AD-A121 264 LANCE Q-FLEX ACCELEROMETER QUALIFICATION TEST PROGRAM (U) ARMY MISSILE COMMAND REDSTONE ARSENAL AL GUIDANCE AND CONTROL.. J S HUNTER ET AL. 08 MAR 82 1/1

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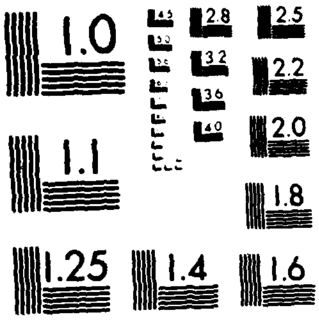

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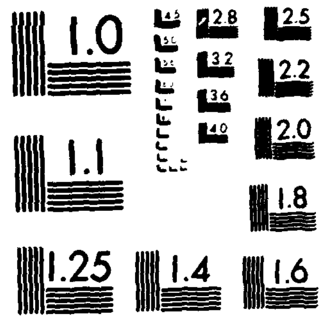

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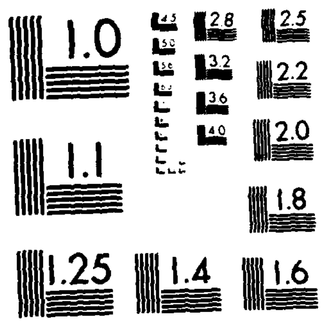

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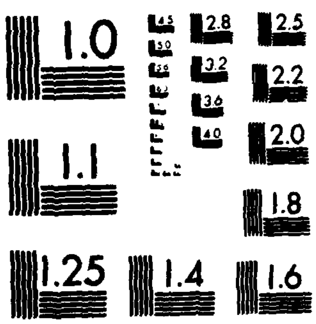

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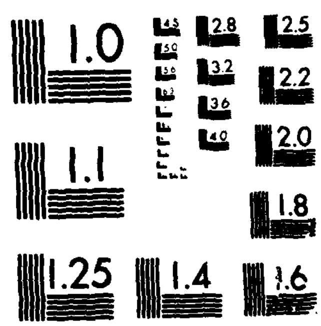

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TECHNICAL REPORT RG-82-6

LANCE Q-FLEX ACCELEROMETER QUALIFICATION TEST PROGRAM

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8 MARCH 1982

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1. REPORT NUMBER RG-82-6	2. GOVT ACCESSION NO. AD-A121 264	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Lance Q-Flex Accelerometer Qualification Test Program		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J.S. Hunter, James N. Mitchell, Troy Hester, Donald Searcy		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander, US Army Missile Command ATTN: DRSMI-RG Redstone Arsenal, AL 35898		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Commander, US Army Missile Command ATTN: DRSMI-RPT Redstone Arsenal, AL 35898		12. REPORT DATE 8 March 82
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

accelerometer, Q-Flex sensor, sensor

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers the performance obtained on Six Sundstrand Q-flex accelerometers during the qualification test program for the LANCE missile. The Qualification Test Program was divided into three parts: (1) Flight Assurance Tests (FAT), (2) Storage and Transportation Tests (SATT) and (3) Reliability Overstress Tests (ROT). All testing was performed in accordance with Vought accelerometer procurement specification 704-166C dated 8 June 1978.

CONTENTS

I. INTRODUCTION

An effort was initiated during July 1979 to procure 16 Q-Flex accelerometers built to the LANCE configuration for use in a qualification and flight test program. The accelerometers delivered under this procurement have improved performance over their predecessors in the areas of bias and scale factor stability due to the completion of two Manufacturing Methods and Technology (MM&T) contracts in those areas.

II. ACCELEROMETER DESIGN DESCRIPTION

The Q-Flex accelerometer is a pendulous accelerometer of the torque-rebalance type. In such accelerometers the torque required to maintain a pendulous mass (proof mass) in a position that is fixed relative to the accelerated structure in which it is mounted is a direct measure of the acceleration. The torque itself is not used as a measure of acceleration, but rather some quantity directly and precisely relatable to it, such as a voltage, current, or frequency; the particular choice of output depends on the instrument and its usage. For the Q-Flex accelerometer, voltage and current outputs are typical modes.

The basic Q-Flex accelerometer is made from two major subassemblies: (1) the Q-Flex sensor and (2) the hybrid servo electronics. The sensor contains the acceleration sensitive element; the servo supplies the current necessary to achieve exact force rebalance. The description given below applies to the general forms of the accelerometer through both programs. The present sensor design has evolved from over a decade of developmental refinements in materials and processes.

The sensor is a linear, single axis, electro-mechanical device for measuring acceleration. Operation is based on measuring one component of the force required to constrain a proof mass such that it will move with the accelerated base.

