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LIQUID ROCKET PLANT

EVALUATION TESTING OF STATHAM PRESSURE TRANSDUCERS
MODEL NO'S. PA732TC, PL732TC, AND PG732TC

Report 8771:2551

2 March 1964

MASTER

AEROJET-GENERAL CORPORATION

SACRAMENTO, CALIFORNIA

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EVALUATION TESTING OF STATHAM PRESSURE TRANSDUCERS
MODEL NO'S. PA732TC, PL732TC, AND PG732TC

Prepared by
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LIQUID ROCKET PLANT
AEROJET-GENERAL CORPORATION

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I INTRODUCTION

Statham pressure transducers, Models PA732TC, PG732TC, and PL732TC were subjected to evaluation tests to determine if they are suitable for use on the NERVA rocket engine. The NERVA environment is expected to impose severe conditions of vibration, shock, temperature, humidity, and irradiation. All of these transducers are similar in design and operation, therefore they are treated as one for the purpose of this report.

II SUMMARY

Evaluation tests for functional acceptance, dynamic response, vibration, shock, humidity, temperature, and irradiation effects were performed on Statham transducer Models PA732TC (PA = absolute), PG732TC (PG = gage), and PL732TC (PL = differential). Five units that failed one or more of these tests were opened and inspected to determine the cause of failure. Broken strain wires caused most of the failures. Humidity testing revealed untreated metal surfaces near the strain wires and rust or corrosion was found on the over-travel post and springs. One transducer, S/N 418, became inoperative during normal shipping and handling.

When the transducers were disassembled the following manufacturing discrepancies were revealed: soft solder was used for junctions, "spitball" resistors were used for zero adjustment, and threaded fasteners (7 screws) were used in the assembly. Many transducers failed acceptance testing because of zero shift, low insulation values, or shorts.

Results of the evaluation tests are not conclusive because at least three design changes, with no corresponding change in model number, were made during the evaluation period. This was not discovered until the transducers were opened for examination to determine the cause of failure.

Statham has been removed from NERVA drawings as a source of supply until quality control procedures are improved, soft soldering is eliminated, and threaded fasteners are replaced with welded or brazed connections. The problem of strain wire breakage is expected to be solved by an improved spring design. The model number is being revised to include the drawing number of the transducer.

III CONCLUSIONS

Meetings were held with the Chief Design Engineer and Vice-President of Statham, AGC Purchasing, and NERVA Engineering Personnel in an effort to improve the quality control and operating characteristics of the transducer. The zero length spring was redesigned, but the transducer is not yet considered satisfactory.

Transducer Models PA, PL, and PG732TC were unable to perform satisfactorily in the simulated NERVA environment. Therefore Statham has been removed from NERVA drawings as a source of supply until further notice.

Engineering evaluation and environmental tests are being performed on two redesigned units of model PA751TC-50-350 and on one PA751TC-1M-350 unit. An evaluation report will be written on these transducers.

IV TECHNICAL DISCUSSION

A. DESCRIPTION OF TRANSDUCERS

The PG, PA, and PL pressure transducers are similar in design and operation. The gas pressure exerts a force on a diaphragm which moves a rod connected to a strain wire. The strain wire (Figure 1) forms a Wheatstone bridge that is unbalanced by the movement of this rod. The difference of potential across the unbalanced Wheatstone bridge is measured and translated into a pressure reading (Figure 2).

B. TEST PROCEDURES

1. Acceptance Tests

Acceptance tests were performed on each transducer to assure compliance with the manufacturer's specifications. Ninety percent of the units failed the acceptance functional test because of zero shift, low insulation resistance, or shorting. The Material Review Board accepted some transducers by downgrading AGC specifications for zero shift. The reject rate for the first 38 units was 75.58 percent.

2. Pre and Post-Test Functions

Absolute and differential pressure transducers were energized with GN_2 and subjected to two ascending and descending pressure transversals at steps approximately 20% of full scale. The output of each transducer was recorded and pre and post-test functional records were compared to check for abnormality or failure.

