CAMERON

Measurement Systems

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ADDENDUM TO BARTON ENGINEERING REPORT NO. R3-580A-29

ENVIRONMENTAL EFFECTS ON 580A, 581A & 583A DIFFERENTIAL PRESSURE SWITCHES

NOTICE: Cameron International Corporation ("Cameron") is the legal owner of the aforementioned product. Instruments qualified under "ITT Barton" will continue to be supported under existing qualifications.

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PREPARED BY	ENGINEERING REPORT	REPORT NO: R3-580A-31
	TITLE:	PAGE NO: 1 OF 12
APPROVED BY 9-29-92	ENVIRONMENTAL EFFECTS ON THE 580 SERIES SWITCHES	DATE
		CASE NO:

1.0 INTRODUCTION

This report shall document the results of a series of tests conducted on the Models 580A and 581A to verify their reaction to temperature, nuclear radiation, and ambient pressure. On April 14, 1986, notification was made to the Nuclear Regulatory Commission that a potential problem existed when the ITT Barton Model 580 Series Differential Pressure Switches were subjected to high temperature during Loss of Coolant Accident (LOCA) testing. The problem manifested itself as microswitch malfunctions attributed to the 350°F temperature exposure. A second notification was conveyed to the NRC on June 16, 1986, which corrected the initial report to indicate that, although the microswitches did fail, the cause was not temperature, but entry of chemical-laden steam into the case. This resulted when the case was deflected by ambient pressure, breaking the torque tube O-ring seal.

While the shore durometer hardness of the ethylene propylene terpolymer (EPT) O-ring is not affected by exposure to Gamma radiation levels of as much as 50 X 10^6 Rads, the elastomer does change shape to conform to its containing cavity, partially losing its sealing ability. Thus, when the rear of the case is deflected by increased external pressure, the seal may allow the outside atmosphere to enter, depending on the amount of radiation exposure and pressure.

Since the time of the NRC notification, the Models 580A, 581A and 583A Switches have been supplied to the nuclear power plant industry for usage in mild environments, not requiring LOCA qualification, but even under mild environment conditions, the instruments may be exposed to radiation, pressure and abnormal temperatures. The primary intent of this test program was to determine the amount of radiation exposure vs external case pressure which would result in failure of the torque tube seal. A secondary series of tests were conducted to determine the effects on switch setpoints when the case was subjected to increasing external pressure then, finally, temperature tests to verify that the instruments would remain within the required parameters.

2.0 RESULTS AND CONCLUSIONS

The following conclusions are based on the information derived from a limited number of test instruments. The graph (Figure 1), provided as a part of this report, showing radiation exposure relative to external case pressure to cause seal failure, is predicated on a single instrument exposed to each radiation level, with the exception of 50 megarads where two instruments were radiated. The second 50 megarad unit withstood approximately 33% more pressure, indicating that radiation vs pressure is not an exact relationship, although the other radiation test points are consistent with the curve. For conservatism, an arbitrary error factor has been applied on the graph by reducing the withstand pressure 10 psi at each radiation exposure level to allow for possible instrument variations. As may be seen on the graph, the integrity of the seal remains intact up to an exposure of 20 megarads when the case is subjected to the 75 psi maximum external pressure. When applying the error factor, the pressure is reduced to 65 psi and, if projected, the 580 Series instruments will withstand the full 75 psi after exposure to 15 MR. Conversely, they will withstand 25 psi external pressure after exposure to 50 MR of radiation.

The second objective, as required by Test Procedure 9999-32672 (Attachment A), is a determination of switch setpoint changes relative to the application of external case pressure. Referring to Figures 2 and 3, indicates that in both instruments, the low switch setpoint decreased, while the high switch setpoint increased as the pressure advanced. The setpoint changes, attributable to deflection of the rear of the case, reached maximums of – 11.8% for the low switch and + 15.4% for the high switch at 75 psi external pressure on one instrument per Figure 2 and –8.3% low switch, + 16.7% high switch on the second unit Per Figure 3.

