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ACCELEROMETERS FOR THE MISTY NORTH EVENT

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ACCELEROMETERS FOR THE MISTY NORTH EVENT (U)*

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ABSTRACT

The design philosophy and the laboratory experiments to qualify accelerometers for the Misty North event are discussed.

The principal difficulty is the necessity to measure low frequency, low amplitude accelerations in the presence of high frequency shocks. In past experiments high frequency shocks have too often excited ringing in the accelerometers.

Most accelerometers were radiation-hardened Endevco 2264/2266 piezoresistive accelerometers.

THE PROBLEM STATEMENT

The Misty North acceleration measuring problem was to measure low frequency accelerations in the presence of high frequency accelerations. The desired data are accelerations at frequencies corresponding to the significant vibration modes of the structure. These occur at frequencies less than 500 Hz and are expected to have amplitudes less than 500 g. The unwanted, parasitic data are accelerations at frequencies from 500 Hz to more than 80,000 Hz. These accelerations are caused by stress wave propagation in the structure. These high frequency accelerations are expected to induce ringing of undamped accelerometers.

JUSTIFICATION FOR THE PROBLEM STATEMENT

How did we know that we would have a problem with accelerometer ringing caused by stress wave induced acceleration?

The structures exposed in the Misty North event are very similar to those that were exposed in the Diana Moon event. Figure 1 shows one of the acceleration traces from the Diana Moon event. Nearly the entire signal is accelerometer resonant ringing. There is essentially no structural response data on this record.

For the first 3 milliseconds the resonant ringing builds up; from 3 to 5 milliseconds on this record and for 10 milliseconds on the original record the ringing amplitude remains nearly constant.

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This particular accelerometer is an undamped piezoresistive accelerometer, Endevco Model 2264M12. It has a full range of 250 g and a resonant frequency of 5000 Hz.

Figure 1

Prior to the Diana Moon event the best information available indicated that the highest frequency to be expected inside the assembly would be 1000 Hz or less. This accelerometer was selected for the Diana Moon event because it was the only radiation hardened accelerometer that was small enough to fit into the available space of one cubic inch in a triaxial configuration.

The record in Figure 1 was the cleanest looking of any of the Diana Moon acceleration data. All the rest of the acceleration data exceeded recording system range and saturated the electronics because of the excessive output due to ringing.

For all practical purposes the acceleration data from the Diana Moon event as measured inside the structures was useless.

In the Misty North event we are again making acceleration measurements inside the same sort of structure but this time instead of one cubic inch volume we have the entire volume of approximately 400 cubic inches into which to fit the accelerometers.

IDEAL ACCELEROMETER

To accomplish this measurement an accelerometer with the following specifications is required:

- a. Radiation hardened against neutrons
- b. Range, g.....500
- c. Amplification factor at resonance, Q.....0.7
- d. Flat frequency response, Hz.....1,000
- e. Sensitivity, microvolts per g.....>20
- f. Weight, grams.....<5

Most important, it must be radiation hardened against neutrons.

Its range and its frequency response must be adequate to measure the expected accelerations due to the significant vibration modes of the structure.

Its damping must be sufficiently high so that the accelerometer will not be excited into ringing by the high frequency stress waves.

Its sensitivity must be greater than 20 microvolts per g so that an adequate signal-to-noise ratio can be obtained.

It must be reasonably small in size and light in weight.

No such accelerometer is available today.

SEVERAL COMPLEMENTARY TECHNIQUES TO MEASURE ACCELERATION

In the absence of an ideal accelerometer, the experiment was expanded to combine the required acceleration measurements with some measurements development experiments. Three different techniques are being used in an attempt to measure the acceleration of the structure.

The first technique is to use several different accelerometers mechanically paralleled to measure one acceleration-time-history.

The second technique using mechanical isolators will be discussed by Bill Comfort in the next paper (UCRL-73578 preprint).

The third technique is currently being evaluated for use on the Misty North event. It assumes that the undamped and lightly damped accelerometers will be excited into ringing and that the ringing amplitude will exceed the desired range of the recording system. Hence it is desirable to filter out some portion or all of this ringing signal prior to the first stage of the electronics. There are some indications that useable data can be extracted from an accelerometer which has low frequency, low acceleration signals superimposed on high frequency, high acceleration ringing.

This technique is a break with tradition because in nearly all past applications we have tried to design acceleration measuring systems so that the highest frequency in the test part is less than 20% of the resonant frequency of an undamped accelerometer, so that the accelerometer will not be stimulated into ringing.