3. Dynamic Response

a. Decreasing Pressure Step Test

The frequency response of the basic transducer sensing system is identical for the high side of the Model PL and PA pressure transducers. Therefore, both PA and PL were used as representative transducers for testing to determine frequency response. Mounting methods and pressure ports were taken into consideration by simulating the inlet configuration with 1/4 inch tubing and a pressure chamber (Figure 3). The configuration approximated a Helmholtz resonator.

b. Shock Tube Tests

Three Model PA732TC-1M-350 and two PL732TC-100-350 transducers were subjected to dynamic response tests in a shock tube device to determine the effect of various tubing lengths and configurations on the system. The shock generator was a dual chamber fixture with an end plate in the smaller chamber to mount the transducers (Figure 4). The chambers were separated by a commercial burst diaphragm. The larger chamber was pressurized to not more than 75% of the transducer full-scale until the diaphragm burst, introducing a step of 5/6 of this pressure into the smaller chamber with a wave front advancing toward the transducers. The burst diaphragms and tubing configurations are shown in Figure 5.

One Model PA732TC-1M-350 failed after the first transient pulse, another failed after the second pulse, and the third survived. The two PL732TC-100-350 pressure transducers physically survived the test but did not give accurate or meaningful data. The absolute transducer that survived the test was used with various tubing lengths and

configurations but results of these tests are not conclusive because of the small sample size (Reference 1).

A Model PA732TC 0 to 1000 psia transducer was connected to a Wiancko Dynamic Test Calibrator, Model Number Q1003. The transducer was excited with a constant 10v dc and pressurized to 40 psig. The pressure was released through a burst diaphragm and the electrical output was photographically recorded from an oscilloscope.

The system natural frequency was found to be approximately 1500 cps and the frequency response was estimated to be flat to 300 cps (Reference 2).

4. Vibration Tests

Evaluation vibration tests were conducted on two Model PA732TC pressure transducers in the LRP vibration laboratory. Gaussian random vibration was applied along three mutually perpendicular axes as follows: Test 1, flat 5 to 2000 cps, $0.10 \text{ g}^2/\text{cps}$ for five minutes at a level of 14 g rms; Test 2, flat 5 to 2000 cps, $0.06 \text{ g}^2/\text{cps}$ for a duration of 20 minutes at 11 g rms. The output of the transducers was recorded on an oscilloscope with the transducers pressurized to 0 and 580 psig respectively. Resonance was found at 1200 and 1800 cps (Reference 3).

Eight transducers were vibration tested. Three PG transducers were pressurized to approximately 75% of full scale, energized, and subjected to 20 minutes of sinusoidal and random vibration along each mutually perpendicular orthogonal axis (Reference 4). The absolute and differential pressure transducers were energized and subjected to 15 minutes of sinusoidal vibration between 5 and 2000 cps along the major

mutually perpendicular axes (Reference 5). The transducers were then subjected to 20 minutes of random vibration from 5 to 2000 cps at $0.06 \text{ g}^2/\text{cps}$; no adverse effects were noted.

5. Shock Tests

Eight pressure transducers were subjected to shock tests, two model PG, three model PA, and three Model PL (References 4 and 5). Each transducer was mounted in a test fixture, installed on a shock test machine, and subjected to an impact shock along each major orthogonal axis. The shock wave form was a terminal peak sawtooth of $30 \text{ g} \pm 10\%$ for 6.5 ± 1.0 millisecond. The transducer output was continuously monitored on an oscilloscope for electrical defects. Each transducer was subjected to a pre and post-test functional.

6. Humidity Tests

Eight pressure transducers were subjected to humidity environmental tests (References 4 and 5). The transducers were placed in a test chamber with controlled humidity and a temperature between 68 and 160°F and subjected to four humidity cycles. During the first two hours the temperature was increased to $160 \pm 3^\circ\text{F}$ and maintained at this level for the next six hours. The temperature was gradually decreased to 68°F during the next 16 hour period. Throughout the test, air velocity was less than 150 feet per minute, relative humidity was maintained at $95 \pm 5\%$, and the chamber was vented to atmosphere.

The chamber was returned to laboratory ambient conditions and the transducers were removed from the chamber and wiped dry with a soft cloth. Each transducer was subjected to a post-test

functional and examined for signs of rust or corrosion. The more severely affected transducers are shown in Figures 6, 7, and 8. Differential pressure transducer, S/N 475, failed the post-test functional.

7. Irradiation Effects

Eight pressure transducers were subjected to irradiation at NERVA levels of total dose (reference GTR Test No. 10). The temperature of each transducer was controlled by cooling and the output was continuously monitored during irradiation. All transducers operated but large zero shifts occurred. The results and details of these tests will be presented in a subsequent report.