The switch setpoints at each case pressure are the average of three successive runs where repeatability and deadband were predominantly less than 0.5% with no indication of blackout between the switch contacts. Case deflections were obtained for Engineering information only, to determine correlation between the movement of the rear surface relative to seal leakage. The amount of deflection varied between 0.021" to 0.055" when the case was exposed to 75 psi external pressure with accompanying radiation levels from 0 to 20 megarads. The torque tube seal remained intact. At radiation levels from 30 to 50 megarads and 0.0215" to 0.032" deflections, there were seal failures, confirming the Figure 1 graph.

The testing which was conducted at various temperatures and internal case vacuum, simulating external pressure, indicated that these conditions were not a factor. The instruments remained within the allowable ± 10% setpoint error band when exposed to temperatures as high as 250°F and when subjected to simultaneous case pressures up to 15 psi. The torque tube seal remained intact under all exposures, as shown in Figures 4 and 5.

3.0 DISCUSSION

The test program was initiated by issuing Test Procedure 9999-3267.2 designed to determine the maximum external pressure that can be applied to the Model 580 Series Case at varying levels of radiation, to cause the torque tube seal to fail. Since an external pressure results in deflecting the back of the case with some residual deformation, it was necessary to expose a minimum of five instruments at radiation levels of 10, 20, 30, 40 and 50 megarads. This number was increased by three when two additional instruments were exposed to the pressure without being radiated, and a second unit was radiated to 50 megarads.

The first two instruments to be tested were installed in succession into a specially designed fixture where pneumatic pressure could be applied to the side and rear of the case, including the Differential Pressure Unit with its associated mounting bracket and torque tube seal. As the pressure was increased in 5 psi increments, the area around the torque tube entry into the case was monitored to determine when air was escaping through the seal.

After reaching the required 75 psi with no indication of seal failure, the test was terminated on both non-radiated instruments. The units to be subjected to nuclear radiation were transported to Radiation Sterilizers, Inc. in Tustin, California, where they were exposed to Gamma sources of $Cobalt^{60}$ at an approximate dose rate of 2×10^6 RADS/Hour. Each instrument was then installed in the test fixture and subjected to external pressure as described previously. The results of these tests are shown in Figure 1.

Although the temperature was not originally a part of the 9999-3267.2 Test Procedure, it was decided that this was a necessary ingredient that must be determined. Instrument were therefore installed into an environmental chamber with the high and low switch wiring routed to a test fixture to determine contact closures and tubing assembled to the differential pressure transducer high pressure housing. Tubing was also routed to a port on the case where vacuum could be applied to simulate external case pressure.

Measurements of switch setpoints were made at a temperature of + 80°F, then the chamber temperature was advanced sequentially to 180°F, 200°F, 225°F and 250°F where setpoints were checked at each level. Vacuum was next applied to the case at 180°F to determine if there were any synergistic effects. Refer to Figures 4 and 5 for the test results

