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ACOUSTIC NOISE TESTS OF ACCELEROMETERS AND AMPLIFIERS

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PREFACE

This report describes a series of acoustic noise sensitivity tests which have been run on accelerometers and accelerometer amplifiers. The test specimens consisted of NRX-A1 type components and two additional piezoelectric accelerometers which are being considered for possible application in radiation environments.

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ACOUSTIC NOISE TESTS OF ACCELEROMETERS AND AMPLIFIERS

1.0 INTRODUCTION

The purpose of the described experiments was to measure the acoustic noise sensitivity of piezoelectric accelerometers and cathode followers of the types used in the NRX-A1 cold flow test. Two additional piezoelectric accelerometer types under consideration for reactor tests and possible NRX application were also tested.

The tests were run at the Westinghouse Research Sound Laboratory in an acoustic noise chamber designed and fabricated at this facility.

2.0 DESCRIPTIONS OF TESTS

2.1 Test Set

The acoustic chamber which was utilized for the tests is a welded steel box surrounded by sand which is enclosed in a larger wooden box. Acoustic energy is generated within the box by large speakers. Sound pressure level is monitored by a calibrated microphone and the sound spectrum is displayed. The sound spectrum is adjustable and the sound waves are diffused (without phase coherence).

2.2 Test Specimens

The following is a list of components which have been tested to determine response.

TABLE I
Tested Components

<u>Component</u>	<u>Mfg.</u>	<u>Mfg. Type No.</u>	<u>WANL Part No.</u>	<u>IDB Code No.</u>
Accelerometer	Gulton	AA310504	964B018H01	Gr-11
Accelerometer	Gulton	TA320214	964B033H01	Gr-15
Accelerometer	Clevite	25D21X	---	G-54
Accelerometer	Endevco	2242M21	---	Gr-28
Cathode Follower	Gulton	F460HTU	---	---

2.3 Test Descriptions and Results

2.3.1 Gulton Accelerometers, Voltage Sensitivity.

The wafer accelerometer, type AA310504, was mounted inside a cluster of core support blocks. The cluster was taped to a lead brick. The triaxial accelerometer, type TA320214, was taped to a lead brick. The sound field was approximately flat in frequency from 50 to 1000 cps. Higher frequencies were eliminated since the Test Cell A accelerometer data acquisition channels cut off above 1000 cps. A summary of results is shown by Table II.

TABLE II
Voltage Sensitivity, Gulton Accelerometers

	<u>SPL (0.05-1 kcs)</u>	<u>G' s (rms)⁽¹⁾</u>	<u>G' s (rms) at SPL=170 db⁽²⁾</u>
Gulton Wafer (Model AA310504)			
In support Blocks	131 db	0.074	6.6
Gulton Triax (Model TA320214)	131 db		
X Axis		< 0.01	< 0.9
Y Axis		< 0.01	< 0.9
Z Axis		< 0.01	< 0.9

(1) Measured

(2) Calculated, assuming sound response can be scaled up linearly.

2.3.2 Combined Voltage Sensitivity, Clevite and Endevco Accelerometers Connected to Gulton Cathode Followers.

Clevite accelerometer type 25D21X, and Endevco accelerometer type 2242M21, were connected to Gulton type F460HTU cathode followers through 6-inch signal leads. A 10 cps RC filter (outside the test chamber) was inserted in each cathode follower output signal lead. Accelerometers and amplifiers were mounted on a lead brick which was suspended in the test chamber by stretchable cables as shown in Figure 1. Measured and calculated results are listed in Table III.

TABLE III

Combined Voltage Sensitivities,
Clevite and Endevco Accelerometers
Connected to Gulton Cathode Followers

	<u>SPL (0-2 kcs)</u>	<u>G' s (rms)⁽¹⁾</u>	<u>G' s (rms) at SPL = 170 db⁽²⁾</u>
Clevite	134 db	0.056	3.6
Endevco	134 db	0.086	5.5

- (1) Output bandwidths; Clevite 0.2 to 2 kcs, Endevco 0.14 to 2 kcs.
The lead mounting brick was resonant at 1.68 kcs; the calculations were adjusted to account for accelerometer motion.
- (2) Calculated, assuming linear acoustic response.

2.3.3 Voltage Sensitivity, Clevite and Endevco Accelerometers, External Cathode Follower.

The Clevite and Endevco accelerometer outputs were connected to a Westinghouse precision cathode follower which was enclosed in about 12 inches of plastic foam outside the acoustic chamber. Measured and calculated results are listed in Table IV.

TABLE IV
Voltage Sensitivities,
Clevite and Endevco Accelerometers,
External Cathode Follower

	<u>SPL (0-2 kcs)</u>	<u>G' s rms⁽¹⁾</u>	<u>G' s rms at SPL = 170 db⁽²⁾</u>
Clevite	134 db	0.052	3.3
Endevco	134 db	0.071	4.5

- (1) Measured data. Output bandwidth Clevite, 0.2 - 2 kcs;
Endevco, 0.04-2 kcs. The indicated g levels were adjusted to account
for accelerometer motion.
- (2) Calculated, assuming linear acoustic response.