The mechanism (see Figure 1) uses quartz flexures for suspension of its proof mass to avoid the inelastic hysteresis of metal flexures and the turn-on hysteresis and vibration rectification errors associated with jewel-pivot systems. The sensor is dry, with no known wearout modes, and has only 17 parts, including its housing and five connector pins. It consists of the following key elements:

A. A proof mass, pendulously supported and ideally constrained so as to allow only one degree-of-freedom about a well-defined axis fixed within the sensor.

B. A pickoff that can sense extremely small displacements of the proof mass along its fixed axis with respect to an absolute geometrical null position.

C. A torquer coil positioned within a permanent magnetic field and attached to the proof mass, allowing an exactly linear force to be applied to the proof mass in response to a current passed through the coil. The current comes from a restorer circuit, or servo, that produces a proportional electrical

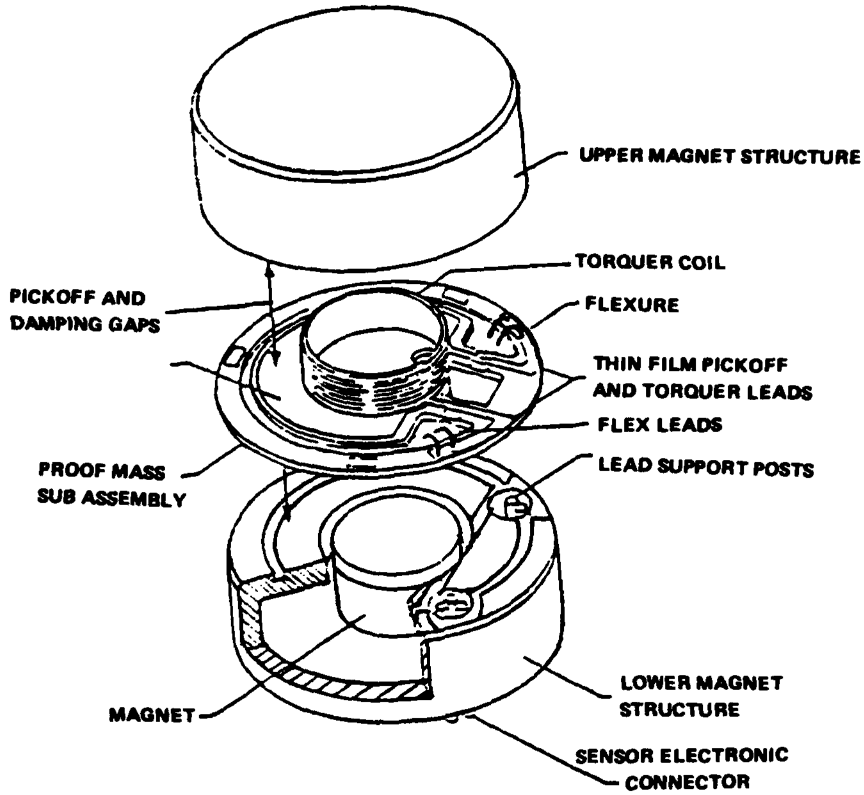

Figure 1. Exploded view of Q-Flex sensor.

The Q-Flex sensor forms the acceleration sensitive part of the accelerometer. The force required to accelerate the proof mass at exactly the same rate as the surrounding metal parts is generated by the interaction of current through coils on the proof mass with the magnetic fields created by the permanent magnets. The value of the current is used as a measure of the acceleration. See Figure 2 for a complete functional diagram.

current through the torquer coil in response to the pickoff signal. The resulting electromagnetic force exactly balances the inertial reactive forces. In this manner, the current passing through the torquer becomes an exact measure of acceleration.

The proof mass and flexures in a Q-Flex accelerometer are formed from a single blank of specially processed fused silica. To begin forming the flexure/proof mass assembly, an annular slot is cut in the blank so as to form a central disc connected to a continuous outer rim by two thin narrow bridges (hinges). The central disc serves as part of the proof mass. The thin bridges serve as flexures and the outer rim is the supporting structure for the flexures and the attached pendulum. The two critical flexure sections are formed by chemical milling in order to produce and control the desired physical characteristics. A portion of the central disc is made conductive by vapor-depositing metallic films to provide electrical surfaces required for the balanced capacitive pickoff. Conducting leads for the pickoff signals and the torquer drive current are carried across both sides of the two flexures by similar vacuum-deposited metallic films. Finally, torque coils are bonded symmetrically to the sides of the central disc and connected electrically to complete the assembly of the proof mass, flexures and flexure support. This subassembly is then clamped between two symmetrical magnetic structures. The use of two symmetric structures improves linearity, decreases vibration rectification, and reduces leakage flux.

The balanced capacitive bridge pickoff is formed by the small gap between the metalized portions of the fused silica structure.