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FIGURE 1

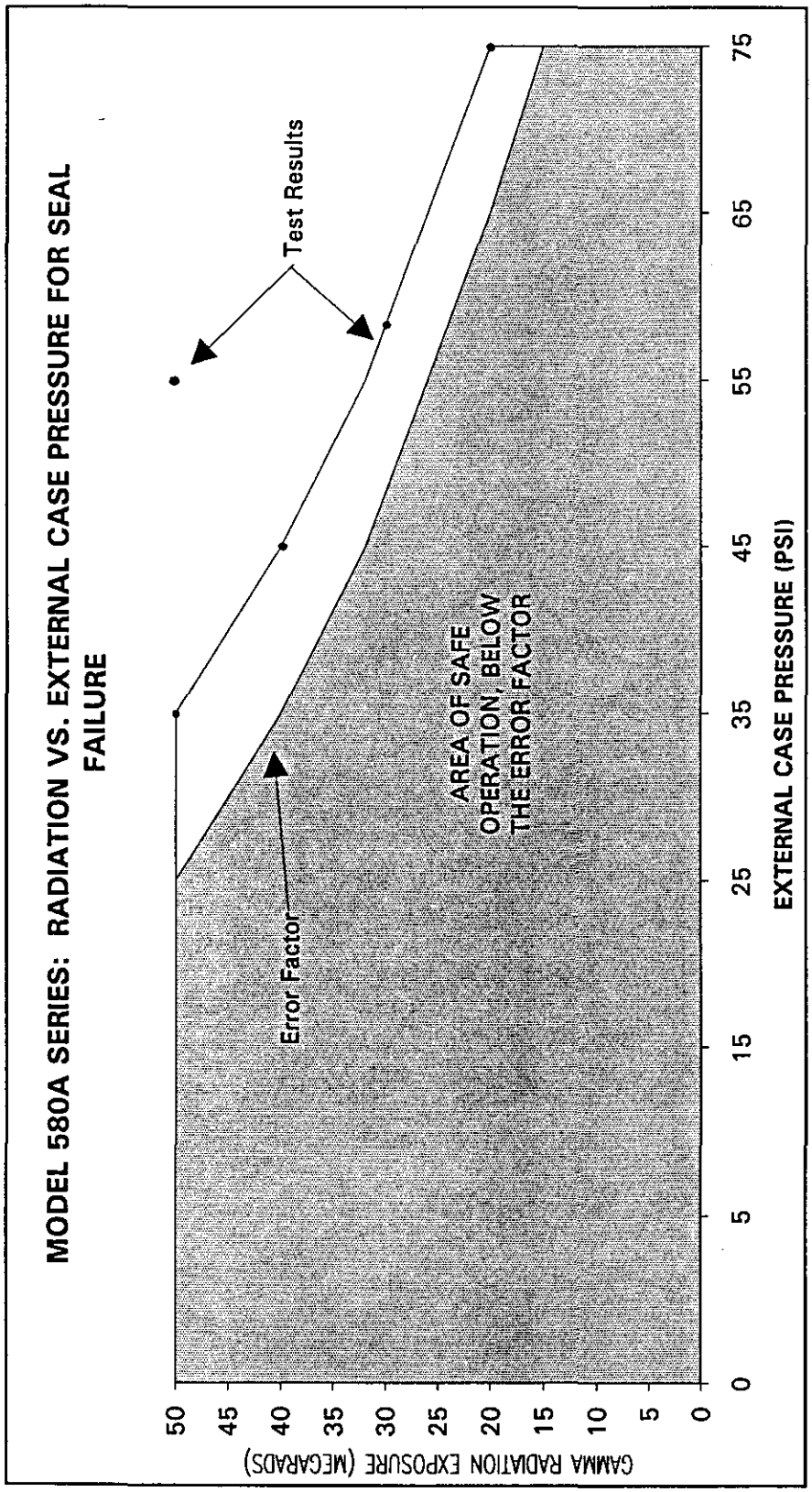

