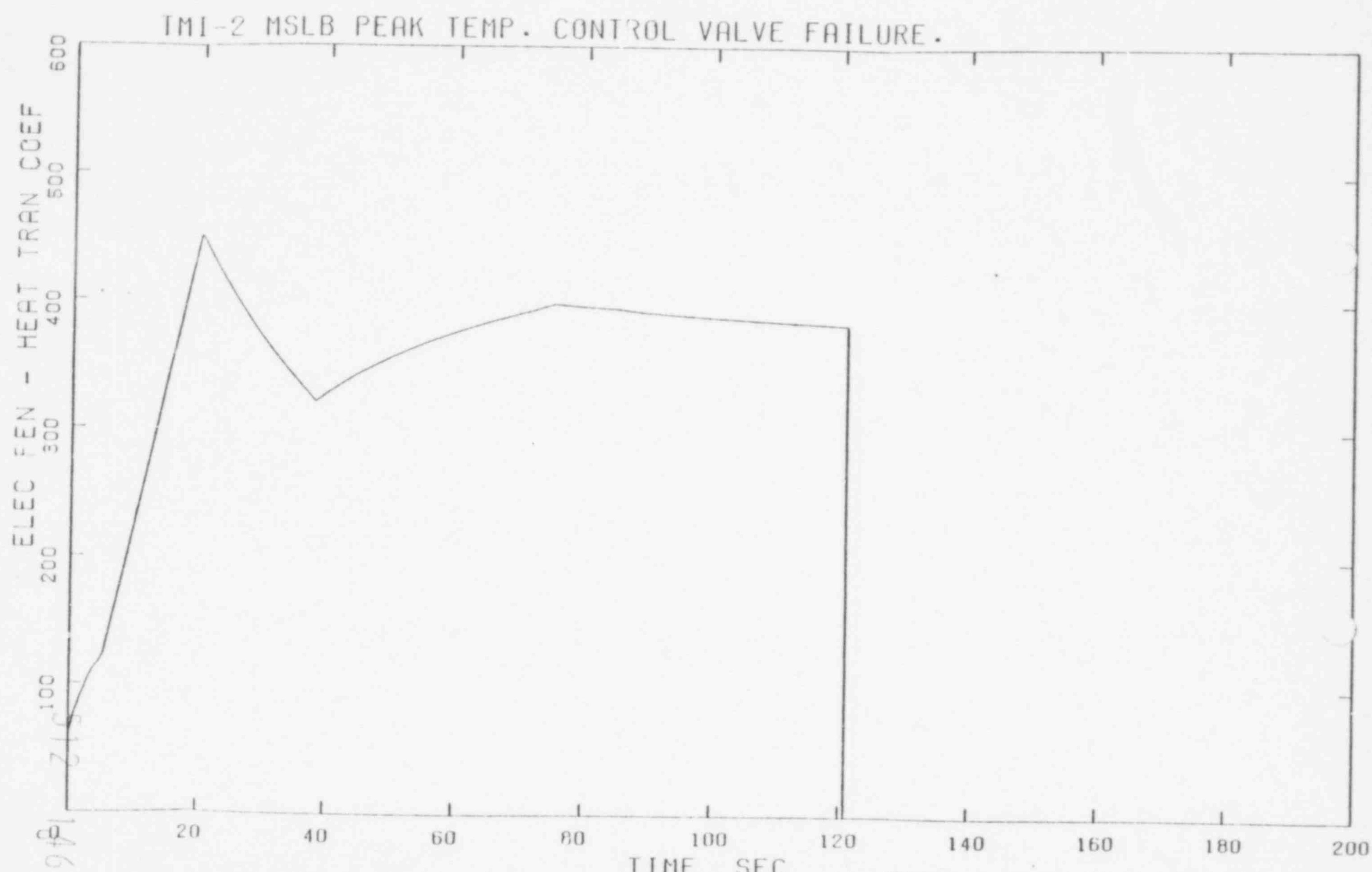
7811080114

NONE 54 see LIST



ELECTRICAL PENETRATIONS - HEAT FLUX

FIGURE 15B-10, SHEET 6A OF 8

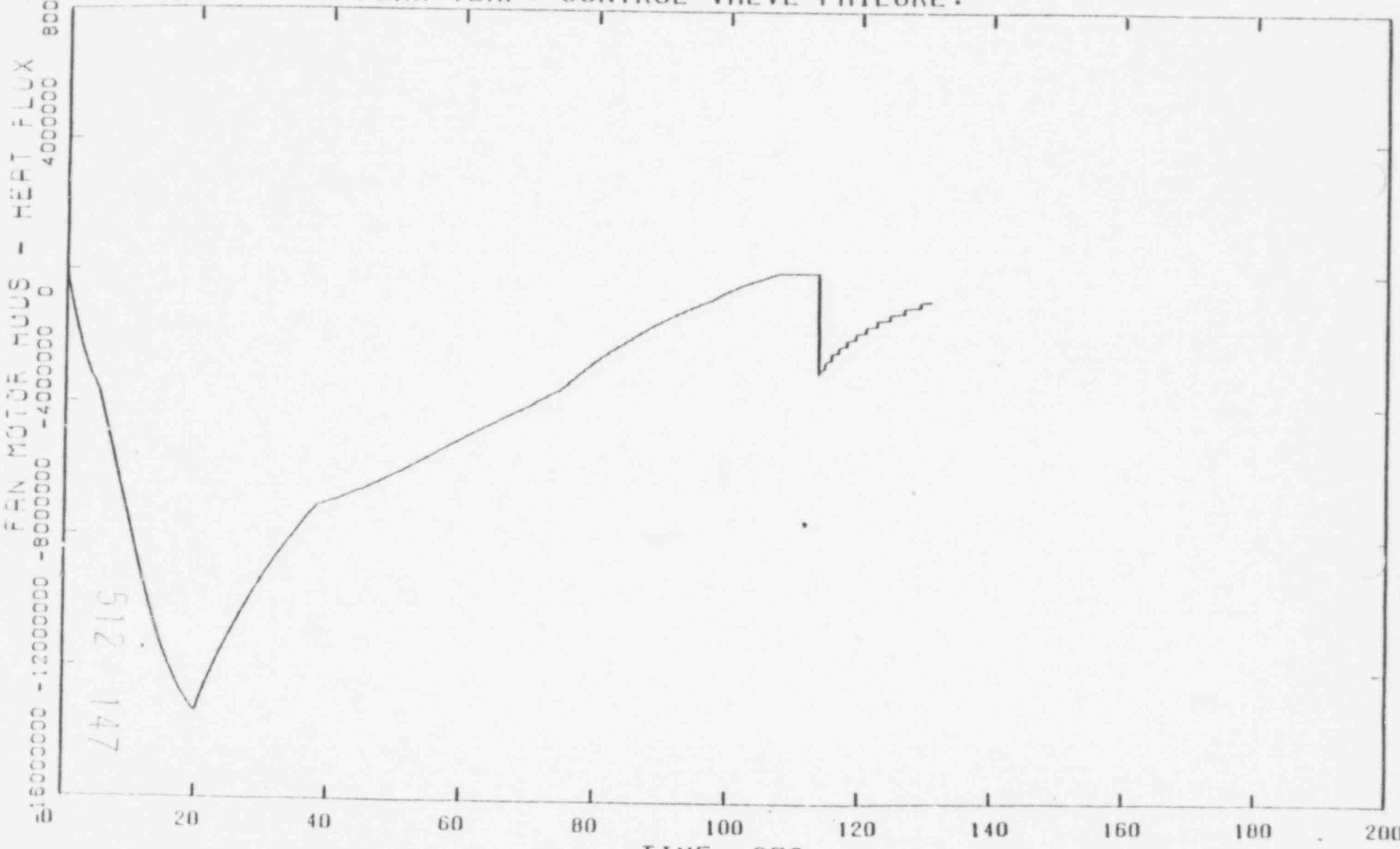


ELECTRICAL PENETRATIONS - HEAT TRANSFER COEFFICIENT

FIGURE 15B-10, SHEET 6B OF 8

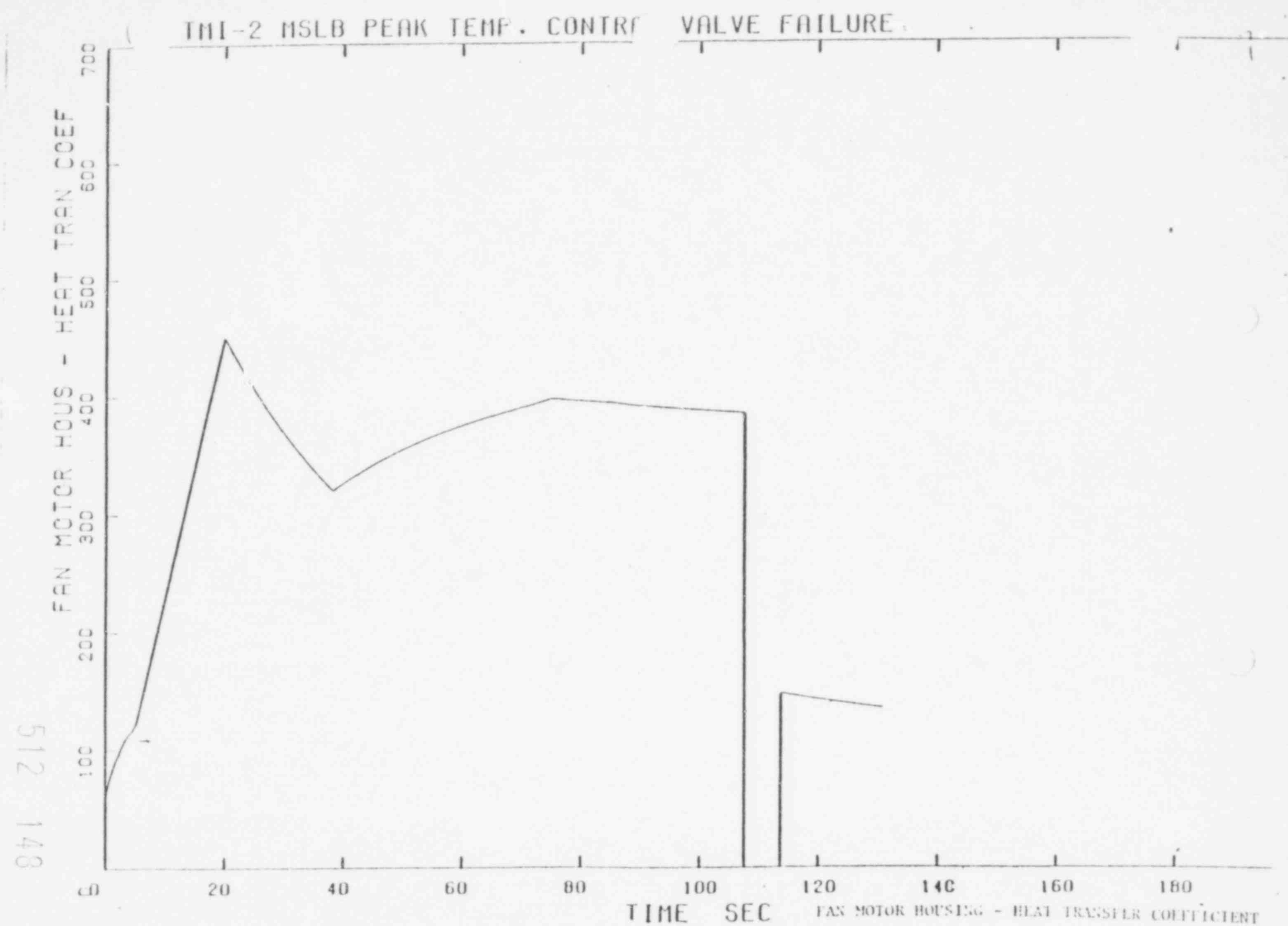
512 146

TMI-2 MSLB PEAK TEMP. CONTROL VALVE FAILURE.