8. Temperature Tests

a. High Temperature

Two model PG732TC-1M-350 pressure transducers were subjected to high temperature tests for four hours at $300 \pm 3^{\circ}\text{F}$ with the relative humidity maintained at less than 15% (Reference 4 and 5). Each transducer was operated while still at 300°F at the end of the four hour period. A post-test functional was conducted at ambient conditions. The transducers performed satisfactorily.

b. Medium Temperature

Three absolute and three differential transducers were subjected to medium temperature tests for four hours at $150 \pm 3^{\circ}\text{F}$ with the relative humidity maintained at less than 15% (Reference 4 and 5). Each transducer was operated at 150°F at the end of four hours. A post-test functional was conducted at ambient conditions. The transducers performed satisfactorily.

c. Low Temperature

Eight transducers were subjected to low temperature tests ($-300 \pm 25^{\circ}\text{F}$) for four hours with the relative humidity maintained at less than 15 percent. One differential transducer, S/N 482, experienced a zero shift from approximately .0113 to 1.49 mv output. The remainder of these transducers performed satisfactorily.

d. Temperature Shock

Eight transducers were exposed to temperature shock tests - six at 150 to $-300 \pm 25^{\circ}\text{F}$, and two at 300 to $-300 \pm 25^{\circ}\text{F}$. The transducers were placed in a chamber that had been stabilized at the specified high pressure and were maintained at that temperature for two hours. Within three minutes after the end of this period, the transducers were transferred to a chamber that had been previously stabilized at $-300 \pm 25^{\circ}\text{F}$. The output of each transducer was monitored during this transfer. The two transducers were maintained at $-300 \pm 25^{\circ}\text{F}$ for two hours, then subjected to post-test functionals. The six transducers were held at $-300 \pm 25^{\circ}\text{F}$ for four hours, then subjected to post-test functionals.

C. ANALYSIS OF INSPECTION

Five inoperative pressure transducers were opened for inspection to determine the nature of the failure. Figures 9 and 10 show typical failures. Three transducers had at least one leg of the strain bridge broken. One absolute unit had a broken zero length spring. Rust or corrosion was found on the over-travel post and zero length spring of one transducer. The location of the strain wire breakage was random.

The following manufacturing discrepancies were noted: soft solder was used for electrical junctions, "spitball" resistors were used to make the zero adjustment (Figure 11), and seven screws were used in the transducer assembly. Humidity tested transducers showed untreated metal surfaces on the low pressure side of the bellows and in the vicinity of the strain gage wires.

At least three design differences were discovered in Model PA732TC-LM-350 transducer with no differentiation in model number. This variation casts doubt on the validity of any conclusions which might be drawn from the evaluation of this transducer. For example: soldering, silver brazing or resistance welding was used to fasten the strain wire to the zero length spring. The only way to tell which method was used is to machine open the transducer.

REFERENCES

1. Memorandum, 2110:4610, Dynamic Response Test of Statham Model PA732TC-1M-350 Pressure Transducers
2. Memorandum 8771:1645, Statham PL732TC Pressure Transducer Response, D. G. Kneeland to K. E. Barr, dated 2 July 1963
3. Memorandum 8767, Vibration Test of Model PA732TC Statham Transducers, S/N 455 and 485, J. E. Bradley to M. G. Felter, dated 17 June 1963
4. Aerojet-General Corporation C.E.L. Report 3617-1, NRX-A-1CF Instrumentation Test of Pressure Transducers
5. Aerojet-General Corporation C.E.L. Report 3482-1, NERVA NRX-A-1CF Instrumentation Environmental Performance Test of Six Each Statham Pressure Transducers