FIGURE 1

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FIGURE 2

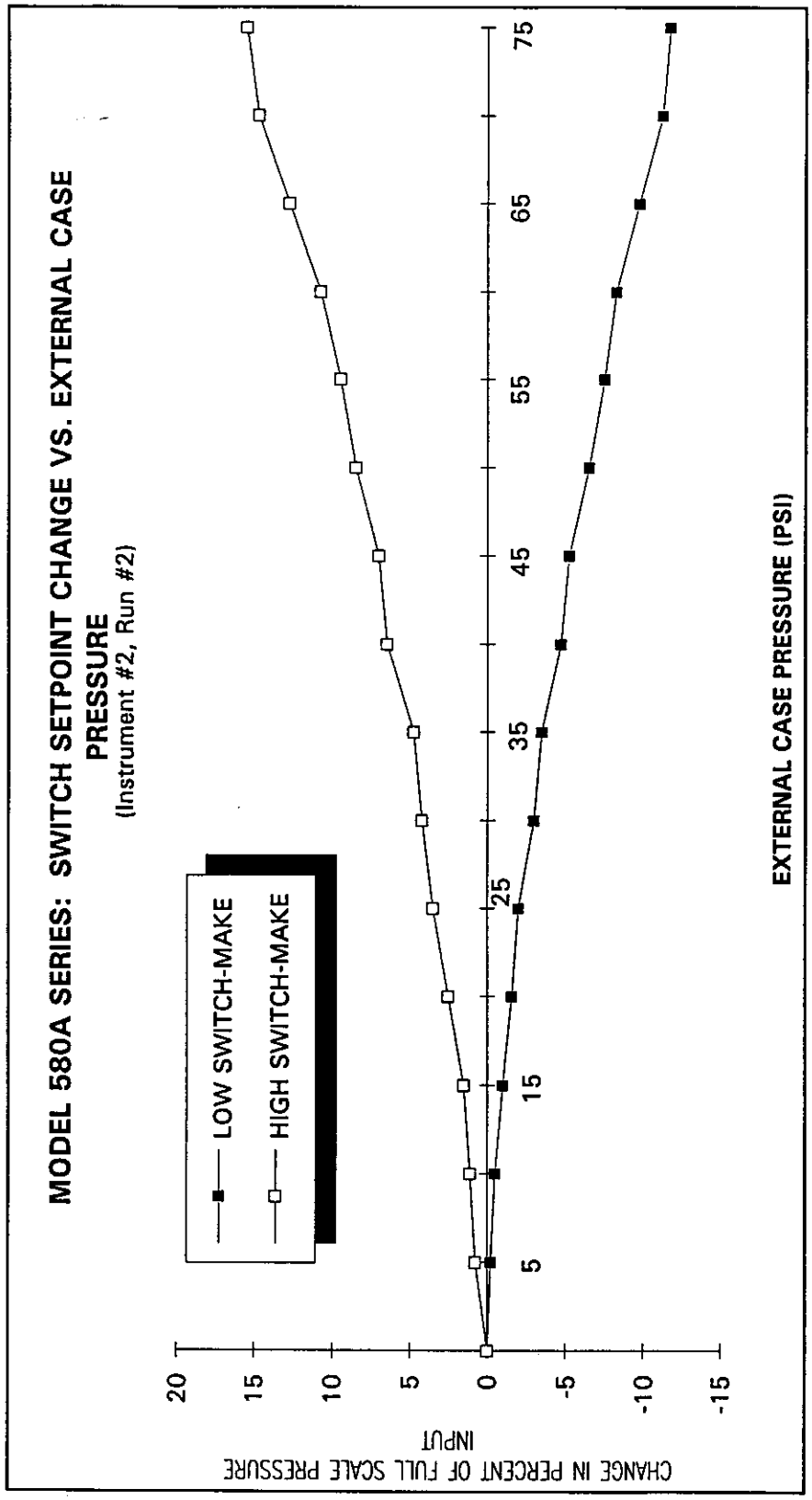