THE FOUR ACCELEROMETERS

The four accelerometers selected to measure the one acceleration-time-history are:

Statham A69TC-500-350

Endevco 2266-1K-Q

Endevco 2266-5K

Endevco 2266-20K

The underlined portion of each model number will be used to identify each accelerometer hereafter.

The Endevco 2266 series is designed to be radiation hardened. It is the successor and replacement for the Endevco 2264 series used on Diana Moon. The Statham accelerometer is not radiation hardened but it is sufficiently radiation tolerant so that radiation damage is not expected to occur at the neutron levels in Misty North.

To our knowledge, piezoelectric accelerometers have not been used successfully on underground tests. Some piezoresistive accelerometers such as Endevco Model 2260 are not generally useable on nuclear events because of high resistivity and resultant high sensitivity to neutron damage.

COMPARISON OF SPECIFICATIONS FOR THE FOUR ACCELEROMETERS

Figure 2 is a comparison of the range, amplification factor at resonance, natural resonance frequency, flat frequency response, sensitivity, and weights of these four accelerometers.

	<u>RANGE, g</u>	<u>Q</u>	<u>f_n, Hz</u>	<u>FREQUENCY RESPONSE, Hz</u>	<u>SENSITIVITY, μV/g</u>	<u>WEIGHT, gm</u>
A69	500	1.3	3,800	1,300	40	85
1K-Q	1,000	7.	10,000	2,000	130	1.5
5K	5,000	200.	35,000	7,000	24	1.5
20K	20,000	200.	80,000	16,000	6	1.5

Figure 2

All four accelerometers have adequate range and flat frequency response for the Misty North measurement.

The A69 is expected to yield the best data because its amplification factor at resonance is quite low and most nearly approaches the Q of 0.7 that was specified for the ideal accelerometer. However, the 85 gram weight of the A69 and its corresponding one cubic inch volume are a significant disadvantage. For most applications the A69 is too heavy and too big.

The 1K-Q accelerometer was selected because it is the only small, radiation hardened piezoresistive accelerometer which is damped, although the damping is a factor of five less than the A69.

The 5K and 20K were initially added to the list in hopes that their high natural resonance frequencies would not be excited into ringing by the stress waves.

The sensitivity of the first three accelerometers is more than ample. The sensitivity of the 20K is quite low and the signal-to-noise ratio will be less than desired.

THE COMPLETE ACCELEROMETER MATRIX

A matrix of nine accelerometers, as shown in Figure 3, was included in each structure to measure the one acceleration-time-history of interest.

	<u>HARDMOUNTED</u>	<u>SOFTMOUNTED</u>
ACTIVE ACCELEROMETERS		
A69	1	0
1K-Q	1	1
5K	1	1
20K	1	0
DUMMY ACCELEROMETERS		
A69-Z	1	0
1K-Z	1	0
5K-Z	1	0
20K-Z	0	0

Figure 3

Four of the active accelerometers were mechanically paralleled and hard mounted.

In addition, there were two active accelerometers which were soft mounted on mechanical isolators in an attempt to filter out some of the high frequency stress waves and to limit the input acceleration to about 1000 g at the accelerometer.

The remaining three accelerometers were dummy accelerometers. They were identical to the active accelerometers in all respects except that they were quite insensitive to acceleration. The purpose of these dummy accelerometers was to provide an electrical noise reference signal for each of the active accelerometers.

BRIDGE COMPLETION, SHIELDING, AND ISOLATION

The completion half-bridge for the Endevco 2266 accelerometers consists of Vishay resistors matched to the resistance of the active arms within a resistance tolerance of 0.1 ohms. Most 2266s had no more than 3 millivolts bridge unbalance at rated excitation of 10 volts after bridge completion.

The electrostatic shield around the excitation and signal lead wires is carried completely around the bridge completion resistors and completely around each accelerometer.

Each accelerometer is electrically isolated from the structure. This is accomplished by using nylon screen, epoxy adhesive, and a small aluminum mounting block on which the 2260 accelerometer is mounted.

CLOSING COMMENTS

In our opinion, we have not yet solved the problem of measuring acceleration in our physics packages.

About the same time that the Misty North assemblies were sealed, sheet H.E. tests were performed on similar assemblies. These sheet H.E. tests demonstrated the presence of multiple shocks which caused bursts of ringing in the accelerometers. These tests seem to indicate that the most desirable accelerometers are those with the highest damping. Hence the undamped 5K and 20K accelerometers are considered to be of limited value for the Misty North application. The A69 has nearly adequate damping but its weight is excessive at 85 grams. The 1K-Q has a small size and light weight but its damping is one order of magnitude less than desired.