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EML-3 SHOCK CALIBRATION

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**Astronuclear Laboratory
Westinghouse Electric Corporation**

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SUMMARY

This report describes two methods available at WANL which are capable of applying the inputs required for the EML-3 Full Reactor Shock Test Series. The results from the actual test are presented in WANL-TME-982. A pre-test calibration, completed in July 1964, was performed in order to determine the specific characteristics and limitations of each system.

Both systems are capable of applying a satisfactory half-sine input to the reactor although each has specific advantages. A 10 G shock of 10 millisecond duration is the maximum magnitude shock which can be applied by the thrusters. The sand drop applied shock spectrum is somewhat higher in the low frequency range from 0 - 10 cps.

CONCLUSIONS:

The shock machine has a high magnitude shock input capability, but requires transportation of the reactor and instrumentation system to perform the test. EML-1 test fixtures and instrumentation are presently assembled to the reactor in the laboratory vibration area requiring no transportation to perform an axial shock test using thrusters. The input capabilities, however, are limited.

The test plan calls for shocks of increasing magnitude to a maximum of 14 G. Evaluation of the data is to take place following each drop and a decision made whether to proceed to the next higher level. The lower level axial inputs can be applied using thrusters immediately following completion of the EML-1 vibration test. If higher levels are called for, the test will be continued on the shock machine.

INTRODUCTION

The shock machine at WANL produces an acceleration pulse by dropping a flat table, holding the specimen to be tested, into a bed of sand. A number of wooden impact

blocks are located underneath the table to control the shock pulse. The quantity of these blocks determines the impact area of the table into the sand.

There are three parameters which can be varied in producing a shock pulse.

1. Height of fall.
2. Number of impact blocks.
3. Weight of specimen.

The magnitude of the acceleration pulse will increase as the drop height is increased, the table having a greater kinetic energy which must be dissipated.

Reducing the number of impact blocks will cause the table to sink further into the sand, increasing the deceleration time and thus increasing the duration of the shock pulse. Increasing the specimen weight will have the same effect, i.e., cause the table to sink further into the sand.

Four quantities are of interest in calibration:

1. Magnitude of the acceleration pulse.
2. Pulse duration.
3. Waveshape.
4. Shock spectrum.

The characteristic initial pulse waveshape for this type of machine approaches a half-sine. Realizing a waveshape of this type indicates that the machine is functioning properly.

Shock testing using electrodynamic shaker systems is a recent innovation which has been used successfully to test small packages. This method has advantages in that instrumentation and vibration fixtures are readily available at the thruster system, greatly reducing handling and setup time.

The input shock acceleration, velocity, and displacement curves ideally would have the characteristics shown in Figure 1. The requirement that the specimen velocity be zero at the conclusion of the shock pulse means that the total integrated area of the acceleration pulse be zero. An optimum shock pulse will thus be one which minimizes the negative portion of the pulse by utilizing the full thruster armature travel. A voltage pulse similar in form to the velocity curve is fed into the thruster amplifier to produce this desired motion.

A shock spectrum is used to compare the damaging potential of different shock waves. It is a plot of the maximum response of a series of lumped mass single degree of freedom systems at each natural frequency to a given shock pulse. This provides a feel for the response magnitude of components within a test specimen resulting from the shock pulse. The waveshape of the input shock becomes unimportant; only the effect it produces being of concern. The severity of half-sine laboratory shocks which are simple to handle, both experimentally and analytically, can thus be more readily correlated with the more complex shocks expected in service.

TEST SETUP

A two-mass system was constructed to roughly simulate reactor impedance in the axial and lateral directions. This system is shown in Figure 2. It consists of two masses, constructed from steel plates weighing 5,000 and 3,000 lb respectively, connected using Korfund isolation mounts. The system impedance is altered by changing the spring rate between the masses from 45,000 lb/in. to 1.5×10^6 lb/in. A constant friction force of 5,000 lb was applied between the masses using snubbers on the Korfund mounts.

This simulated mass was mounted to both the shock table and to three Ling thrusters for calibration. Shocks were applied to the system under both impedance conditions.

Calibration of the shock machine was performed using 26, 20 and 14 block impacting configurations as shown in Figure 10. The table drop height was increased until a 15 G input was obtained. Two drops were made at each level and the sand raked after each drop.

The simulated mass was attached to three thrusters using an EML-1 drive cone. An Exact Corporation Wave Synthesizer was used to form an input voltage pulse to the thruster amplifier system. This input pulse was altered as required to produce the desired shock input.

TEST RESULTS

Sand Drop

A curve showing input G vs. drop height and number of blocks is given in Figure 4. A typical shock input is shown in Figure 5.

The large mass and stiffness of the simulated reactor make the shock table fairly rigid producing a good input pulse as seen in Figure 5. The initial non-uniform acceleration is a result of the drop hook release and table free fall characteristics. During free fall the acceleration levels off at -1G. The shock pulse is followed by a residual response of the table and test system.

The 20 block configuration appears to be best for testing a mass of this large size. The input shock is not appreciably affected by changing the dynamic characteristics of the test system. Good control is also indicated in that reasonably large changes in drop height are required in order to change the pulse magnitude. A 2.75 in. drop height is required to produce a 14 G shock.

Because of the large mass involved, little success was achieved in varying the pulse duration. The pulse duration for all block configurations is approximately 10 milliseconds.

Electrodynamic Shaker

A good half-sine input was obtained with very little alteration of the input voltage waveshape required. Some typical shock input curves are shown in Figures 6 and 7. The maximum magnitude acceleration pulse of 10 millisecond duration which could be obtained, was 10 G. Altering the system impedance by changing the spring constant had little effect on the input.

Shock spectrums plotted using peak G levels for 10 G half-sine inputs of 10 millisecond duration for both input systems are shown in Figures 8 and 9. A digital computer analysis of the shock waves was used to obtain these plots.

The spectrum produced by the shock machine is more severe in the low frequency range from 0 - 10 cps. This difference is due to the relatively longer time for the shock table to reach its peak velocity during free fall allowing low frequency systems to achieve a greater initial velocity.

Relatively large displacements always occur in the low frequency range of a shock spectrum. The higher spectrum level from the drop table should, therefore, be given consideration in interpretation of test results. This is especially true if impacting in clearances between low natural frequency reactor components can occur.

At higher frequencies, both spectrums approach the peak input shock level as expected.

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2. "Using an Electrodynamic Vibration Machine for Shock Testing" Edward C. Adams, A.C. Spark Plug Division of General Motors.

FIGURE 1

IDEAL THRUSTER SHOCK

FIGURE 2

THRUSTER SHOCK STAND

FIGURE 3
SHOCK STAND

FIGURE 4
"G" VS. DROP HEIGHT SHOCK MACHINE

FIGURE 5

TYPICAL SHOCK INPUT FROM DROP TABLE

(Two accelerometers are shown mounted on opposite sides of the table.)

FIGURE 6
TYPICAL SHOCK INPUT FROM THRUSTERS

FIGURE 7

TYPICAL THRUSTER INPUTS

SHOCK SPECTRA

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SHOCK SPECTRA

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