FIGURE - 2

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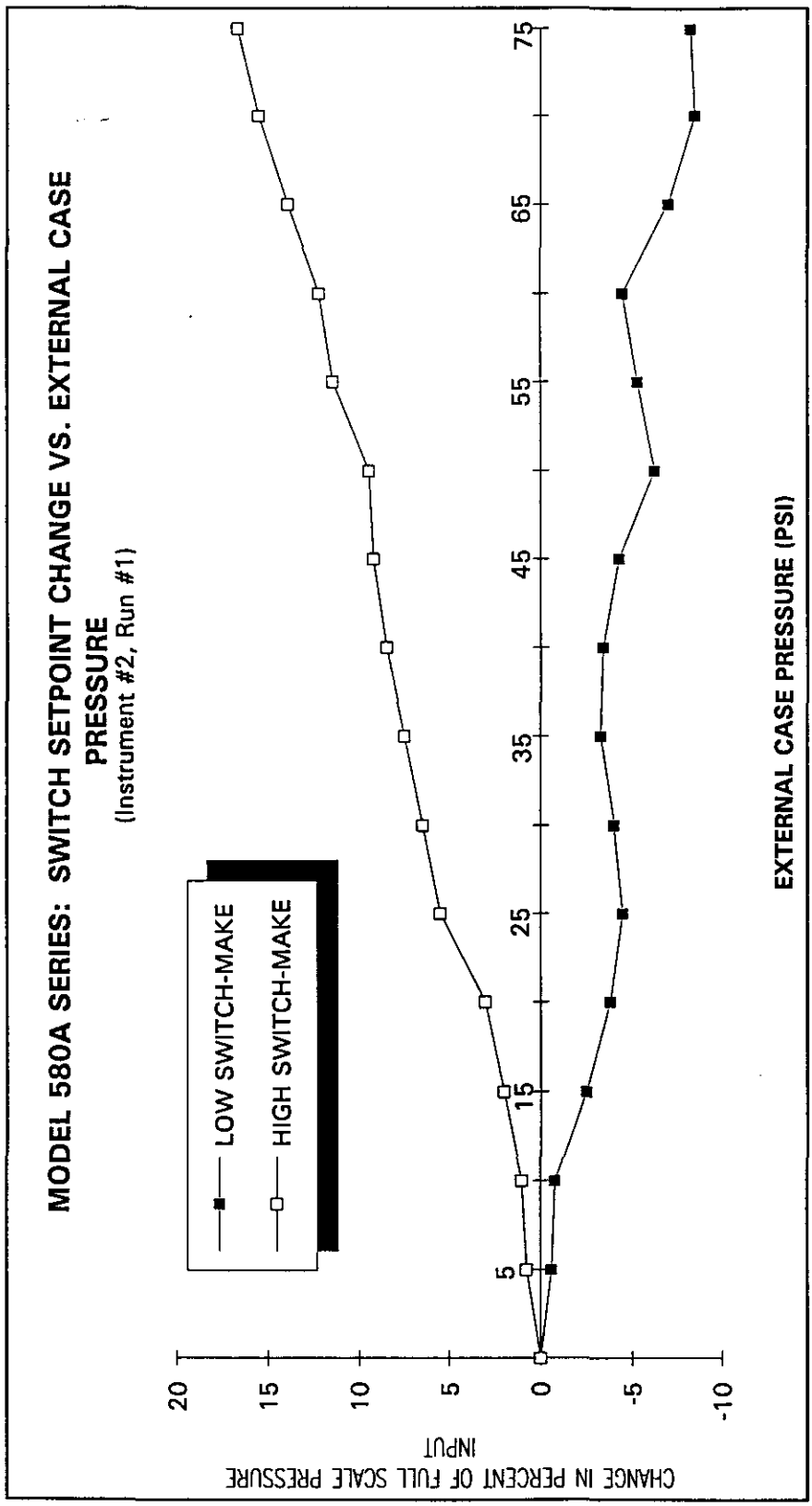