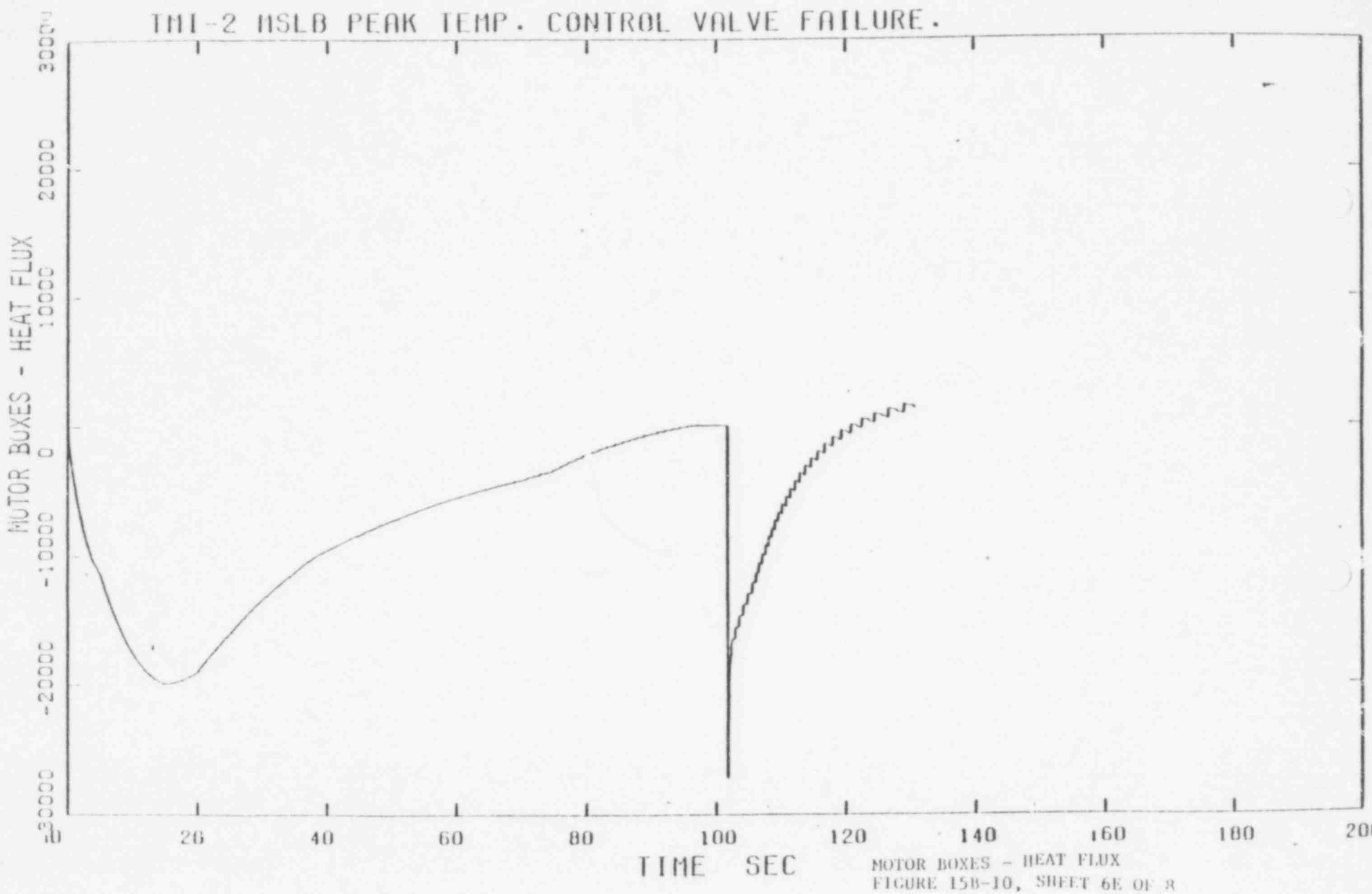
FAN MOTOR HOUSING - HEAT FLUX
FIGURE 15B-10, SHEET 6C OF 8

512 147



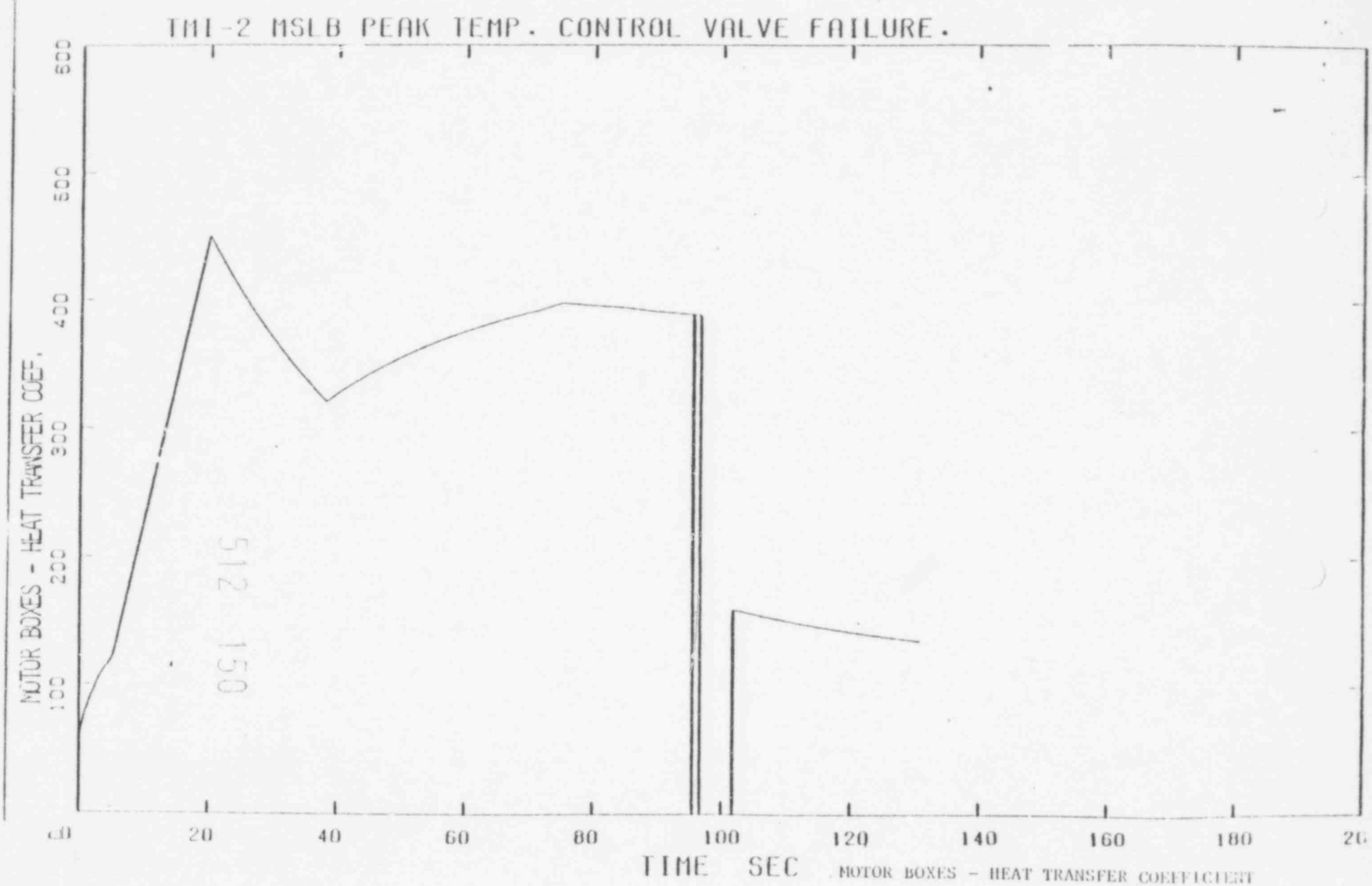
FAN MOTOR HOUSING - HEAT TRANSFER COEFFICIENT
FIGURE 15b-10, SHEET 6D OF 8

512 148

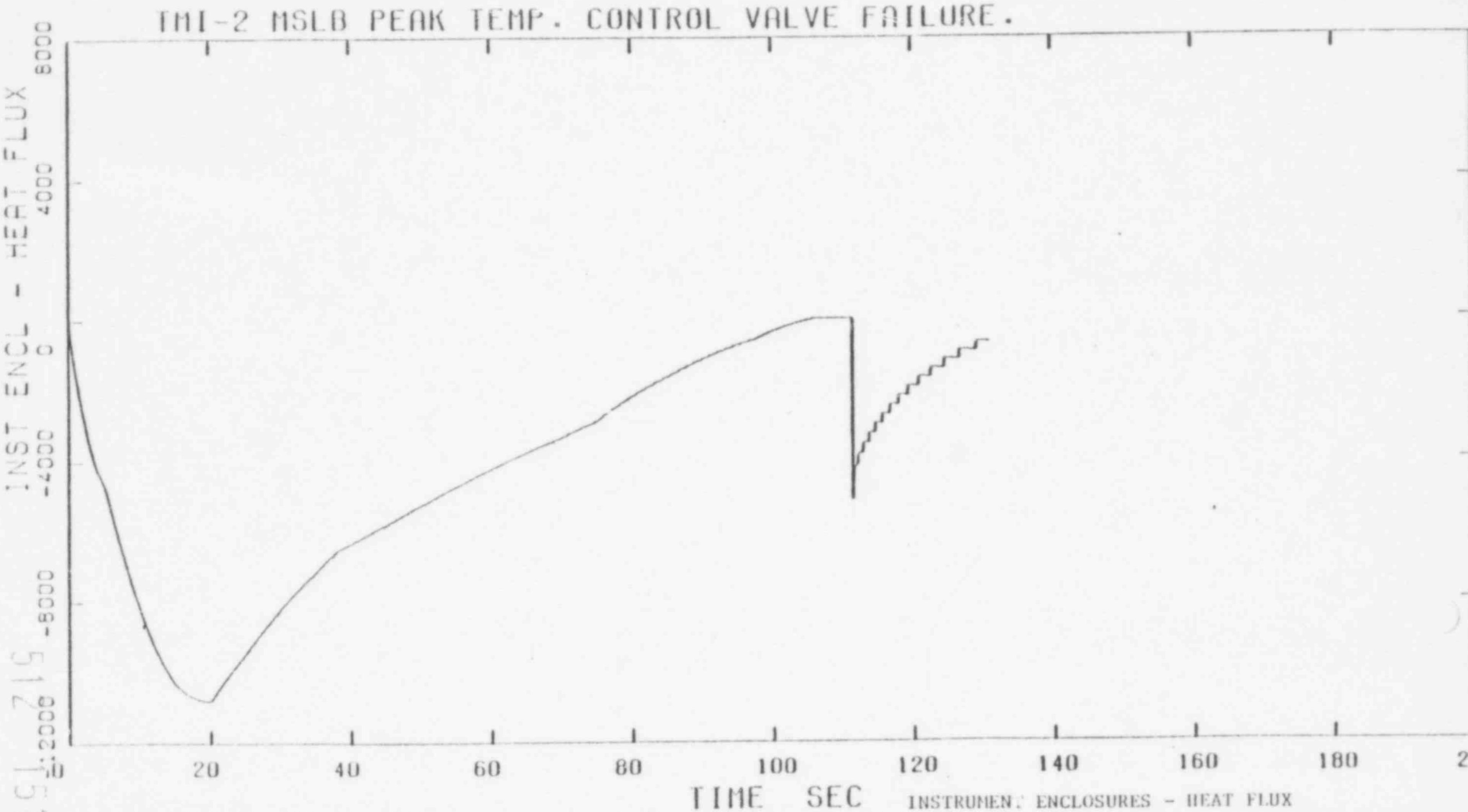


MOTOR BOXES - HEAT FLUX
FIGURE 15B-10, SHEET 6E OF 8

512 149



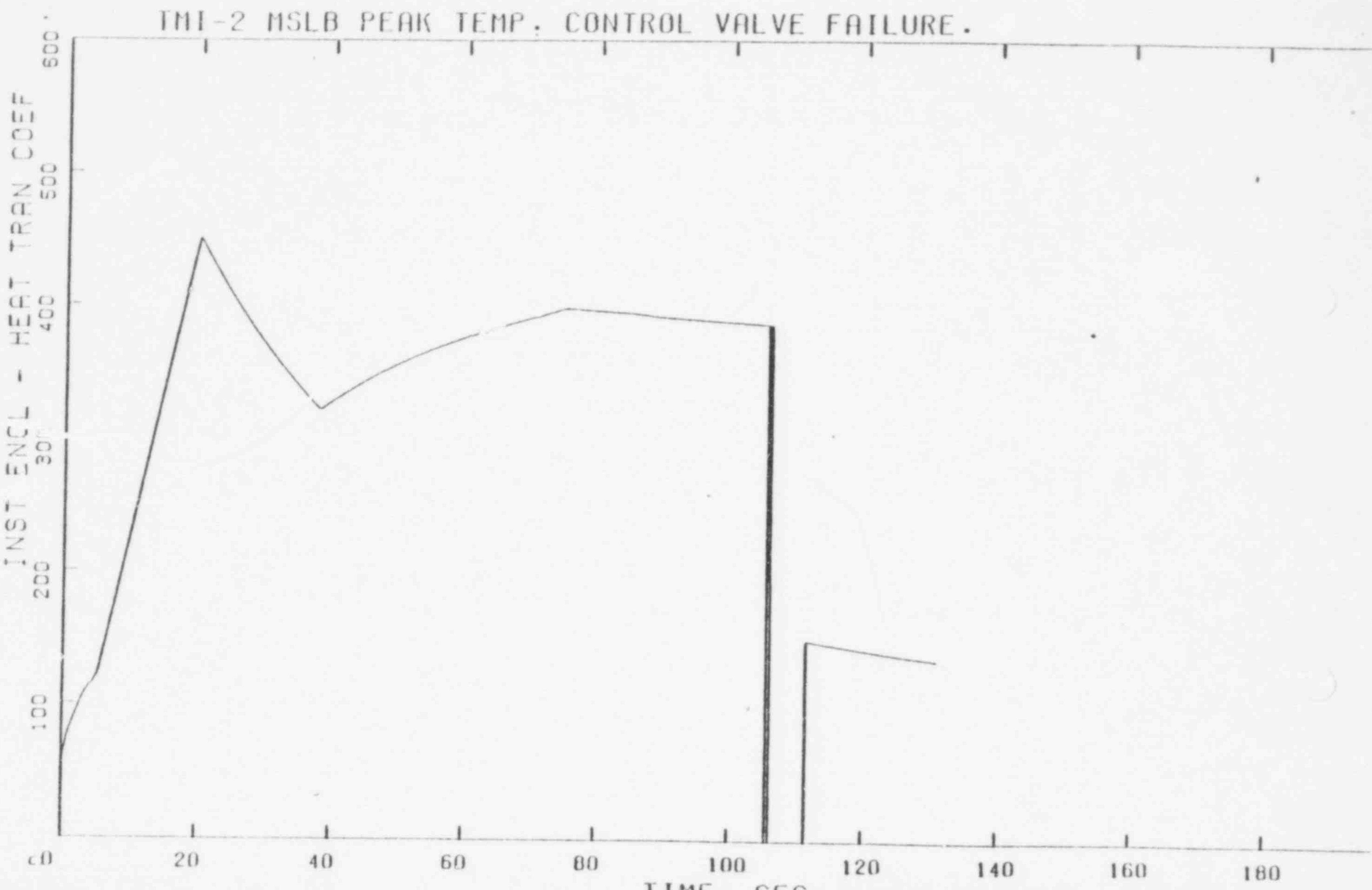
MOTOR BOXES - HEAT TRANSFER COEFFICIENT
FIGURE 15B-10, SHEET 6F OF 8



INSTRUMEN: ENCLOSURES - HEAT FLUX

FIGURE 15B-10, SHEET 6G OF 8

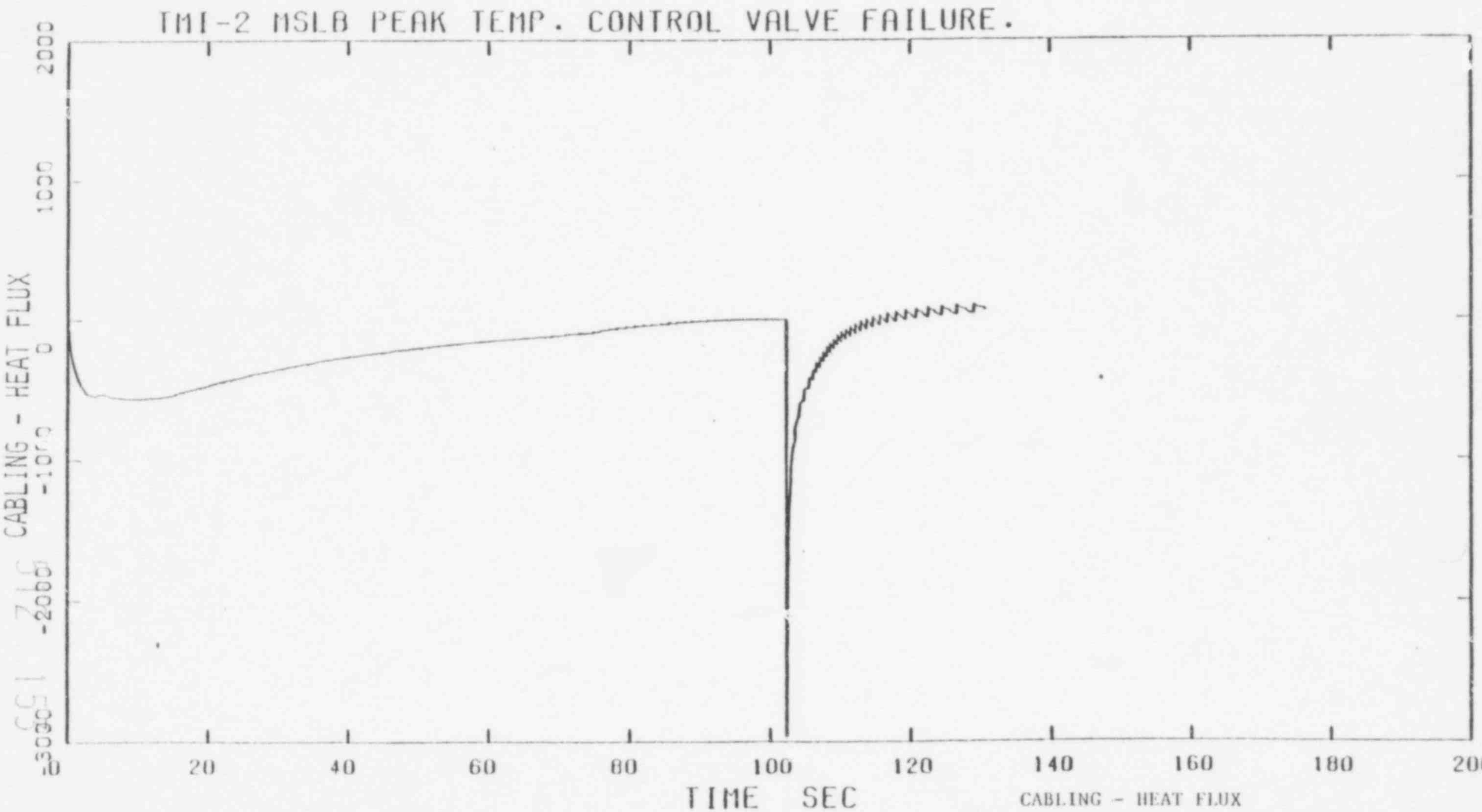
512 151



INSTRUMENT ENCLOSURES - HEAT TRANSFER COEFFICIENT

FIGURE 15B-10, SHEET 6H OF 8

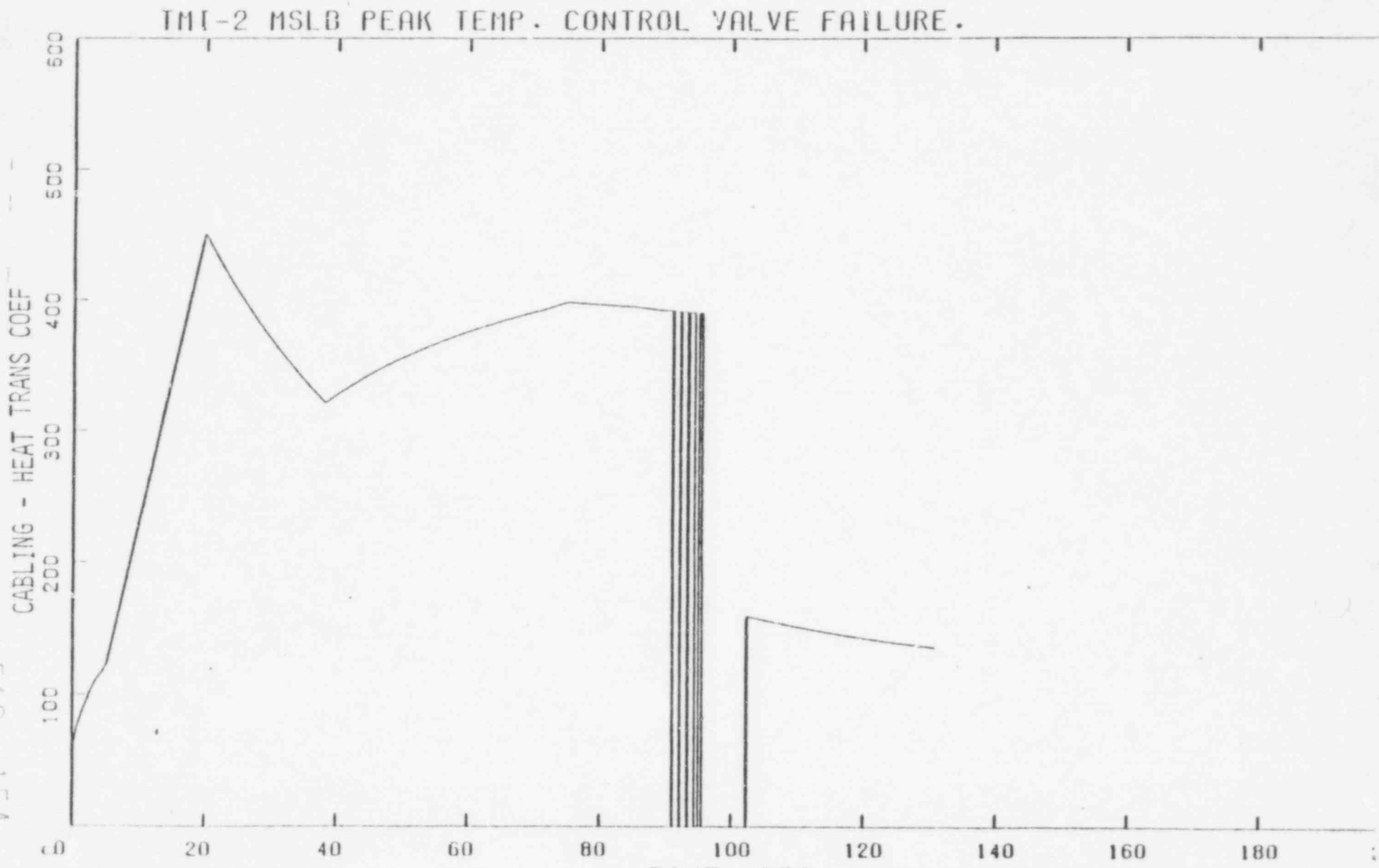
512 152



CABLING - HEAT FLUX

FIGURE 15B-16, SHEET 6I OF 8

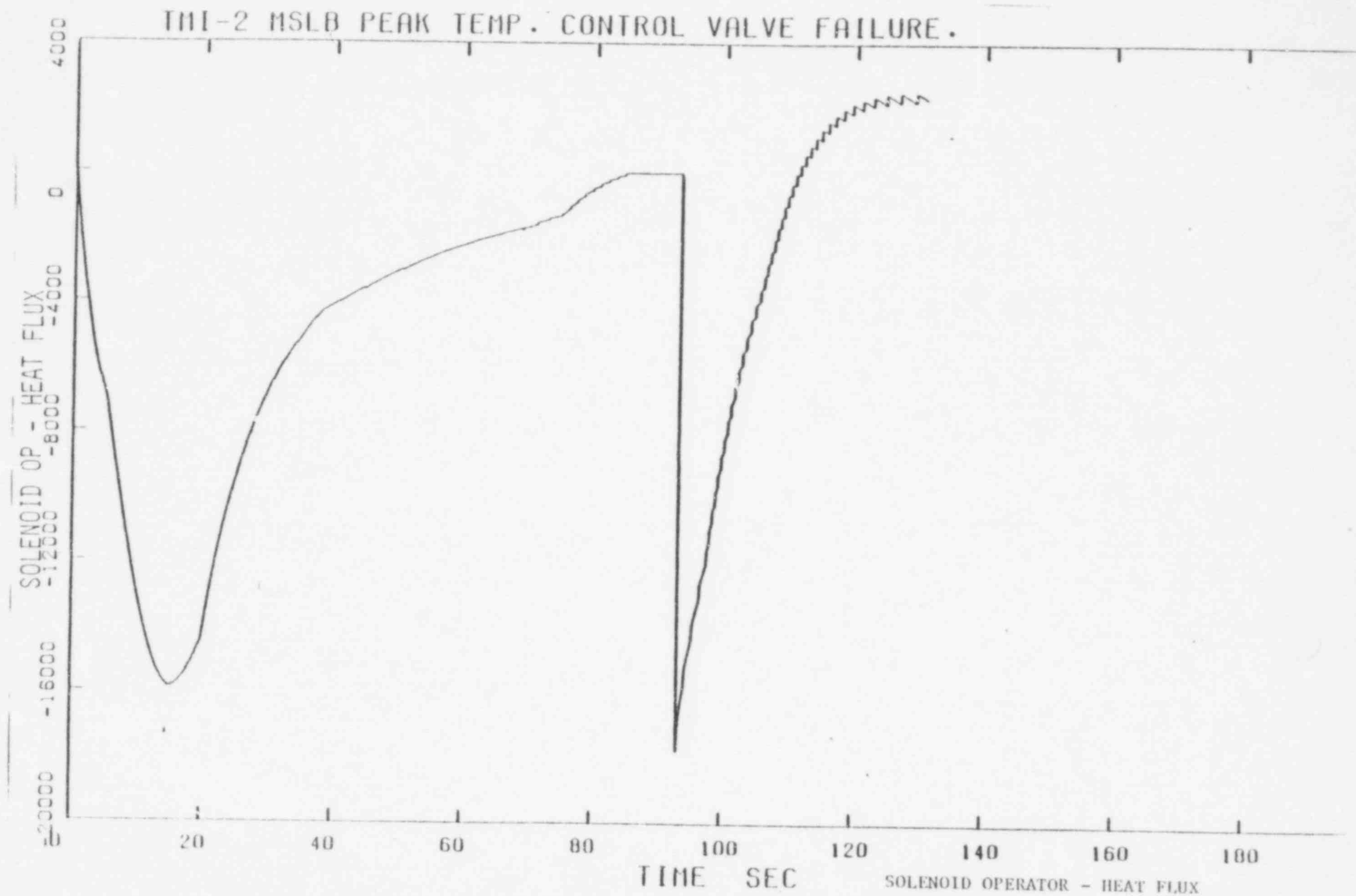
516 155



CABLING - HEAT TRANSFER COEFFICIENT

FIGURE 15B-10, SHEET 6J OF 8

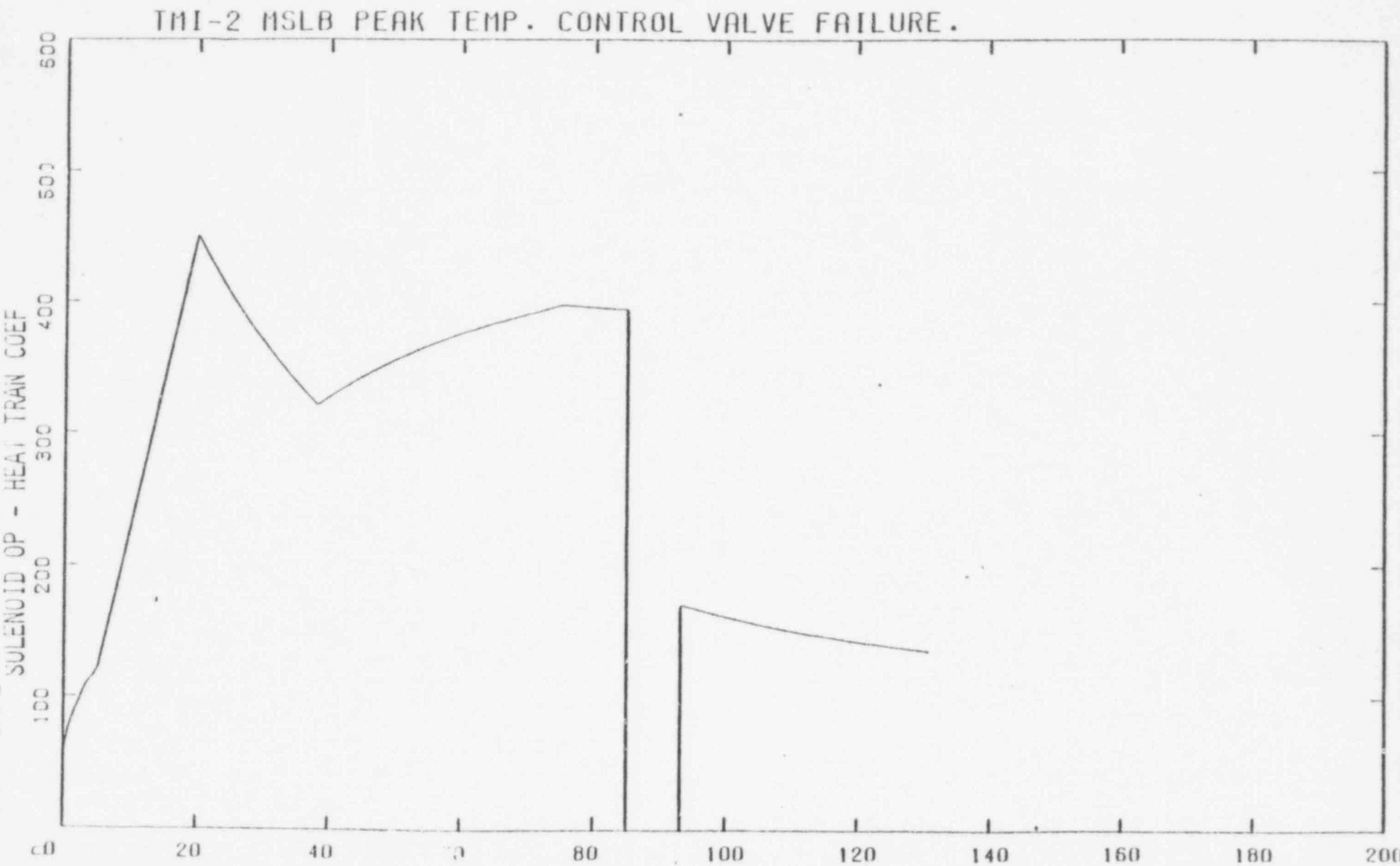
512 154



SOLENOID OPERATOR - HEAT FLUX

FIGURE 15B-10, SHEET 6K OF 8

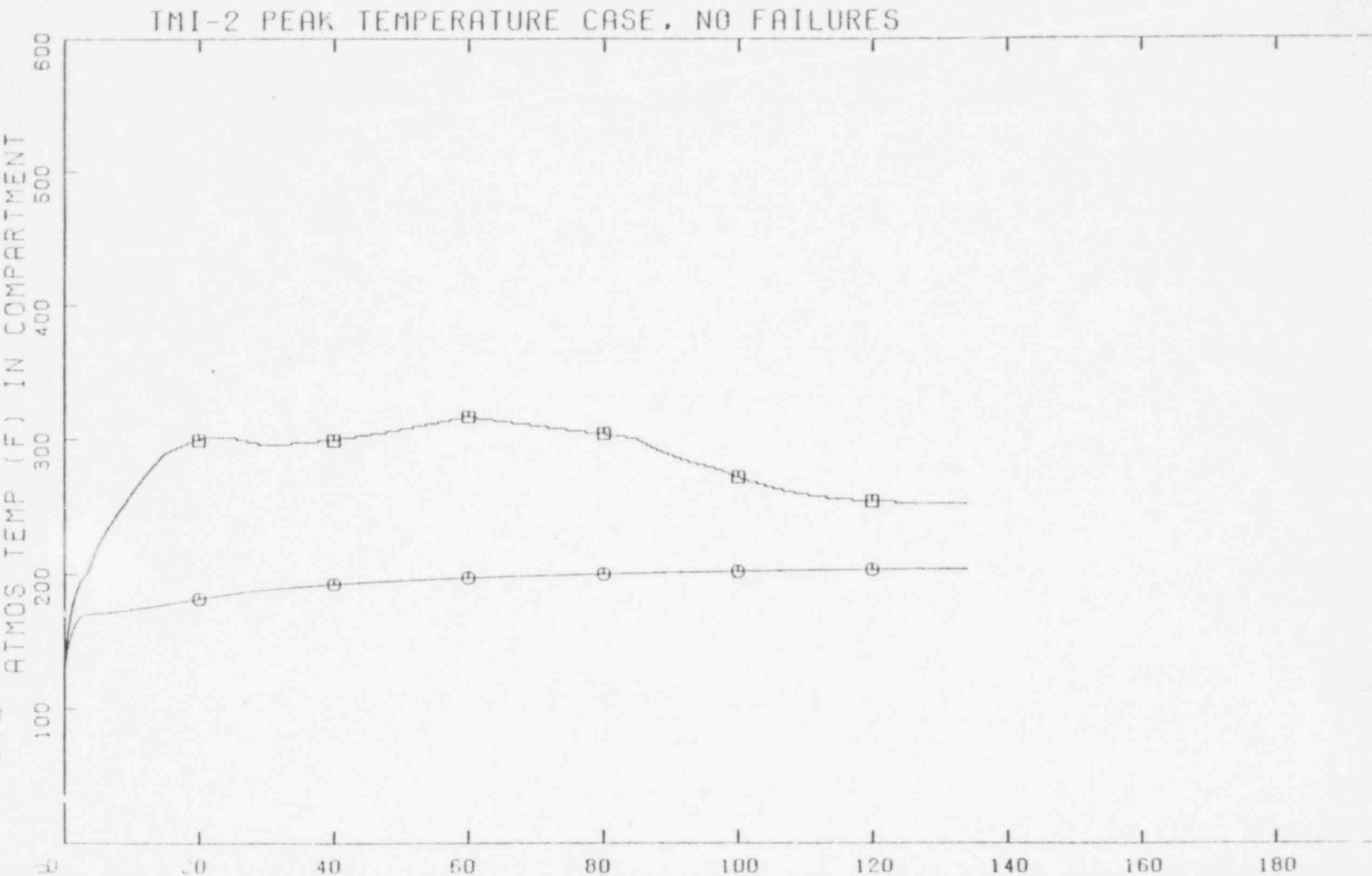
512 155



SOLENOID OPERATOR - HEAT TRANSFER COEFFICIENT

FIGURE 15B-10, SHEET 6L OF 8

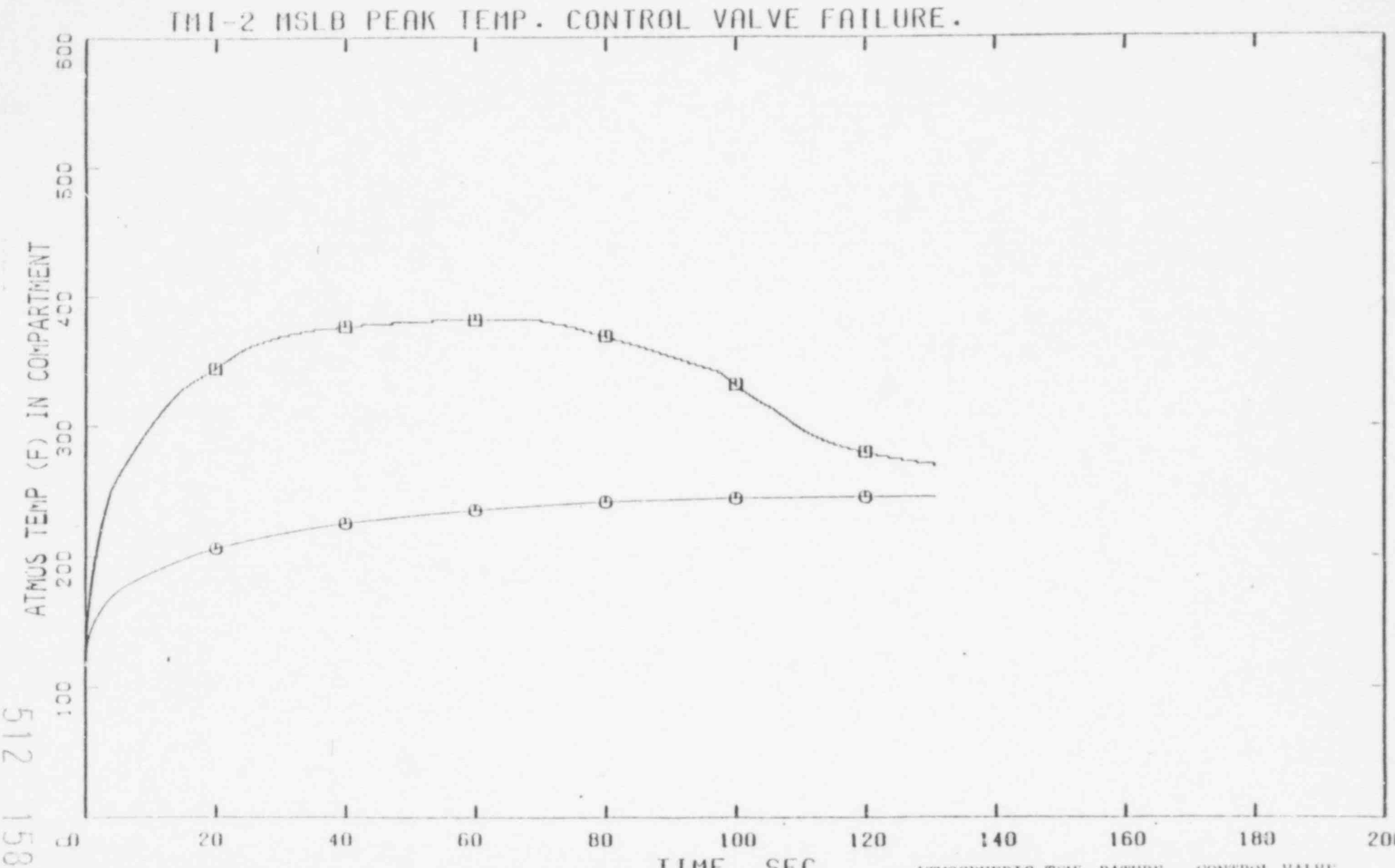
512 156



ATMOSPHERIC TEMPERATURE - NO FAILURES, PEAK TEMPERATURE CASE

FIGURE 15B-10, SHEET 6M OF 8

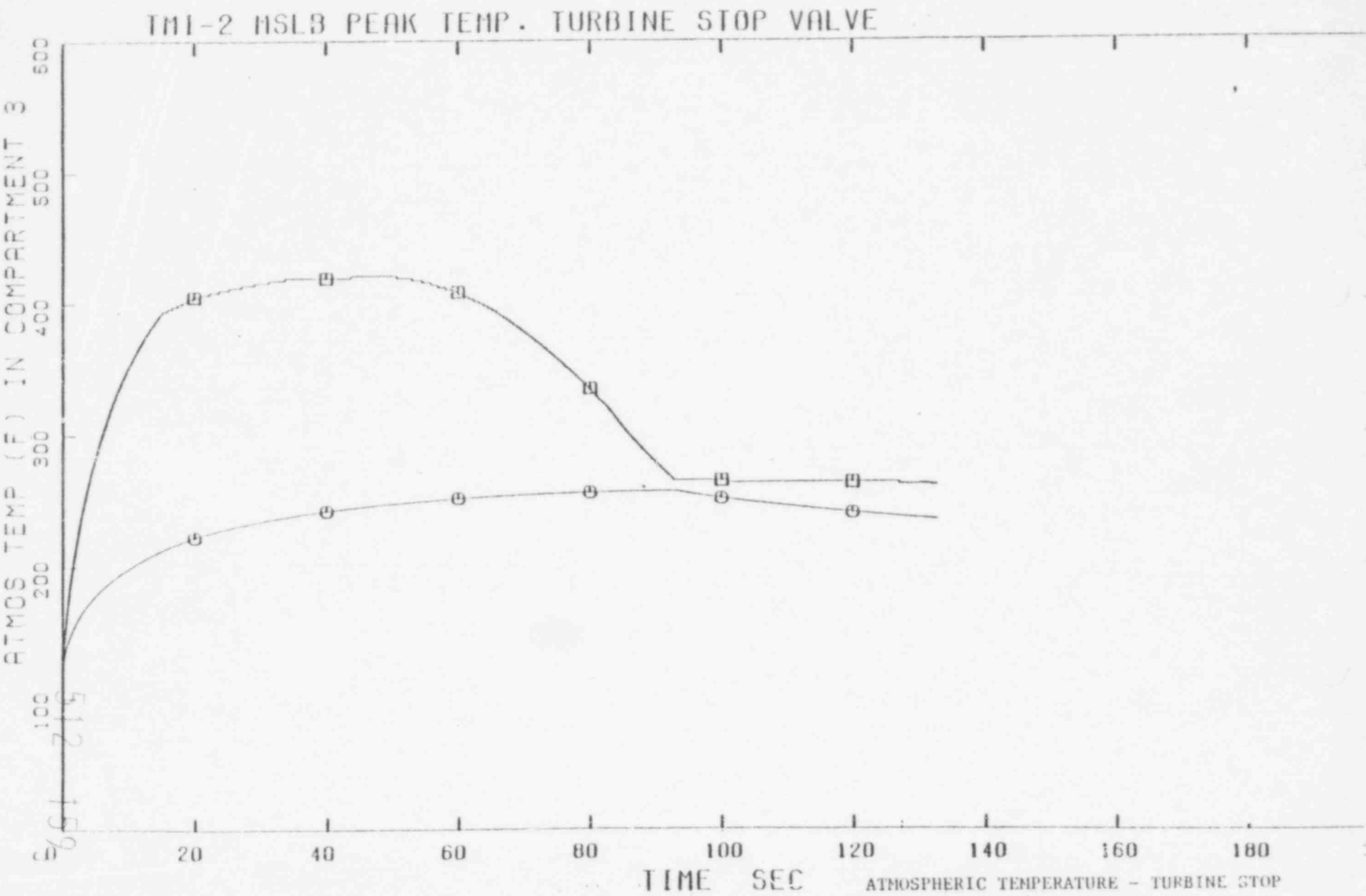
512 157



ATMOSPHERIC TEMPERATURE - CONTROL VALVE FAILURE, PEAK TEMPERATURE CASE

FIGURE 15B-10, SHEET 6N OF 8

512 158



ATMOSPHERIC TEMPERATURE - TURBINE STOP VALVE FAILURE - PEAK TEMPERATURE CASE

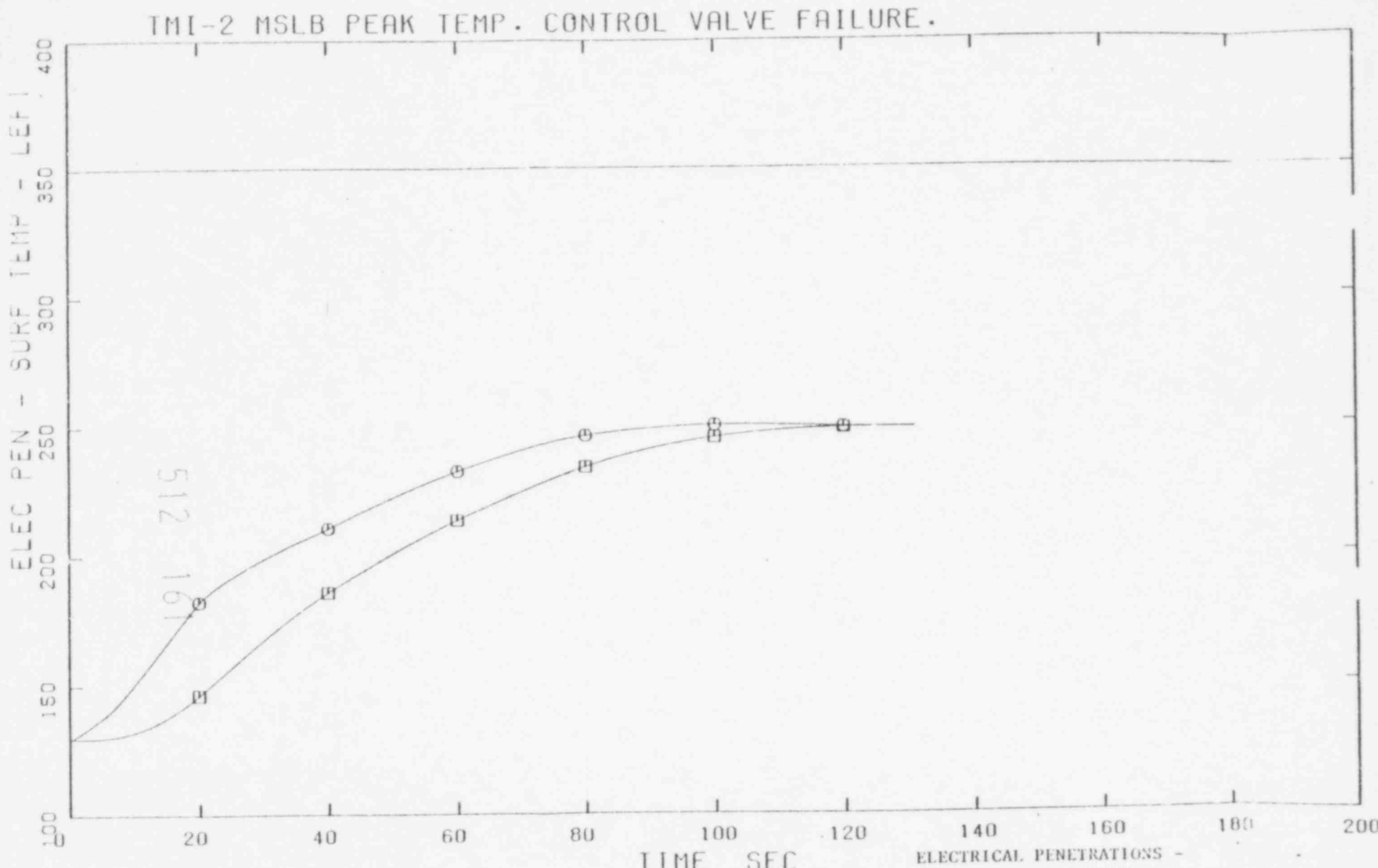
FIGURE 15B-10, SHEET 60 OF 8

512 159

DELETED

FIGURE 15B-10

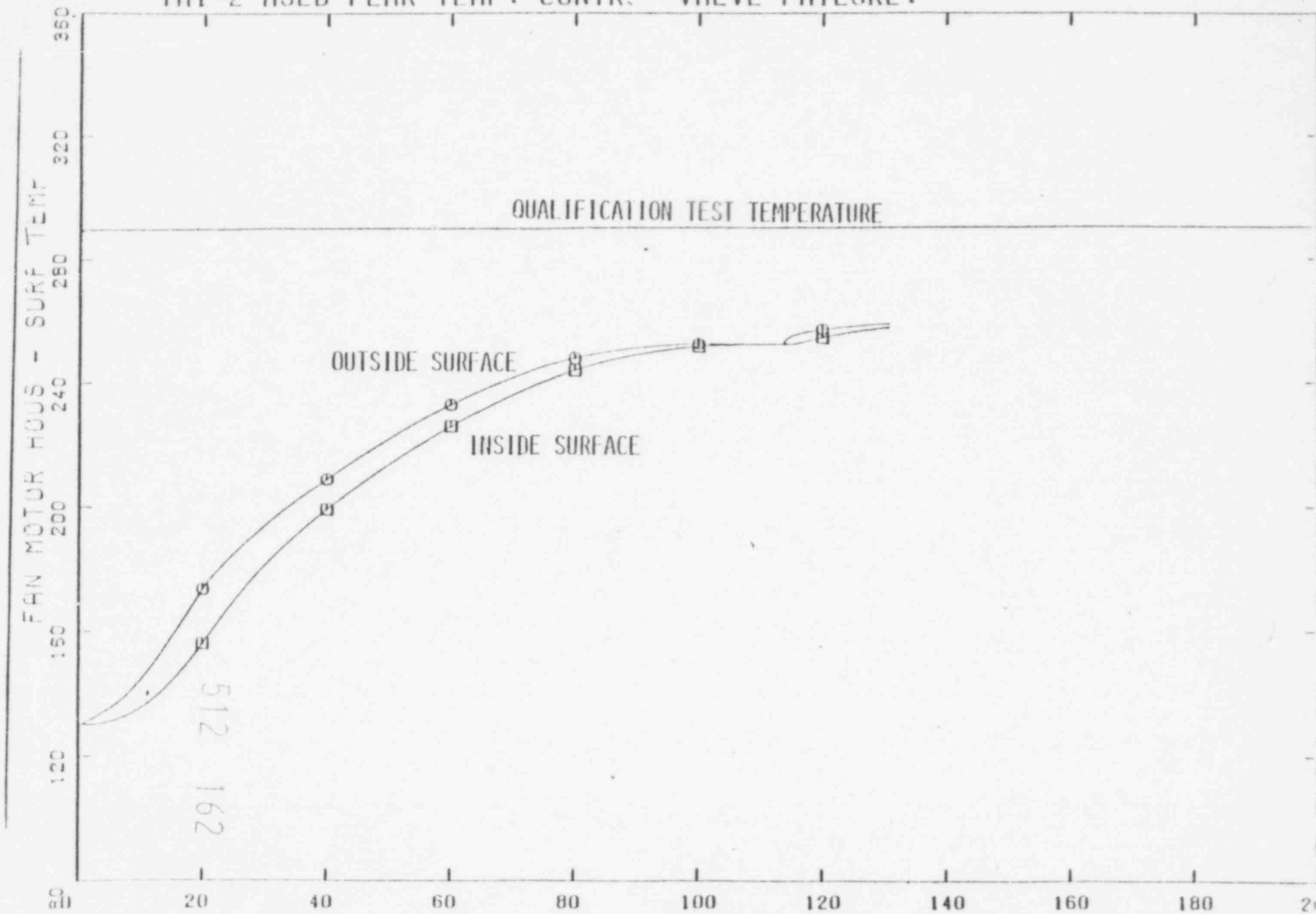
SHEET 7 OF 8



ELECTRICAL PENETRATIONS - SURFACE TEMPERATURE

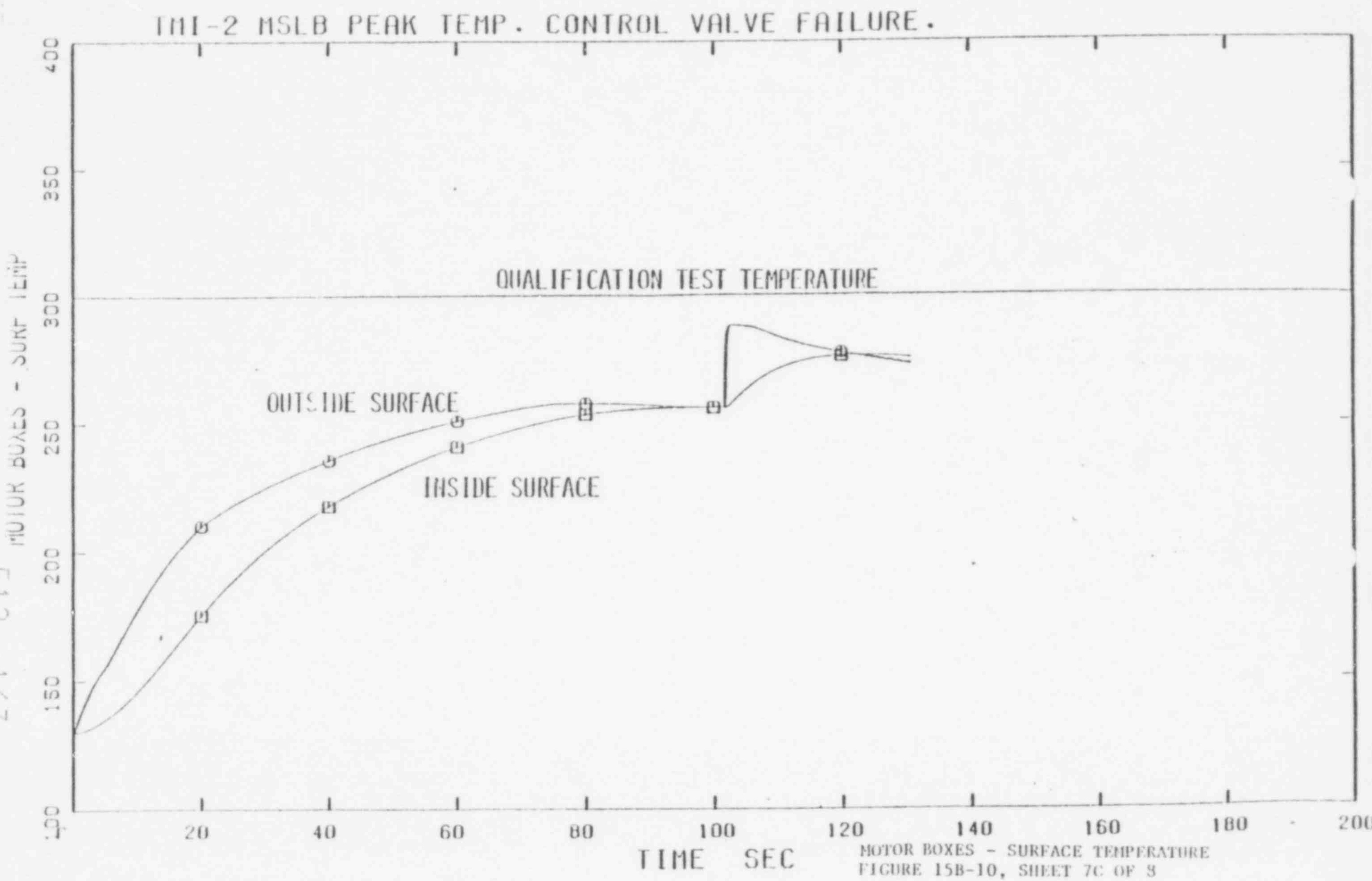
FIGURE 15B-10, SHEET 7A OF 8

TMI-2 MSLB PEAK TEMP. CONTR. VALVE FAILURE.