The small, precise gap between the magnet housing and the proof mass assembly also provides damping through gas motion. Thus, a high level of damping is achieved without the use of liquids. This damping is augmented with circuit damping achieved by conventional servo techniques. Therefore, the Q-Flex provides lower signal shift than oil filled sensors, which can be important in high performance strap-down navigation systems.

The present servo electronics design is a third generation design. It utilizes a Sundstrand developed and fabricated hybrid that mounts directly on top of the sensor mechanism. The present servo closes the loop within the accelerometer and provides a convenient current output allowing flexibility in application. See Figure 2 for the Sensor Functional Diagram.

The servo electronics includes an excitation oscillator, a precision differential proximity detector, a servo amplifier and a feedback servo compensation circuit.

Figure 3 shows the QA2000 Electrical Schematic.

The proprietary oscillator/detector circuit supplies a DC output voltage proportional to the linear displacement of the seismic element. The design minimizes the effects of distortion, component tolerances, stability and temperature. The proximity detector gain is high, minimizing the effects of servo amplifier input offset voltage and current.

The detector signal is amplified and impressed across the torquer in series with the accelerometer readout resistor (or load impedance). The loop gain and bandshaping are controlled by feedback around the servo amplifier. The frequency response, dynamic range, vibration rectification, carrier noise and loop stability are controlled by this feedback network.

III. TEST MATRIX

Table 1 outlines the FAT requirements; Table 2 outlines the acceptance test procedure (ATP) for all tests requiring ATP; Table 3 outlines the storage and transportation test requirements, and Table 4 outlines the reliability overstress test requirements.

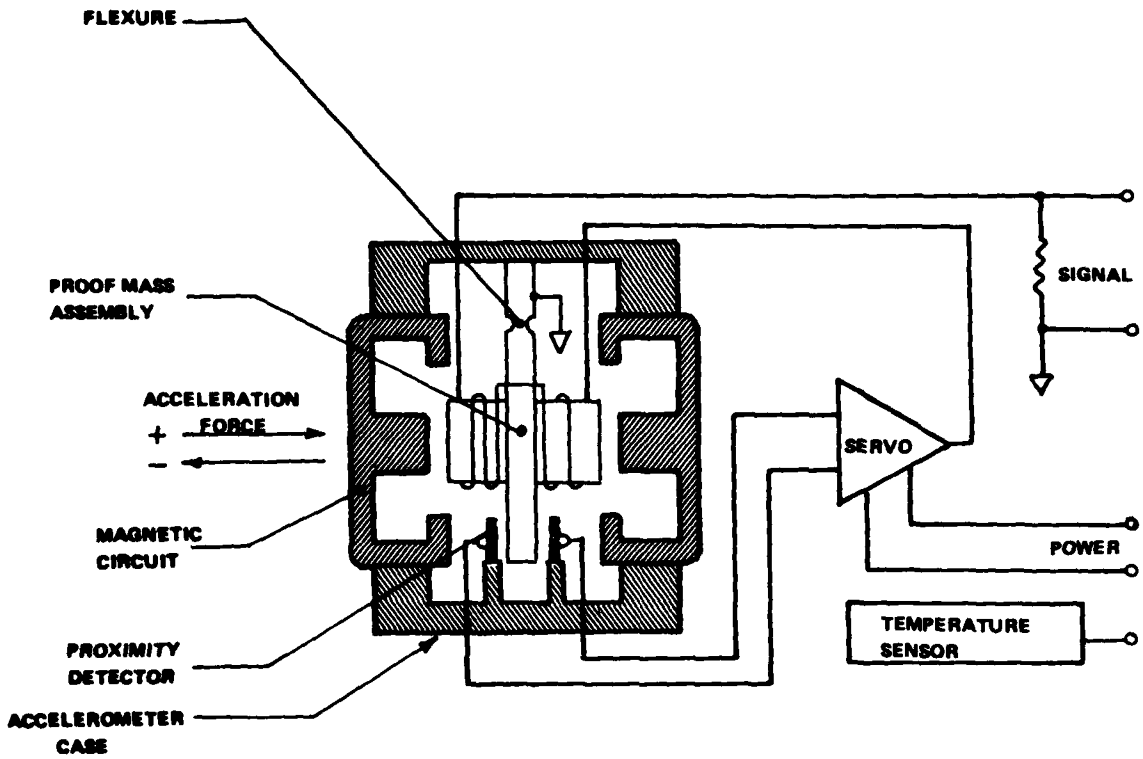

Figure 2. Accelerometer functional diagram.

The servo supplies current of the correct magnitude and direction through the coils so that the net force on the proof mass positions it centered between the two halves of the proximity detector. This current is linearly related to the acceleration; a load resistor in series with the coils converts the current into a voltage signal. The output from the temperature sensor can be used to correct for the fact that the output depends on temperature as well as acceleration.