FIGURE - 3

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FIGURE 4

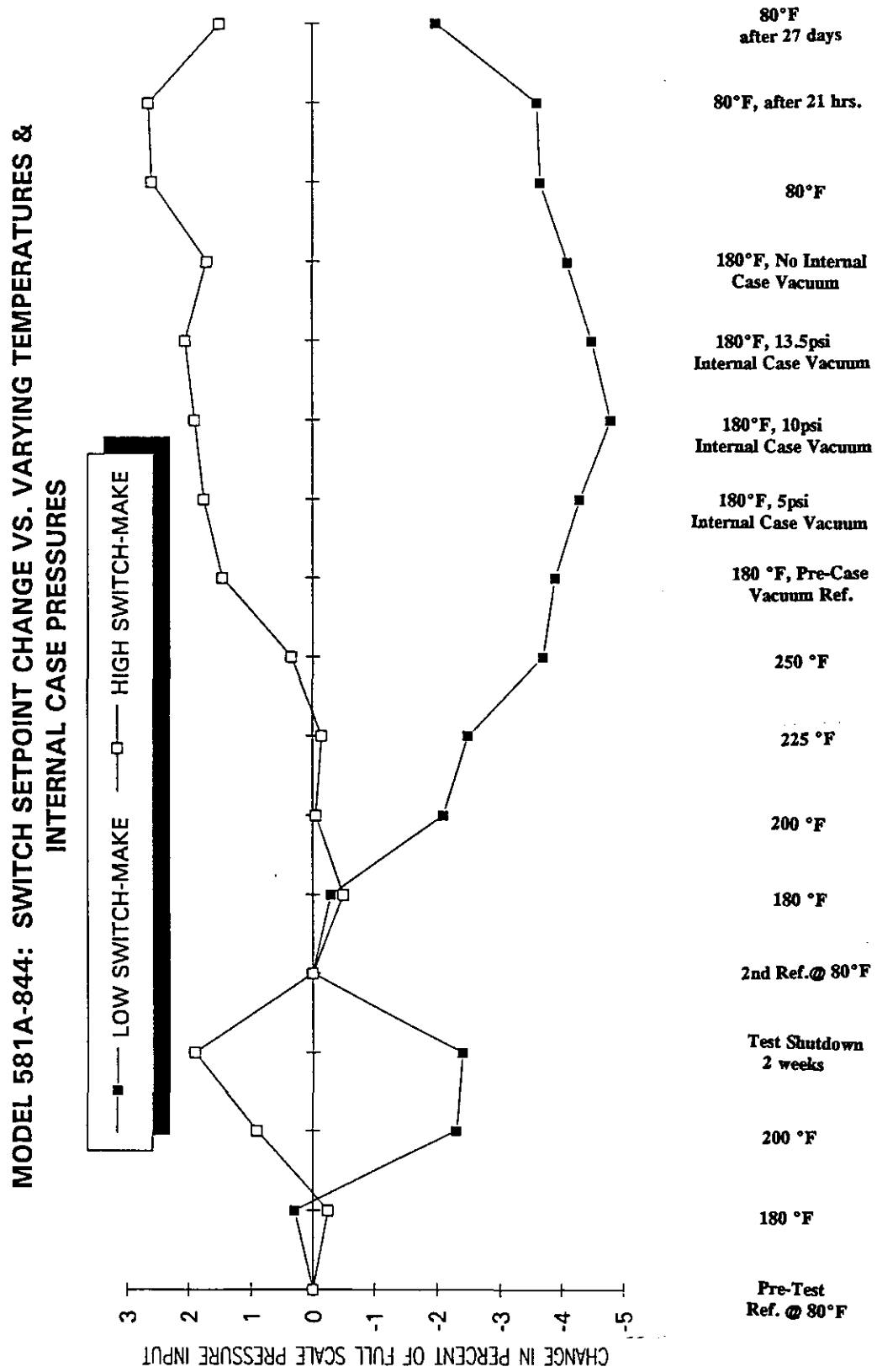

FIGURE-4

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FIGURE 5

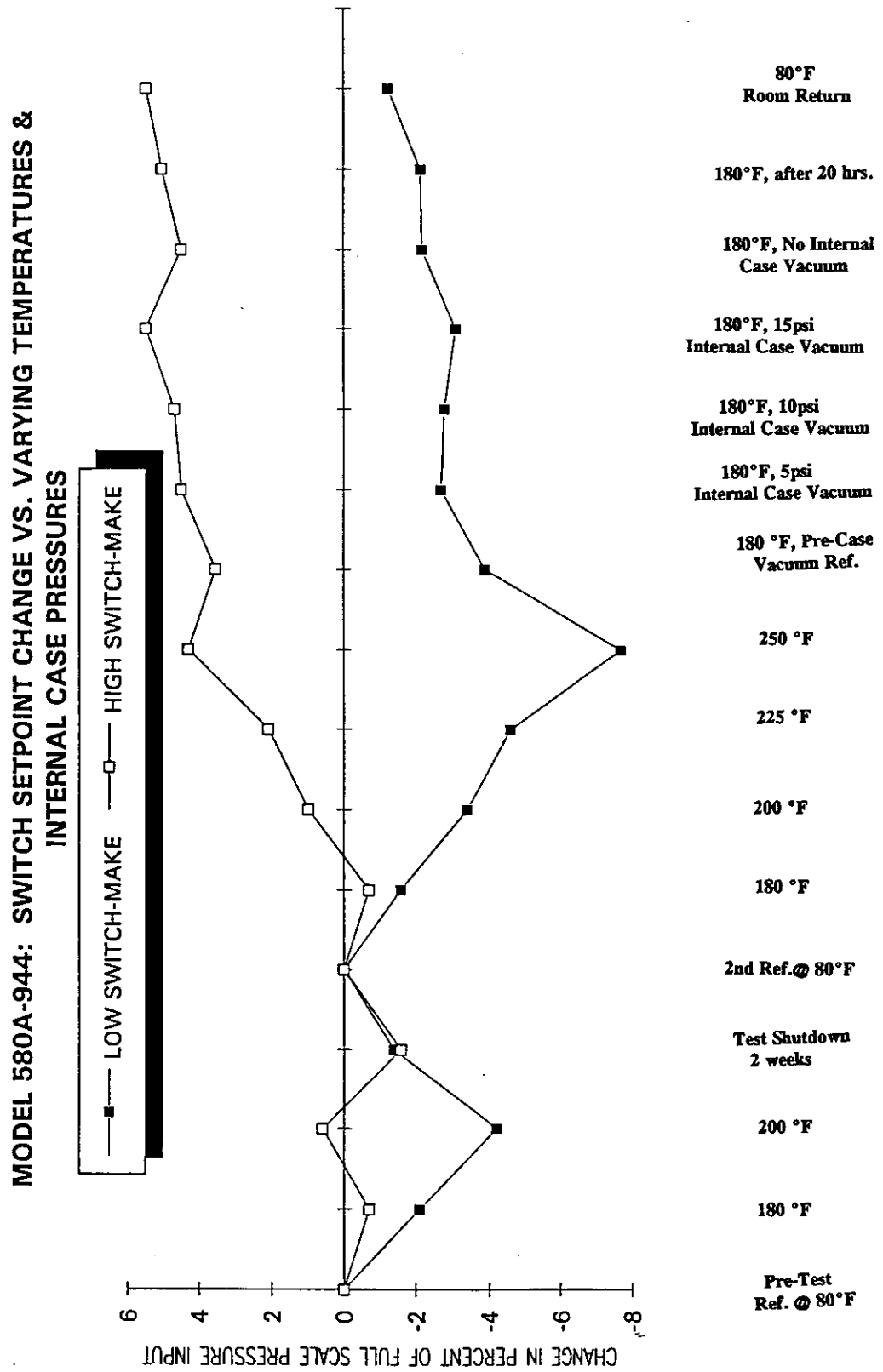

FIGURE-5

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APPENDIX A

L. Leyrer PREPARED BY	**ENGINEERING REPORT** TITLE: 580 SERIES TEST PROCEDURE RADIATION VS EXTERNAL CASE PRESSURE	REPORT NO: 9999-3267.2 PAGE NO: 1 OF DATE October 10, 1990 CASE NO:
C. Long 10/10/90 APPROVED BY		

PURPOSE:

1. To determine the effects of external pressure on the case, causing leakage through the torque tube seal after exposure to escalating radiation levels.