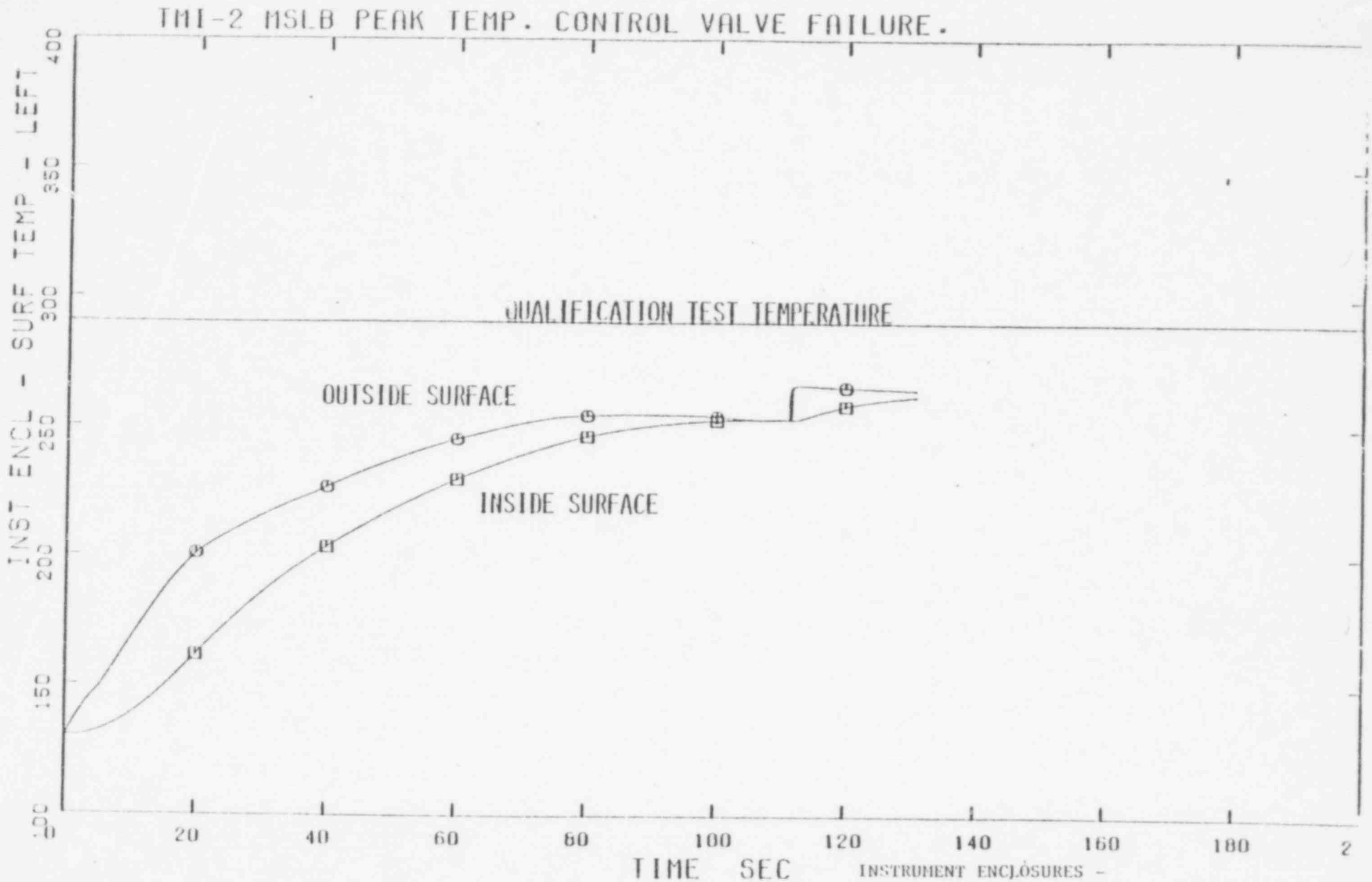
FAN MOTOR HOUSING - SURFACE TEMPERATURE

FIGURE 15B-10, SHEET 7B OF 8



MOTOR BOXES - SURFACE TEMPERATURE
FIGURE 15B-10, SHEET 7C OF 8

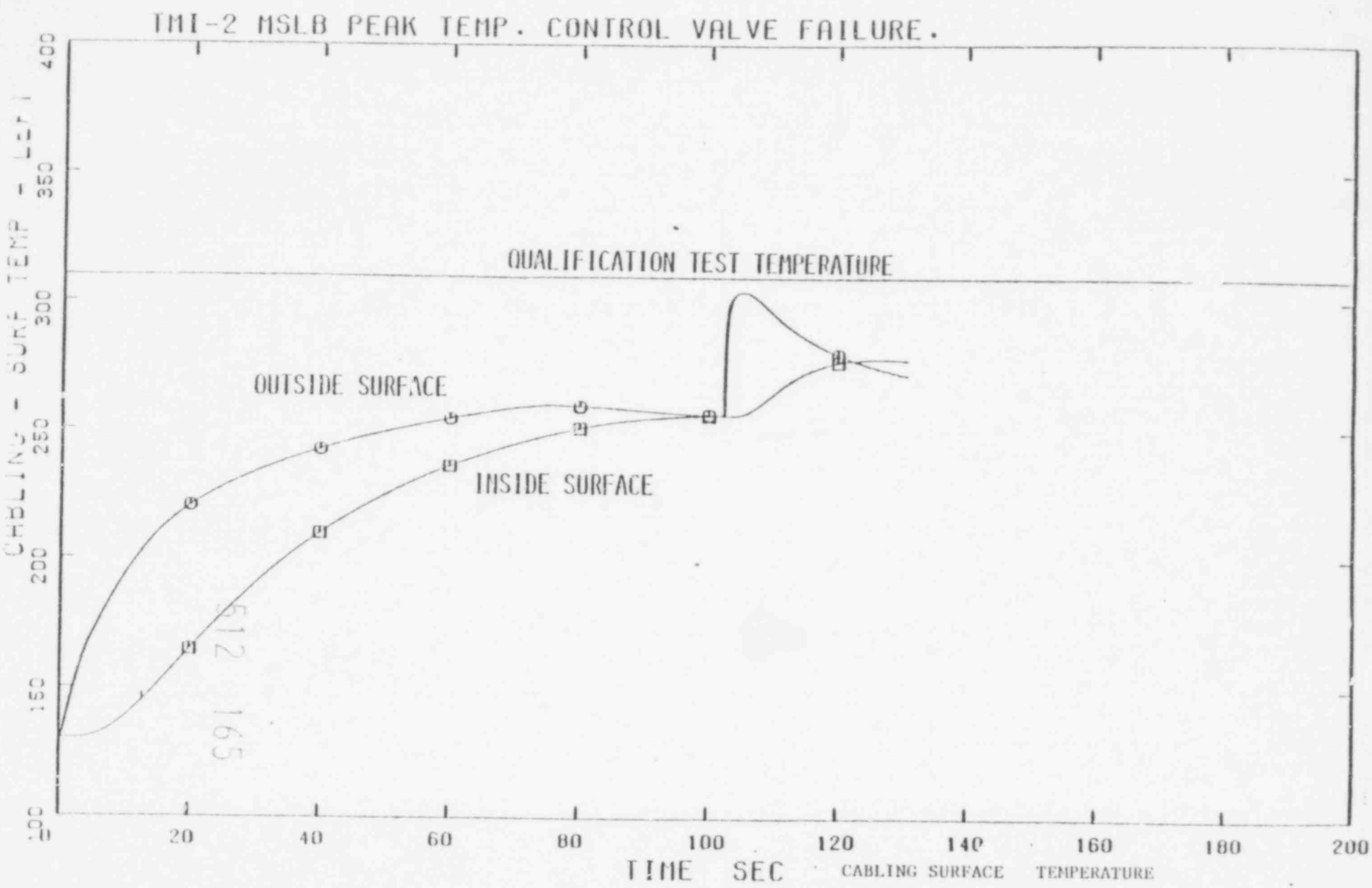
512 163



INSTRUMENT ENCLOSURES -
SURFACE TEMPERATURES

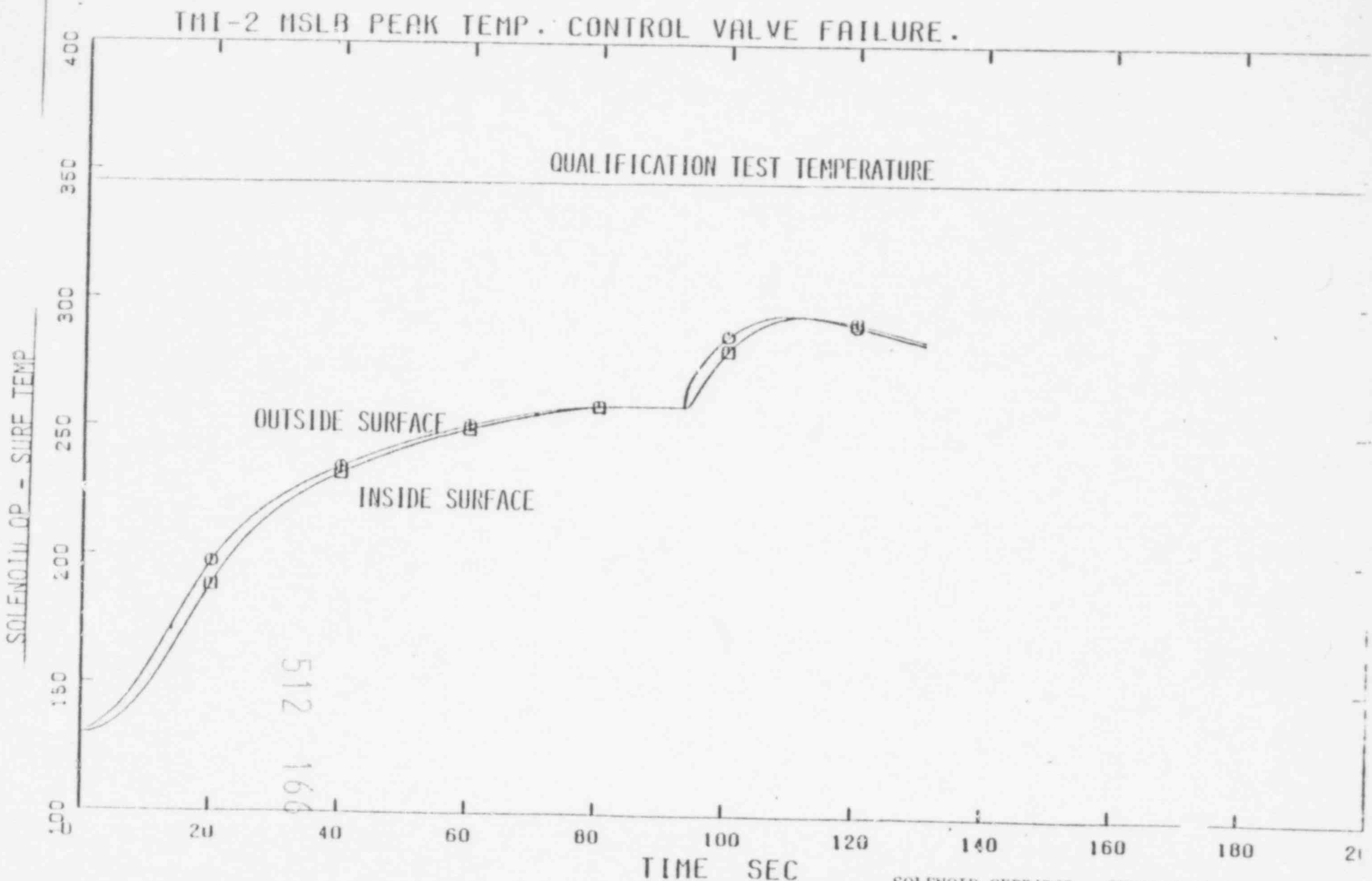
FIGURE 15B-10, SHEET 7D OF 8

512 164



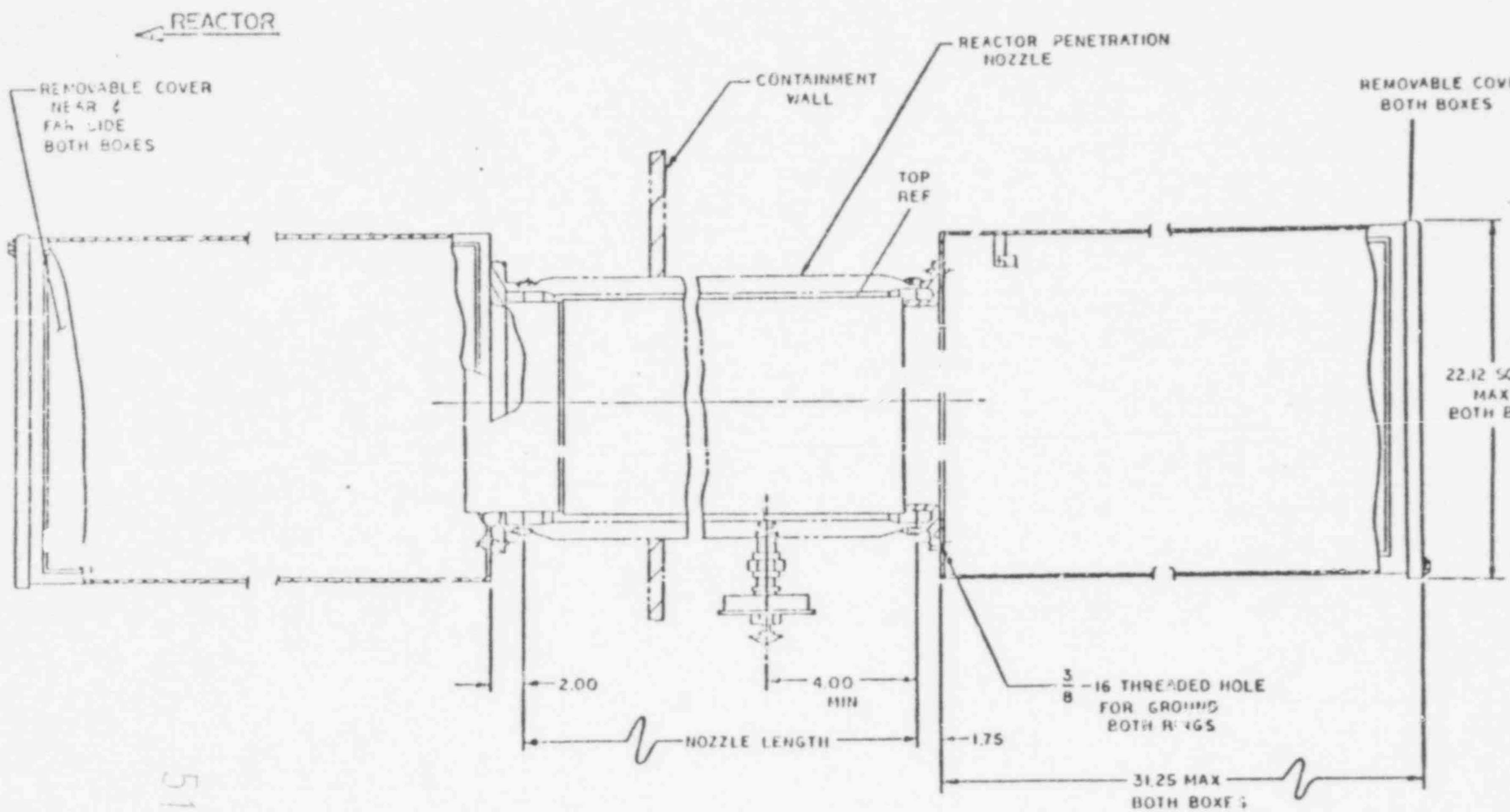
CABLING SURFACE TEMPERATURE

FIGURE 15B-10, SHEET 7E OF 8



SOLENOID OPERATOR - SURFACE TEMPERATURE

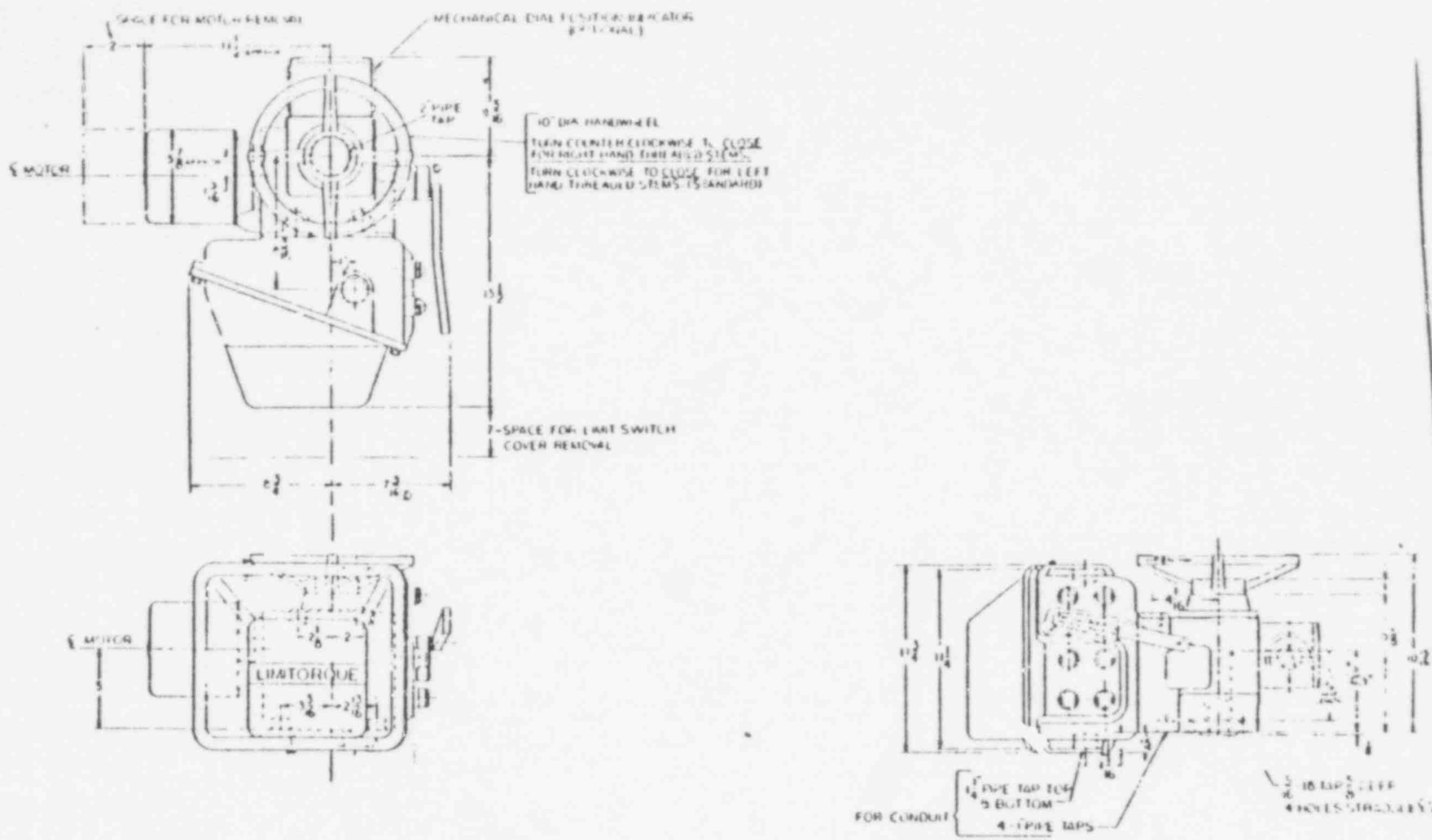
FIGURE 15B-10, SHEET 7F OF 8



PENETRATION ASSEMBLY - CROSS SECTION

FIGURE 15B-14A

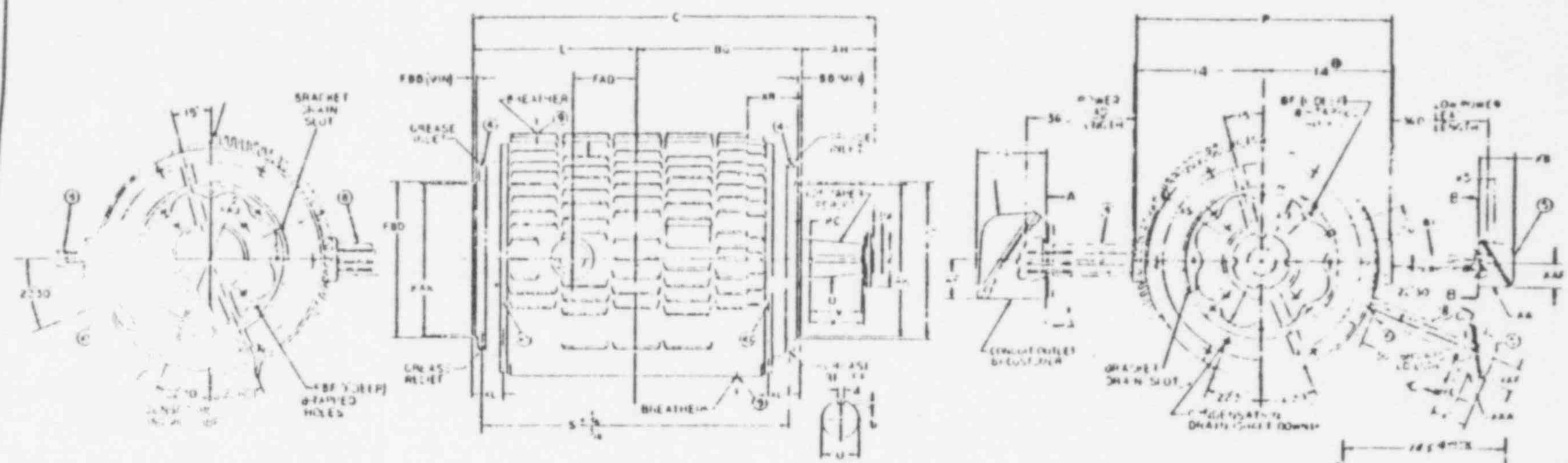
512 167



MOTOR BOXES - CROSS SECTION

FIGURE 15B-14B

512 163

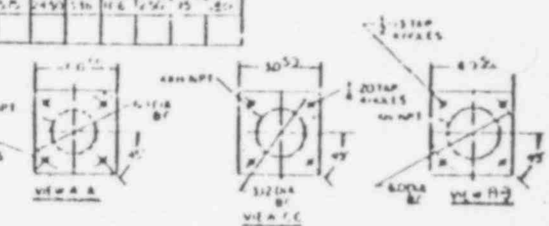


DIMENSIONS ARE IN INCHES AND CORRESPOND TO LETTERS ABOVE

FRAME SIZE	C	L	P	S	U	V	X	Z	AF	AH	AJ	AK	BB	BC	BD	BF	BG	BM	[illegible]	XA	XB	XC	XAF	[illegible]	[illegible]	[illegible]	[illegible]	FBB	FEC	FEF	XE tap a	XE tap b	H	XH	XL	XG	XS	XD	XE	AA	XAA	XXH
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.25	.48	[illegible]	[illegible]	[illegible]	[illegible]	6	[illegible]	7.56	2.50	1.94	12	[illegible]	[illegible]	[illegible]	.25	[illegible]	[illegible]	.88	.44	3	[illegible]	[illegible]	5.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE ② "U" VARIES +.0.0 -.001
NOTE ③ AK & FAK VARIES +.00 -.005 FACE RUNOUT & ECCENTRICITY .002 T.I.R.
NOTE ④ IF GREASE LEADS ARE REQUIRED REMOVE PIPE PLUGS FROM GREASE FITTING AND REPLACE WITH 1/8 THREADED PIPE OF NECESSARY LENGTH. GREASE FITTING MUST REMAIN IN MOTOR END BELL. GREASE RELIEF 1/4 N.P.T.

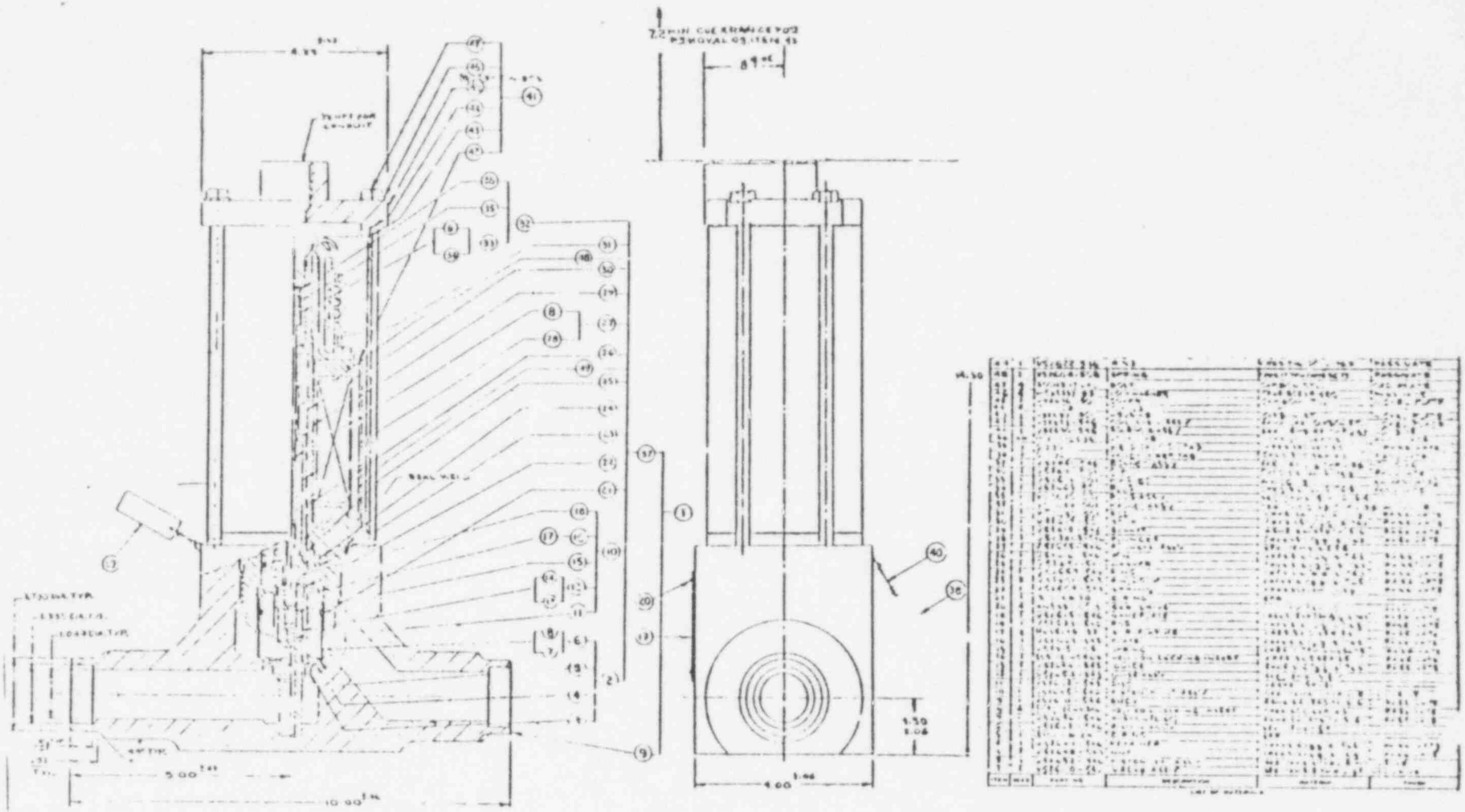
NOTE ⑤ FOR SHIPMENT ONLY, ASSEMBLY CONDUIT BOXES ON BASES & PACKAGE SEPARATELY WITH MOTOR. CONDUIT BOXES ARE TO BE MOUNTED OUTSIDE FAN CASING BY CUSTOMER.
NOTE ⑥ "3 LOOSE FIT BEARINGS AT BOTH ENDS.
NOTE ⑦ DRIVE END BEARING HELD BY INNER CAP.
NOTE ⑧ CONDUIT PIPE TO BE FURNISHED BY CUSTOMER.
NOTE ⑨ BREATHERS TO BE FURNISHED BY CUSTOMER (1/4 N.P.T.)
NOTE ⑩ LOCATION OF BRG. RTD LEADS
NOTE ⑪ APPLICABLE TO FRAME 5003 & 5005 ONLY.