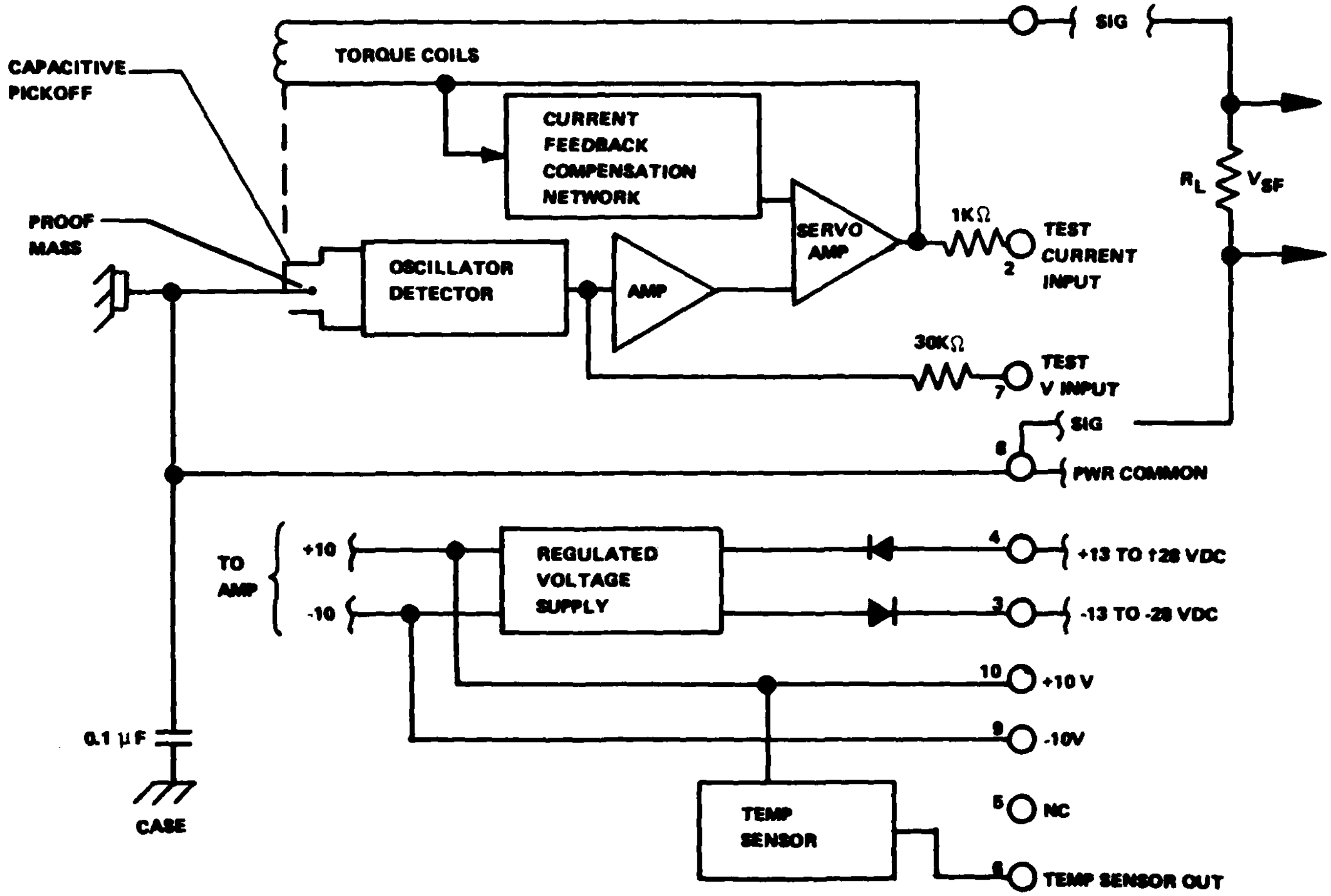

Figure 3. QA2000 electrical block diagram.

This figure shows the electrical portion of Figure 2 in more detail.