TYPICAL STATHAM PRESSURE TRANSDUCER

FIGURE 1

DYNAMIC RESPONSE TEST SET-UP

FIGURE 3

FIGURE 4

SHOCK TUBE GENERATOR

FIGURE 5

BURST DIAPHRAGMS, TUBING, AND STATHAM TRANSDUCERS

RUST ON PORT SIDE OF STATHAM TRANSDUCERS

FIGURE 6

RUST ON PRESSURE END OF STATHAM TRANSDUCERS
FIGURE 7

FIGURE 8

RUST ON SIX-PIN RECEPTACLE

FIGURE 9

BROKEN STRAIN WIRE ON STATHAM TRANSDUCER

FIGURE 10

BROKEN ZERO LENGTH SPRING

FIGURE 11

SPITBALL RESISTOR IN STATHAM TRANSDUCER

13 March 1964

SUPPLEMENT 1

REPORT NO. 8771:2551

EVALUATION TESTING OF STATHAM PRESSURE TRANSDUCERS

MODEL NO'S. PA751TC-1M-350 AND PA751TC-50-350

Prepared by
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I ABSTRACT

Evaluation test results and conclusions were derived from environmental testing of the following Statham candidate pressure transducers: one 0-1000 psia Model PA751TC-1M-350, S/N 5, and two 0-50 psia Model PA751TC-50-350, S/N 2 and 3. Environmental testing consisted of conducting pressure calibration cycles at specific points over a temperature range of 77 to 800°F.

II SUMMARY

A. TEST OBJECTIVES

The objective of the evaluation test was to determine if the performance of the transducers would be compatible with the environmental conditions imposed by NERVA reactor tests. The particular points of interest were linearity, hysteresis, repeatability, zero output, full-scale output, and the effects on these values brought about by temperature changes over a wide range.

B. CONCLUSIONS

The transducers were found to be within tolerance of the specifications as set forth by the manufacturer, however, they should not be operated at temperatures in excess of 600°F. At temperatures above 600°F a drastic change was observed in the output at both zero and full-scale pressure. The most pronounced effect was on the zero output. The 0-1000 psia unit took a permanent 27.01% zero set (5.35 mv) when operated above 600°F. Both 50 psia units exhibited sharp changes in output curves above 600°F, especially S/N 2, which had an approximate 7% shift in zero output from 600 to 700°F.

Supplement 1
Report No. 8771:2551

P/N PA751-1M-350 S/N 5 Range: 0-1000 psia Date: 20 Feb 1964

$77 \pm 3^{\circ}\text{F}$

% FS APPLIED						
<u>PRESS</u>	<u>INC</u>	<u>DEC</u>	<u>INC</u>	<u>DEC</u>		
0	0	0		0	Full Scale	= 19.80MV
20	2000	2010	2000	2010	Zero Output	= .25MV
40	4010	4025	4010	4025	Linearity	= .20%
60	6020	6035	6020	6035	Hysteresis	= .15%
80	8020	8030	8020	8030	Repeatability	= 0%
100	10000		10000			

$200 \pm 20^{\circ}\text{F}$

0	0	0			Full Scale	= 19.77MV
20	2003	2008			Zero Output	= .18MV
40	4011	4026			Linearity	= .19%
60	6019	6034			Hysteresis	= .15%
80	8017	8027			Zero Shift	= -.35%
100	10000				Full Scale Shift	= -.15%

$300 \pm 20^{\circ}\text{F}$

0	0	0			Full Scale	= 19.73MV
20	2007	2007			Zero Output	= .02MV
40	4014	4024			Linearity	= .23%
60	6021	6036			Hysteresis	= .15%
80	8023	8033			Zero Shift	= -1.16%
100	10000				Full Scale Shift	= -.35%

NOTE: When increasing temperature from 200 to 300°F, it was unintentionally raised to 350°F and then lowered to 300°F for the test.

Supplement 1
Report No. 8771:2551

P/N PA751-1M-350

S/N 5

Range: 0-1000 psia

Date: 21 Feb 1964

$77 \pm 3^{\circ}\text{F}$

% FS
APPLIED
PRESS

INC

DEC

0	0	0
20	2002	2012
40	4009	4024
60	6016	6031
80	8018	8028
100	10000	

Full Scale	=	19.78MV
Zero Output	=	.22MV
Linearity	=	.18%
Hysteresis	=	.15%

$200 \pm 20^{\circ}\text{F}$

0	0	0
20	2007	2012
40	4014	4029
60	6026	6036
80	8023	8033
100	10000	

Full Scale	=	19.78MV
Zero Output	=	.14MV
Linearity	=	.26%
Hysteresis	=	.15%
Zero Shift	=	-.40%
Full Scale Shift	=	0%