FAN COOLER - CROSS SECTION

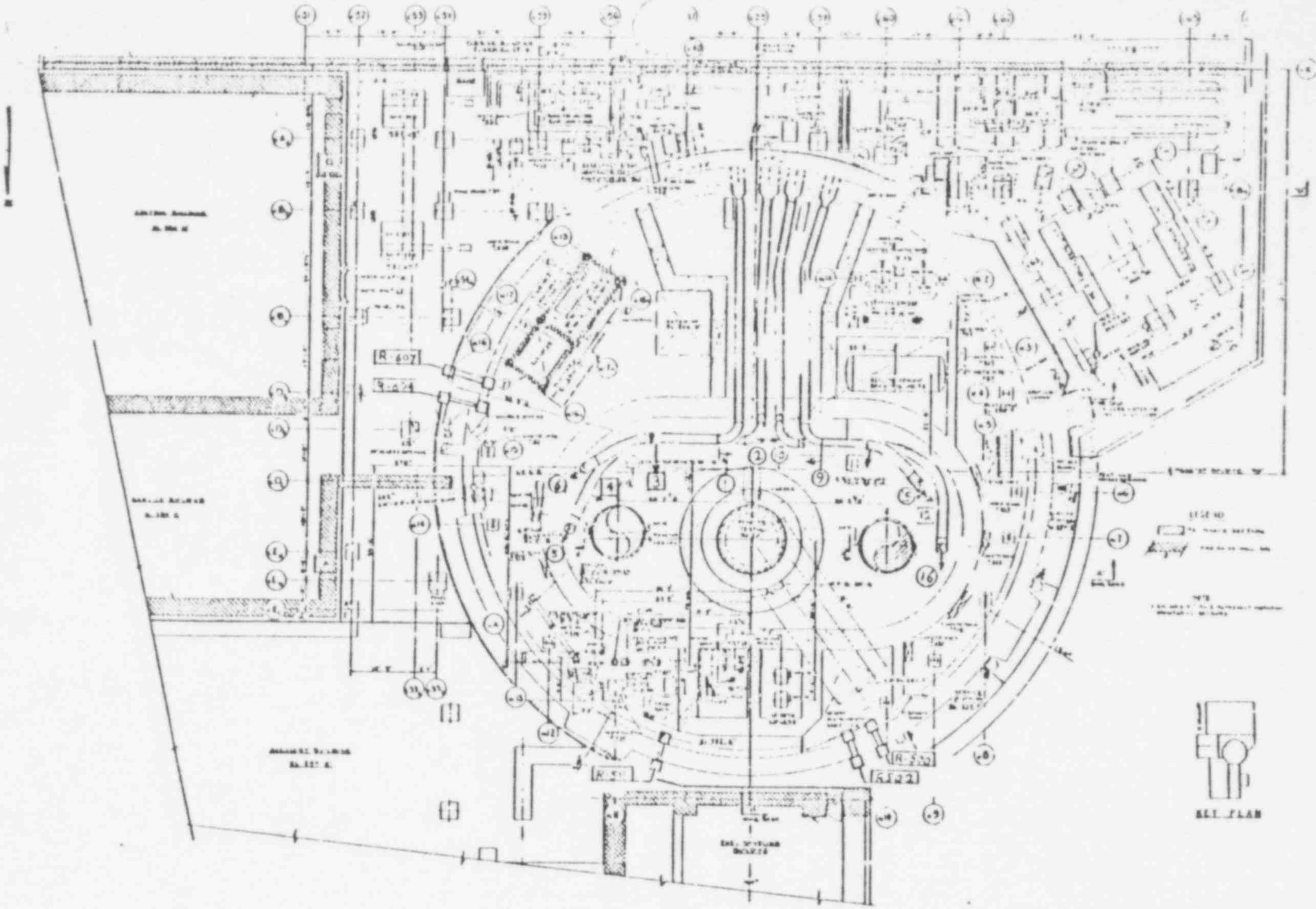
FIGURE 15B-14C

512 169



SOLENOID OPERATOR - CROSS SECTION

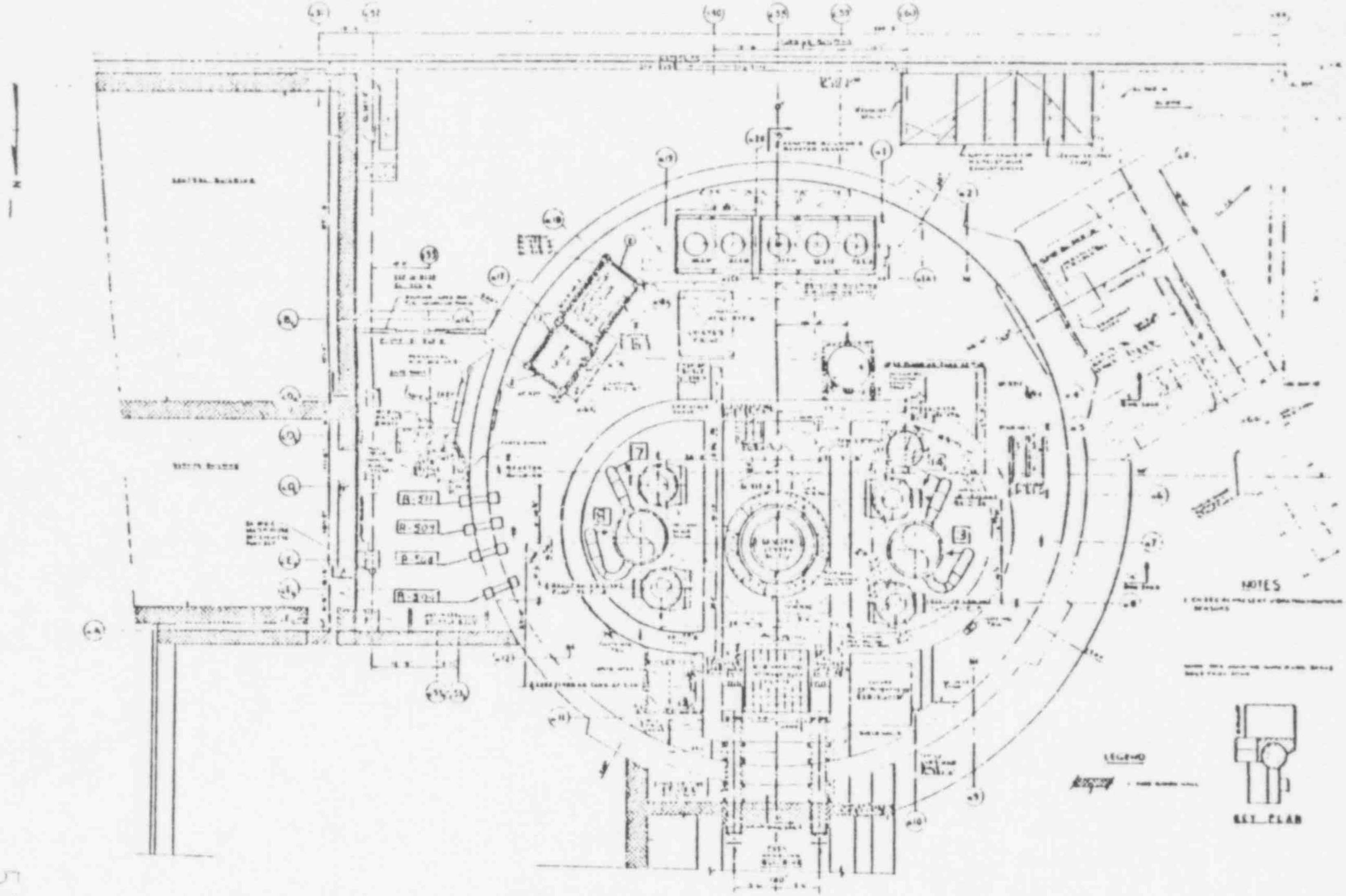
FIGURE 15B-14D



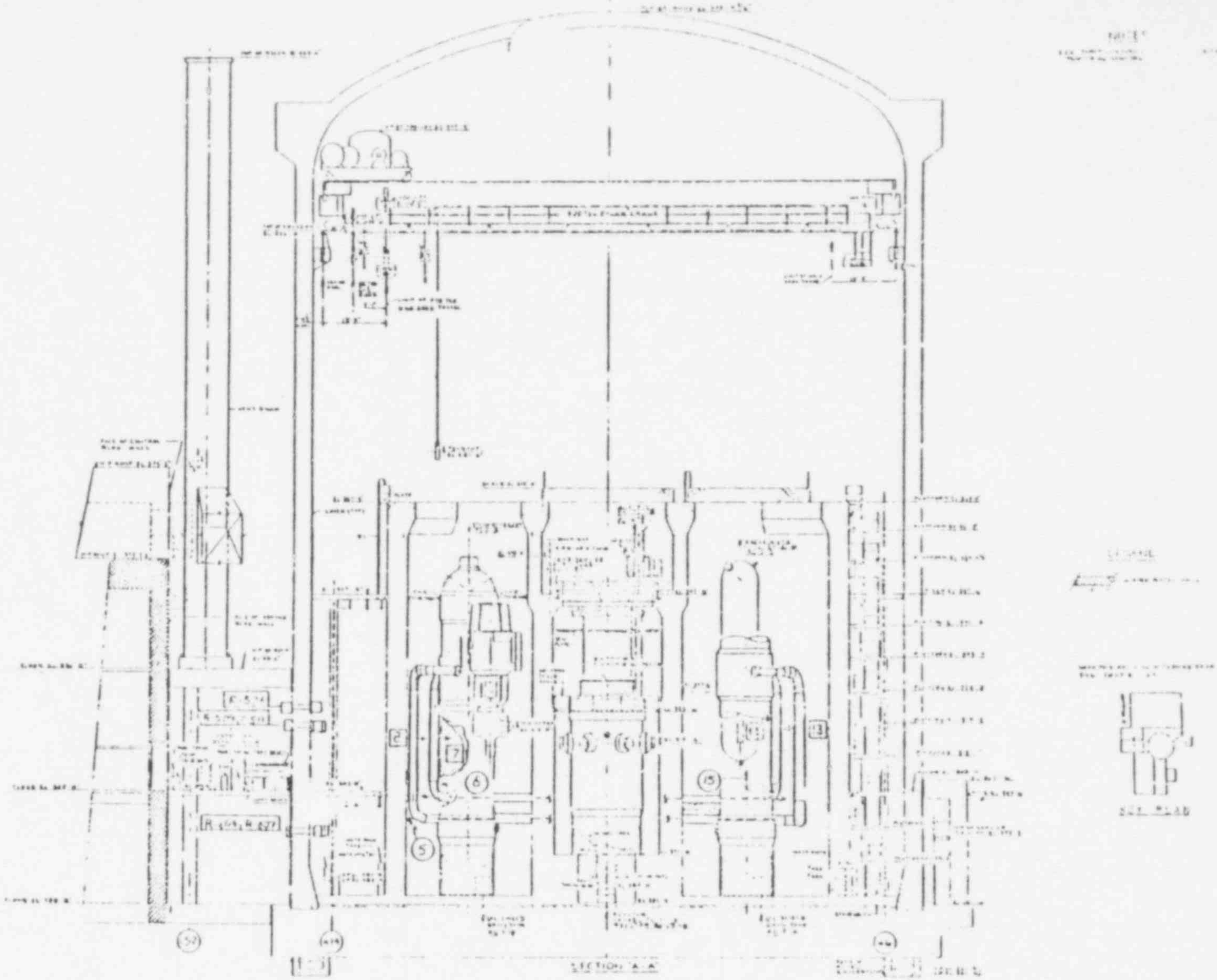
LOCATIONS OF PENETRATION BOXES
REACTOR BUILDING BASEMENT FLOOR

FIGURE 15B-15A

512 171



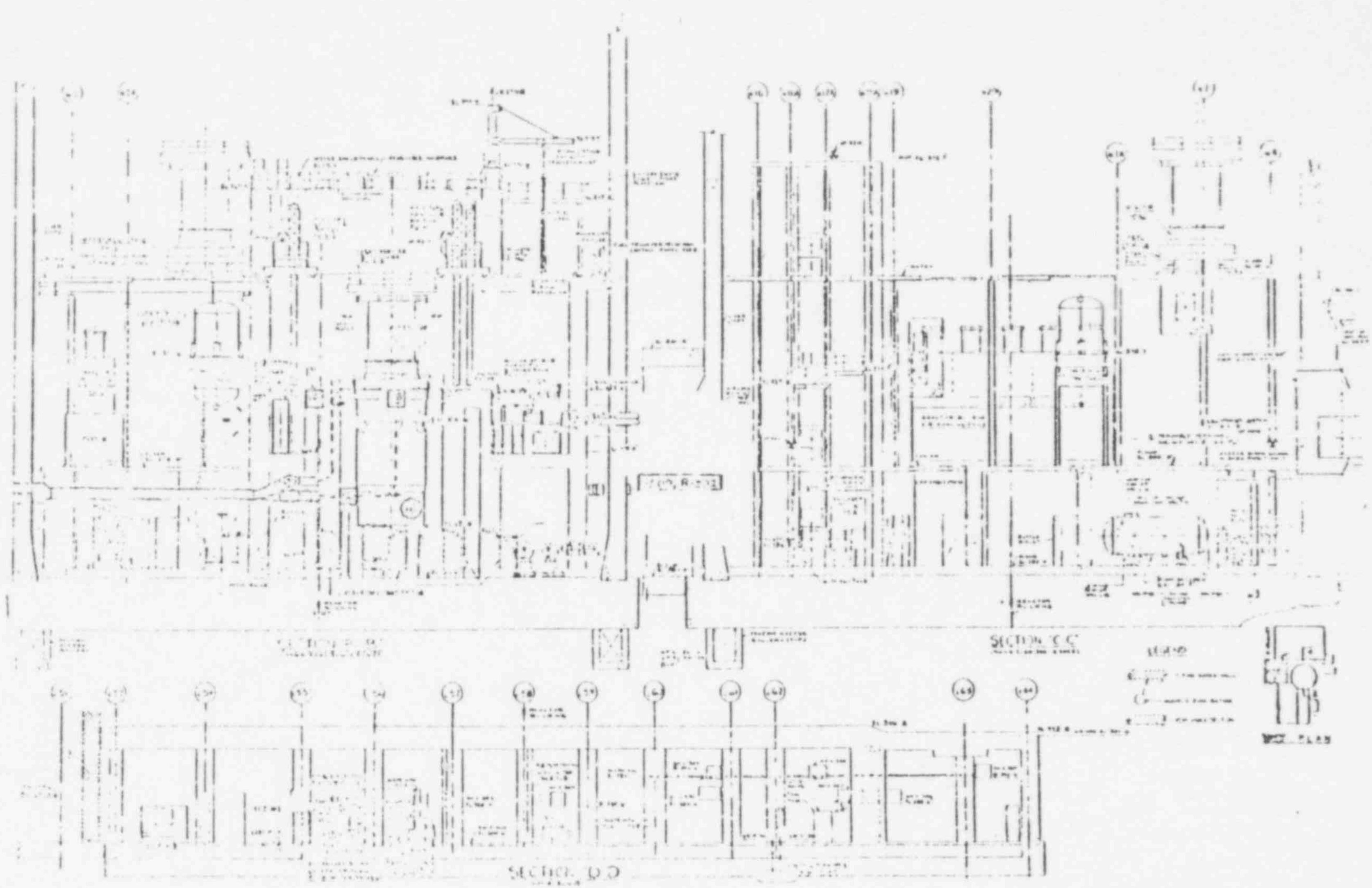
LOCATIONS OF PENETRATION BOXES
REACTOR BUILDING GROUND FLOOR
FIGURE 15B-15B



LOCATION OF PENETRATION BOXES

REACTOR BUILDING SECTION A-A

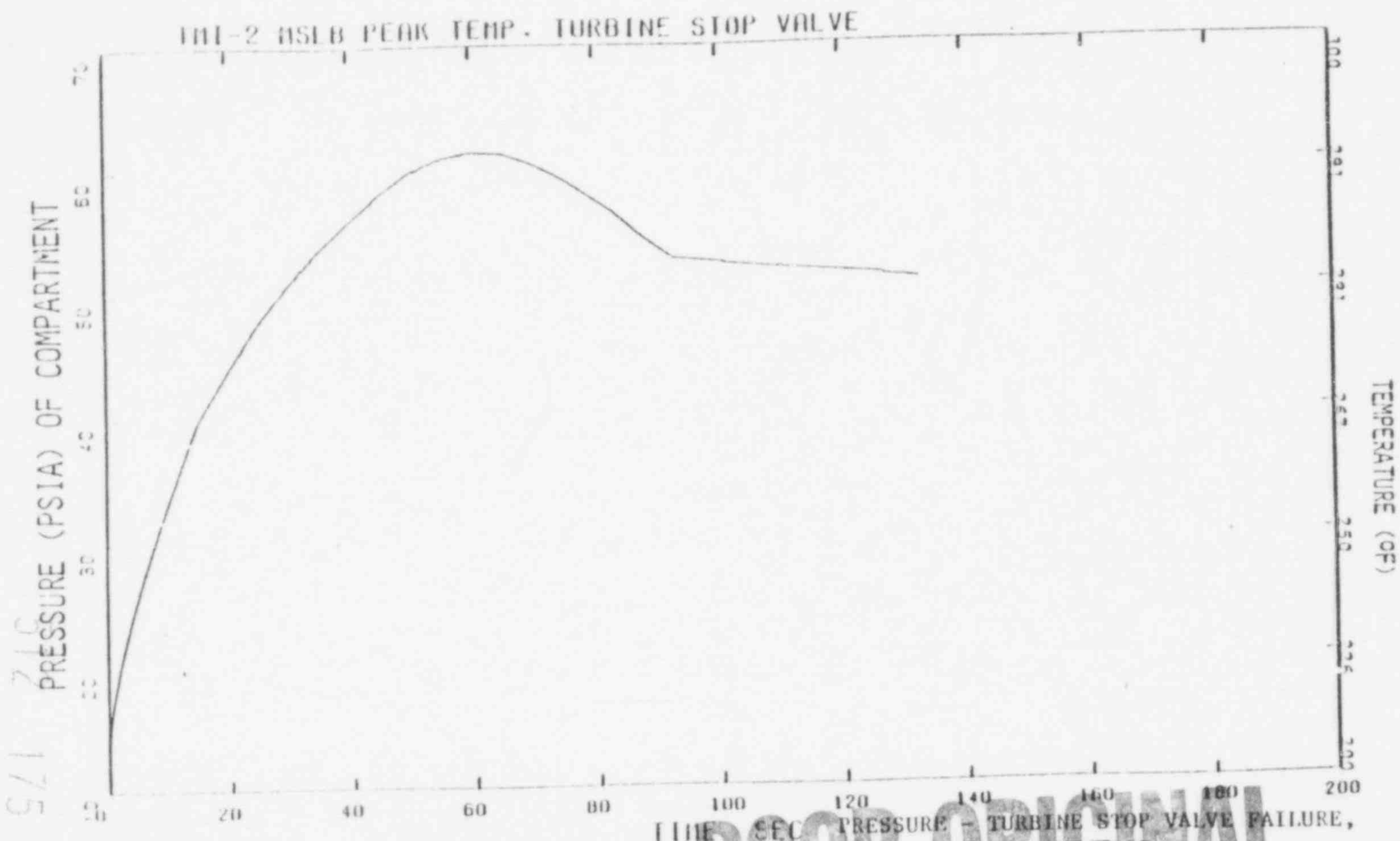
FIGURE 15B-15C



LOCATIONS OF PENETRATION BOXES

REACTOR BUILDING SECTIONS B-B, C-C, D-D

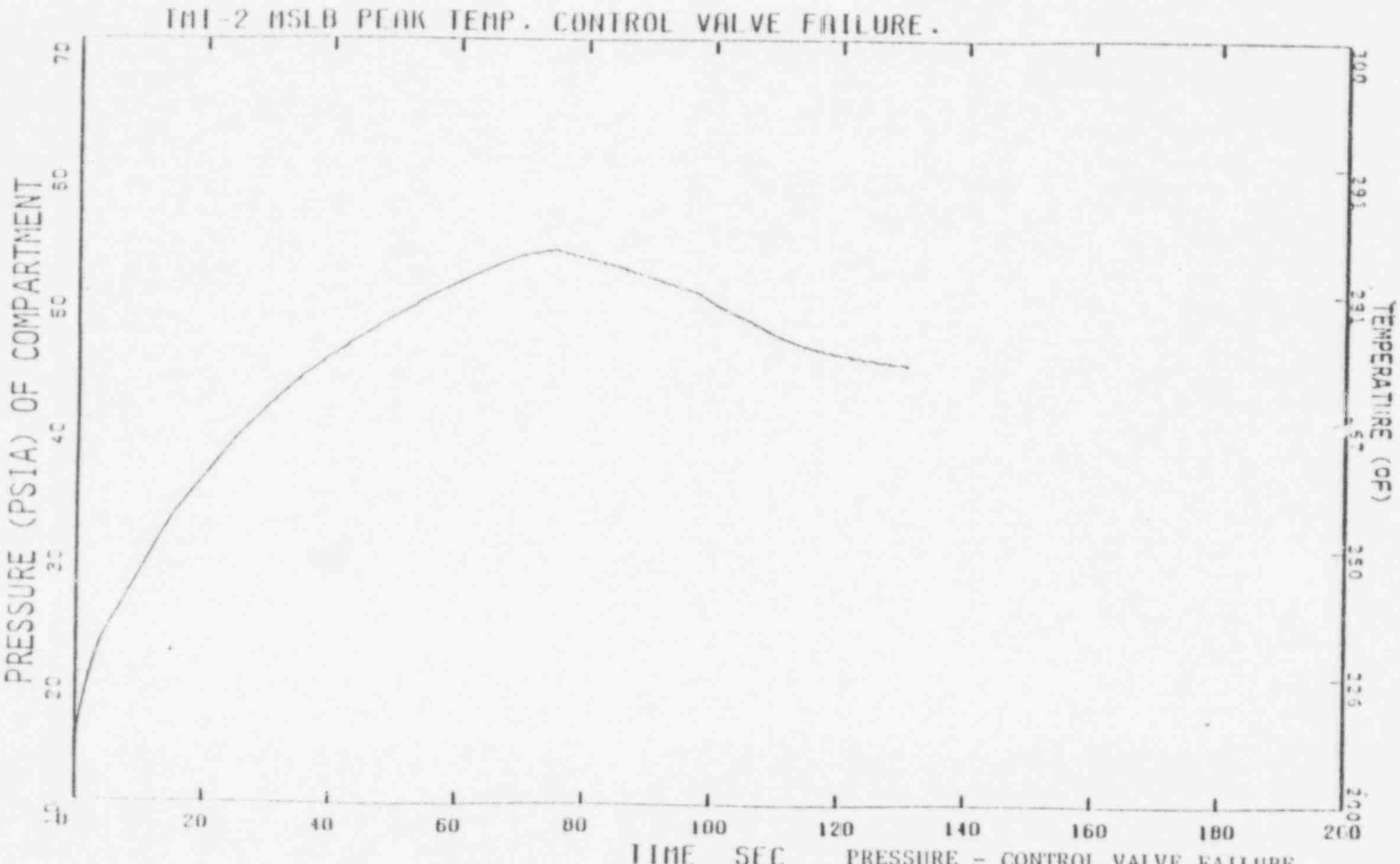
FIGURE 15B-15D



PRESSURE - TURBINE STOP VALVE FAILURE,
PEAK TEMPERATURE CASE

FIGURE 15B-16A

POOR ORIGINAL



PRESSURE - CONTROL VALVE FAILURE,
PEAK TEMPERATURE CASE
FIGURE 15B-16B

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55-320

Technical

FINAL REPORT
F-C2232-01

Report

TEST OF A LIMITORQUE VALVE OPERATOR
UNDER A SIMULATED REACTOR CONTAINMENT
POST-ACCIDENT STEAM AND CHEMICAL ENVIRONMENT

by

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Prepared for

The Philadelphia Gear Corporation
King of Prussia, Pennsylvania

November, 1968 512 177

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

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SUMMARY

A Model SMB-0 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-brake 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 necessary 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 geared limit switch. Both indicating lights remained on even though the valve stem had been moved to the full open position.

At the er 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 satisfactoril throughout the test.

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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 FIRL 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 program.

The conditions simulated for the test were the pressure-temperature-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/NSG/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 shock tests were not included in the program at FIRL. Neither were post-test inspections or other acceptance criteria.

II. EQUIPMENT TESTED

The equipment tested was (a) a Limitorque valve operator and (b) a motor-brake assembly as identified and described below.

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

NAME: SMB-0 Limitorque Valve Operator
Order No. 600198

MANUFACTURER: Philadelphia Gear Corporation

MOTOR: Reliance Built Torque Motor
Identification No. 435571-JTR

START: 15 ft.-lb.

RUN: 3 ft.-lb.

TYPE:	P	FRAME:	M56
PHASE:	3	RPM:	1700
CYCLES:	60	VOLTS:	230/460
CODE:	-	AMPS:	5.6/2.8

Temp. Rise at Run Torque of 15 Minutes: 75°C

Type H Insulation

Gear Unit

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(b) Torque Motor with Brake (Test Unit 2)

MOTOR

MANUFACTURER: Reliance Electric Company
3300 10th Street
Columbus, Indiana

IDENTIFICATION #: 442010-JTR

START:	15 ft.-lb.	FRAME:	-
RUN:	3 ft.-lb.	RPM:	1700
TYPE:	-	VOLTS:	230/460
PHASE:	3	AMPS:	5.6/2.8
CYCLE	60		
CODE:	-		

Rise at RUN Torque: 75°C (15 minutes)

DINGS MAGNETIC DISC BRAKE

MODEL:	6-61009-50	VOLTS:	230
SERIAL NO :	157010	Continuous Duty	
TORQUE:	3 ft.-lb.		

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 facility including the test chamber with the Limitorque and motor-brake assembly mounted (Figure 1). Both figures show the chamber temperature recorder mounted on the upper right wall, the dual channel pressure recorder mounted directly below and the Limitorque and brake assembly temperature recorder mounted under the right hand table. On the 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 Conax 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 seating force as measured by strain gages on the valve stem guide protruding 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.

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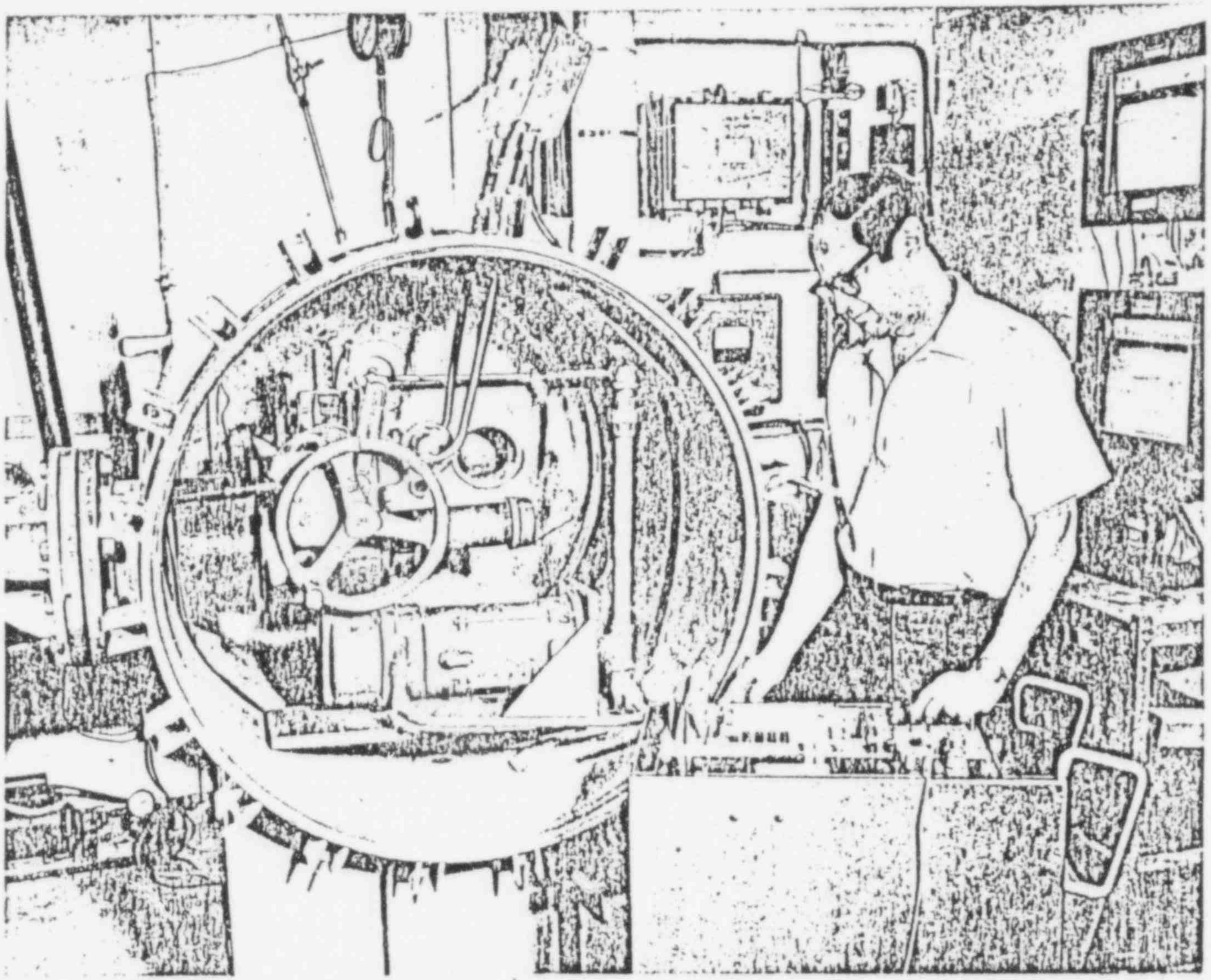

Fig. 1 - Test Facility Before Test

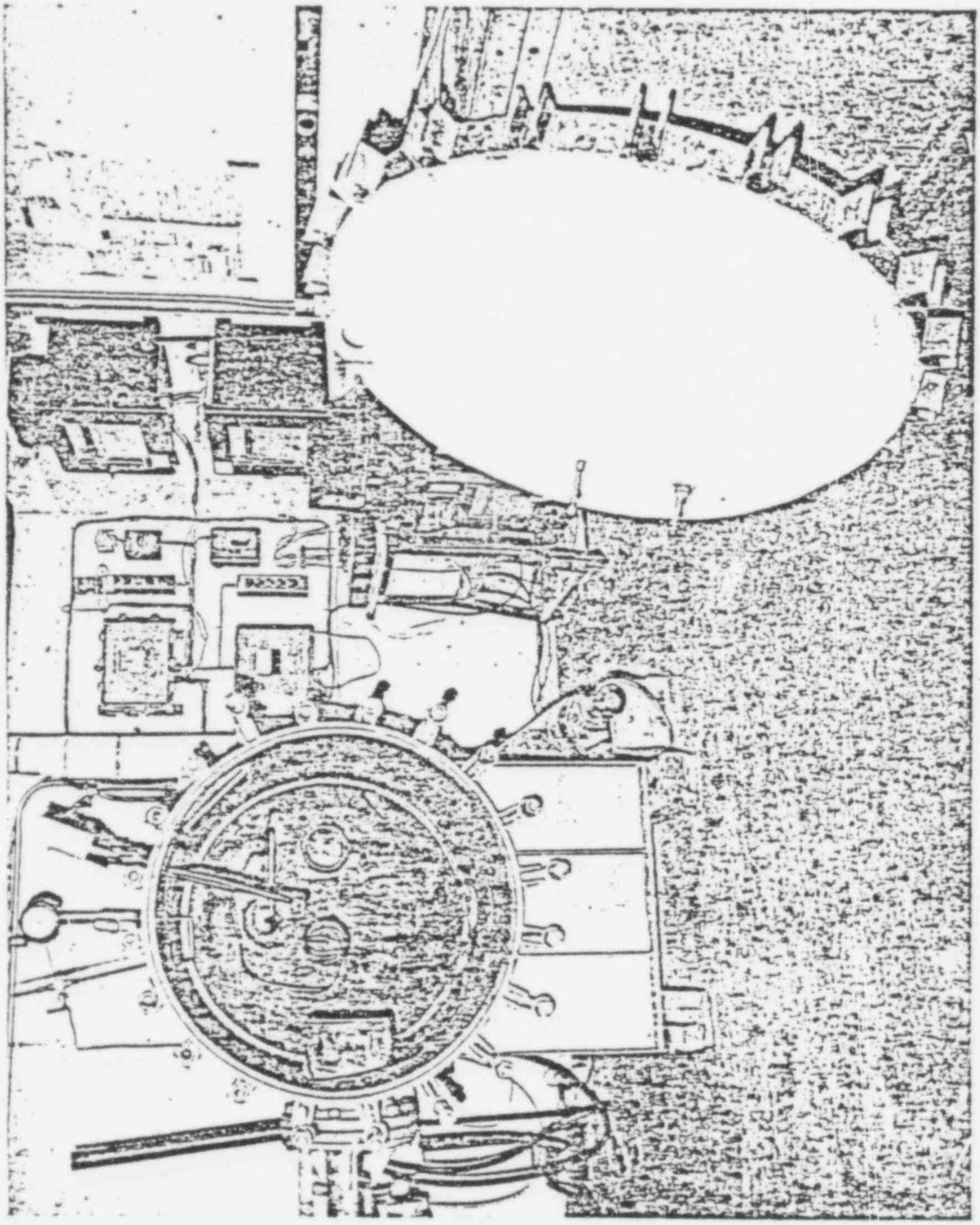

Fig. 2 Test Facility After Test

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 meter 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 (H_3BO_3) 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 reagent 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.

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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) <u>Valve Operator Seating Force in Valve Closed Position</u>

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) <u>Motor Insulation Resistance Before and After Test</u>

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.

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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.