V_{SF} = SCALE FACTOR VOLTAGE = I_{SF}RL
I_{SF} = SCALE FACTOR CURRENT = 1.2 MA/g NOMINAL
R_L = LOAD RESISTOR OHMS

TABLE 1. FLIGHT ASSURANCE TEST (FAT) MATRIX

TEST PARAMETER	VOUGHT 704-166-C REQUIREMENT	
	REQUIREMENT	TEST METHOD
1. Incoming ATP	See ATP Matrix	
2. Temperature, Operating	3.7.2.1	4.8.2.1
3. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
4. Vibration, operating	Satisfactory Perfor	3.7.2.3
5. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
6. Shock, operating	Satisfactory Perfor	3.7.2.4
7. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
8. Frequency response	3.6.14	4.7.27
9. Thermal gradient sensitivity	3.6.17	4.7.30
10. Spin sensitivity	3.6.10	4.7.23
11. Input voltage	3.5.2.5	4.7.7
12. Input current	3.5.2.6	4.7.8
13. Output drift	3.5.2.9	4.7.11
14. Linear acceleration (non-linearity)	3.6.13	4.7.26.3
15. Final ATP	See ATP Matrix	

NOTE: FAT may proceed in any sequence desirable except it must begin and end with ATP.

TABLE 2. ACCEPTANCE TEST PROCEDURE (ATP) MATRIX

		VOUGHT 704-166-C REQUIREMENT	
	TEST PARAMETER	REQUIREMENT	TEST METHOD
1.	Scale factor temperature sensitivity	3.6.6	4.7.21
2.	Bias temperature sensitivity	3.6.7	4.7.21
3.	Vertical alignment temp. sensitivity	3.6.8	4.7.22
4.	Horizontal alignment temp. sensitivity	3.6.9	4.7.22
5.	Vibration Rectification	3.6.11	4.7.24
6.	Scale factor stability	3.6.12	4.7.25
7.	1 G linearity	3.6.13	4.7.26.2.1
8.	Spin sensitivity	3.6.10	4.7.23
9.	Centering	3.5.3.3	4.7.14
10.	Input current	3.5.2.6	4.7.8
11.	Insulation	3.5.2.2	4.7.4
12.	Torque coil circuit resistance	3.5.2.3	4.7.5
13.	Input voltage	3.5.2.5	4.7.7
14.	Warmup time	3.5.2.11 (3 minutes max from turn-on)	
15.	Output drift	3.5.2.9	4.7.11
16.	Output impedance	3.5.2.7	4.7.9
17.	Output noise	3.5.2.8	4.7.10
18.	Scale factor	3.6.2	4.7.19
19.	Bias	3.6.3	4.7.19

TABLE 3. STORAGE AND TRANSPORTATION TEST (SATT) MATRIX

TEST PARAMETER	VOUGHT 704-166-C REQUIREMENT	
	REQUIREMENT	TEST METHOD
1. Incoming ATP	See ATP Matrix	
2. Temperature, Operating	3.7.1.1	4.8.1.1
3. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
4. Sine vibration, non-op	3.7.1.4	3.7.1.4
5. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
6. Shock, non operating	3.7.1.5	3.7.1.5
7. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
8. Thermal shock, non-op	3.7.1.6	4.8.1.6
9. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
10. Final ATP	See ATP Matrix	

NOTE: SATT may proceed in any sequence desirable except it must begin and end with ATP.

TABLE 4. RELIABILITY OVERSTRESS TEST (ROT) MATRIX

TEST PARAMETER	VOUGHT 704-166-C REQUIREMENT: REQUIREMENT	VOUGHT 704-166-C REQUIREMENT: TEST METHOD
1. Bias stability thru temp.	Each unit shall receive 25 cycles of temperature exposure to -65°F and 160°F for 2 hours minimum stabilization time. Each unit shall be stabilized at ambient temperature between extremes to permit bias and scale factor measurements. These measurements shall occur at least once every three cycles. At the end of 25 cycles, each unit shall be subjected to an additional 25 cycles between -65°F and 200°F.	N/A
2. Random vibration, operating	Test amplitude shall be 12.5g RMS for 10 seconds each of 3 axes, then repeated at 20g RMS.	4.8.2.2
3. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
4. Shock, non-operating	3.7.1.5	4.8.1.5
5. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
6. Sinusoidal vibration, non-op	3.7.1.4	4.8.1.4
7. Scale factor & bias	3.6.2 & 3.6.3	4.7.19
8. Final ATP	See ATP Matrix	

NOTE: ROT must progress in the sequence defined above.

IV. TEST RESULTS

The LANCE Q-Flex accelerometer qualification program test results are summarized in Tables 5 through 9. The test methods for all the tests listed in Tables 1 through 4 are contained in Vought Accelerometer Procurement Specification 704-1066C dated 8 June 1978. The test method paragraphs are listed for each of the tests contained in Tables 1 through 4. The performance requirements are listed with the test results in Tables 5 through 9.

The acceptance tests conducted at the manufacturers facility prior to shipment are summarized in the Appendix.

V. CONCLUSIONS AND RECOMMENDATIONS

The acceptance test results obtained on accelerometers (SN 158, 159 and 160) which were subjected to flight assurance tests are contained in Table 5. All acceptance test parameters were well within specification with the exception of bias on S/N 158. Serial Number 158 fell only slightly outside the specification requirements. It can be noted by reviewing the Sundstrand Acceptance Test Summary Sheet in the Appendix that S/N 158 was very close to the maximum specification when it was tested by the manufacturer.