$300 \pm 20^{\circ}\text{F}$

0	0	0
20	2008	2013
40	4016	4026
60	6024	6039
80	8022	8032
100	10000	

Full Scale	=	19.77MV
Zero Output	=	.05MV
Linearity	=	.24%
Hysteresis	=	.15%
Zero Shift	=	-.86%
Full Scale Shift	=	-.05%

$400 \pm 20^{\circ}\text{F}$

0	0	0
20	2008	2013
40	4026	4026
60	6029	6039
80	8027	8032
100	10000	

Full Scale	=	19.77MV
Zero Output	=	-.06MV
Linearity	=	.29%
Hysteresis	=	.10%
Zero Shift	=	-1.42%
Full Scale Shift	=	-.05%

NOTE: The cable connector became faulty between 400 and 500°F preventing further tests at this time.

Supplement 1
Report No. 8771:2551

P/N PA751-1M-350 S/N 5 Range: 0-1000 psia Date: 24 Feb 1964

$77 \pm 3^{\circ}\text{F}$

% FS
APPLIED

PFSS

INC

DEC

0	0	0
20	2002	2012
40	4014	4024
60	6021	6031
80	8023	8028
100	10000	

Full Scale	=	19.78MV
Zero Output	=	.24MV
Linearity	=	.23%
Hysteresis	=	.10%

$500 \pm 20^{\circ}\text{F}$

0	0	0
20	2009	2009
40	4023	4023
60	6037	6032
80	8031	8031
100	10000	

Full Scale	=	19.76MV
Zero Output	=	-.02MV
Linearity	=	.37%
Hysteresis	=	.05%
Zero Shift	=	-2.02%
Full Scale Shift	=	-.10%

NOTE: The cable used during previous tests of this unit was changed because of a temperature failure of the cable connector between 400 and 500°F.

Supplement 1
Report No. 8771:2551

P/N PA751-1M-350

S/N 5

Range: 0-1000 psia

Date: 25 Feb 1964

$77 \pm 3^{\circ}\text{F}$

% FS
APPLIED
PRESS

INC

DEC

0	0	0
20	1999	2009
40	4013	4023
60	6017	6032
80	8016	8026
100	10000	

Full Scale	=	19.81MV
Zero Output	=	.24MV
Linearity	=	.17%
Hysteresis	=	.15%

$600 \pm 20^{\circ}\text{F}$

0	0	0
20	2012	2007
40	4029	4029
60	6046	6036
80	8038	8038
100	10000	

Full Scale	=	19.78MV
Zero Output	=	-.27MV
Linearity	=	.46%
Hysteresis	=	.10%
Zero Shift	=	-2.57%
Full Scale Shift	=	-.15%

$700 \pm 20^{\circ}\text{F}$

0	0	110
20	2012	2107
40	4019	4104
60	6051	6096
80	8043	8068
100	10000	

Full Scale	=	20.03MV
Zero Output	=	.47MV *
Linearity	=	.51%
Hysteresis	=	1.10%
Zero Shift	=	+2.37%
Full Scale Shift	=	+1.11%

$800 \pm 20^{\circ}\text{F}$

0	0	215
20	2043	2223
40	4081	4236
60	6099	6174
80	8067	8112
100	10000	

Full Scale	=	20.02MV
Zero Output	=	1.76MV
Linearity	=	.99%
Hysteresis	=	2.15%
Zero Shift	=	+7.67%
Full Scale Shift	=	+1.06%

* Instability (drifting) was first noticed on these readings at 700°F .

Although the transducer had been stabilized at 800°F for more than one hour, zero and full-scale outputs drifted continuously in a positive direction making actual readings difficult to obtain. A second zero and full-scale reading was taken with approximately 2.5MV change in each.

Supplement 1
Report No. 8771:2551

P/N PA751-1M-350

S/N 5

Range: 0-1000 psia

Date: 28 Feb 1964

$77 \pm 3^{\circ}\text{F}$

% FS
APPLIED

<u>PRESS</u>	<u>INC</u>	<u>DEC</u>	<u>INC</u>	<u>DEC</u>		
0	0	15		20	*Full Scale	= 19.63MV
20	2012	2027	2027	2043	Zero Output	= 5.35MV
40	4019	4035	4045	4055	Linearity	= .45%
60	6006	6026	6037	6062	Hysteresis	= .41%
80	8003	8044	8034	8074	Repeatability	= .41%
100	10000		10041			