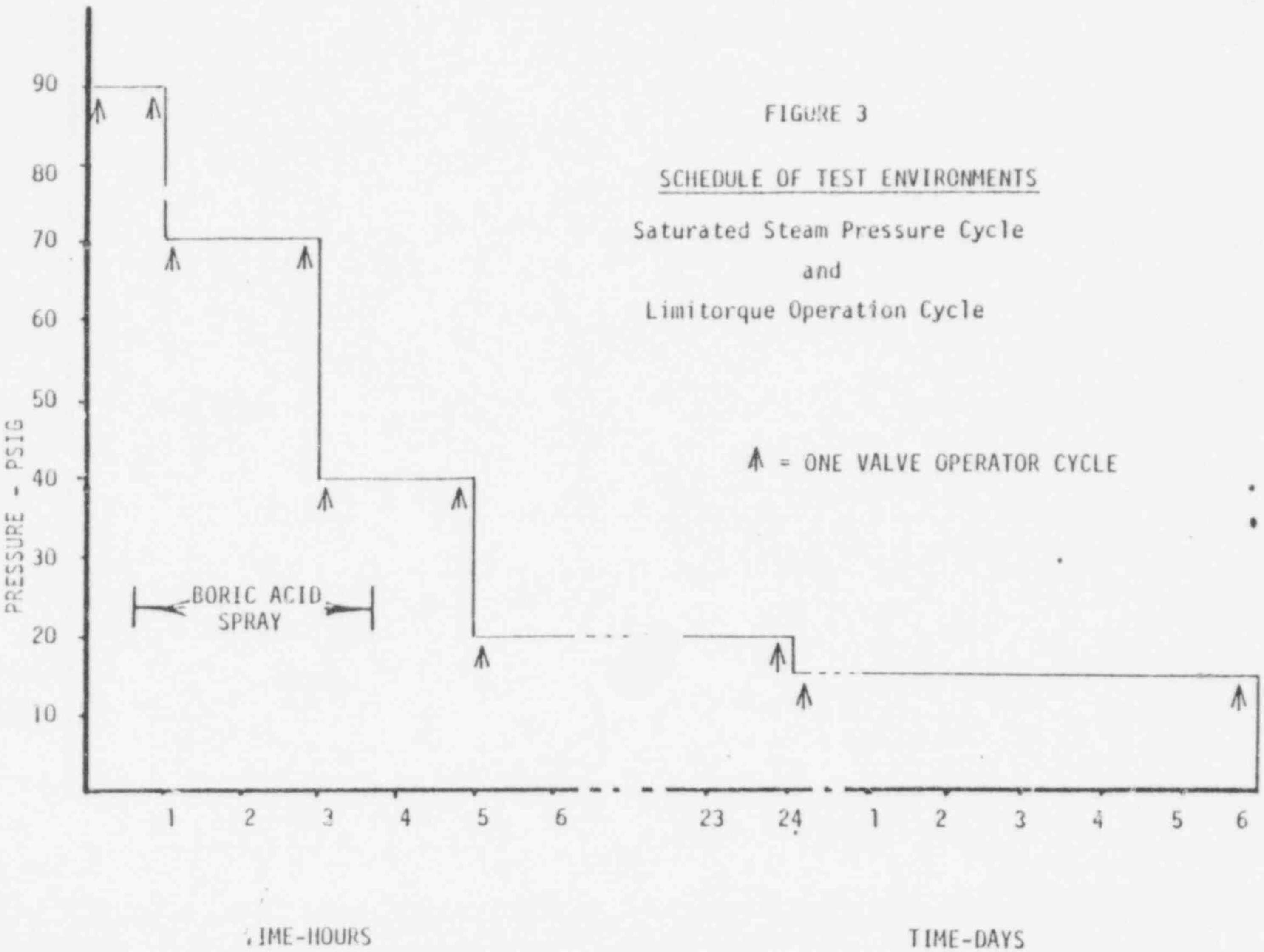
(2) Start of Test

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.

FIGURE 3

SCHEDULE OF TEST ENVIRONMENTS

Saturated Steam Pressure Cycle
and
Limitorque Operation Cycle



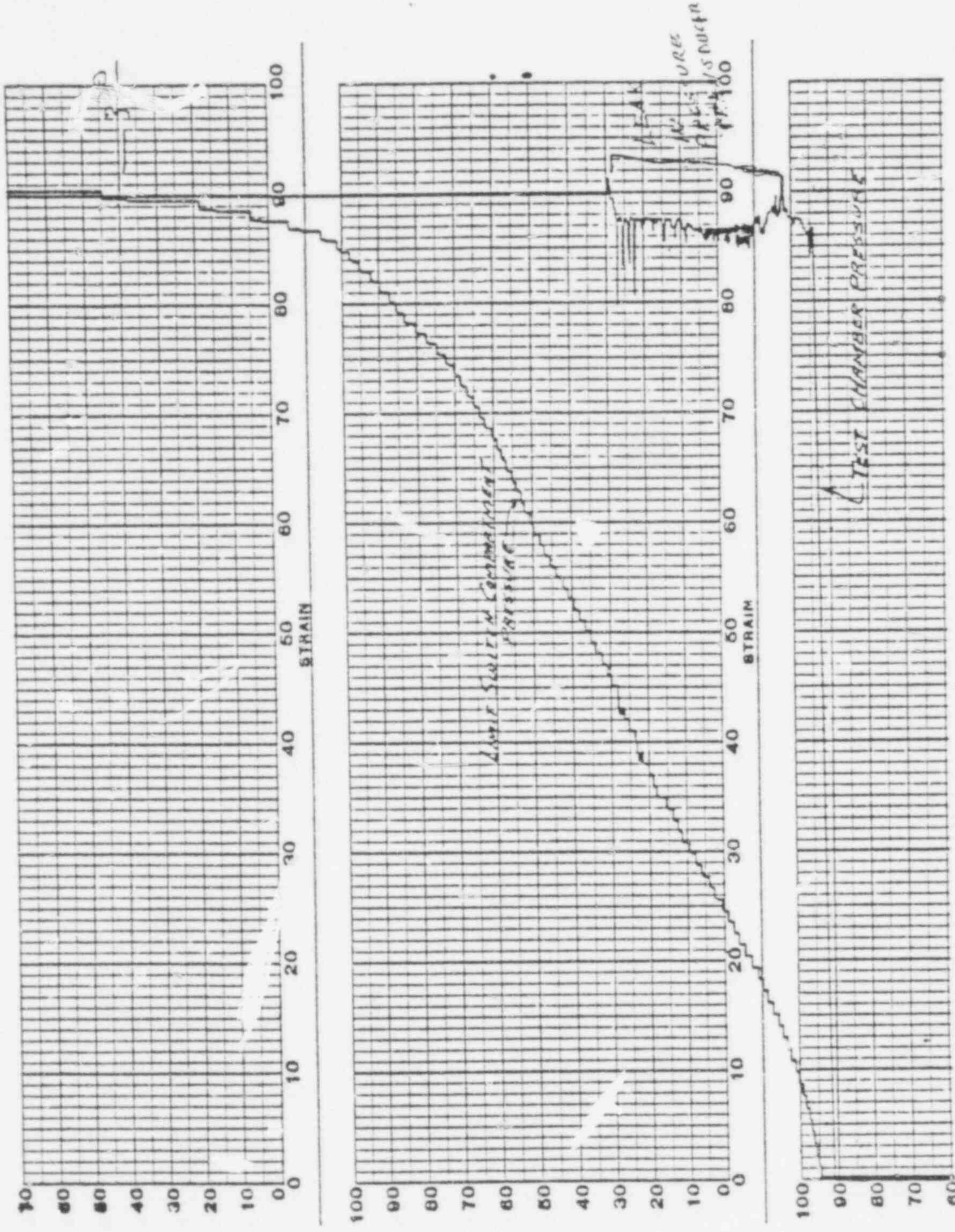


Fig. 4 - Recording of Initial Pressure Rise to 90 psig.

POOR ORIGINAL

(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 - 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 reduced to 70 psig in the test chamber within a period of three minutes.

(7) Limitorque Operation

Seven minutes 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 psi level the Limitorque and motor-brake were again operated. Operation was normal.

(9) Pressure Reduced to 40 psig

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 Operation

Five minutes after reaching the 40 psig saturated 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 Stopped

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 again operated. Operation was normal.

(13) Pressure Reduced to 20 psig

Five hours after the start of the test the pressure regulator was adjusted from the 40 psig setting to the 20 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

Five minutes after reaching the 20 psig level, the Limitorque and the motor-brake assembly were operated through one complete cycle. The motor-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 stopped 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 psig. This was accomplished as before by adjusting the regulating valve and running cold water through the cooling coil. Pressure reduction time was

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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 for a short period of time with the brake released. The Limitorque operated as in the immediately preceeding 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 satisfactorily. 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 previously was to no avail 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 acid 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 hand-wheel 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".

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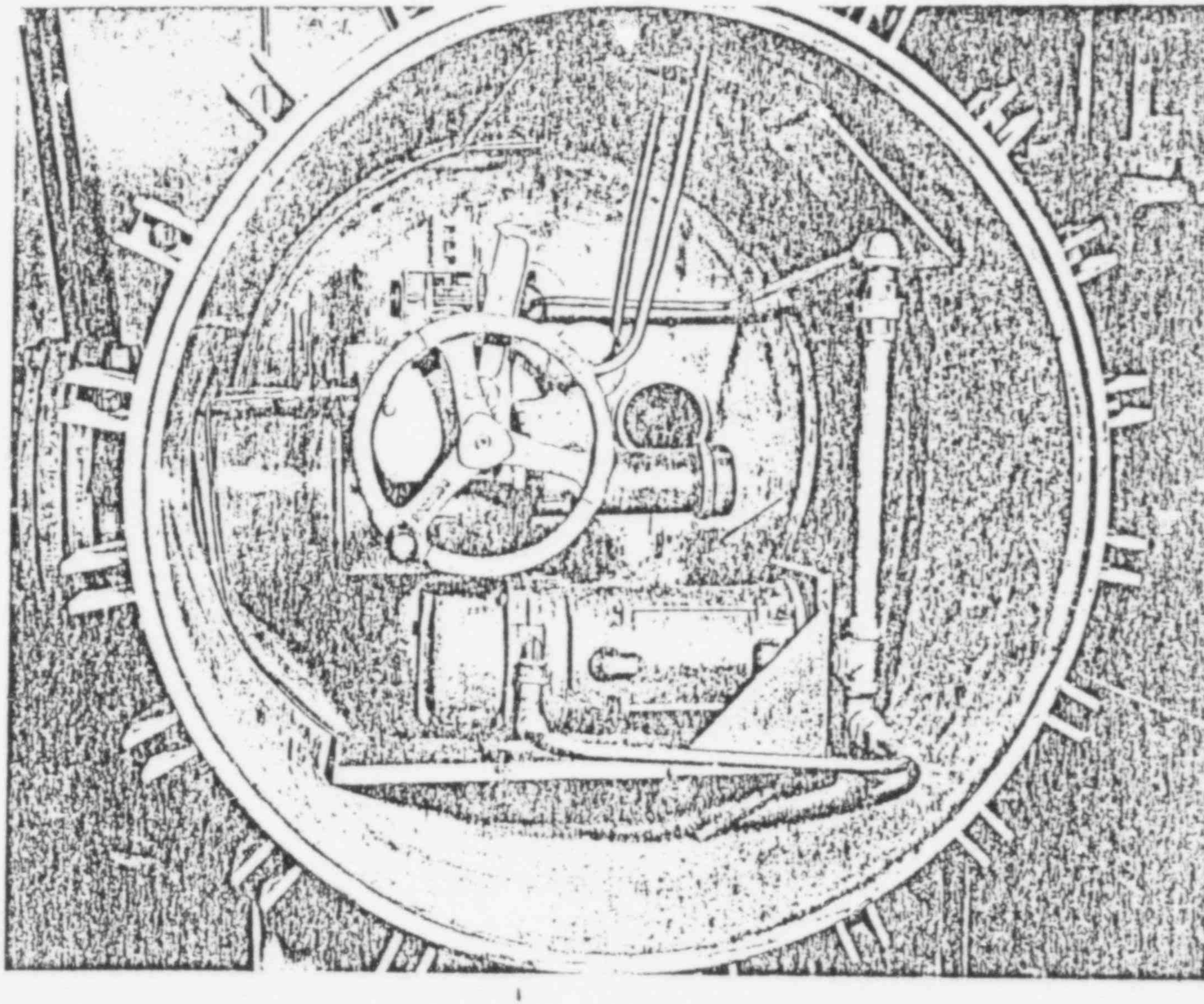

Fig. 5 - Limitorque and Motor-Brake Before Test

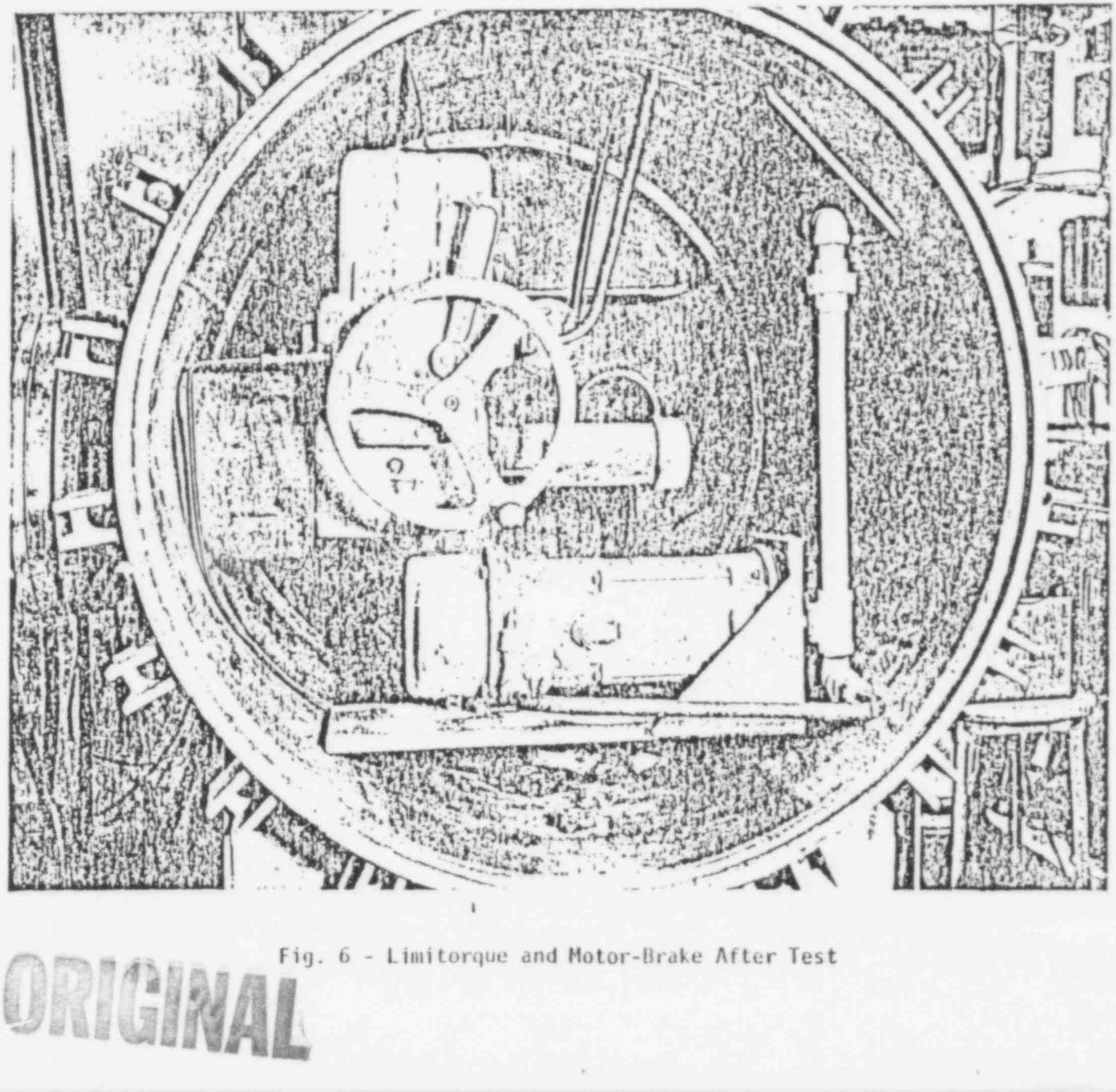

Fig. 6 - Limitorque and Motor-Brake After Test

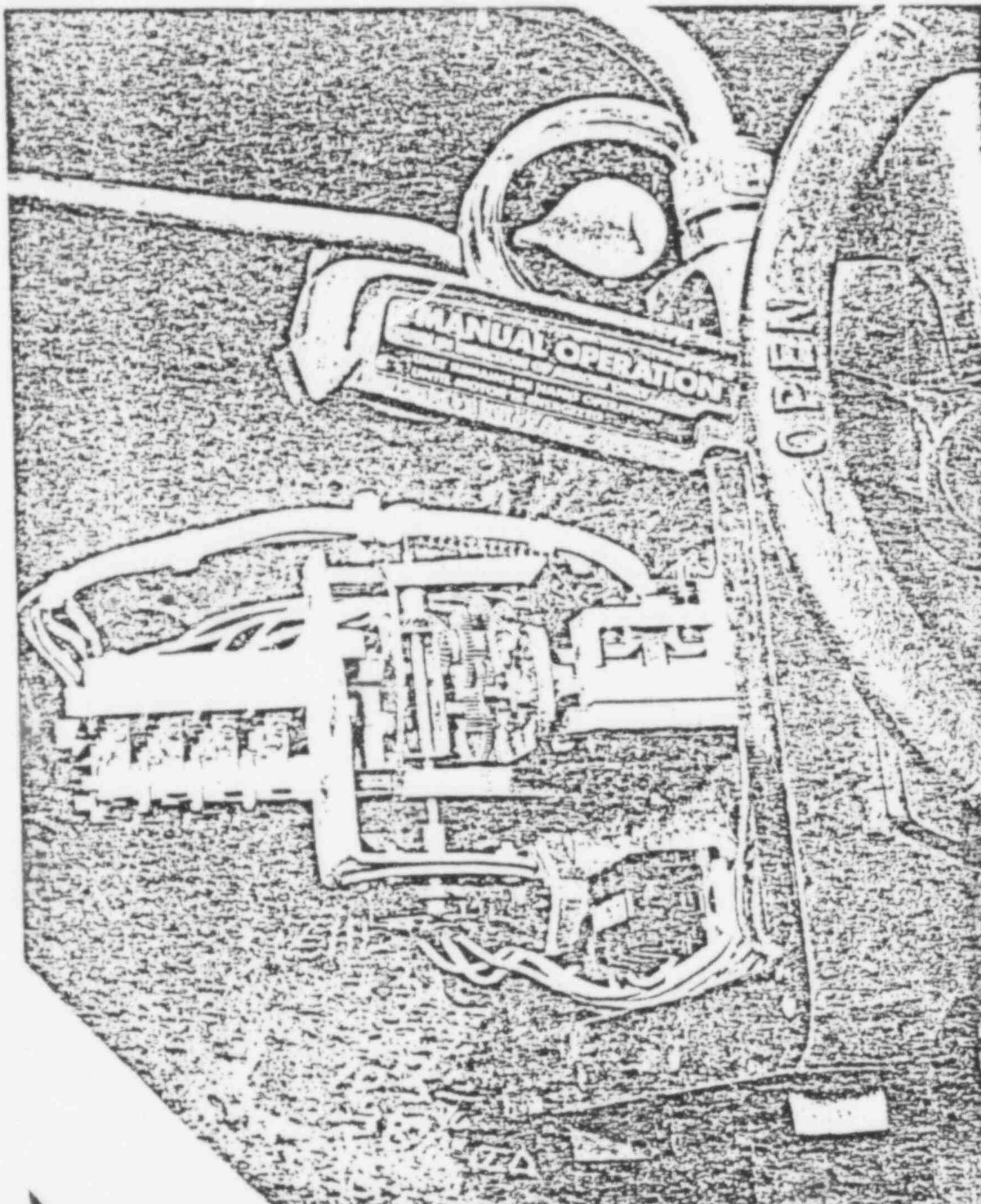

Fig. 7 - Limit Switch Compartment Before Test

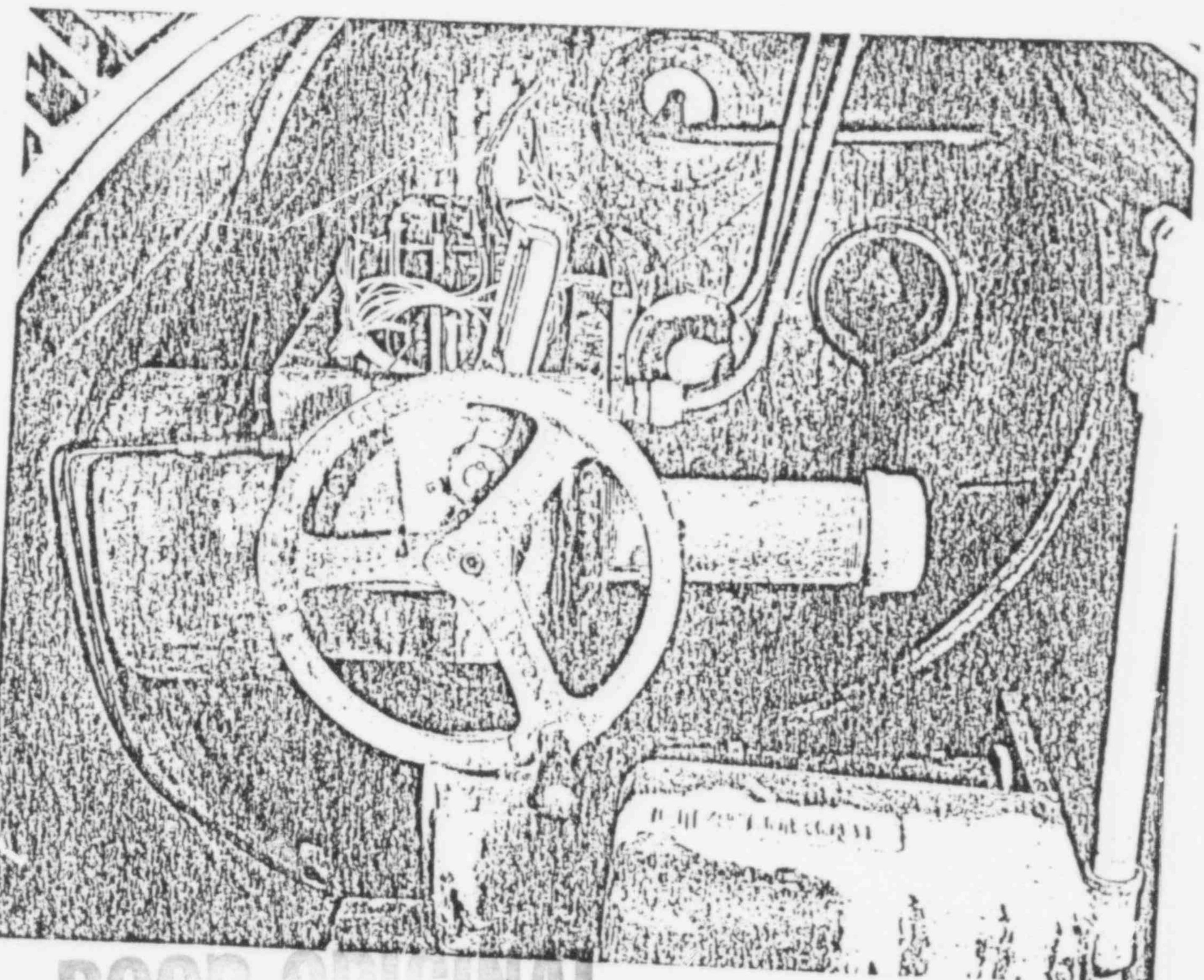

Fig. 8 — Limit Switch Compartment After Test

APPENDIX I

TEST DATA SHEETS

Date Oct. 31, 1968

ENVIRONMENT TEST CYCLE

TEST LEVEL I

Time at Start of Test: Oct 31 1968 Hour 1515

Initial Pressure 15 Psig Temp. 142 °F

Pressure Rise Time: 14 Seconds

Chamber: Press. 90 PSIG Temp. 329 °F

Test Unit: Press. 90 Psig Temp. 328 °F

First Test Cycle of Motor: 1521 Hours
at this Level

Start of Boric Acid Spray (40 minutes after Level I)

Time: 1555 Hour ____________ Minutes

Boric Acid Flow Rate: 1555 gph

Temp. 70.7 °F ph 7.67

Second Test Cycle of Motor
at this Level: Time: 1610 Hour

End of Level I:

Time: 1615 Hours

Chamber Press. 91 psig Temp. 329 °F

Unit Press. 91 psig Temp. 329 °F

Date Oct. 31, 196?
L. E. Witcher

ENVIRONMENT TEST CYCLE

TEST LEVEL NO. II DESIGNATED STEAM PRESS. 70 PSIG SATURATION TEMP. 316 °F

Time Level Reached: 1618 Hours

Air 1.37%

Time from Previous Level: 38 Minutes

Chamber Press: 70 psig Temp.: 312 °F

Test Unit: Temp. 312 °F Press. 70 Psig

First Test Cycle of Motor at this Level: Time: 1625 Hours

Boric Acid Spray

Flow Rate 10 gph Temp. 70.7 °F PH 7.67

Second Test Cycle of Motor at this Level: Time: 1810 Hours

End of Level No. II

Time: 1815 Hour

Chamber Temp. 315 °F Press. 70 Psig.

Unit Temp. 315 °F Press. 70 Psig

312 207

Date Oct. 31, 1968
L. E. Witcher

ENVIRONMENT TEST CYCLE

TEST LEVEL NO. IV DESIGNATED STEAM PRESS. 20 PSIG SATURATION TEMP. 259 °F

Time Level Reached: 2022 Hours

Time from Previous Level: 4 Minutes

Chamber Press: 20 psig Temp.: 272 °F

Test Unit: Temp. 271 °F Press. 20 Psig

First Test Cycle of Motor at this Level: Time: 2035 Hours

4.9 TD

Boric Acid Spray

Flow Rate none Temp. _______ °F PH _______

Nov. 1, 1968

Second Test Cycle of Motor at this Level: Time: 1510 Hours

End of Level No. _______

Time: 1517 Hour

Chamber Temp. 256 °F Press. 20 Psig.

Unit Temp. 256 °F Press. 20 Psig

311-C2232-01

Date Oct 31, 1966
L. E. Witcher

ENVIRONMENT TEST CYCLE

TEST LEVEL NO. III DESIGNATED STEAM PRESS. 40 PSIG SATURATION TEMP. 287 °F

Time Level Reached: 1820 Hours

Time from Previous Level: 10 Minutes

Chamber Press: 40 psig Temp.: 300 °F

Test Unit: Temp. 287 °F Press. 40 Psig

First Test
Cycle of Motor
at this Level: Time: 1828 Hours

Boric Acid Spray

Flow Rate 10 gph Temp. 70.7 °F PH 7.62

Acid Spray stropped at 1955 hours

Second Test
Cycle of Motor
at this Level: Time: 2010 Hours

End of Level No. ____

Time: 2018 Hour

Chamber Temp. 287 °F Press. 41.0 Psig

Unit Temp. 287 °F Press. 40.5 Psig

512 209

Date Nov 1, 1968
L.F. Witcher

ENVIRONMENT TEST CYCLE

TEST LEVEL NO. V DESIGNATED STEAM PRESS. 15 PSIG SATURATION TEMP. 250 °F

Time Level Reached: 1524 Hours

Time from Previous Level: 7 Minutes

Chamber Press: 15 psig Temp.: 250 °F

Test Unit: Temp. 250 °F Press. 16.2 Psig

First Test Cycle of Motor at this Level: Time: 1528 Hours

5.2 %

This level maintained continuously through Nov 7, 1968

Boric Acid Spray

Flow Rate None Temp. ____ °F PH ____

Nov 7, 1968

Second Test Cycle of Motor at this Level: Time: 1528 Hours

End of Level No. Final Test Nov 7, 1968

Time: 1528 Hour

Chamber Temp. 247 °F Press. 14.7 Psig.

Unit Temp. 247 °F Press. 14.5 Psig

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APPENDIX II.

Performance Test Data of Limitorque Valve Operator

Table 1, Collected Data.

Table 2, Average and Peak Values.

TABLE 1. #31=C2232-01

PERFORMANCE TEST DATA OF LIMITORQUE VALVE OPERATOR

COLLECTED DATA

Test Pres. Psig	Time	Line 1-2	Volt. 3-1	A-C 3-2	Current 1	Current 3	Pwr. KW	Stg. For-lbs.	Stem Close Seconds	Travel Open Seconds
	10/31									
0	1502	500	512	498	2.86	3.08	.50	16,500	110	
	1506	504	514	498	2.75	2.95	.51			110
90	1521	504	516	500	2.85	3.00	.53	16,500	110	
	1524	504	516	500	2.65	2.60	.60			110
	1610	500	512	500	2.80	2.97	.51	16,500	110	
	1613	500	514	500	2.68	2.83	.55		1	110
70	1625	500	514	496	2.68	2.97	.50	16,100	110	
	1628	504	516	500	3.05	2.89	.52			110
	1810	506	518	504	2.73	3.07	.50	16,500	110	
	1813	508	518	504	2.92	2.98	.56	16,500		110
40	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	
	2014	508	518	504	2.83	3.02	.51		1	107
20	2031	508	520	504	2.96	3.10	.50	17,000	110	
	2039	508	520	504	2.84	3.02	.51			112
	11/1									
	1510	500	514	496	2.85	3.00	.46	17,500	110	
	1513	500	514	496	2.70	287	.47			112
15	1528	500	514	496	2.84	2.98	.46	17,800	115	
	1532	500	514	496	2.70	2.90	.50			118
	11/7									
	1528	498	514	496	2.98	2.82	.43	17,200	111	
	not recorded	500	514	496	2.72	2.89	.50			111
	Final	500	514	496			.46	17,000		
	Final	500	514	496			.50			

TABLE 2.
Average and Peak Values

PERFORMANCE TEST OF LIMITORQUE VALVE OPERATOR

Oct. 31	Test Pressure Psig	Ave. Voltage -3 φ	Ave. Current	Peak Current	Power Peak KW
		503.3	2.97	3.40	1.30
		509.3	2.85		.90
	90	506.7	2.92	3.45	1.57
		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
		506.7	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.[illegible]0		.88
	Final	503.7			1.52
	Final	507.7			.95

REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED

REV.																													
SHEET	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53

REV. STATUS	REV.																								
OF SHEETS	SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS FRACTIONS ANGLES

DRAWN E.J. Namitho DATE 10/31/77
CHECKED [illegible] 11/16/77
ENGINEER E.J. Namitho 11-2-77
Q.C. [illegible] 11-3-77
PRODUCTION

VALCOR ENGINEERING CORPORATION
KENILWORTH, NEW JERSEY

TITLE: QUALIFICATION TEST REPORT FOR IEEE CLASS IE SOLENOID VALVE P/N V52600-515, VALVE TYPE I

SIZE	CODE IDENT. NO.	DOCUMENT NO.
A	96487	QR52600-515

512 214

SCALE | SHEET 1 of 27

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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APPENDIX E - Figure 1 - Test Chamber

Figure 2 - Steam Generator

Figure 3 - Control & Instrumentation Panel

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Table I - Summary of Data Acquisition System

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 IEE. 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:

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Valve Actuator Type/Size SMB-0

Manufacturer ....Limitorque Corporati..n

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

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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^{o}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.

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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.

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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.

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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.)

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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

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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°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.

