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(12)

COPY NO. 9

WANL-TME-555
September 26, 1963
EE-3296

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~~INFORMATION CATEGORY~~
~~Classified~~
~~Classified~~
~~Authorized Classifier Date~~
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FUEL CLUSTER ASSEMBLY
MECHANICAL TEST
(PRELIMINARY REPORT)
(Title Unclassified)
(WR 00:00:75-5W)

sep

SPECIAL REVIEW FINAL DETERMINATION Class: <u>U</u>	Reviewers	Class.	Date
	<u>KAW</u>	<u>U</u>	<u>5-11-82</u>

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ABSTRACT

A seven full length fuel cluster assembly with simulated lateral support was excited laterally and a preliminary study of its response characteristics was made. A brief investigation of resistance to wear of a niobium coated cluster under vibratory motion was made.

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PURPOSE

The purpose of this test is to develop a knowledge of the fundamental mechanical response of a full length fuel cluster assembly while subjected to vibration at ambient temperatures and to determine the areas where structural deterioration and degradation will occur.

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INTRODUCTION

The results reported here were obtained from tests confined to lateral excitation only. Analysis of data is based upon information obtained from triaxial accelerometers mounted on the support blocks of the cluster assemblies and on the test rig. Uncoated, unfueled clusters were used for the lateral excitation tests. However, a test, in which a niobium coated cluster was substituted for an uncoated cluster, was conducted to determine the amount of fretting caused by vibration

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TEST SET-UP AND PROCEDURE

The test assembly is suspended from isolation mounts by means of cables and aligned to an electrodynamic shaker by adjusting the isolator mounts. The test assembly is then bolted to a 5000 pound MB electrodynamic shaker which supplies the force and motion necessary to obtain the prescribed "g" level as shown in Fig. 1 (b) and Fig. 1 (c).

The initial testing consisted of an investigation of the resonant frequencies of the test rig minus the test components. The resonant frequencies for the test rig in the range of 20 to 500 cps for input accelerations from 1 to 5 "g's" were studied and noted.

The second phase of testing was concerned with lateral vibrational excitation of the seven full length uncoated, unfueled cluster assembly. The cluster assembly was excited at various peak input "g" levels from 1 to 5 "g's" inclusively in 1 "g" increments; and a frequency scan of 20 to 500 cps at each "g" level was conducted. The cluster assembly was excited at various discrete frequencies and held for approximately one minute to assure a steady state condition before recording data. Five cps frequency increments were selected between 20 to 100 cps, 10 cps increments between 100 to 300 cps and 50 cps increments between 300 to 500 cps as well as any resonant frequencies which could be detected between increments with a monitoring scope. These discrete frequency dwells were conducted with the peak input acceleration range of 1 to 5 "g's". One of the fuel clusters was disassembled and inspected for fretting upon completion of the lateral test.

The test assembly was reassembled and a niobium coated cluster was substituted for the central uncoated cluster; the peripheral clusters will remain uncoated. The coated cluster was subjected to lateral excitation of 3 "g's" for 30 minutes each at 30 and 58 cps. The test assembly was then again disassembled and inspected.

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TEST RESULTS AND CONCLUSIONS

A check out of the test rig minus the test components at various "g" levels from 1 to 5 "g's" reveals distinct resonances at 100 cps and 200 cps for the frequency range of 20 to 500 cps. At 100 cps the resonance is minor and in the axial direction only. However, the resonance at 200 cps is quite severe and both, axial and transverse modes are excited. A reading of 25 "g's" peak to peak in the direction of excitation was recorded for a 5 "g" peak input.

Analysis of data obtained from the accelerometers mounted on the support blocks of the central and a peripheral cluster indicates that the cluster assembly resonates laterally as a rigid unit. The shape and magnitude of the accelerometer output curves for both clusters are identical with no measureable phase shift between them. Output from the accelerometers monitoring the axial direction of the central and peripheral cluster reveals relative motion in that direction.

An indication of the magnitude of resonant coupling in the axial direction may be obtained from the amplification factor defined as the "g" response (measured at the support blocks) divided by the "g" input (recorded at the shaker). The amplification factor in the axial direction has an average value of approximately 0.50 for the frequency range of 10 to 100 cps for all "g" input levels. This value increases as the frequency is increased from 100 cps and attains peak values at 200 cps. The peak values at 200 cps decrease from a value of 4.6 at 1 "g" input to a value of 1.0 at 5 "g's". Further increase in frequency reveals a sharp reduction in amplification to approximately 0.50 for frequencies from 250 to 500 cps for all "g" input levels (See Fig. 2). It is difficult to evaluate whether the cluster resonance at 200 cps is significant because of the resonance of the test rig at 200 cps, and the data indication of increased damping of the cluster as "g" level is increased.

In studying the motion in the direction of excitation, it appears that a resonant condition occurs in the frequency range of 40 to 70 cps. The amplification factor in this range varies from a maximum of 6.2 at 2 "g's" input to a minimum of 4.2 at 5 "g's". A lateral response occurs at 200 cps similar to the axial response, namely a pronounced increase in damping at this frequency as the peak input is increased from 1 to 5 "g's".

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After completion of lateral excitation tests, an inspection of a cluster revealed chipping on the outer periphery of the cluster at the mating surface of the support block and elements (See Fig. 4). The exact cause of this fretting is not known at the present time, but because of the location of the fretting, it is possible that either the relative motion of the clusters in the axial direction or the relative rotational motion of the clusters may be the cause.

Lateral excitation of the assembly containing the niobium coated, central cluster was limited and an external visual inspection revealed no evidence of additional chipping or fretting. The next phase of the coated cluster test program calls for axial excitation at which time a more complete evaluation and analysis will be made.

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RECOMMENDATION

The present test set-up has a lateral adapter as shown in Fig. 1 (b). It is felt that the present lateral adapter concentrates the driving force at the center of the test assembly producing rather high acceleration at the ends of the test assembly due to whipping action. It is recommended that a new lateral adapter be designed in which the driving force is distributed more uniformly along the entire length of the test assembly, and that the previous lateral testing be duplicated using the new adapter.

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FIGURE 1 (a) SEVEN CLUSTER VIBRATION TEST ASSEMBLY

FIG 1 (b) AXIAL VIBRATION

FIG 1 (c) LATERAL VIBRATION WITH CLUSTERS VERTICAL

CURVE NO. 595669B

FIGURE 2 CLUSTER RESPONSE IN THE AXIAL DIRECTION

FIGURE 3 CLUSTER RESPONSE IN THE DIRECTION OF EXCITATION (LATERAL)

CURVE NO. 595670C