$800 \pm 20^{\circ}\text{F}$

0	0	140			Full Scale	= 19.33MV
20	2064	2131			Zero Output	= 4.30MV
40	4144	4025			Linearity	= 2.39%
60	6239	6073			Hysteresis	= 1.66%
80	8163	8091			Zero Shift	= -5.35%
100	10000				Full Scale Shift	= -1.53%

$900 \pm 20^{\circ}\text{F}$

0	0	122		197	Full Scale	= 18.77MV
20	2200	2323	--	--	Zero Output	= 7.07MV
40	4395	4331	--	--	Linearity	= 6.63%
60	6585	6473	--	--	Hysteresis	= 2.13%
80	8663	8450	--	--	Zero Shift	= +8.76%
100	10000		9989		Full Scale Shift	= -4.38%

* Transducer output indicated a permanent set had taken place due to the 800°F test conducted 25 February 1964. During the ambient run of this test the zero and full scale output indicated +27.01% zero shift and -.91% full scale shift from the ambient run of 25 February 1964.

P/N PA751-1M-350 S/N 5 Range: 0-1000 psia

Supplement 1
Report No. 8771:2551

P/N PA751-1M-350

S/N 5

Range: 0-1000 psia

Date: 28 Feb 1964

Base line represents a reference line derived from ambient (77°F) calibration made during this test. However, this base line also represents the following values using the ambient (77°F) calibration made 2-25-64 as reference.

$$*F.S. = -.91\% \quad \phi = +27.01\%$$

This is the result of a permanent set being indicated by the difference in ambient (77°F) reading taken 2-25-64 and the reading taken during this test at ambient.

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 2

Range: 0-50 psia

Date: 4 Mar 1964

77°F

% FS
APPLIED
PRESS

INC

DEC

INC

DEC

0	0	11		11	Full Scale	=	18.61MV
20	2053	2063	2058	2063	Zero Output	=	5.71MV
40	4089	4100	4094	4100	Linearity	=	1.04%
60	6099	6110	6104	6110	Hysteresis	=	.11%
80	8076	8082	8076	8082	Absolute Zero	=	.05MV
100	10000		10000		Repeatability	=	.05%

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 2

Range: 0-50 psia

Date: 5 Mar 1964

% FS
APPLIED
PRESS

77°F

INC

DEC

0	0	27
20	2061	2077
40	4095	4112
60	6103	6114
80	8078	8084
100	10000	

Full Scale	=	18.63MV
Zero Output	=	5.70MV
Linearity	=	1.03%
Hysteresis	=	.27%
Absolute Zero	=	.06MV

200°F

0	0	0
20	2056	2061
40	4095	4101
60	6103	6114
80	8084	8084
100	10000	

Full Scale	=	18.63MV
Zero Output	=	5.61MV
Linearity	=	1.03%
Hysteresis	=	.11%
Full Scale Shift	=	0%
Zero Shift	=	-.48%

300°F

0	0	5
20	2060	2060
40	4099	4104
60	6110	6116
80	8090	8090
100	10000	

Full Scale	=	18.64MV
Zero Output	=	5.55MV
Linearity	=	1.10%
Hysteresis	=	.06%
Full Scale Shift	=	+.05%
Zero Shift	=	-.80%

400°F

0	0	0
20	2058	2063
40	4100	4105
60	6115	6120
80	8087	8092
100	10000	

Full Scale	=	18.66MV
Zero Output	=	5.50MV
Linearity	=	1.15%
Hysteresis	=	.05%
Full Scale Shift	=	+.16%
Zero Shift	=	-1.07%

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 2

Range: 0-50 psia

Date: 5 Mar 64 Cont'd.

500°F

% FS
APPLIED

PRESS

INC

DEC

0 0 5
20 2066 2061
40 4112 4106
60 6130 6130
80 8105 8105
100 10000

Full Scale = 18.63MV
Zero Output = 5.46MV
Linearity = 1.30%
Hysteresis = .06%
Full Scale Shift = 0%
Zero Shift = -1.29%

600°F

0 0 16
20 2086 2086
40 4129 4134
60 6155 6150
80 8129 8123
100 10000

Full Scale = 18.65MV
Zero Output = 5.12MV
Linearity = 1.55%
Hysteresis = .16%
Full Scale Shift = +.11%
Zero Shift = -3.11%