512 227

Specified Accident Profile

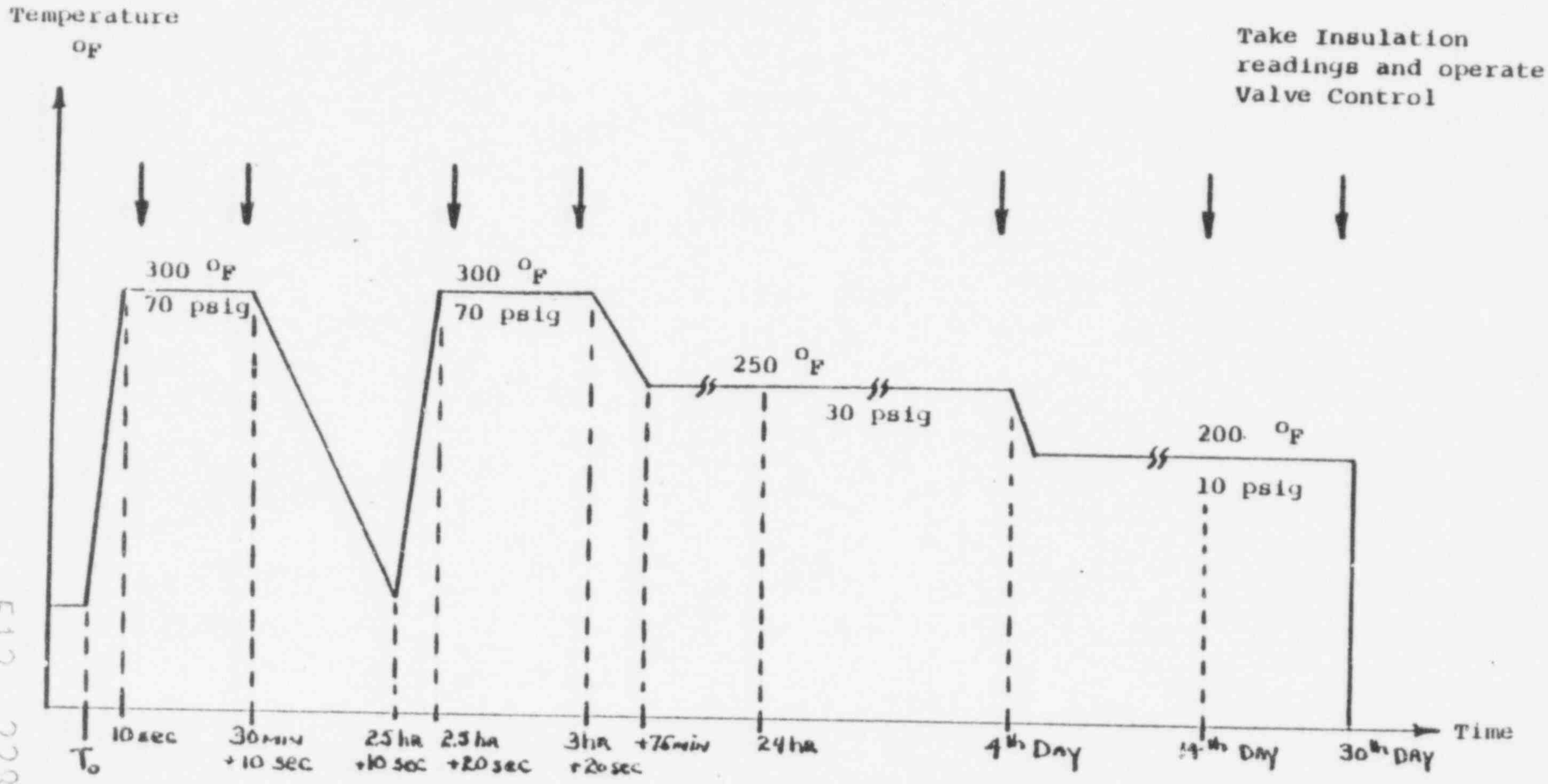

Figure 5

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 torque 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.

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The test data obtained is presented in Appendix B.

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 3.4.2 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

512 231

K·E 20 x 20 TO THE INCH · 7 x 10 INCHES KEUFFEL & ESSER CO. 46 1200

ACTUAL ACCIDENT PROFILE

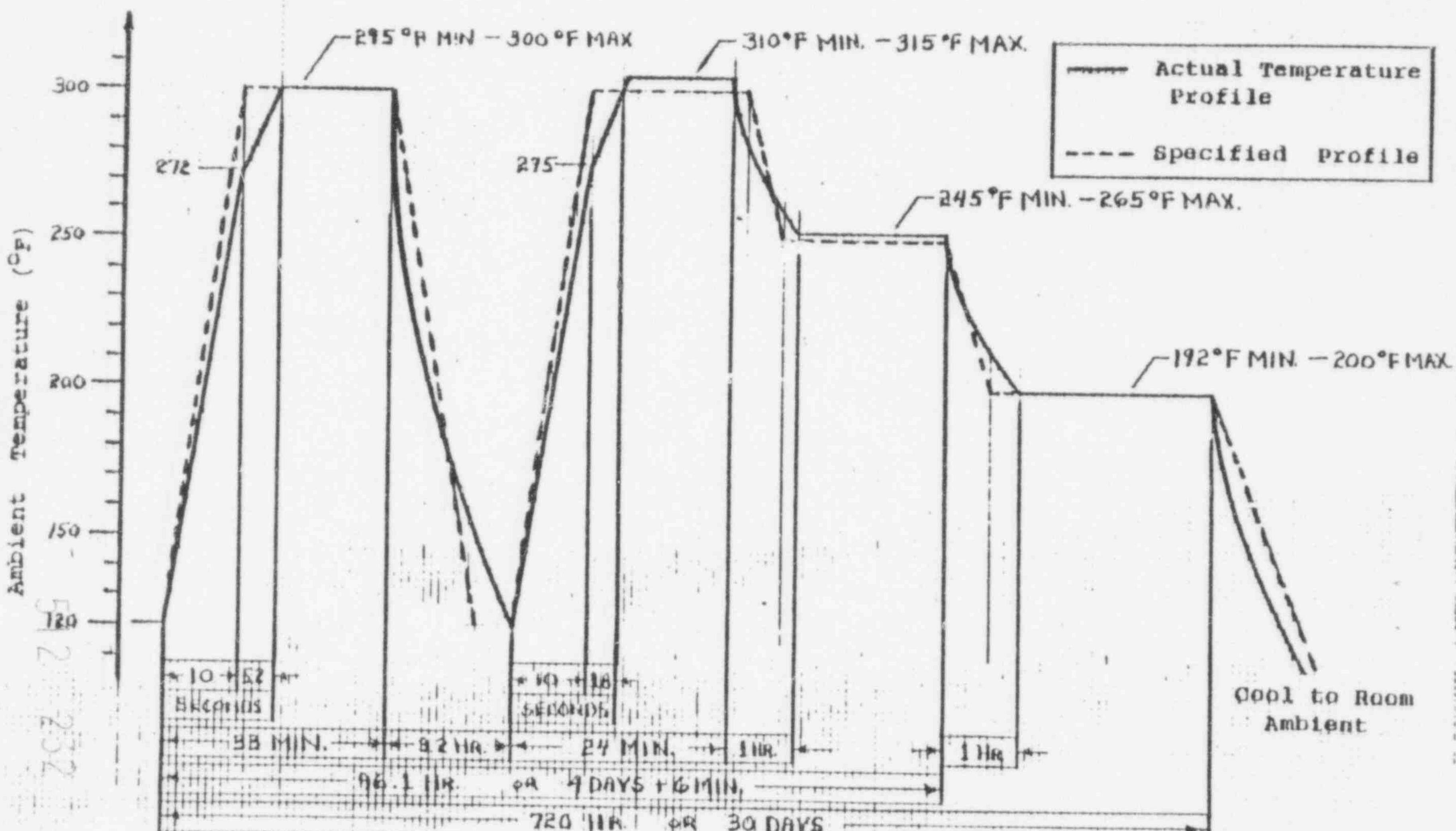
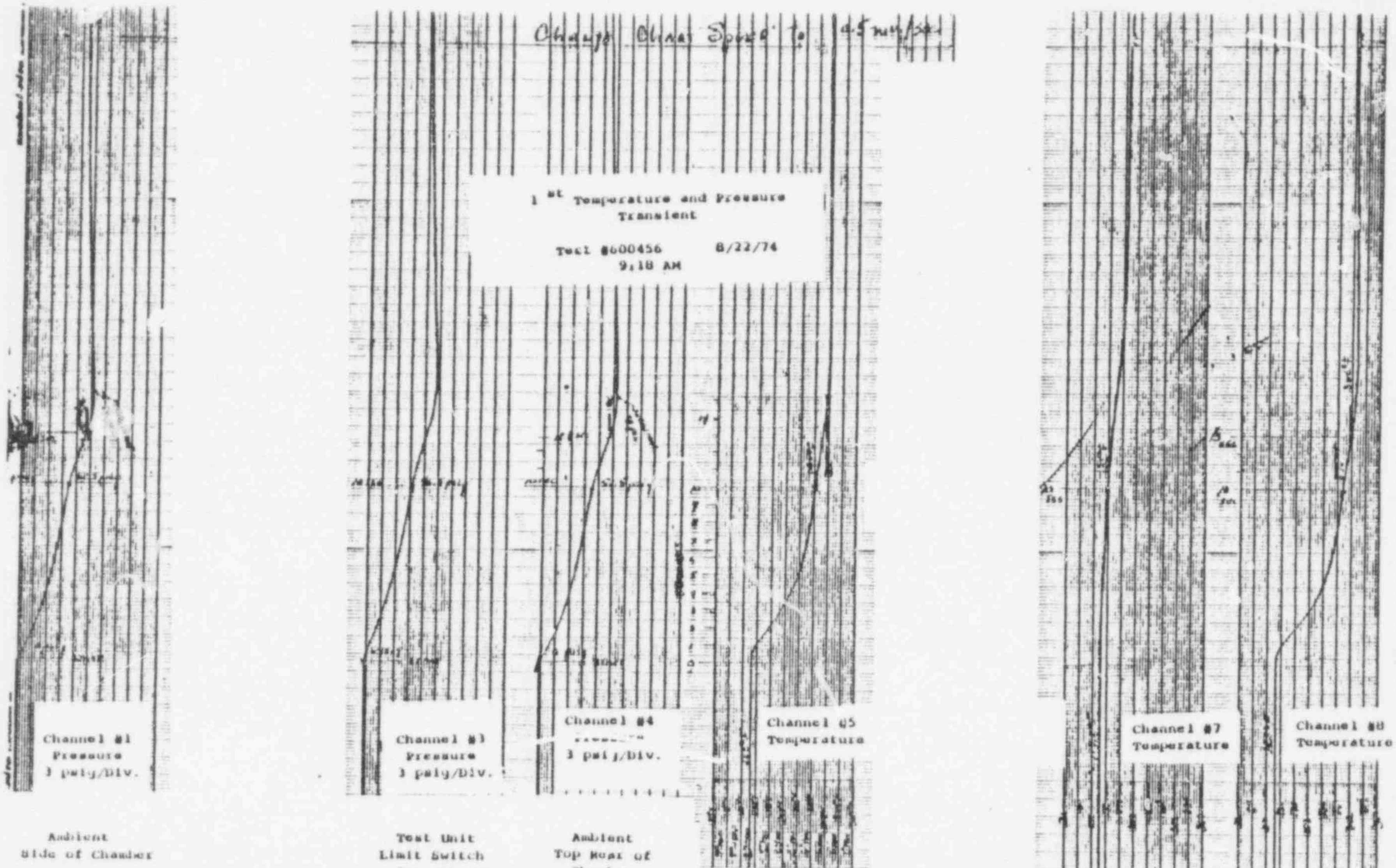


FIGURE 6

POOR ORIGINAL

3/11/75 W.S



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

POOR ORIGINAL

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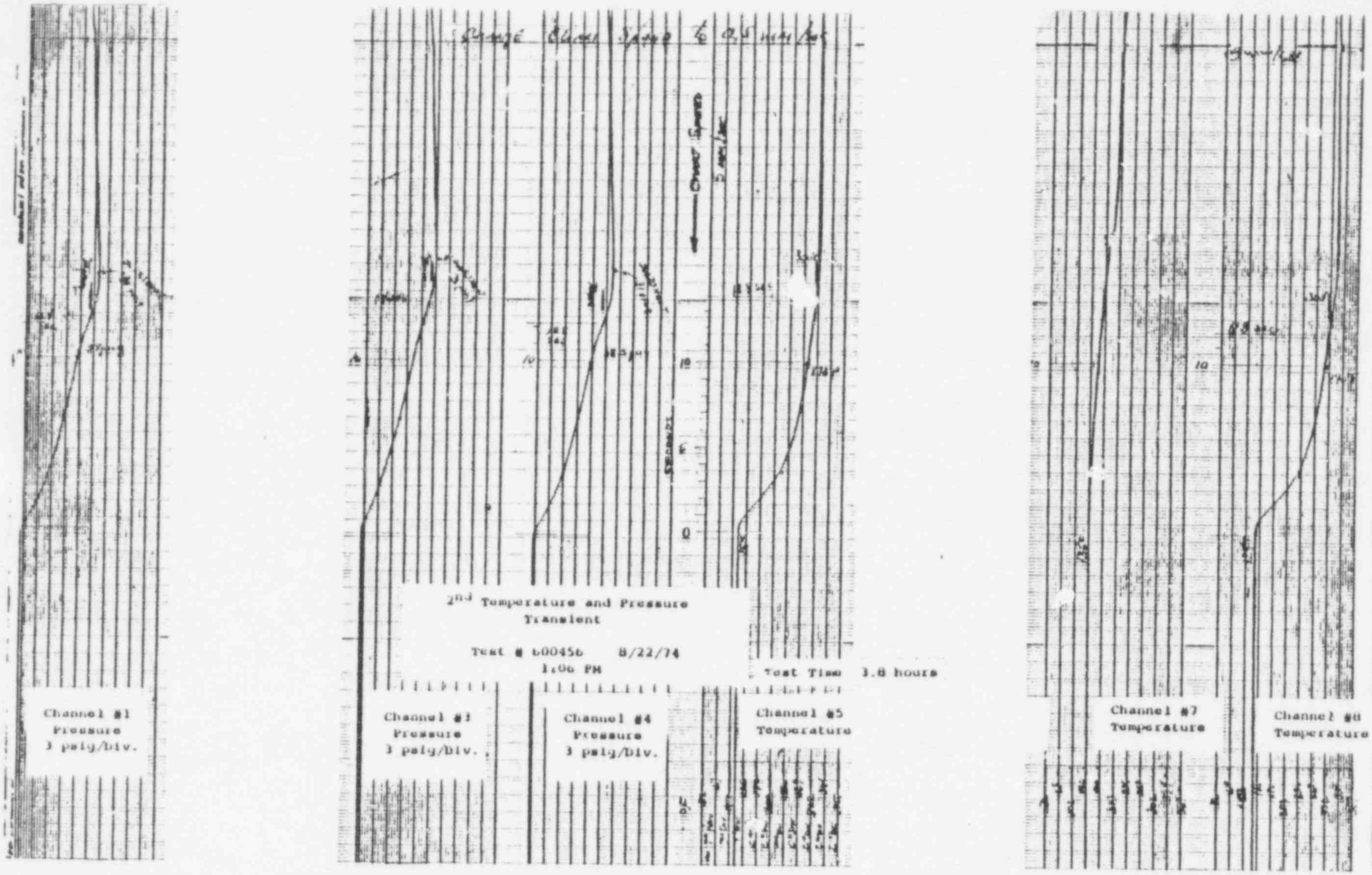

Figure #8

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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.

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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 bottom 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 extinguished. This phenomena was noticed only on the "close" light circuit and no other indicating lights or circuits

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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.

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TABLE III

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

512 240

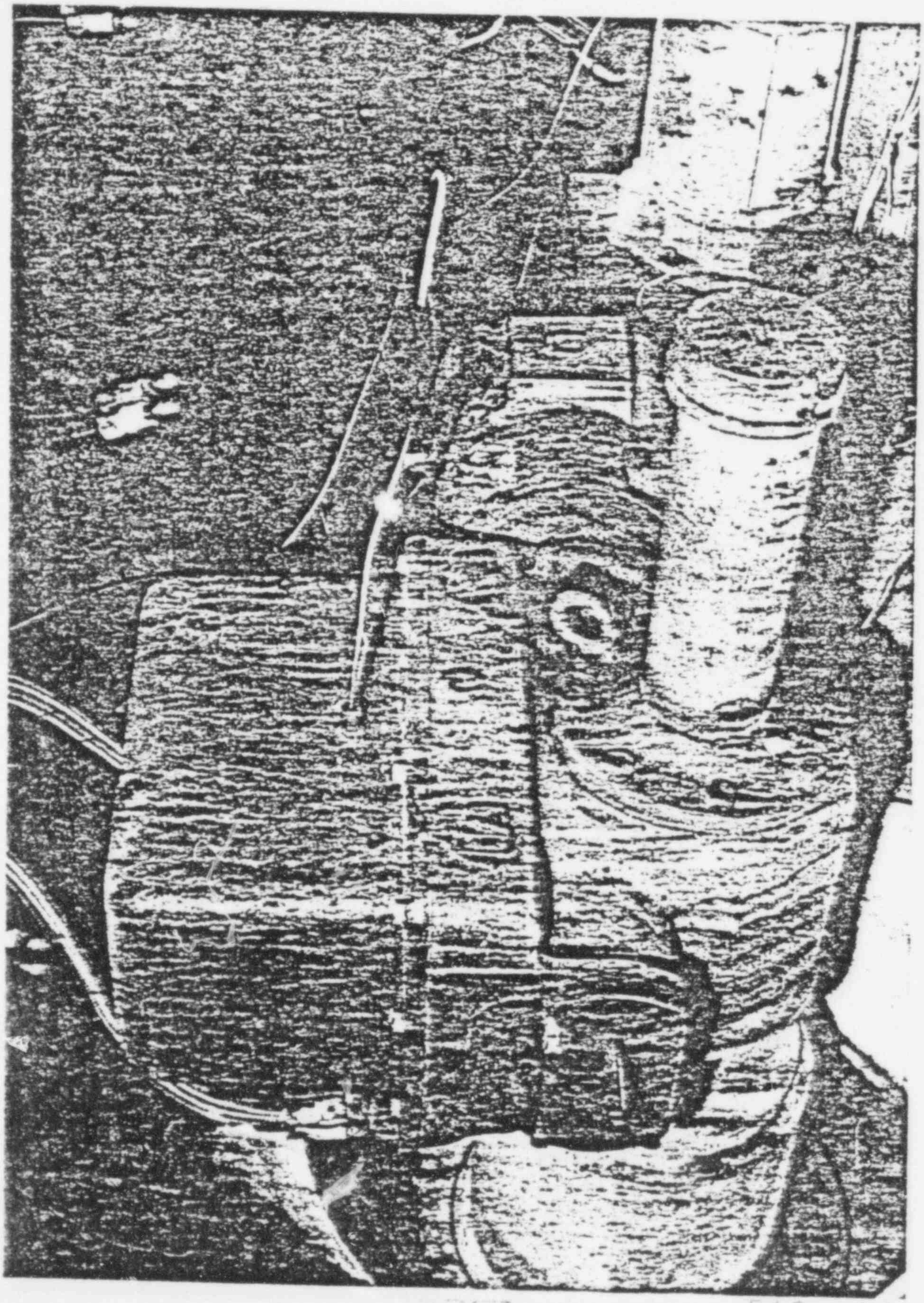

Figure 9 Post LOCA Conditions

512 241

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.

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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

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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

512 244

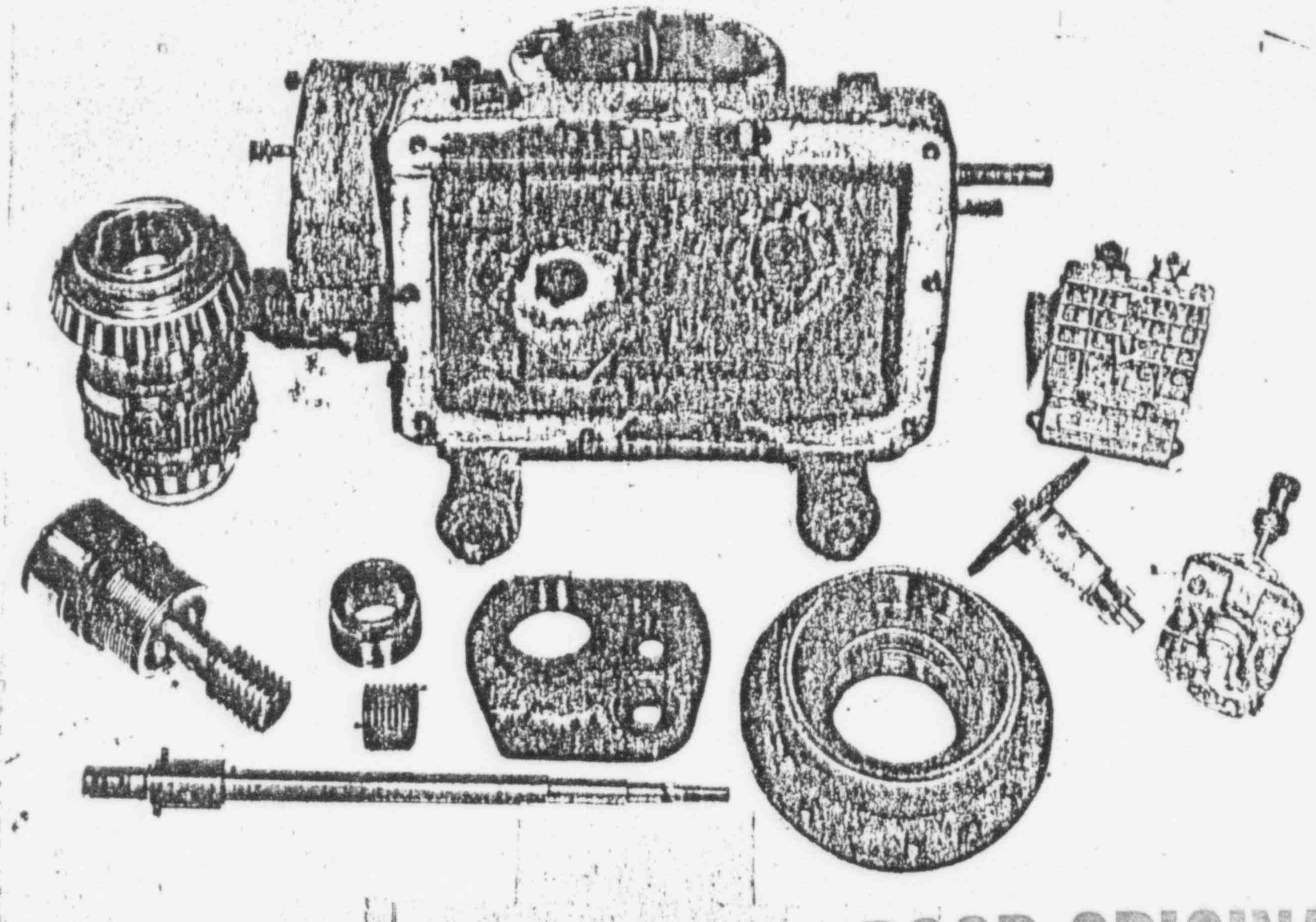

Figure 10
Test Unit Final Inspection

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.

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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.

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APPENDIX A

Reliance Electric Company - Certificate

of Compliance

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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. Haskins

Quality Control Department

F-3548 Printed in USA

512 249

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

512 250

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

INITIAL TORQUE SWITCH SETTING 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

MECHANICAL AGING 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 pound*
Total No. of Cycles: 1208

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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: 8/19/7

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"	16,332

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.

512 252

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.

512 253

APPENDIX C

Radiation Exposure - Isomedix Certificate of Performance

512 254

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 0 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.

512 255

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

512 256

PROTOTYPE TESTING QUALIFICATION REPORT

I N D E X

Number	Test
EPAQ-001	Low voltage leak rate test
EPAQ-002	Medium voltage leak rate test
EPAQ-003	Shielded signal leak rate test
EPAQ-004	Low voltage hydrostatic pressure test
EPAQ-005	Medium voltage hydrostatic pressure test
EPAQ-006	Shielded signal hydrostatic pressure test
EPAQ-007 —	Low voltage maximum emergency environment test
EPAQ-008 —	Medium voltage maximum emergency environment test
EPAQ-009 —	Shielded signal maximum emergency environment test
EPAQ-010 —	Shielded signal maximum emergency environment test
EPAQ-011	Shielded signal thermocycle test
EPAQ-012	Medium voltage thermal test
EPAQ-013	Medium voltage corona test

512 257

Number	Test
EPAQ-014	Medium voltage high potential test
EPAQ-015	Conductor steam test (insulation resistance)
EPAQ-016	Conductor insulation resistance and high potential test
EPAQ-017	Installation welding thermal test
EPAQ-018	Medium voltage, short circuit test
EPAQ-019	High voltage, short circuit test
EPAQ-020	High voltage, basic impulse level test
EPAQ-021	High voltage, high potential test
EPAQ-022	High voltage, corona test
EPAQ-023	High voltage, surge current test
EPAQ-024	High voltage, thermal test
EPAQ-025	Cast epoxy, flame exposure test
EPAQ-026	Performance of spliced thermocouple extension wires
EPAQ-027	Low voltage, insulation resistance test
EPAQ-028	Medium voltage insulation resistance test
EPAQ-029	Low voltage, thermal test
EPAQ-031	High voltage high potential test
EPAQ-032	High voltage, short circuit test
EPAQ-033	High voltage, leak rate test
EPAQ-034	High voltage, basic impulse level test.
EPAQ-035	High voltage, thermal test

512 258

Number	Test
EPAQ-036	High voltage, surge current test
EPAQ-037	Epoxy, insulation resistance test
EPAQ-038	Shielded signal, insulation resistance test
EPAQ-039	Shielded signal, insulation resistance test
EPAQ-040	Medium voltage, high potential test
EPAQ-041	Low voltage, high potential test
EPAQ-042	Shielded signal, high potential test
EPAQ-043	Low voltage, insulation resistance test
EPAQ-044	Low voltage, conductor flame resisting test
EPAQ-045	Medium and high voltage conductor flame resisting test
EPAQ-046	Epoxy, radiation test
EPAQ-047	Low voltage, conductor radiation test
EPAQ-048	Low voltage, hydrostatic pressure test
EPAQ-050	Medium voltage, hydrostatic pressure test
EPAQ-051	Shielded signal, hydrostatic pressure test
EPAQ-052	Low voltage, hydrostatic pressure and humidity test
EPAQ-053	Medium voltage, hydrostatic pressure and humidity test
EPAQ-054	Shielded signal, hydrostatic pressure and humidity test

512 259

Number	Test
EPAQ-055	Low voltage, emergency environment test
EPAQ-056	Medium voltage, emergency environment test
EPAQ-057	Shielded signal emergency environment test
AEPAQ-1	Effects of jet forces
AEPAQ-2	Stress analysis report
AEPAQ-3	Cable radiation tests
AEPAQ-4	Radiation damage to elastomers, organic liquids and plastics
EPAQ-058	High voltage, short circuit test
EPAQ-059	Low voltage, low temperature test
EPAQ-60	Maximum Emergency Environmental Test - Signal
EPAQ-61	Maximum Emergency Environmental Test - Low Voltage.

512 260

TITLE:	Leak Rate Test — Test #EPAQ-001
PRODUCT:	Low voltage power and control penetration assembly
OBJECTIVE:	Verify the electrical penetration assembly will meet the leak rate requirements of nuclear reactor containments.
DESCRIPTION:	Temperature: 175°F Pressure: 63 psig (helium) Duration: 15 minutes The low voltage electrical penetration assembly was pressurized with helium under the above conditions and the leak rate through the assemblies was measured using a helium mass spectrometer. Procedure per GE Test Instruction NEBS Quality Control, Electrical Penetration Leak Test Instruction, #TI 765.
RESULTS:	Leak rate: $< 1X10^{-6}$ cc/sec The assembly successfully met the test requirements.
DATE:	9/67
LOCATION:	GE, Nuclear Instrumentation Department, San Jose, Calif.
CONDUCTED BY:	GE, Nuclear Instrumentation Department, San Jose, Calif.

512 261

TITLE: Leak Rate Test — Test #EPAQ-002

PRODUCT: Medium voltage power penetration assembly

OBJECTIVE: Verify the electrical penetration assembly will meet the leak rate requirements of nuclear reactor containments.

DESCRIPTION:

Temperature: 175°F
Pressure: 63 psig (helium)
Duration: 15 minutes

The medium voltage electrical penetration assembly was pressurized with helium under the above conditions and the leak rate through the assembly was measured using a helium mass spectrometer. Procedure per GE Test Instruction, NEBS Quality Control, Electrical Penetration Leak Test Instruction, #TI 765.

RESULTS:

Leak rate: $< 1 \times 10^{-6}$ cc/sec

The assembly successfully met the test requirements.

DATE: 9/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jo[illegible], Calif.

512 202

TITLE: Leak Rate Test — Test #EPAQ-003

PRODUCT: Shielded signal penetration assembly

OBJECTIVE: Verify the electrical penetration assembly will meet the leak rate requirements of nuclear reactor containments.

DESCRIPTION:

Temperature: 175°F
Pressure: 63 psig (helium)
Duration: 15 minutes

The shielded signal electrical penetration assembly was pressurized with helium under the above conditions and leak rate through the assembly was measured using a helium mass spectrometer. Procedure per GE Test Instruction, NEBS Quality Control, Electrical Penetration Leak Test Instruction #TI 765.

RESULTS:

Leak rate: $< 1 \times 10^{-6}$ cc/sec (through the assembly)

The assembly successfully met the test requirements

DATE: 9/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 263

TITLE: Hydrostatic (pneumatic) Pressure Test — Test #EPAQ-004

PRODUCT: Low voltage power and control penetration assembly

OBJECTIVE: Verify penetrations will maintain integrity when exposed to high pressure.

DESCRIPTION:

Temperature: 77°F
Pressure: 158 psig (Nitrogen)
Duration: 30 minutes

The low voltage power and control electrical penetration assembly was pressurized with nitrogen under the above conditions. The leak rate through the assembly was measured using gas chromotography.

Procedure per GE Test Instruction, NEBS Field Engineering Qualification Test 12" Reactor Containment Penetration Assembly, #TI 717.

RESULTS:

Leak rate: $< 1X10^{-6}$ cc/sec.

The assembly successfully met the test requirement.

DATE: 8/7/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 264

TITLE: Hydros'atic (pneumatic) Pressure Test — Test #EPAQ-005

PRODUCT: Medium voltage power penetration assembly

OBJECTIVE: Verify penetrations will maintain integrity when exposed to high pressure.

DESCRIPTION:

Temperature: 77°F
Pressure: 158 psig (nitrogen)
Duration: 30 minutes

The medium voltage power penetration assembly was pressurized with nitrogen under the above conditions. The leak rate through the assembly was measured using gas chromotography.

Procedure per GE Test Instruction, NEBS Field Engineering Qualification Test 12" Reactor Containment Penetration Assembly, #TI 717.

RESULTS:

Leak rate: $< 1X10^{-6}$ cc/sec.

The assembly successfully met the test requirements.

DATE: 12/29/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

TITLE: Hydrostatic (pneumatic) Pressure Test — Test #EPAQ-006

PRODUCT: Shielded signal penetration assembly

OBJECTIVE: Verify penetrations will maintain integrity when exposed to high pressure.

DESCRIPTION:

Temperature: 77°F
Pressure: 158 psig (nitrogen)
Duration: 30 minutes

The shielded signal penetration assembly was pressurized with nitrogen under the above conditions. The leak rate through the assembly was measured using gas chromotography.

Procedure per GE Test Instruction, NEBS Field Engineering, Qualification Test 1'' Reactor Containment Penetration Assembly, #TI 717.

RESULTS:

Leak rate: $< 1X10^{-6}$ cc/sec

The assembly successfully met the test requirements.

DATE: 12/19/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

TITLE: Maximum Emergency Environmental Test — Test #EPAQ-007

PRODUCT: Low voltage power and control penetration assembly

OBJECTIVE: Verify the penetration assembly will maintain its integrity when exposed to reactor maximum emergency conditions.

DESCRIPTION:

Temperature:	281°F
Pressure:	63 psig
Relative humidity:	90% to 100%
Duration:	240 hours

The low voltage power and control assembly was pressurized under the above conditions. The assembly was leak rate tested throughout the period using gas chromotography equipment with nitrogen as the tracer gas.

Procedure per GE Test Instruction, NEBS Field Engineering Qualification Test 12" Reactor Containment Penetration Assembly, #TI 717.

RESULTS:

Leak rate: $< 1X10^{-6}$ cc/sec

The assembly successfully met the test requirements.

DATE: 8/7/67 (Start)

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 267

TITLE: Maximum Emergency Environmental Test — Test #EPAQ-008

PRODUCT: Medium voltage power penetration assemblies

OBJECTIVE: Verify the penetration assembly will maintain its integrity when exposed to reactor maximum emergency conditions.