Flight assurance test results (Table 6) were all well within the specification requirement with the exception of bias on S/N 158 as noted earlier. The nonlinearity test results obtained during the qualification program showed very good correlation with the results obtained by the manufacturer (compare results shown in Table 6 with the Appendix).

Storage and Transportation tests were conducted on Serial Numbers 151, 155 and 162. The acceptance test results obtained on the storage and transportation units are shown in Table 7. All results were well within specification with the exception of centering on S/N 162. Sundstrand's acceptance test summary sheet (Appendix) indicates S/N 162 was well within specification with respect to effective center of mass (ECM) or centering. The storage and transportation test results shown in Table 8 are all well within specification requirements.

The three flight assurance test accelerometers and the three storage and transportation accelerometers were grouped together and subjected to reliability overstress tests. The results of these tests are presented in Table 9. Bias stability testing over temperature was not conducted due to the extensive amount of previous testing that has been completed on the Q-Flex sensor during two manufacturing methods and technology (MM&T) programs. All reliability overstress test results were well within specification requirements with the exception of S/N 158, which continued to have a slightly high bias. It should, however, be noted that the final value of the bias on S/N 158 was only 35 micro-g's higher than the bias measured at the factory.

The test results contained in this report are presented in summary form so that the reader will not have to sift through many pages of raw test data. The raw test data will, however, be maintained in the author's file and will be available for review by personnel who have an interest and a need to know.

With the successful completion of the flight assurance, the storage and transportation and the reliability overstress testing; it is concluded that the LANCE configuration Q-Flex accelerometer is now qualified for use as the control accelerometer on the LANCE missile.

TABLE 5. ACCEPTANCE TEST RESULTS

TEST PARAMETER	REQUIREMENT	TESTED VALUE S/N 158	S/N 159	S/N 160
1. Scale factor temp. sens.	± 0.018%/°C	+0.000856	+0.001428	+0.000754
2. Bias temp. sens.	± 0.0108 mg/°C	+0.000609	-0.000294	-0.003689
3. Vertical align. temp. sens.	± 0.018 mrad/°C	+0.000943	+0.002088	+0.000302
4. Horiz. align. temp. sens.	±0.018 mrad/°C	+0.001916	+0.000465	+0.002448
5. Vibration rectification				
(A) 1.3 g RMS	0.16 mg/g^2	-0.027218	+0.007100	-0.002366
(B) 5.3 g RMS	0.16 mg/g^2	+0.033535	+0.000427	-0.003195
6. Scale factor stability	0.026%	0.0033	0.0017	0.0054
7. 1 g Linearity				
(A) NL 30	± 0.2 mg or 0.02%	-0.0582	-0.0392	-0.0415
(B) NL 60	± 0.2 mg or 0.02%	-0.0384	-0.0103	-0.0214
8. Spin sensitivity	± 0.034 mg/rps^2	-0.01219	-0.0101	-0.0205
9. Centering	0.127 cm	0.0859	0.1085	+0.0878
10. Input current				
(A) to pin F	35 mA	15.81	15.83	15.58
(B) to pin h	34 mA	13.89	14.17	13.85
11. Insulation	100 megohms @ 200 Vdc	N.A.	N.A.	N.A.
12. Torque coil resistance	1373 to 1623 ohms	1458	1454	1449
13. Input Voltage	-------	N.A.	N.A.	N.A.
14. Warmup time	≤ 3.0 min	Satisfactory	Satisfactory	Satisfactory
15. Output drift	100 μV	9	9	1
16. Output impedance	1250 ± 350 ohms	1221.4	1230.6	1224.5
17. Output noise	-------	N.A.	N.A.	N.A.
18. Scale factor	.50000 ± .00125 Vdc	0.499921	.499848	.499984
19. Bias	± 0.2 mg	$\boxed{-0.209}$	-0.173	-0.053