700°F

0 0 5
20 2064 2075
40 4123 4117
60 6139 6123
80 8144 8085
100 10000

Full Scale = 18.75MV
Zero Output = 3.83MV
Linearity = 1.44%
Hysteresis = 1.59%
Full Scale Shift = +.64%
Zero Shift = -10.04%

800°F

0 0 50
20 2146 2252
40 4298 4415
60 6434 6522
80 8514 8569
100 10000

Full Scale = 18.03MV
Zero Output = 4.72MV
Linearity = 5.14%
Hysteresis = 1.17%
Full Scale Shift = -3.22%
Zero Shift = -5.26%
Absolute Zero = -1.35MV

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 2

Range: 0-50 psia

Date: 5 Mar 1964

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 3

Range: 0-50 psia

Date: 4 Mar 1964

77°F

% FS
APPLIED
PRESS

INC

DEC

INC

DEC

0	0	11		11	Full Scale	=	18.42MV
20	2047	2057	2052	2057	Zero Output	=	6.09MV
40	4077	4088	4082	4088	Linearity	=	.91%
60	6086	6097	6091	6097	Hysteresis	=	.11%
80	8067	8073	8067	8067	Repeatability	=	.05%
100	10000		10000		Absolute Zero	=	.51MV

Supplement 1
Report No. 8771:2551

P/N PA752TC-50-350 S/N 3 Range: 0-50 psia Date: 5 Mar 1964

77°F

% FS
APPLIED
PRESS

INC

DEC

0	0	27
20	2056	2067
40	4086	4096
60	6093	6104
80	8068	8074
100	10000	

Full Scale	=	18.43MV
Zero Output	=	6.09MV
Linearity	=	.93%
Hysteresis	=	.27%
Absolute Zero	=	.52MV

200°F

0	0	5
20	2048	2048
40	4079	4085
60	6089	6094
80	8072	8072
100	10000	

Full Scale	=	18.41MV
Zero Output	=	5.93MV
Linearity	=	.89%
Hysteresis	=	.06%
Full Scale Shift	=	-.11%
Zero Shift	=	-.87%

300°F

0	0	0
20	2052	2052
40	4082	4088
60	6097	6102
80	8073	8078
100	10000	

Full Scale	=	18.42MV
Zero Output	=	5.86MV
Linearity	=	.97%
Hysteresis	=	.06%
Full Scale Shift	=	-.05%
Zero Shift	=	-1.25%

400°F

0	0	5
20	2053	2053
40	4090	4090
60	6105	6105
80	8078	8078
100	10000	

Full Scale	=	18.41MV
Zero Output	=	5.85MV
Linearity	=	1.05%
Hysteresis	=	0%
Full Scale Shift	=	-.11%
Zero Shift	=	-1.30%

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 3

Range: 0-50 psia

Date: 5 Mar 1964 Cont'd.

500°F

% FS
APPLIED
PRESS

INC

DEC

0	0	0
20	2053	2053
40	4096	4096
60	6111	6111
80	8088	8088
100	10000	

Full Scale	=	18.41MV
Zero Output	=	5.84MV
Linearity	=	1.11%
Hysteresis	=	0%
Full Scale Shift	=	-.11%
Zero Shift	=	-1.36%

600°F

0	0	0
20	2062	2062
40	4102	4102
60	6120	6120
80	8095	8095
100	10000	

Full Scale	=	18.43MV
Zero Output	=	5.84MV
Linearity	=	1.20%
Hysteresis	=	0%
Full Scale Shift	=	0%
Zero Shift	=	-1.36%

700°F

0	0	-32
20	2051	2029
40	4085	4074
60	6104	6087
80	8095	8063
100	10000	

Full Scale	=	18.53MV
Zero Output	=	5.67MV
Linearity	=	1.04%
Hysteresis	=	.32%
Full Scale Shift	=	+.54%
Zero Shift	=	-2.28%

800°F

0	0	-134
20	2017	1980
40	4056	4056
60	6089	6105
80	8079	8106
100	10000	

Full Scale	=	18.64MV
Zero Output	=	5.19MV
Linearity	=	.89%
Hysteresis	=	1.34%
Full Scale Shift	=	+1.14%
Zero Shift	=	-4.88%
Absolute Zero	=	-1.45MV

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350

S/N 3

Range: 0-50 psia

Date: 5 Mar 1964

DEV IN %
OF ROOM F.S.