2. To determine the degree of switch setpoint change at increasing levels of external case pressure.

PROCEDURE: Phase 1

A. Obtain six Model 580 Case Assemblies, Barton Part Number 0580-1121.1. These may be new or old cases, but must never have been exposed to external pressure. Ask Model Shop to check the back of each for flatness.

B. Obtain 6 Hole Plugs, Part Number 0224-0269C; 3 Multiheaders, Part Number 0580-1072C; 1 Torque Tube Assembly, Part Number 0224-1180B; 1 Torque Tube Lock Nut, Part Number 0224-1182C; 10 Torque Tube O-Rings, Part Number 0001-1064R; 2 Mounting Plates, Part Number 0580-1059C; 1 Center Block, Part Number 0224-0915C; O-Rings: Plug Part Number 0001-1051R; Cover, Part Number 0001-1057R; Header, Part Number 0001-1066R; Torque Tube to Case, Part Number 0001-1069R (10 each).

C. Assemble as instructed by C. Long or L. Leyrer.

D. Assemble test unit into pressure housing and fill pressure housing 3/4 full with water.

E. Fill inside of case with water.

F. Slowly apply air pressure into the pressure housing while observing inside of the case to detect bubbles, indicating the seal is leaking. The maximum pressure to be applied is 75 psi. Record the pressure attained.

G. Reduce the pressure when either a leak is observed, or 75 psi is reached.

H. Remove the case assembly from the pressure housing. Disassemble the bracket from the case, and reassemble to a new case with a new O-ring seal.

I. Transport the test unit to radiation sterilizers for 10 megarads of exposure.

J. Return the radiated unit to Barton and repeat Paras. D through G.

K. Repeat Paras. H and I, except radiate to 20 megarads.

L. Continue to subject new case and seal assemblies to radiation levels in 10 megarad steps, determining seal leakage under external case pressure until reaching 50 megarads exposure. Record pressure required to make seal leak at each radiation level.

PROCEDURE: Phase 2

A. Assemble or obtain a complete Model 580 Switch. The unit must not have been subjected to previous external case pressure.

B. Check that the instrument is indicating correctly and that the high and low switches are set close to 70% and 30% actuation points.

C. Assemble the test unit into the pressure housing with switch wires and pressure tubing from the DPU exiting through the housing cover.

D. Recheck indicator and switchpoint calibrations.

E. Apply pressure externally to the 580 case in 5 psi increments to 75 psi maximum, checking indicator and switchpoint actuation at each pressure increment. Record pressure at switchpoint and deviations of indication.

Note 1: Switchpoint calibration requires inputting DPU pressure to approximately mid-range, where both switches are in an unswitched position. Slowly reduce DPU pressure until the low switch actuates, recording the pressure.

Reduce the pressure further (approx. 10%); then slowly increase pressure until the low switch changes state. Record this pressure as the deadband. Continue increasing DPU pressure until the high switch actuates, recording the pressure and continuing to increase approx. 10% above the high switchpoint.

Reduce the pressure to the point where switching again occurs, which is the deadband point for the high switch. Deadband is the difference between switchpoints for increasing and decreasing pressure.

Also observe if blackout takes place when the open and closed contacts do not actuate simultaneously. Record the amount of blackout if it occurs. Second and third switchpoint checks, as described, should be conducted at each increment to determine repeatability.

Note 2: During both Phases 1 and 2, at the points of maximum pressure application, a measurement of deflection shall be made at the rear of the case adjacent to the torque tube. Use a dial indicator, measuring from the pressure housing cover to reduce error caused by the cover deflection under pressure. Record deflection vs pressure.

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