NOTE: *Out of spec test results are shown enclosed by a rectangular box.*

TABLE 6. FLIGHT ASSURANCE TEST RESULTS

TEST PARAMETER	REQUIREMENT	TESTED VALUE S/N 158	S/N 159	S/N 160
1. Incoming ATP	See previous page			
2. Temperature, operating	-40°C to 93.3°C	Satisfactory	Satisfactory	Satisfactory
3. Scale factor	0.50000 ± 0.00125 Vdc	.499921	.499848	.499984
4. Bias	± 0.2 mg	-.209	-.173	-.053
5. Vibration, operating	Satisfactory performance	Yes	Yes	Yes
6. Scale factor	0.50000 ± 0.00125 Vdc	.499983	.4998815	.5000345
7. Bias	± 0.2 mg	-.196	-.121	-.050
8. Shock, operating	Satisfactory performance	Yes	Yes	Yes
9. Scale factor	0.50000 ± 0.00125 Vdc	.4999665	.499873	.500007
10. Bias	± 0.2 mg	-.167	-.144	-.021
11. Frequency response	-3 db @ 70 Hz	Satisfactory (-3 db @ 597 Hz)	Satisfactory (-3 db @ 580 Hz)	Satisfactory (-3 db @ 597 Hz)
12. Thermal gradient sens.	0.36 mg/°C	N.A.	N.A.	N.A.
13. Spin sensitivity	± 0.034 mg/rps^2	-.01219	-.0101	-.0205
14. Input voltage	≤ 100 μV	N.A.	N.A.	N.A.
15. Input current				
(a) at pin F	< 35 mA	15.81	15.83	15.58
(b) at pin H	< 34 mA	13.89	14.17	13.85
16. Output drift	< 100 μV/15 min.	9	9	1
17. Non-linearity				
(A) 0-3 g				
(1) NL 30	± 0.2 mg or 0.02%	-.0582	-.0392	-.0415
(2) NL 60	± 0.2 mg or 0.02%	-.0384	-.0103	-.0214
(B) 17 g	± 0.02%	0.0109	-0.00267	0.0199
(C) 26 g	± 0.02%	-0.0181	-0.0164	0.0063
(D) 33 g	± 0.03%	-0.0051	-0.0141	0.0094

TABLE 7. ACCEPTANCE TEST RESULTS

TEST PARAMETER	REQUIREMENT	TESTED VALUE S/N 151	S/N 155	S/N 162
1. Scale factor temp. sens.	± 0.0187%/°C	0.0006	0.0006	0.0004
2. Bias temp. sens.	± 0.0108 mg/°C	-0.0027	-0.0008	-0.0024
3. Vertical align. temp. sens.	± 0.018 mrad/°C	0.0006	-0.0011	N/A
4. Horiz. align. temp. sens.	± 0.018 mrad/°C	0.0011	0.0012	N/A
5. Vibration rectification				
(A) 1.3 g RMS	0.16 mg/g^2	0.015	0.001	0.057
(B) 5.3 g RMS	0.16 mg/g^2	0.006	0.003	0.008
6. Scale factor stability	0.026%	0.000	0.001	-0.004
7. 1 g Linearity				
(A) NL 30	± 0.2 mg or 0.02%	-0.0195	-0.0258	-0.0004
(B) NL 60	± 0.2 mg or 0.02%	-0.0099	-0.0083	-0.0078
8. Spin sensitivity	± 0.034 mg/rps^2	-0.0118	-0.0070	0.0014
9. Centering	≤ 0.127 cm	0.0895	0.0858	$\boxed{0.1374}$
10. Input Current				
(A) to pin F	35 mA	16.1	16.2	15.7
(B) to pin h	34 mA	14.4	14.6	15.2
11. Insulation	100 megohms @ 200 Vdc	N/A	N/A	N/A
12. Torque coil resistance	1373 to 1623 ohms	1448	1457	1468
13. Input voltage	------	N/A	N/A	N/A
14. Warmup time	≤ 3.0 min	sat.	sat.	sat.
15. Output drift	100 μV	6	20	6
16. Output impedance	1250 ± 350 ohms	1222	1220.8	1213.4
17. Output noise	------	N/A	N/A	N/A
18. Scale factor	0.50000 ± 0.00125 Vdc	0.499907	0.499950	0.499954
19. Bias	< ± 0.2 mg	0.026	-0.048	0.007

NOTE: Out of spec test results are shown enclosed by a rectangular box.

TABLE 8. STORAGE AND TRANSPORTATION TEST RESULTS

TEST PARAMETER	REQUIREMENT	TESTED VALUE S/N 151	S/N 155	S/N 162
1. Incoming ATP	See previous page			
2. Temp. (nonoperating)	Satisfactory performance	Yes	Yes	Yes
3. Post temp. scale factor	0.50000 ± 0.00125 Vdc	0.499949	0.499985	0.499941
4. Post temp bias	± 0.2 mg	0.018	-0.145	0.012
5. Sine Vibration (non-op)	Satisfactory performance	Yes	Yes	Yes
6. Post vib scale factor	0.50000 ± 0.00125 Vdc	0.499921	0.499998	0.499977
7. Post vib bias	± 0.2 mg	0.062	-0.114	-0.029
8. Shock (non-op)	Satisfactory performance	Yes	Yes	Yes
9. Post shock scale factor	0.5000 ± 0.00125 Vdc	0.499907	0.499996	0.499974
10. Post shock bias	± 0.2 mg	0.091	-0.141	-0.032
11. Thermal shock (non-op)	Satisfactory performance	Yes	Yes	Yes
12. Final scale factor	0.50000 ± 0.00125 Vdc	0.499907	0.499950	0.499954
13. Final bias	± 0.2 mg	0.026	-0.048	0.007