Supplement 1
Report No. 8771:2551

P/N PA751TC-50-350 S/N 2 Range: 0-50 psia Date: 12 Mar 1964

POST AMBIENT CALIBRATION

77°F

% FS APPLIED <u>PRESS</u>	<u>INC</u>	<u>DEC</u>	<u>INC</u>	<u>DEC</u>		
0	0	5		0	Full Scale	= 18.40MV
20	2054	2054	2054	2060	Zero Output	= 4.18MV
40	4087	4098	4087	4098	Linearity	= 1.03%
60	6103	6109	6103	6109	Hysteresis	= .11%
80	8076	8081	8076	8081	Repeatability	= .06%
100	10000		10000		*Zero Shift	= -8.15%
					*Full Scale Shift	= -1.23%
					*Absolute Zero Shift	= -8.05%

P/N PA751TC-50-350 S/N 3 Range: 0-50 psia Date: 12 Mar 1964

77°F

% FS APPLIED <u>PRESS</u>	<u>INC</u>	<u>DEC</u>	<u>INC</u>	<u>DEC</u>		
0	0	0		0	Full Scale	= 18.39MV
20	2028	2034	2028	2034	Zero Output	= 1.82MV
40	4056	4062	4051	4062	Linearity	= .63%
60	6063	6068	6058	6068	Hysteresis	= .11%
80	8048	8053	8048	8053	Repeatability	= .05%
100	10000		10000		*Zero Shift	= -23.17%
					* Full Scale Shift	= -.22%
					*Absolute Zero Shift	= -22.95%

* Data obtained from ambient return following the temperature run of 800°F of 5 March 1964. The zero and full scale shift values are permanent shifts as referenced to the normal ambient data obtained 5 March 1964.

Supplement 1
Report No. 8771:2551

P/N PA751TC-1M350 S/N 5 Range: 0-1000 psia Date: 13 Mar 1964

POST AMBIENT CALIBRATION

77°F

% FS APPLIED						
<u>PRESS</u>	<u>INC</u>	<u>DEC</u>	<u>INC</u>	<u>DEC</u>		
0	0	21		16	Full Scale	= 19.01MV
20	2036	No reading	2020	1957	Zero Output	= 10.64MV
40	4024	3945	4024	3961	Linearity	= .36%
60	6013	5981	6018	5997	Hysteresis	= .79%
80	8001	8006	8017	8033	Repeatability	= .27%
100	10000		10010		*Zero Shift	= +52.5%
					*Full Scale Shift	= -4.03%

* This was the ambient return after completing the 800 and 900°F calibration tests. Prior to this test the permanent zero shift was +27.01% and full scale was -.91%, using the ambient run of 25 Feb 1964 as a reference. There were many additional shifts due to this test.

MEMORANDUM

[Handwritten signature]

TO: Distribution 13 March 1964
FROM: A. R. Larson ARL 8771:2551
EXT.502;BLDG.2931
SUBJECT: Supplement to Report 8771:2551
DISTRIBUTION: Sacramento: R M Beattie, V R Boulton, J R Close, A E Cooper,
G R Deppe, R H Dow, W K Hazelrigg, A B Johnson,
G N Kapandritis, R L Mapes, D J Morken, R A Redding,
S Takeda, R D Wesley, D E Robertson
Azusa: T F McGrath, R Siev, N R Irvine, W C Stark, J W Wingrove,
M Mather
WANL: E H C Brown, C Polak, R L Ramp, R F Roller, L J Wickas
IASL: C R Tallman
NRDS: C R Dippel, T W Smith, P Blau
Reference: (a) Report 8771:2511, "Evaluation Testing of Statham Pressure
Transducers, Model No's PA732TC, PL732TC, and PG732TC",
dated 2 March 1964
Enclosure: (1) Supplement 1 to Report 8771:2551, Evaluation Testing of
Statham Pressure Transducers, Model No's PA751TC-1M-350
and PA751TC-50-350

Evaluation tests were performed on two additional Statham candidate pressure transducers. The results of these tests are presented in enclosure (1) which should be incorporated in reference (a) report.

[Handwritten signature: A. R. Larson]
A. R. Larson, Manager
Instrumentation Development Department
Test Instrumentation Division
Liquid Rocket Plant