DESCRIPTION:

Temperature:	$281^{\circ}F$
Pressure:	63 psig
Relative humidity:	90% to 100%
Duration:	240 hours

The medium voltage power penetration was pressurized under the above conditions. The assembly was leak rate tested throughout the period using gas chromotography equipment with nitrogen as the tracer gas.

Procedures per GE Test Instruction, NEBS Field Engineering, Qualification Test 12" Reactor Containment Penetration Assembly, #TI 717.

RESULTS: Leak rate: $< 1 \times 10^{-6}$ cc/sec

The assembly successfully met the test requirements.

DATE: 12/29/67 (Start)

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 268

TITLE:	Maximum Emergency Environmental Test — Test #EPAQ-009
PRODUCT:	Shielded Signal Penetration Assembly
OBJECTIVE:	Verify the penetration assembly will maintain its integrity when exposed to reactor maximum emergency conditions.

DESCRIPTION:

Temperature:	281°F
Pressure:	63 psig
Relative humidity	90% to 100%
Duration:	240 hours

The shielded signal penetration assembly was pressurized under the above conditions. The assembly was leak rate tested throughout the period using gas chromotograpny equipment with nitrogen as the tracer gas.

Procedure per GE Test Instruction, NEBS Field Engineering, Qualification Test 12" Reactor Containment Penetration Assembly, #TI 717.

RESULTS:

Leak rate: $< 1X10^{-6}$ cc/sec

The assembly successfully met the test requirements.

DATE:	12/19/67 (start of test)
LOCATION:	GE Nuclear Instrumentation Department, San Jose, Calif.
CONDUCTED BY:	GE Nuclear Instrumentation Department, San Jose, Calif.

512 269

TITLE:	Maximum Emergency Environmental Test — Test #EPAQ-010
PRODUCT:	Shielded Signal Penetration Assembly
OBJECTIVE:	Verify the penetration assembly will maintain its integrity when exposed to reactor maximum emergency conditions.

DESCRIPTION:

Temperature: 281°F
Pressure: 63 psig
Relative humidity: 90% to 100%
Duration: 240 hours

Immediately after test, tested again to the following:

Temperature: 320°F
Pressure: 125 psig
Relative humidity: 90% to 100%
Duration: 2 hours

The shielded signal penetration assembly was pressurized under the above conditions. The assembly was leak rate tested throughout the period using gas chromotography equipment with nitrogen as the tracer gas.

Procedure per GE Test Instruction, NEBS Field Engineering, Qualification Test 12" Reactor Containment Penetration Assembly, #TI 717.

RESULTS:

Leak rate $< 1X10^{-6}$

The assembly successfully met the test requirement.

DATE:	12/1/67
LOCATION:	GE, Nuclear Instrumentation Department, San Jose, Calif.
CONDUCTED BY:	GE, Nuclear Instrumentation Department, San Jose, Calif.

512 270

TITLE:	Thermocycling Test - Test #EPAQ-011
PRODUCT:	Shielded Signal Penetration Assembly
OBJECTIVE:	Verify the penetration assembly can withstand the thermocycling due to normal reactor start-up and shut-down during the 40 years of operation.

DESCRIPTION:

Maximum Temperature:	150°F
Minimum Temperature:	50°F
Cycle Definition:	50°F-150°F-50°F (constant temperature rate of change)
Cycle Duration:	24 hours
Cycle Specification:	100 cycles
Relative Humidity:	100%
Pressure:	15 psig (nitrogen)

The shielded signal penetration assembly was exposed to the above conditions. The leak rate through the penetration was monitored during the test uding gas chromotography.

RESULTS:

Leak rate $< 1X10^{-6}$ cc/sec

Cycles: 100

The assembly successfully met the test requirements.

DATE:	4/21/68 (start of test)
LOCATION:	GE, Nuclear Instrumentation Department, San Jose, Calif.
CONDUCTED BY:	GE, Nuclear Instrumentation Department, San Jose, Calif.

512 271

TITLE: Thermal Test — Test #EPAQ-012

PRODUCT: Medium voltage power penetration assembly

OBJECTIVE: Verify the current carrying capabilities of the penetration assembly.

DESCRIPTION:

(1) Medium voltage penetration {6- 1000 MCM conductors / 2- 250 MCM conductors}
(2) Assembly temperature monitored by - 40 thermocouples
(3) Conductor temperature determined by: conductor resistance measurements.
(4) Three phase, six conductor te[illegible] at following currents/conductor:

a) 465 amperes
b) 620 amperes
c) 700 amperes

(5) Three phase, three conductor tests at following currents/conductor:

a) 585 amperes
b) 700 amperes
c) 780 amperes
d) 800 amperes

(6) Relative humidity: ambient (50%)
(7) Temperature: ambient (70°F)
(8) Pressure: 0 psig

512 272

Currents	3Ø, 3 Conductors Maximum Temperature Rise	3Ø, 6 Conductors Maximum Temperature Rise
465 amperes	—	6°C - outer case 12°C - conductor terminals 25°C - conductor
585 amperes	5°C - outer case 20°C - conductor terminals 34°C - conductors	9°C - outer case 21°C - conductor terminals 41°C - conductors
620 amperes	6°C - outer case 22°C - conductor terminals 37°C - conductors	11°C - outer case 21°C - conductor terminals 47°C - conductors
700 amperes	8°C - outer case 29°C - conductor terminals 46°C - conductors	15°C - outer case 31°C - conductor terminals 59°C - conductors
780 amperes	9°C - outer case 35°C - conductor terminals 63°C - conductors	—
800 amperes	10°C - outer case 37°C - conductor terminals 70°C - conductors	—

The results of this test have been included as part of the data used in establishing conductor rating criteria for penetrations.

DATE: 3/21/68 (start of test)

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 273

TITLE: Corona Test — Test #EPAQ-013

PRODUCT: Medium Voltage Power Penetration Assembly (5kv)

OBJECTIVE: Verify the penetration assembly configuration will meet IPCEA S-19-81 corona requirements.

DESCRIPTION:
(1) Medium voltage penetrations: {6- 1000 MCM conductors / 2- 250 MCM conductors
(2) Test six conductors (1000 MCM) connected together.
(3) Test each conductor individually.
(4) 1MhZ Radio influence voltage measured by radio noise meter, Stoddart NM-20B. Radio influence voltage circuit sensitivity greater than 40 pico coulombs per centimeter (IPCEA S-19-81).
(5) Pressure: 0 psig
Temperature: Ambient ($70^{o}F$)
Relative humidity: Ambient (50%)

RESULTS:
(1) No corona up to 3 kv for all conductors tied together.
(2) Internal spark from one of the imbedded thermocouples wires to case was detected above 3 kv. The spark signal was detected with Blander-Tongue field strength meter (model 4127, No. MHB 119030) and a tuned dipole antenna five feet from end of the penetration assembly. Frequency of spark 85MhZ.
(3) Six of the eight conductors remained corona free up to the maximum required voltage of 3.7 kv.

DATE: 3/21/68 (start of test)

LOCATION: GE High Power Laboratory, Philadelphia, Pa.

CONDUCTED: GE High Power Laboratory, Philadelphia, Pa.

512 274

TITLE:	High Potential Test — Test #EPAQ-014
PRODUCT:	Medium Voltage Power Penetration Assembly (5kv)
OBJECTIVE:	Verify the penetration assembly will meet the high potential requirements of IPCEA S-19-81.
DESCRIPTION:	Medium voltage assembly: 6- 1000 MCM conductors 2- 250 MCM conductors
	Test voltage: 11.5 kv
	Duration: 60 seconds
	Temperature: Ambient (70°F)
	Pressure: 0 psig
	Relative humidity: Ambient (50%)
	All conductors (8) tested to outer case.
RESULTS:	All conductors successfully passed the test.
DATE:	3/21/6
LOCATION:	GE High Power Laboratory, Philadelphia, Pa.
CONDUCTED BY:	GE High Power Laboratory, Philadelphia, Pa.

512 275

TITLE: Conductor Steam Test (Insulation Resistance)- Test #EPAQ-015

PRODUCT: Cross-linked Polyethylene Insulated Conductors

OBJECTIVE: Verify the conductors will continue to meet performance specifications when exposed to Reactor Incident Conditions.

DESCRIPTION: Cross-linked polyethylene insulation - GE Type SI 57275, #18 AWG (3 samples).

Temperature: 352°F
Duration: 30 minutes
Other: saturated steam environment

The conductors were exposed to the above conditions and then the following environment.

Temperature: 309°F
Duration: 23-1/2 hours
Other: saturated steam environment

Insulation resistance measured with general radio megohmmeter.

Test voltage: 500 VDC
Test made on two areas of the conductor: (one test made where conductor was clamped for the test).

RESULTS:

SAMPLE NUMBER	INSULATION RESISTANCE 1st area	INSULATION RESISTANCE 2nd area (clamped area)
1	4×10^{12}	9.5×10^{12}
2	9×10^{12}	1.2×10^{13}
3	1.8×10^{13}	1.2×10^{13}

The high insulation resistance levels showed the conductors would continue to perform after exposure to such conditions.

DATE: 3/11/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 276

Test #EPAQ-016

TITLE:	Conductor Insulation Resistance and High Potential Test —
PRODUCT:	Cross-linked Polyethylene Insulated Conductors
OBJECTIVE:	Verify the conductors will continue to meet performance specifications when exposed to reactor incident conditions.
DESCRIPTION:	Cross-linked polyethylene insulated conductors - GE Type SI-57275, #18 AWG (10 samples).

Temperature:	281°F
Pressure.	62 psig
Other:	High humidity nitrogen (90-100%)
Duration:	348 Hours

Insulation resistance measured at three points along each sample. Megohmmeter (500 volt test voltage) used to test samples after exposure to above conditions.

High potential test: 200 volt, DC, applied between center of conductor and copper shim wrapped around the wire. Tested after insulation resistance test.

RESULTS:

(1) Average insulation resistance: $2 \times 10^{13}\Omega$ (ten samples, three tests per sample.)

(2) All samples passed high potential test successfully.

The test results show the conductors would continue to meet performance specifications.

DATE:	3/8/68
LOCATION:	GE, Nuclear Instrumentation Department, San Jose, Calif.
CONDUCTED BY:	GE, Nuclear Instrumentation Department, San Jose, Calif.

512 277

TITLE: Installation Welding Thermal Test — Test #EPAQ-017

PRODUCT: Medium Voltage Penetration Assembly (5kv)
Shielded Signal Penetration Assembly

OBJECTIVE: To assure that no degradation of the penetration assembly materials will occur during field installation welding.

DESCRIPTION: Maximum allowable temperature: 250°F.

Two penetration assemblies were instrumented with 20 thermocouples each in the area being welded. Shielded metal arc weld process was used.

RESULTS: Maximum sealant temperature: 210°F

The established welding procedure did not cause degradation of the penetration assembly.

The test was successfully completed.

DATE: 10/30/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 278

TITLE: Short Circuit Test — Test #EPAQ-018

PRODUCT: Medium Voltage Power Penetration Assembly (5kv)

OBJECTIVE: Verify the medium voltage power penetration assembly can withstand the effects of surge currents and still meet performance specifications.

DESCRIPTION: Medium Voltage Assembly: {6- 1000 MCM conductors
2- 250 MCM conductors (grounds)

All surge current tests were three phase tests. When testing, the two-three phase systems (3- 1000 MCM plus 1- 250 MCM ground) the circuit was connected such that there were two isolated 3 phase faults fed from a common source.

512 279

RESULTS:

Time	Peak Inrush Current Amps	RMS Avg Inrush Current Amps (3Ø)	Avg. AC End of Fault Current Amps
The tests for the single 3 - Ø connections were:			
4 sec.	ØA 64,000 ØB 43,000 ØC 55,000	32,000	20,000
4 sec.	ØA108,100 ØB 85,200 ØC 88,700	55,000	33,300
1 sec.	ØA116,000 ØB 80,000 ØC101,000	58,300	39,600
1 sec.	ØA200,000 ØB150,000 ØC166,500	101,500	67,800
The tests for the double 3 - Ø connections were:			
4 sec.	ØA109,000 ØB 82,000 ØC 85,000	54,000	32,300
4 sec.	ØA192,000 ØB230,000 ØC138,000	113,000	50,000

Leak rate: No detectable leakage. Integrity of the seal was maintained after short circuit tests.

The assembly passed the test successfully.

DATE: 4/22/68 (Start of test)

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 280

TITLE: Short Circuit Test — Test #EPAQ-019

PRODUCT: High Voltage Power Penetration Assembly (15KV)

OBJECTIVE: Verify the high voltage power penetration assembly can withstand the effects of surge currents and still meet performance specifications.

DESCRIPTION: High Voltage Power Penetration - 18" diameter, ceramic bushing design (3 phase, 3 conductors).

Two configurations were tested. In the first, the bushings were tied together with copper bus bars while cables were attached to the three bushings in the second configuration.

The test was per ASA C37.20-1965, paragraph 20-5.2.3. Temperature 10°C - 30°C. Current tests to be at 20K, 40K, 60K, 80K amperes, rms (60 cycle AC) for 10 cycles (three phase).

RESULTS: Configuration 1, bushings bussed together, passed all the tests successfully.

The cable configuration failed its test at 80000 amperes. The excessive forces due to cable movement during the short circuit test caused the failure of the bushing, thus causing depressurization of the assembly.

DATE: 4/69

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 281

TITLE: Basic Impulse Level Test — Test #EPAQ-020

PRODUCT: High Voltage Power Penetration Assembly (15KV)

OBJECTIVE: Verify the high voltage power penetration assembly will meet the impulse requirements.

DESCRIPTION: High voltage power penetration - 18" diameter, ceramic bushing design (3 phase, 3 conductors).

At each voltage level the potential was applied three times.

Environmental temperature: 10°C - 30°C
Standard: ASA C37.20 - 1965, paragraph 20-5.2.12
Crest Voltage: 75KV, 95KV

RESULTS: All tests were successfully completed.

TEST	NOZZLE	BUSHING A	BUSHING B	BUSHING C*
1	Ground	75KV	Ground	Ground
2	Ground	Ground	75KV	Ground
3	Ground	95KV	Ground	Ground
4	Ground	Ground	95KV	Ground

*Bushing C, instrumented with thermocouples, was not tested.

DATE: 4/69

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 282

TITLE: High Potential Test — Test #EPAQ-021

PRODUCT: High Voltage Power Penetration Assembly (13KV)

OBJECTIVE: Verify the high voltage power penetration assembly will meet wet and dry high potential requirements.

DESCRIPTION: High voltage power penetration assembly - 18" diameter, ceramic bushing design.

Environmental temperature: $10^{o}C$ - $30^{o}C$
Dry High Potential Standard: ASA C37.20 - 1964, paragraph 20-5.2.1.1
Test Voltages: 27KV, 36KV (rms)
Wet High Potential Standard: ASA C77.1 - 1943
Test Voltages: 24KV, 26KV (rms)

RESULTS: All tests were successfully completed

TEST	NOZZLE	BUSHING A	BUSHING B	BUSHING *C	TEST	NOZZLE	BUSHING A	BUSHING B	BUSHING *C
1	Ground	27KV	Ground	Ground	1	Ground	24KV	Ground	Ground
2	Ground	Ground	27KV	Ground	2	Ground	Ground	24KV	Ground
3	Ground	36KV	Ground	Ground	3	Ground	26KV	Ground	Ground
4	Ground	Ground	36KV	Ground	4	Ground	Ground	26KV	Ground

*Bushing C, instrumented with thermocouples, was not tested.

DATE: 4/69

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 283

TITLE: Corona Test — Test #EPAQ-022

PRODUCT: High Voltage Power Penetration Assembly (15KV)

OBJECTIVE: Verify the high voltage power penetration assembly will meet corona test requirements.

DESCRIPTION: High voltage power penetration assembly - 18" diameter, ceramic bushing design.

Temperature:	10°C - 30°C
Standard:	IPCEA S-19-81
Test Circuit:	NEMA 107 RIV
Two Tests:	(1) Atmospheric pressure (2) 25 PSIG nitrogen

RESULTS:

TEST	BUSHING A	BUSHING B
1	Corona Start at 6KV(rms)	Corona Start at 4KV(rms)
2	Corona Start at 6KV(rms)	Corona Start at 10KV(rms)

Bushing C, instrumented with thermocouples, was not tested.

DATE: 4/69

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 284

TITLE: Surge Current Test — Test #EPAQ-023

PRODUCT: High Voltage Power Penetration Assembly (15KV)

OBJECTIVE: Verify the high voltage power penetration assembly will meet the requirements for surge currents due to motor starting.

DESCRIPTION: High Voltage Power Penetration Assembly -18" diameter ceramic bushing design.

Temperature: 10°C - 30°C

Current Values: 3600 am 4500 amperes, 4800 amperes; rms (60 s)

*Duration: 30 secon

The temperature of the conductors will be monitored during the test in which the specified currents will be applied to each conductor simultaneously.

*Duration varied from 30 - 40 seconds because of time required to attain the desired cur. nts. Total time at full current is 30 seconds.

512 285

RESULTS:

TIME	3600 AMPERES	4500 AMPERES	4800 AMPERES
10 seconds	3.4°C (temperature rise of conductor)	5°C rise	3.4°C rise
20 seconds	9.45°C rise	15.6°C rise	19.5°C rise
30 seconds	16.7°C rise	34.4°C rise	39°C rise
35 seconds	21°C rise	40°C rise	50°C rise
40 seconds	25°C rise	—	—

The tests proved the assembly would meet the surge current requirements without degradation of the assembly.

DATE: 4/69

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 286

TITLE: Thermal Test (Continuous Current Test) — Test #EPAQ-024

PRODUCT: High Voltage Power Penetration Assembly (15 kv)

OBJECTIVE: Verify the current carrying capabilities of the High Voltage Power Penetration Assembly.

DESCRIPTION: High Voltage Power Penetration Assembly - 18" diameter ceramic bushing design.

Standard: A[illegible] 37.20-1965, paragraph 20-5.22
Temperature: 10°-30°C
Test Currents: 600, 650, 700, 750, 800 amperes

Temperature of conductors to be monitored by thermocouples. Temperature to be monitored horizontally and vertically about the nozzle.

RESULTS:

750 AMP TEST

T/C Location \ Time	4 Hours	8 Hours	12 Hours
Bushing Clamping Ring	40°C rise	43°C rise	43°C rise
Conductor Expansion Joint	27°C rise	33°C rise	36°C rise
Air between textolite & outer shell	8°C rise	14°C rise	18°C rise
Outer shell	5°C rise	10°C rise	11°C rise

512 287

RESULTS: (Continued)

Maximum Conductor Temperature Rise	20°C	31°C	36°C	49°C
Current	600 amps	675	750	860

The test data has been used to establish current carrying capability rules for the High Voltage Penetration Assembly.

DATE: 4/69

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 288

TITLE: Flame Exposure Test — Test #EPAQ-025

PRODUCT: Cast Epoxy Insulating Compounds

OBJECTIVE: Determine the flame resistance properties of cast epoxy insulating compounds

DESCRIPTION: Standard: Method 2021, Federal Test Method Standard No. 406 (identical to ASTM-D635, test for flammability of rigid plastics)

Five types of epoxy were tested.

Specimen size: 5" long, 1/2" wide, 1/4" thick (engraved marks at 1" and 4" from end)

No. of specimens: 10 per sample were ignited for 30 seconds. Certain specimens were coated with non-flammable heat and moisture resisting paint and tested.

RESULTS:

	Unpainted Specimen	Painted Specimen
EPOXY #1	Rated "burning by this test"	—
** EPOXY #2	Rated "self-extinguishing"	Rated "self-extinguishing
** EPOXY #3	Rated "self-extinguishing"	Rated "self-extinguishing
EPOXY #4	* Rated "self-extinguishing"	—
EPOXY #5	Rated "self-extinguishing"	Rated "self-extinguishing

* Properties varied drastically depending on the hardener used with the resin.

** Epoxy used in present design.

512 289

DATE: 1966 - 1967

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 290

Test #EPAQ-026

TITLE: Performance of Spliced Thermocouple Extension Wires —

PRODUCT: Thermocouple Wires as passed through the Penetration Assembly.

OBJECTIVE: Verify the method for passing thermocouple wires through the electrical penetration assemblies does not cause significant error in temperature measurement.

DESCRIPTION: Two types of thermocouples were tested:

1. Thermo-Electric Co.Type GG-18-CL (solid (CA-Al)
2. Honeywell Type 5W2P36

Two types of splices were to be evaluated with the two types of thermocouple leads. Continuous solid wire thermocouple leads were the standard with which to compare the test results.

Twenty thermocouple leads were to be tested as follows:

*1) 4 - continuous solid wire leads through the penetration
2) 4 - stranded thermocouple wire with butt splices
3) 4 - stranded thermocouple wire with parallel splices
4) 4 - solid thermocouple wire with butt splices
5) 4 - stranded thermocouple wire with parallel splices

* standard

A. Differential temperature across splices (-7.7°F to 157.4°F)

B. Maximum header temperature - 268.4°F

Splices were subjected to differential temperature (greater than would be experienced even in abnormal conditions) to determine if any significant error was introduced due to voltages being generated by dissimilar metals at the junction of the splicing sleeve and the thermocouple wires. The thermocouple splices were cast in epoxy and the standard penetration seal was formed. A known temperature was measured so the thermal EMF effects could be noted as a measurable difference in the thermocouple affected.

Output of each thermocouple measured with a fast response Leeds & Northrup adjustable zero, adjustable range recorder.

512 291

RESULTS:

The maximum error recorded for spliced wires was considerably less than the standard limits of error for thermocouples without splices, as found in American Standard for Temperature Measurement Thermocouples, Pub. C96.1.
Normal operating conditions, differential temperature: 25°F, changing slowly (increasing 2°F per minute).

TYPE OF WIRE	TYPE OF SPLICE	MAXIMUM DEVIATION DEGREES F	PERCENT OF STANDARD LIMIT OF ERROR
Solid	Butt	0.4	10
Stranded	Butt	<0.1	<2.5
Solid	Parallel	<0.1	<2.5
Stranded	Parallel	-0.1	2.5

Normal operating conditions, differential temperature: 25°F, changing rapidly (decreasing 6.28°F per minute).

TYPE OF WIRE	TYPE OF SPLICE	MAXIMUM DEVIATION DEGREES F	PERCENT OF STANDARD LIMIT OF ERROR
Solid	Butt	1.0	25
Stranded	Butt	0.35	8.7
Solid	Parallel	0.18	4.5
Stranded	Parallel	-0.05	1.2

512 292

Emergency conditions, differential temperature: 157.9°F

TYPE OF WIRE	TYPE OF SPLICE	MAXIMUM DEVIATION DEGREES F	PERCENT OF STANDARD LIMIT OF ERROR
Solid	Butt	2.03	50.7
Stranded	Butt	1.34	33.5
Solid	Parallel	0.4	10.0
Stranded	Parallel	0.26	6.5

DATE: 9/16/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 293

TITLE: Insulation Resistance Test — Test #EPAQ-27

PRODUCT: Low Voltage Power Electrical Penetration Assembly

OBJECTIVE: Verify the insulation resistance levels of the conductors of the Electrical Penetration Assembly will meet acceptable levels after exposure to reactor emergency conditions.

DESCRIPTION: A low voltage power penetration (600 volt conductors) was exposed to the following conditions:

Temperature:	281°F
Pressure:	63 psig
Relative Humidity:	90%-100%
Duration:	240 hours

Insulation resistance measurements were made using a megohmmeter (GRXL - 0105), 500 volt test.

Two sets of readings were taken. One was taken immediately after the test and the other one day later after the samples had been exposed to ambient conditions (70°F, 50% RH) for the period.

512 294

RESULTS: INSULATION RESISTANCE

	First Test	Second Test	Product Specification
Conductors to Case	all greater-$1.5x10^6 \Omega$ average-$1.33x10^7 \Omega$	all greater than - $2.0x10^8 \Omega$ average-$2.04x10^8 \Omega$	all greater $10^{10} \Omega$
Conductor to Conductor	all greater-$1.8x10^7 \Omega$ average-$2.36x10^7 \Omega$	all greater-$8.x10^{10} \Omega$ average-$1.33x10^{11} \Omega$	all greater $10^{10} \Omega$

The values obtained after the first test indicate the conductor will continue to function under normal electrical loading. The second test indicates the conductors regain almost of all of their capabilities when returned to normal conditions for a short period of time.

DATE: 8/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 295

TITLE: Insulation Resistance — Test #EPAQ-28

PRODUCT: Medium Voltage Power Penetration Assembly

OBJECTIVE: Verify the insulation resistance levels the Medium Voltage Electrical Penetration Assembly Conductors will meet acceptable levels after exposure to reactor emergency conditions.

DESCRIPTION: A medium voltage power penetration (5kv) was exposed to the following conditions:

Temperature:	281°F
Pressure:	63 psig
Relative humidity:	90%-100%
Duration:	240 hours

Insulation resistance measurements were made using a megohmmeter (GEXL-0105), 500 volt test. The tests were made immediately after exposure to the above conditions.

RESULTS: Insulation Resistance: (conductor to case) — all greater than $2.3 \times 10^{11}\Omega$ (product specification $10^{10}\Omega$)

The results indicate the electrical conductors will continue to function even during and after reactor accident conditions.

DATE: 1/30/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 296

TITLE: Thermal Test — Test #EPAQ-29

PRODUCT: Low Voltage Power Penetration Assembly

OBJECTIVE: Verify the current carrying capabilities of the Low Voltage Power Electrical Penetration Assemblies.

DESCRIPTION: Two low voltage power penetration assemblies were tested to determine the heat dissipating capabilities of the assemblies.

Penetration 1: 1161 #18 AWG conductors
Penetration 2: 414 #10 AWG conductors

The assemblies were instrumented to determine the temperature throughout the assembly. The assembly conductors were loaded and the temperature distribution was recorded.

RESULTS: Conductor rating rules were developed, in part, from the test data.

	Containment Temperature				
Permissible watts/ft.	70°C	65°C	60°C	50°C	40°C
12" Penetration	12	15	18	25	32
10" Penetration	10	12.5	15	21	27
8" Penetration	8	10	12	17	21

EFFECTIVE DUTY CYCLE (based on % time in operation)

Time in 8 Hours	Effective Duty
0-1/2 hours	0
1/2-2 hours	1/2
2 - 8 hours	1

If the current per conductor is less than 5% of that allowed by the National Electric Code, Table 310-12, page 70-108, there is no effective heating due to that conductor.

5122 297

DATE: 1968

LOCATION: GE, Nuclear Instrumentation Dept., San Jose Calif. and GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, Nuclear Instrumentation Dept., San Jose, Calif. and GE, High Power Laboratory, Philadelphia, Pa.

512 298

TITLE: High Potential Test — Test #EPAQ-031

PRODUCT: High Voltage Power Penetration Assembly (15kv)

OBJECTIVE: Verify the High Voltage Power Penetration Assembly will meet wet and dry high potential requirements.

DESCRIPTION: High Voltage Power Penetration - 18" diameter, concentric, shielded cable design.

Cable type: GE SI-58224
Environmental temperature: 10°C - 30°C
Dry High Potential Standard: ASA C37.20-1964, paragraph 20-5.2.1.1
Test Voltages: 27KV, 36KV (rms)
Wet High Potential Standard: ASA C77.1 - 1943
Test Voltages: 24KV, 26KV (rms)

512 299

RESULTS: All tests were successfully completed.

TEST	NOZZLE	BUSHING A	BUSHING B	BUSHING *C	TEST	NOZZLE	BUSHING A	BUSHING B	BUSHING *C
1	Ground	27KV	Ground	Ground	1	Ground	24KV	Ground	Ground
2	Ground	Ground	27KV	Ground	2	Ground	Ground	24 KV	Ground
3	Ground	Ground	Ground	27KV	3	Ground	Ground	Ground	24KV
4	Ground	36KV	Ground	Ground	4	Ground	26KV	Ground	Ground
5	Ground	Ground	36KV	Ground	5	Ground	Ground	26KV	Ground
6	Ground	Ground	Ground	36KV	6	Ground	Ground	Ground	26KV

DATE: 1/70

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 300

TITLE: Short Circuit Test — Test #EPAQ-032

PRODUCT: High Voltage Power Penetration Assembly (15kv)

OBJECTIVE: Verify the high voltage power penetration assembly can withstand the effects of short circuit currents and still meet performance specifications.

DESCRIPTION: High Voltage Power Penetration - 18" diameter, concentric shielded cable design.

Cable type: GE SI-58224

The test was per ASA C37.20-1965, paragraph 20-5.2.3. Temperature 10°C - 30°C. Current tests to be at 20K, 40K, 60K, 80K amperes, rms (60 cycle AC) for 10 cycles (three phase).

512 301

RESULTS: All tests were completed successfully.

TEST	INRUSH CURRENT, REQUIRED AMP, RMST	MAX Ø INRUSH CURRENT ACTUAL AMP; RMST	END-OF-FAULT CURRENT, ACTUAL AMP, RMST	DURATION 1/2~
Before Runs	—	—	—	—
1	20,000	18,800	12,300	23.
2	40,000	36,200	22,900	23.3
3	60,000	56,000	37,600	23.4
*4	80,000	82,000	52,400	23.5

*A slight leak developed in one of the seals after the 80,000 amperes test but the current carrying capability for the assembly was not reduced.

DATE: 1/23/70

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 302

TITLE:	Leak Rate Test — Test #EPAQ-033
PRODUCT:	High Voltage Power Penetration Assembly (15kv)
OBJECTIVE:	Verify the High Voltage Power Electrical Penetration Assembly will meet the leak rate requirements of nuclear reactor containments.
DESCRIPTION:	High Voltage Power Penetration - 18" diameter concentric shielded cable design.

Cable type:	GE SI-58224
Temperature:	Ambient (70°F)
Pressure:	63 psig (helium)
Duration:	15 minutes

The high voltage power penetration assembly was pressurized with helium under the above conditions and the leak rate through the assemblies was measured using a helium mass spectrometer. Procedure per GE Test Instruction NEBS Quality Control, Electrical Penetration Leak Test Instruction, #TI 765.

RESULTS:	Leak rate: $< 1X10^{-6}$ cc/sec The assembly successfully met the test requirements.
DATE:	1/70
LOCATION:	GE, Nuclear Instrumentation Department, San Jose, Calif.
CONDUCTED BY:	GE, Nuclear Instrumentation Department, San Jose, Calif.

512 303

TITLE: Basic Impulse Level Test — Test #EPAQ-034

PRODUCT: High Voltage Power Penetration Assembly (15kv)

OBJECTIVE: Verify the high voltage power penetration assembly will meet the impulse requirements.

DESCRIPTION: High Voltage Power Penetration - 18" diameter, concentric shielded cable design.

Cable type: GE SI-58224

At each voltage level the potential was applied three times.

Environmental temperature: $0^{\circ}C$ - $30^{\circ}C$
Standard: ASA C37.20 - 1965, paragraph 20.5.2.12
Crest Voltage: 75KV, 95KV, 110KV

RESULTS: All tests were completed successfully.

TEST	NOZZLE	CONDUCTOR A	CONDUCTOR B	CONDUCTOR C
1	Ground	75KV	Ground	Ground
2	Ground	Ground	75KV	Ground
3	Ground	Ground	Ground	Ground
4	Ground	95KV	Ground	Ground
5	Ground	Ground	95KV	Ground
6	Ground	Ground	Ground	95KV
7	Ground	110KV	Ground	Ground
8	Ground	Ground	110KV	Ground
9	Ground	Ground	Ground	110KV

DATE: 1/70

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 304

TITLE: Thermal Test (Continuous Current Test) — Test #EPAO-035

PRODUCT: High Voltage Power Penetration Assembly (15kv)

OBJECTIVE: Verify the current carrying capabilities of High Voltage Power Penetration Assembly.

DESCRIPTION: High Voltage, Power Penetration Assembly - 18" diameter, concentric shielded cable design.

Standard: ASA 37.20-1965, paragraph 20-5.22
Temperature: $10^{\circ}-30^{\circ}C$
Test Currents: 600, 650, 700, 750, 800 amperes

Temperature of conductors to be monitored by thermocouples. Temperature to be monitored horizontally and vertically about the nozzle.