2.3.4 Charge Sensitivity, Clevite and Endevco Accelerometers.

The Clevite and Endevco accelerometers were connected directly to Philbrick type UPA-2 operational amplifiers, connected to measure charge, through 994 pf cables. Mounting of the specimens in the test chamber was the same as that utilized in the voltage sensitivity test. No signal filtering was employed. (The charge amplifiers were not in the acoustic chamber.) Measured and calculated results are given in Table V.

TABLE V
Charge Sensitivities,
Clevite and Endevco Accelerometers

	<u>SPL (0-2 kcs)</u>	<u>G' s rms⁽¹⁾</u>	<u>G' s rms at SPL = 170 db⁽²⁾</u>
Clevite	134 db	0.056	3.5
Endevco	134 db	0.027	1.7

- (1) Measured data. Output bandwidths both units, 0.04-2 kcs. As in the case of voltage sensitivity, the g levels shown were adjusted to account for resonance of the test fixture.
- (2) Calculated, assuming linear sound response.

2.3.5 Voltage Sensitivity of the Gulton Cathode Follower

The output of a Gulton cathode follower, type F460HTU, mounted outside the chamber in the foam plastic was measured. The 10 cps filter was in the cathode follower output. Measured and calculated data are shown in Table VI.

TABLE VI

Voltage Sensitivity of the Gulton Cathode Follower

SPL (0-2 kcs)	SPL (0-1 kcs) ⁽¹⁾	Millivolts SPL (0-2 kcs) = 134 db	Millivolts SPL (0-1 kc) = 170 db
134 db	125 db	0.081	14.4

- (1) Calculated by use of sound spectrum oscillograms.
- (2) Measured. Output bandwidth was 0.04 to 0.35 kcs.
- (3) Calculated using SPL (0-1 kcs) = 125 db and assuming linear acoustic response of the tested item.

3.0 DISCUSSION

Particular care was taken to reduce motion of the tested items; however, it cannot be said that motion was in fact eliminated. Rather, the test fixture used was the one, of several experimental configurations, which resulted in the lowest electrical output when the test specimen, mounted in the fixture, was subjected to the acoustic energy. The results indicated above should therefore be considered as system, rather than device, acoustic sensitivities. Accuracy of acoustic tests could be increased by use of a higher intensity sound field.

The Gulton type AA 310504 accelerometer and F460HTU cathode follower were not tested together because in normal usage they would not be mounted in a common acoustic environment. The calculated output of the combination, mounted in a 170 db (0.04-2 kcs) SPL environment is 6.7 g¹ s rms.

The sensitivity of the Clevite 25D21X is 27.75 mv/g and the capacity is 1600 pf; the Endevco sensitivity is 9.3 mv/g and the unit capacity is 103 pf. Noise sensitivity of the Clevite unit is not specified. Noise sensitivity of the Endevco 2242 series is specified as 0.15 g rms at 140 db SPL. The specified Endevco noise output can be extrapolated to 4.75 g's rms at 170 db SPL which is in agreement with the calculated output shown in Table IV.

Figure 2 shows four oscillograms made during test of the Clevite and Endevco units with the external cathode follower (see 2.3.3). View 2A is the spectrum of system noise with the sound off. The rms value was 20 microvolts. The sound spectrum is shown by 2B and the sound pressure level (ref. 2×10^{-4} dynes/cm²) was 134 db. View 2C is the spectrum of the Clevite output which was 1300 microvolts rms and 2D is the spectrum of the Endevco unit output which was 320 microvolts rms. Accelerometer outputs for various frequency bands can be determined by scaling the oscillograms and utilization of the square-root-of-the-sum-of-the-squares rule applicable to the combination and separation of rms levels. Tables VII and VIII were so derived.

TALBE VII

Accelerometer Noise Output as a Function of Cut-Off Frequency

Cut-Off Frequency cps	134 db 40-2000 cps				SPL/one G ^(db)	
	Output Microvolts Clevite	Endevco	Output g's Clevite	Endevco	Clevite	Endevco
200	<100	38	<0.0036	0.0041	>183	185
400	288	81	0.0104	0.0087	174	177
600	602	114	0.0217	0.0123	167	172
800	738	134	0.0266	0.0144	165	170
1000	883	157	0.0318	0.0169	163	169
1200	970	175	0.0350	0.0189	162	168

TABLE VIII
Accelerometer Noise Output
As a Function of Specific Frequency
40-2000 cps Non-Coherent Noise

Frequency (cps)	Sound Pressure Level/one b ^(db)	
	Clevite	Endevco
100	183	185
200	183	185
400	174	180
600	174	180
800	172	180
1000	172	175

4.0 CONCLUSIONS

With no analysis of their output spectro, piezoelectric accelerometers can be expected to give a one g spurious output in 0-2 kcs sound levels of approximately 185 db when used in a system having a 200 cps cut-off frequency. (See Table VII).

With frequency analysis of their output spectra and in applications where narrow band vibration data are acceptable piezoelectric accelerometers can be used subject to the conditions indicated by Table VIII.

FIGURE 1
TEST FIXTURE

(A)
SYSTEM NOISE
20 Microvolts rms

(B)
SOUND SPECTRUM
134 db

(C)
CLEVITE ACCELEROMETER
OUTPUT
1300 Microvolts rms

(D)
ENDEVCO ACCELEROMETER
OUTPUT
320 Microvolts rms

ACCELEROMETER ACOUSTIC NOISE TEST OSCILLOGRAMS

FIGURE 2