TABLE 9. RELIABILITY OVERSTRESS TEST RESULTS

	TEST PARAMETER	REQUIREMENT	TEST VALUE					
			158	159	160	151	155	162
1.	Bias stability (thru temp.)	See (ROT) Matrix	-	-	-	-	-	-
2.	Random vibration (operating)	Satisfactory performance	Yes	Yes	Yes	Yes	Yes	Yes
3.	Post vib. scale factor	0.50000 ± 0.00125 Vdc	0.499982	0.499880	0.500019	0.499995	0.500039	0.500110
4.	Post vib bias	± 0.2 mg	$\boxed{-0.232}$	-0.117	-0.019	-0.007	-0.081	0.073
5.	Shock (non-op)	Satisfactory performance	Yes	Yes	Yes	Yes	Yes	Yes
6.	Post shock scale factor	0.50000 ± 0.00125 Vdc	0.499970	0.499860	0.500008	0.499913	0.499987	0.499970
7.	Post shock bias	± 0.2 mg	$\boxed{-0.216}$	-0.108	-0.085	0.050	-0.111	-0.037
8.	Sinusoidal vibration (non-op)	Satisfactory performance	Yes	Yes	Yes	Yes	Yes	Yes
9.	Final scale factor	0.50000 ± 0.00125 Vdc	0.499971	0.499877	0.500013	0.499941	0.500017	0.499998
10.	Final bias	± 0.2 mg	$\boxed{-0.215}$	-0.115	-0.026	0.048	-0.121	-0.027

NOTE: Out of spec test results are enclosed by rectangular box.

APPENDIX

SUNDSTRAND ACCEPTANCE TEST SUMMARY SHEET

TEST PARAMETER	REQUIREMENT	TESTED VALUE SN158	SN159	SN160	SN151	SN155	SN162
1. Nonlinearity							
(A) 0-3 g							
(1) NL 30	± 0.2 mg	-0.0035	0.0003	-0.0440	-0.0404	0.0197	0.0152
(2) NL 60	± 0.2 mg	-0.0149	0.0068	-0.0085	-0.0261	-0.0199	0.0421
(B) 17 g	± 0.02 %	0.0025	-0.0028	0.0053	-0.0001	-0.0007	0.0022
(C) 26 g	± 0.02 %	-0.0031	-0.0058	0.0060	-0.0020	-0.0021	0.0022
(D) 33 g	± 0.03 %	-0.0023	-0.0175	0.0001	0.0074	-0.0119	-0.0064
2. Scale factor temp. coefficient	≤ 0.018 %/°C	0.0007	0.0012	0.0007	0.0006	0.0006	0.0003
3. Bias temp. coefficient	≤ 0.0108 mg/°C	0.0006	0.0021	0.0039	0.0027	0.0008	-0.0024
4. Vibration rectification coeff.	≤ 0.160 mg/g^2rms	-0.032	0.0108	0.0109	-0.0108	0.0000	-0.011
5. ECM location	≤ 0.127 cm	0.0594	0.0291	0.0548	0.0438	0.0258	0.0564
6. Input current							
I_1	0 to 34 ma	15.8	15.9	15.6	16.0	16.3	15.7
I_2	0 to -34 ma	-13.9	-14.2	-13.8	-14.3	-14.6	-15.2
7. Insulation resistance	> 100 megohms	>100	>100	>100	>100	>100	>100
8. Torque coil resistance	1498 ± 125 ohms	1459.5	1453.0	1450.4	1450.8	1458.9	1471
9. Output impedance	900 to 1600 ohms	1221.8	1234.9	1223.7	1221.3	1220.1	1213.3
10. Input axis misalignment							
Vertical	± 0.500 mr	0.053	0.067	0.068	0.006	0.046	0.0400
Horizontal	± 1.5 mr	-0.007	-0.017	-0.036	0.018	0.236	-0.01
11. Spin sensitivity	± 0.034 mg/RPS^2	0.0175	0.0075	0.0275	0.015	0.0075	-0.0037
12. Scale factor	0.50037 ± 0.00125 V/g	0.500456	0.500387	0.500521	0.500400	0.500478	0.500516
13. Bias	± 0.200 mg	-0.181	-0.143	-0.067	0.048	-0.036	0.0589
14. Boost coefficient	≤ 0.038	0.0237	0.0205	0.0164	0.0108	0.0079	0.0116
15. Sustain coefficient	_ 0.380	0.2690	0.1723	0.3199	0.1815	0.0910	0.0910

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