RESULTS:

Maximum Conductor Temperature Rise (°C)	14	16	23	31
Current (amperes)	600	675	750	850

The test data is used to establish current carrying capability rules for the High Voltage Power Penetration.

DATE: 1/70

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 305

TITLE: Surge Current Test — Test #EPAQ-036

PRODUCT: High Voltage Power Penetration Assembly (15kv)

OBJECTIVE: Verify the high voltage power penetration assembly will meet the requirements for surge currents due to motor starting.

DESCRIPTION: High Voltage Power Penetration Assembly - 18" diameter, concentric shielded cable design.

Temperature: 10°C-30°C.
Current Values: 3000 amperes, 4000 amperes
4500 amperes, 5100 amperes
*Duration: 30 seconds

The temperature of the conductors will be monitored during the test in which the specified currents will be applied to each conductor simultaneously.

*Duration varied because of time required to attain the desired currents. Total time at full current is 30 seconds.

RESULTS: The tests proved the assembly would meet the surge current requirements without degradation of the assembly.

Maximum Conductor Conductor Rise (°C)	9°	10°	14°	20°
Current (amperes)	3000	4000	4500	5100

DATE: 1/70

LOCATION: GE, High Power Laboratory, Philadelphia, Pa.

CONDUCTED BY: GE, High Power Laboratory, Philadelphia, Pa.

512 306

TITLE: Epoxy Insulation Resistance Test -- Test #EPAQ-037

PRODUCT: Cast Epoxy Insulating Compounds

OBJECTIVE: Verify the vacuum cast epoxy can withstand a long term high humidity environment.

DESCRIPTION: Ten different epoxy formulations were tested. Fifty samples were made with electrodes cast in the epoxy. The samples were inserted in glass tubes which had water at the bottom of the tube. The tube was heated for the duration of the test to keep the relative humidity limits high.

Insulation resistance measured periodically at 500 and 1000 volts test voltage.

Relative humidity: approximately 100%
Duration: 19 months

RESULTS:

(1) Three epoxy formulations broke down after six weeks exposure (epoxy became soft).

(2) All other samples remained intact, some exhibiting a slight loss in hardness from Shore D 55 down to Shore D 25.

(3) Insulation resistance levels: $1x10^{8}$ ohm-cm (except for formulations that broke down).

Results indicate the vacuum cast epoxy used in the penetration assemblies can withstand the long term effects of high humidity and still maintain insulation resistance levels which allow operation of electrical circuits.

DATE: 2/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 307

TITLE: Insulation Resistance Test — Test #EFAQ-038

PRODUCT: Shielded Signal Penetration Assembly

OBJECTIVE: Verify the shielded signal penetration coaxial cables can meet insulation resistance requirements.

DESCRIPTION: Coaxial cables insulation resistance from conductor to shield and shield to ground was measured using a megohmmeter. Test Voltage was 500 VDC.

Temperature: Ambient (70°F)
Pressure: 0 psig
Relative humidity: Ambient (50%)

Eight coaxial cables and their connectors were tested. (Standard production test presently).

RESULTS: *All but one of the cables measured:

Insulation Resistance: $>1x10^{12}$ ohm - conductor to shield; $>1x10^{8}$ ohm - shield to ground

*The one cable that failed ($5x10^{5}$ ohm) was due to an assembly error.

The coaxial cables successfully met the test requirements.

DATE: 1/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 308

TITLE: Insulation Resistance Test — Test #EPAQ-039

PRODUCT: Shielded Signal Penetration Assembly

OBJECTIVE: Verify the shielded signal penetration twisted shielded cables can meet insulation resistance requirements.

DESCRIPTION: The insulation resistance of twisted shielded cables was measured using a megohmmeter. The test voltage was 500 VDC. The insulation resistance between conductors and shields and ground was measured.

Temperature:	Ambient (70°F)
Pressure:	0 psig
Relative Humidity:	Ambient (50%)

(Standard production test presently)

RESULTS:

All cables measured the following:

Conductors to shield: $>1x10^{11}$
Shield to ground: $>1x10^{8}$

All conductors successfully met the test requirements.

DATE: 1/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 309

TITLE: High Potential Test — Test #EPAQ-040

PRODUCT: Medium Voltage Power Penetration Assembly (5kv)

OBJECTIVE: Verify the conductors of the medium voltage power penetration will meet or exceed high potential requirements.

DESCRIPTION:

Temperature:	Ambient (70°F)
Pressure:	0 psig
Relative humidity:	Ambient (50%)

Standard IPCEA S-19-81 (11KV for 1 minute)

Each conductor of the 3 phase system was tested. The assembly conductors were tested at levels higher than the standard required.

RESULTS: All conductors passed high potential tests that exceeded the IPCEA standard requirements.

	TEST	IPCEA
Test Voltage	13.5 KV	11 KV
Duration	4 minutes	(minute)

DATE: 3/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

TITLE: High Potential Test — Test #EPAQ-041

PRODUCT: Low Voltage Power Penetration Assembly

OBJECTIVE: Verify the low voltage power penetration conductors will meet high potential requirements.

DESCRIPTION: Each conductor of the low voltage power penetration (600 volt conductors) was tested to all other conductors and to ground.

Temperature:	Ambient (70°F)
Pressure:	0 psig
Relative humidity:	Ambient (50%)
Test Voltage:	2800 VRMS
Duration of test:	4 seconds

(Standard production test presently)

RESULTS: All conductors passed the high potential test successfully.

DATE: 3/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 311

TITLE: High Potential Test — Test #EPAQ-042

PRODUCT: Shielded Signal Penetration Assembly

OBJECTIVE: Verify the shielded signal penetration assembly conductors can meet high potential requirements.

DESCRIPTION: Shielded signal penetration assembly contained coaxial cables and twisted shielded conductors. Each conductor was tested to withstand the specified voltage without breakdown to all other conductors, shields and ground. The test voltages were:

	VOLTAGE	DURATION
Coaxial cables	2300 VRMS	4 seconds
Twisted shielded pairs	1000 VRMS	4 seconds

(Presently a production test)

RESULTS: All conductors successfully passed the test.

DATE: 3/67

LOCATION: GE, Nuclear Instrumentation Department, San Jose, California

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, California

512 312

TITLE: Insulation Resistance Test Test #EPAQ-043

PRODUCT: Low Voltage Power Penetration Assembly

OBJECTIVE: Verify the low voltage power penetration assemblies conductors will meet the required insulation resistance levels.

DESCRIPTION: The low voltage power penetration contained 600 volt conductors. The insulation resistance between conductors and between conductors and ground was measured.

(Test voltage was 500 VDC)

(Presently a standard production test)

RESULTS: For all cables the insulation resistance was greater than $1X10^{8}\ \Omega$.

All conductors successfully met the test requirements.

DATE: 3/67

LOCATION: G.E. Nuclear Instrumentation Dept., San Jose, Calif.

CONDUCTED BY: G.E. Nuclear Instrumentation Dept., San Jose, Calif.

DOCUMENTATION:

TITLE: Vertical Flame Resisting Test — Test #EPAQ-0.4

PRODUCT: Cross-linked polyethylene insulated conductors

OBJECTIVE: Verify the conductors used in the low voltage power and control assemblies will meet the vertical flame test per IPCEA S-19-81.

DESCRIPTION: Cable Type: GE SI-57275

Tested per IPCEA S-19-81, NEMA WC3-1964, paragraph 6.19.6

RESULTS: The conductors successfully met the requirements of the vertical flame resisting test.

DATE: —

LOCATION: GE, Wire & Cable Department, Bridgeport, Connecticut

CONDUCTED BY: GE, Wire & Cable Department, Bridgeport, Connecticut

512 314

TITLE: Flame Resisting Test — Test #EPAQ-045

PRODUCT: Cross-linked polyethylene insulated conductors

OBJECTIVE: Verify the conductors of the medium (5kv) and high (15kv) will meet the requirements of IPCEA S-19-81 flame resisting test.

DESCRIPTION: Cable types: GE SI-58065
GE SI-58224

Tested per IPCEA S-19-81

Vertical flame test: paragraph 6.19.6
Horizontal flame test: paragraph 6.13.2

RESULTS: The conductors successfully met the requirements of the horizontal flame resisting test but did not pass the vertical flame resisting test. The conductors are classified flame resisting by the horizontal flame resisting test only.

DATE: —

LOCATION: GE, Wire and Cable Department, Bridgeport, Connecticut

CONDUCTED BY: GE, Wire and Cable Department, Bridgeport, Connecticut

512 315

TITLE: Epoxy Radiation Test — Test #EPAQ-046

PRODUCT: Cast Epoxy Insulating Compounds

OBJECTIVE: Verify the vacuum cast epoxy used as the sealant in Electrical Penetration Assemblies will meet radiation requirements.

DESCRIPTION: The base resin was exposed to a radiation source, cobalt 60. The radiation was mainly gamma photons.

RESULTS:

(1) Resin unchanged when exposed to 10^8 rads

(2) 2.5% weight loss at 3×10^8 rads

DATE: —

LOCATION: Minnesota Mining & Manufacturing Company, St. Paul, Minn.

CONDUCTED BY: Minnesota Mining & Manufacturing Company, St. Paul, Minn.

Test #EPAQ-047

TITLE: Cross-linked Polyethylene Insulation Radiation Test —

PRODUCT: Cross-linked Polyethylene Insulation

OBJECTIVE: Verify the cross-linked polyethylene insulated conductors will meet radiation exposure requirements.

DESCRIPTION: Cable type: GE SI-57275

Two samples of each of AWG #14, AWG #12, AWG #2

One sample of each size exposed to the following

4×10^7 Roentgens

2×10^7 Roentgens

The samples were exposed to elevated temperatures (140°-180°C) and allowed to cool. Then the samples were soaked in water for six hours and then hi-potted. Elongation and tensile tests were then conducted

RESULTS: Hi Potential Tests

#14 AWG - 3 KV (AC) for 5 minutes

#12 AWG - 3 KV (AC) for 5 minutes

2 AWG - 3.5 KV (AC) for 5 minutes

All conductors passed the high potential test.

Samples	Tensile Strength of Insulation (psi)	% Elongation of Insulation
#14 (2×10^7 Roentgens)	1998	260
#14 (4×10^7 Roentgens)	1839	163
#12 (2×10^7 Roentgens)	2015	237
#12 (4×10^7 Roentgens)	2014	157
#2 (2×10^7 Roentgens)	2616	167
#2 (4×10^7 Roentgens)	2786	125
Typical original values	2000	220
Guaranteed values	1800	150

512 317

All samples will withstand the emergency temperature, radiation and relative humidity requirements without failure.

DATE: —

LOCATION: GE, Test Reactor Facility, Vallecitos, California

CONDUCTED BY: GE, Test Reactor Facility, Vallecitos, California

512 318

TITLE: Hydrostatic Pressure Test — Test #EPAQ-049

PRODUCT: Low Voltage Power & Control Penetration Assembly

OBJECTIVE: Verify the low voltage power and control penetration assembly will maintain its integrity when exposed to high pressure.

DESCRIPTION:

Temperature:	Ambient ($70^{o}F$)
Pressure:	124 psig (air), then 186 psig
Relative Humidity:	Ambient (50%)
Duration:	60 minutes

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leak rate 1×10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 5/67

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 319

TITLE:	Hydrostatic Pressure Test — Test #EPAQ-050
PRODUCT:	Medium Voltage Power Penetration (5 KV)
OBJECTIVE:	Verify the medium voltage power penetration assembly will maintain its integrity when exposed to high pressure.

DESCRIPTION:

Temperature:	Ambient (70°F)
Pressure:	124 psig (air), then 186 psig
Relative Humidity:	Ambient (50%)
Duration:	60 minutes

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leak rate 1×10^{-3} cc/sec.

RESULTS:	The assembly successfully met the test. No detectable Leakage.
DATE:	5/67
LOCATION:	Ogden Technology Laboratories, Inc., Sunnyvale, Calif.
CONDUCTED BY:	Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 320

TITLE: Hydrostatic Pressure Test — Test #EPAQ-051

PRODUCT: Shielded Signal Penetration Assembly

OBJECTIVE: Verify the shielded signal penetration assembly will maintain its integrity when exposed to high pressure.

DESCRIPTION:

Temperature:	Ambient (70°F)
Pressure:	124 psig (nitrogen), then 186 psig (air)
Relative Humidity:	Ambient (50%)
Duration:	60 minutes

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leakage rate $1 \times 10^{-?}$ cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 12/66

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 321

TITLE: Hydrostatic Pressure and Humidity Test — Test #EPAQ-052

PRODUCT: Low Voltage Power and Control Penetration Assembly

OBJECTIVE: Verify the low voltage power and control penetration assembly will maintain its integrity when exposed to containment vessel design pressure and high humidity.

DESCRIPTION:

Temperature:	Ambient (70°F)
Pressure:	62 psig (air)
*Relative Humidity:	100%
Duration:	180 minutes

*Submerge one end of the assembly in deaerated water for duration of test. Other end, ambiant humidity (50%).

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leakage rate 1 x 10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 5/67

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 322

TITLE: Hydrostatic Pressure and Humidity Test — Test #EPAQ-053

PRODUCT: Medium Voltage Power Penetration Assembly

OBJECTIVE: Verify the medium voltage power penetration assembly will maintain its integrity when exposed to containment vessel design pressure and high humidity.

DESCRIPTION:

Temperature:	Ambient (70°F)
Pressure:	62 psig (air)
*Relative Humidity:	100%
Duration:	180 minutes

*Submerge one end of the assembly in deaerated water for duration of test. Other end, ambient humidity (50%).

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leakage rate 1×10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 5/67

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 323

TITLE: Hydrostatic Pressure and Humidity Test — Test #EPAQ-054

PRODUCT: Shielded Signal Penetration Assembly

OBJECTIVE: Verify the shielded signal penetration assembly will maintain its integrity when exposed to containment vessel design pressure and high humidity.

DESCRIPTION:

Temperature:	Ambient (70°F)
Pressure:	62 psig (air)
*Relative Humidity:	100%
Duration:	180 minutes

*submerge one end of the assembly in deaerated water for duration of test. Other end, ambient humidity (50%).

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leakage rate 1×10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 12/66

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 324

TITLE: Emergency Environmental Test — Test #EPAQ-055

PRODUCT: Low Voltage Power and Control Penetration Assembly

OBJECTIVE: Verify the low voltage power and control penetration assembly will meet accident environment conditions.

DESCRIPTION:

(1) Apply saturated steam (124 psig, 352°F) at one end of the assembly for 30 minutes.

(2) Reduce to 62 psig, 309°F saturated steam for 23-1/2 hours.

(3) Allow assembly to cool to 135°F (submerge in 135°F water), pressure (62 psig). Maintain temperature and keep assembly submerged for 3 hours.

(4) Monitor leak rate throughout the test.

Leak rate determined by volumetric method. Submerge penetration seal in container of [illegible] water. minimum detectable leakage rate 1×10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 5/67

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 325

TITLE: Emergency Environmental Test — Test #EPAQ-056

PRODUCT: Medium Voltage Power Penetration Assembly

OBJECTIVE: Verify the medium voltage power penetration assembly will meet accident environment conditions.

DESCRIPTION:

(1) Apply saturated steam (124 psig, 352°F) at one end of the assembly for 30 minutes.

(2) Reduce to 62 psig, 309°F saturated steam for 23-1/2 hours.

(3) Allow assembly to cool to 135°F (submerge in 135°F water), pressure (62 psig). Maintain temperature and keep assembly submerged for 3 hours.

(4) Monitor leak rate throughout the test.

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leakage rate 1 x 10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 5/67

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 326

TITLE: Emergency Environmental Test — Test #EPAQ-057

PRODUCT: Shielded Signal Penetration Assembly

OBJECTIVE: Verify the shielded signal penetration assembly will meet accident environment conditions.

DESCRIPTION:

(1) Apply saturated steam (124 psig, 352°F) at one end of the assembly for 30 minutes.

(2) Reduce to 62 psig, 309°F saturated steam for 23-1/2 hours.

(3) Allow assembly to cool to 35°F (submerge in 135°F water), pressure (62 psig). Maintain temperature and keep assembly submerged for 3 hours.

(4) Monitor leak rate throughout the test.

Leak rate determined by volumetric method. Submerge penetration seal in container of deaerated water. Minimum detectable leakage rate 1×10^{-3} cc/sec.

RESULTS: The assembly successfully met the test. No detectable leakage.

DATE: 12/66

LOCATION: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

CONDUCTED BY: Ogden Technology Laboratories, Inc., Sunnyvale, Calif.

512 327

Report #AEPAQ 1

TITLE: Effects of Jets Forces on Electrical Penetrations —

PRODUCT: Electrical Penetration Assemblies

OBJECTIVE: Verify by analysis that the electrical penetration assemblies will maintain containment integrity when exposed to jet forces.

DESCRIPTION: The penetration is installed in a nozzle (12", schedule 80 pipe) with junction boxes provided at both ends of the penetration. A jet of steam and water (1250 psig) for 200 seconds would result from severing the recirculation header. The effects of jets from different directions was investigated, as was the effect on the penetration cables.

RESULTS:

	Low Voltage & Signal Penetration	Medium Voltage Penetration
Maximum moment stressing weld between nozzle and containment wall	1,857,000 in-lb	1,867,000 in-lb
Maximum shear force on the weld between the nozzle and containment wall.	401,000 lb.	251,000 lb.
Maximum force (jet directed front of assembly)	770,000 lb.	770,000 lb.
Integrity maintained	yes, jets from any direction	yes, jets from any direction (cables larger than 250MCM have release couplings to prevent transmission of excessive forces to pressure barrier)

512 328

DATE: 1967

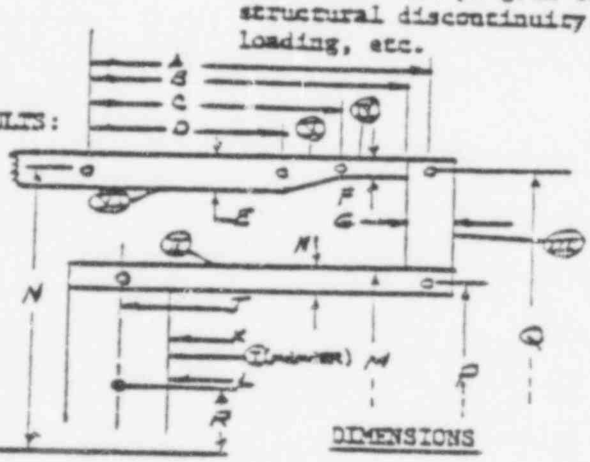
LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 329

TITLE:	Stress Analysis Report — Report #AEPAQ-2
PRODUCT:	Electrical Penetration Assemblies
OBJECTIVE:	Verify the structural material and fabrication of the Electrical Penetration Assembly shall be in accordance with requirements of the ASME Boiler and Pressure Vessel Code, Section III, Class B Vessel.
DESCRIPTION:	The standardized configuration for the Low Voltage Power Penetration Assembly, Medium Voltage Power Penetration Assembly, Medium Voltage Power Penetration Assembly, and Shielded Signal Penetration Assembly was analyzed as component parts. A model was designed to determine the stresses in the individual members. A computer program, Multi-Shell III (SNAP), was used to evaluate the model stresses. The program considers thermal stresses, structural discontinuity, different material, physical loading, etc.

RESULTS:



The analysis confirmed that the configurations are structurally acceptable for use in Class B Vessel ASME Boiler & Pressure Vessel Code per GE final product specification.

A 6.310 inches
B 6.120 inches
C 5.370 inches
D 4.370 inches
E 0.687 inches
F 0.375 inches
G 0.380 inches
H 0.453 inches

J 4.193 inches
K 4.630 inches
L 0.875 inches
M 5.500 inches
N 6.032 inches
P 5.272 inches
Q 6.187 inches
R 0.420 inches

512 330

RESULTS: (Continued)

SEN-3A Electrical Penetration Seal R Side, 12" Dia. 62 PSI 310°F SS, w/o Reinf.

		MIDDLE SURFACE STRESSES psi		BENDING STRESSES psi		EFFECTIVE STRESSES psi ($P_L + P_b + Q$)	
Member	Joint	Tangential	Circumferential	Tangential	Circumferential	Inner Surface	Outer Surface
1	1	0	- 3288	0	- 15,319	19,107	12.531
	2	- 1737	- 1759	- 4233	- 5,506	6,712	3,304
2	2	358	1979	-15,794	- 4,738	26,401	21,592
	3	358	- 1388	- 3864	- 1,159	3,138	4,341
[illegible]	3	459	- 1357	- 5489	- 1,897	4,419	5,699
	4	211	- 1109	1396	- 52	2,407	1,126
4	5	- 509	265	- 2722	- 816	2,993	1,916
	4	- 509	- 1325	- 1433	- 430	1,856	1,575
5	6	- 292	671	- 246	- 83	975	778
	5	- 503	194	- 2722	- 842	2,954	1,923
6	7	- 299	525	0	0	722	722
	6	- 299	607	- 246	- 74	934	709

DATE: 1/10/68

LOCATION: GE, Nuclear Instrumentation Department, San Jose, Calif.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, Calif.

512 331

TITLE: Summary LOFT Cable Tests — Report #AEPAQ-3

PRODUCT: Various types of cable

OBJECTIVE: Determine the effects of radiation on different types of cable.

DESCRIPTION: Several different types of cable were tested. The tests included irradiation, exposure to high humidity and temperature (autoclave test), and chemical testing.

RESULTS:

Insulation Material	Test	Results
Synthetic Rubber	Irradiated to 5×10^5R plus autoclave and chemical testing	Insulation resistance dropped 3 deca[illegible] [illegible] samples $>1 \times 10^{[illegible]}$ Ω/ft. (Minimum acceptable value)
Chemically cross-linked polyethylene (GE SI-57275)	Irradiated to 1×10^5R plus autoclave and chemical testing	Minimum insulation resistance 2.5×10^7 Ω/ft. Irradiation effects on resistance negligible. Chemical decontamination solutions only slightly discolored samples. Minimum acceptable value 1×10^7 Ω/ft.
Polyethylene with PVC jacket (RG-59 coax)	Irradiated to 5×10^5R plus autoclave testing	Cable failed. Insulation resistance dropped to 2×10^7 Ω/ft. on second autoclave test. Center conductor buckled. Minimum acceptable value 1×10^{12} Ω/ft.
Irradiated cross-linked polyethylene primary with irradiated cross-linked polyolafin jacket. (RG-59 coax)	Irradiated to 5×10^5R plus autoclave and chemical testing	Several samples were given the tests in different sequence. All samples, insulation resistance below minimum acceptable value of 1×10^{12} Ω/ft. Lowest value was 2×10^8 Ω/ft. on a sample after it was given a second autoclave test.

512 332

RESULTS: (Continued)

Insulation Material	Test	Results
Cross-linked polyethylene primary with jacket (RG-59 coax)	Irradiated to 5×10^5R plus autoclave and chemical testing	Insulation resistance below minimum acceptable value of $1 \times 10^{12}\ \Omega$/ft. Little effect from decontamination solutions.
Teflon primary and jacket (RG-59 coax)	Irradiated to 10^5R plus autoclave testing	Insulation resistance decreased to $2 \times 10^{12}\ \Omega$/ft. from radiation alone. Porousity of teflon jacket allowed steam to enter and rust shield.
Polyethylene (coax)	Irradiated to 10^6R plus autoclave testing	Sample failed due to short between center conductor and inner shield.
Teflon primary with teflon jacket (coax)	Irradiated to 10^6R plus autoclave testing.	Steam and water leakage from exposed cable ends during autoclave test. Insulation resistance $2 \times 10^7\ \Omega$/ft. Minimum acceptable value $1 \times 10^{12}\ \Omega$/ft.

DATE: 6/68

LOCATION: Nuclear Reactor Testing Station, Idaho Falls, Idaho

CONDUCTED BY: Nuclear Reactor Testing Station, Idaho Falls, Idaho

512 333

— Report #AEPAQ-4

TITLE: "Radiation Damage to Elastomers, Organic Liquids and Plastics"

PRODUCT: Elastomers, Organic Liquids and Plastics

OBJECTIVE: Determine the radiation damage to the materials listed below.

DESCRIPTION: Irradiation temperature 75°F - 105°F

The threshold and 25% damage due to gamma photons was determined.

RESULTS:

Plastic	Roentgens of Gamma Photons	
	Threshold	25% Damage
Nylon (FM 10001, FM-1, FM 3003)	9.2×10^{5}	5.0×10^{6}
Polyethylene (Polythene)	2.0×10^{7}	9.6×10^{7}
Teflon	2×10^{4}	4.5×10^{4}
PVC (Geon 2046)	2.2×10^{7}	1.3×10^{3}
Polyvinyl Formal (Formvar)	1.7×10^{7}	8.9×10^{7}
Mylar	3.4×10^{7}	1.4×10^{3}

Material	Threshold	25% Damage
Natural Rubber	2.1×10^{6}	2.6×10^{7}
Butyl Rubber	2.1×10^{5}	4.1×10^{6}
Buna-S	2.1×10^{6}	1.1×10^{7}
Hycar OR	2.2×10^{6}	7.5×10^{6}
Neoprene	2.2×10^{6}	6.1×10^{6}
Hycar PA	1.1×10^{6}	3.6×10^{6}
Thiokol ST	5.7×10^{5}	1.7×10^{6}
Silicone Rubber SE 550	9.8×10^{5}	6.0×10^{6}
Silicone Rubber SE 550	9.8×10^{5}	8.2×10^{6}
Silicone Rubber SE 551	9.8×10^{5}	1.1×10^{7}
Silicone Rubber SE 371	9.8×10^{5}	1.3×10^{7}
Silicone Rubber SE 750	9.3×10^{5}	6.8×10^{5}
Silicone Rubber Silastic 7-170	1.4×10^{6}	4.6×10^{6}

REPORT: Issued by Office of Technical Services, U.S. Department of Commerce

512 334

TITLE: Short Circuit Test -- Test No. EPAQ-058

PRODUCT: High Voltage Penetration Assembly

OBJECTIVE: Verify the superior performance of the concentric shielded cable design over the porcelain bushing design.

DESCRIPTION: Two 15 KV rated penetration assemblies were subjected to momentary current tests. The first was a concentric shielded cable design and the other was a "hybrid" design with porcelain bushings at one end of the assembly and epoxy bushings at the other end. Each unit had three conductors in a triangular configuration to simulate a three phase circuit. The conductors were terminated to cables, mounted perpendicular to the penetration assembly. The assembly was pressurized to 60 psig and a gauge was used to monitor the pressure during the test.

Cable Type: GE SI-58224

The test was per ASA C37.20-1965, paragraph 20-5.2.3. Temperature- 10°-30°C. Currents tests to be at 40K, 60K, 80K amperes, rms (60 cycle AC) for 10 cycles (three phase).

RESULTS: The concentric shielded cable design successfully passed all the tests as did the epoxy bushing, while the porcelain bushing failed (shattered) at 60,000 amperes.

512 335

Concentric Shielded Cable Design

Run	Inrush Current Amp, RMST (Max)	End-of-Fault Current Amp, RMST (Max)	Duration 1/2~	Pressure Psig	Conductor Resistance Ohms		
					A	B	C
Before	--	--	--	60	117	118	117
1	30,000	21,800	22	60	117	118	117
2	21,000	14,600	21	60	117	118	117
3	83,000	47,900	21.5	60	117	118	117

Bushing Design

Run	Inrush Current Amp, RMST (Max)	End-of-Fault Current Amp, RMST (Max)	Duration 1/2~	Pressure Psig	Conductor Resistance Ohms		
					A	B	C
Before	--	--	--	60	70	70	70
1	8,750	6,800	24	60	70	70	70
2	43,000	28,500	23	60	70	70	70
3	60,000	40,000	23	0	70	70	70
4	85,500	52,500	23	0	70	70	70

512 336

TITLE: Low Temperature Test -- Test No. EPAQ-059

PRODUCT: Low Voltage Assembly

OBJECTIVE: Verify the performance of the penetration assemblies when exposed to low temperature and rapid temperature change.

DESCRIPTION: The prototype assembly included three No. 2/0 AWG in a steel header. A thermocouple was used to monitor internal epoxy temperature. The assembly was mounted to two sealed chambers to allow an 8 psi differential pressure to be applied across the seal. The entire assembly was placed into a temperature controlled oven and thermocycled 5 times. The cycle was:

-20°F to 180°F	In 8 hours
180°F	For 4 hours
180°F to -20°F	In 4 hours
-20°F	For 4 hours

RESULTS: The assembly successfully maintained mechanical integrity throughout the thermocycling.

512 337

TITLE: Maximum Emergency Environmental--Test #EPAQ-060.

PRODUCT: Shielded Signal Penetration Assembly.

OBJECTIVE: Verify the penetration will maintain its integrity and electrical functions when exposed to reactor maximum emergency conditions.

DESCRIPTION:

Temperature, °F	340	340	320	250	200*
Pressure, psig	63	35	35	25	20*
Relative Humidity %	100	100	100	100	100*
Duration	15 min	3 hr	6 hr	24 hr	36 hr*

*Long term accident conditions tests had been conducted previously, (See EPAQ-007, 008, 009, 010)

A shielded signal penetration assembly containing #18 AWG and triaxial cables was pressurized under the above conditions. The insulation resistance of two of the triaxial cables and the #18 AWG cables was measured throughout the test. This was done to verify that electrical functions would be maintained when exposed to the above conditions.

A gas analyzer was used to determine the penetration leak rate throughout the test.

Thermocouples were used to monitor the temperature throughout the test.

A pressure transducer and gauge were used to monitor the pressure during testing.

The penetration conductors were loaded such that 15 watts/foot of I^2R heating was generated.

512 338

RESULTS:

LEAK-RATE

Time Sample Taken (elapsed hours)	2.5	2.5	5.5	10	22	33	68
Temperature (°F)	340	340	320	250	250	250	200
Pressure (psig)	35	35	35	25	25	25	20
Leak Rate (cc/sec)	**1.1X10^{-3}	**5.8X10^{-3}	**5.8X10^{-3}	**8.7X10^{-4}	**8.7X10^{-4}	**2.4X10^{-4}	**2.4X10^{-4}

**Triaxial cables leaked. Maximum temperature rating of triaxial cables was 176°F.

After resealing the triaxial cables the penetration leak rate was 1X10^{-6} cc/sec (helium) at 63 psig. Containment integrity was verified.

ELECTRICAL

Temperature °F IR(Ω)	70 (pre test)	340	340	325	250	250	210	200	70 (post test)
#18 AWG (average value)	1.22X10^{12}	2.95X10^{8}	0.85X10^{8}	1.08X10^{8}	9.18X10^{8}	1.05X10^{9}	2.58X10^{9}	4.55X10^{9}	2.75X10^{11}

The #18 AWG conductors maintained high insulation resistance values throughout the test verifying that electrical functions would be maintained during the emergency conditions.

DATE: 4/30/71

LOCATION: GE, Nuclear Instrumentation Department, San Jose, California.

CONDUCTED BY: GE, Nuclear Instrumentation Department, San Jose, California.

Title: Maximum Emergency Environmental Test -- Test No. EPAQ-061

Product: Low Voltage Electrical Penetration Assembly

Objective: Verify that the electrical penetration assembly will maintain its integrity (the penetration assembly leak rate shall not exceed 1×10^{-4}cc/sec of nitrogen) when exposed to the specified maximum emergency environmental conditions.

Description:

	Phase 1	Phase 2
Temperature	340°F	281°F
Pressure	65 psig	65 psig
Relative Humidity	100%	100%
Duration (elapsed time)	6 hours	10 days

One end of the penetration assembly was exposed to Phase 1 conditions followed by Phase 2 conditions. The penetration assembly was leak tested throughout the period using gas chromatography equipment with nitrogen as the tracer gas. The equipment had a sensitivity of 1×10^{-6}cc/sec. A post-leak rate test at 65 psig was conducted using a helium mass spectrometer.

Results: Leak Rate (Gas Chromotography): $<1 \times 10^{-6}$cc/sec of nitrogen through the penetration assembly.

Leak Rate (Helium Mass Spectrometer): $<1 \times 10^{-6}$cc/sec of helium through the penetration assembly.

Date: The test was successfully completed 10/21/71 through 10/31/71.

Location: G. E. Nuclear Power Generation Control Department, San Jose, California.

Conducted By: G. E. Nuclear Power Generation Control Department, San Jose, California.

512 340