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ABSTRACT													
A dynamic model was set up to determine the fundamental frequencies of the BIPS. The model consists of a radiator which supports four discrete masses by means of interface structures. Various materials and several different sizes of interface structures were used in the analysis. The fundamental frequencies varies from 38 cps to 227 cps dependent upon the material and the size of interface structure. The built in strength of all the interface structures are in excess of the 25 g's limit loading criteria.													

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NATURAL FREQUENCY ANALYSIS OF THE BIPS

76-311773

April 8, 1976

1.0 INTRODUCTION

The BIPS consists of a cylindrical radiator which supports four discrete masses by means of interface structures consisting of beams and struts. The four discrete masses are two heat source heat exchangers, the recuperator and the Mini-BRU turbine unit. The BIPS is mounted atop the satellite which is mounted atop the interim upper stage (IUS). The IUS is mounted on the space shuttle.

The design criteria requires that the BIPS components and mounting pads should be designed to a minimum limit loading of 50 g's. The BIPS interface structure should be designed to a minimum limit loading of 25 g's. The interface structures must also have sufficient stiffness to maintain the BIPS component natural frequencies above 60 cps which is about five times higher than the fundamental frequencies of the space shuttle. The analysis is based on the following components weights:

HSA	-	180 lbs
Recuperator	-	100 lbs
Mini-BRU	-	38 lbs
Interface Structure	-	42 lbs
Miscellaneous	-	20 lbs
<hr/>		
TOTAL	-	380 lbs

NOTICE

TO: [illegible] It
[illegible]
[illegible] to permit the broadest possible avail-
ability.

2.0 CONCLUSION

Three materials, namely: aluminum, Lockalloy and Beryllium and various sizes of the interface structures were utilized in the dynamic analysis of the BIPS system. The fundamental frequency varies from 38 cps to 227 cps dependent upon the material and the size of the interface structures. The built in strength of all the interface structures are in excess of the 25 g's. This limit loading should also satisfy requirements for all other loadings such as prelaunch environment, launch environment, operational environment and crash landing, requirements. The BIPS system is considered to have adequate stiffness and strength for the preliminary design phase. The analysis is based upon mechanical properties shown on Table 3. The natural frequencies are very sensitive to variations in these properties.

3.0 RECOMMENDATION

- (a) All interface structures be fabricated from the material Lockalloy for the flight system.
- (b) All the upper interface structure be 1-1/2 in. by 1/16 in. tube. And all lower interface structure be 1 in. by 1/8 in. tube.
- (c) See Figure 3 for the recommended recuperator mounting pad.

4.0 DISCUSSION

The approach to the BIPS fundamental frequencies includes features as follows:

- (1) The natural frequencies of the individual interface structures are first determined. The most critical individual interface structures are the upper tubular beams which

directly carry the weight of the HSA. These beams are subject to bending and twisting. The fundamental frequency is 70 cps for 1-1/2 in. by 1/16 in. Lockalloy tube, which has a section modulus 0.097 in.³. The required section modulus for a limit loading of 25 g's is 0.068 in.³.

- (2) The fundamental frequency of the radiator was determined by using Kalnin's program. The radiator was analyzed as a 0.03 in. cylindrical shell with one end fixed. A discrete mass of 380 lbs was supported at the free end. The fundamental frequencies varies from 70 cps to 570 cps dependent upon the material of construction and the vibration mode. Table 1 summarizes the results.
- (3) A dynamic model as shown in Figure 1 was set up to determine the fundamental frequencies of the interface structures as a system. The model consists of the major interface structures (due to the limitation of the program utilized, it is impossible to include all the beams and struts) the four discrete masses and the simulated radiator. The program used does not have the ability to handle plates and shells. Therefore, the radiator was replaced by six columns which have the same overall lateral and axial stiffnesses as the cylindrical radiator. The interface structures are grouped as upper beams and lower beams depending upon their relative position above or below the upper header. Fundamental frequencies were calculated for three materials and various combination of tube sizes. Table 2 summarizes the results. The computation is extremely time consuming. Basically the fundamental frequencies of the aluminum beams were first calculated. The frequencies for the other materials were ratioed according to the square root of the ratio of the Young's modulus and density. Since the actual system is more rigid than the model itself. It is believed that the results are conservative.

5.0 MOUNTING PADS

All the mounting pads are designed for a limit loading of 50 g's. The recuperator is mounted at three points. Figure 2 shows the mount location and the maximum load at each mount. It is a statically determinate system, which eliminates self induced thermal loads and installation misalignment loads. The HSA is supported at top and the bottom. There are three mounts at the top to carry the weight of the HSA. The lower support takes only the lateral load.

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lh

FORM P723A-1

WT = 100 LBS

MOUNT LOAD FOR A MAXIMUM LIMIT LOAD OF 50g

	NO. 1.			NO. 2		NO. 3
	X	Y	Z	X	Z	X
50g's X DIRECTION	0	0	0	-25g	0	-25g
50g's Y DIRECTION	0	-50g	-16.5g	0	+16.5g	0
50g's Z DIRECTION	0	0	-25g	0	-25g	0

			RECUPERATOR MOUNTS	FIGURE 2
PREPARED	S.Y.	3/76		
WRITTEN				
APPROVED			AirResearch Manufacturing Company of Arizona

FIGURE 3

RECUPERATOR MOUNTS

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S.Y.

PREPARED

WRITTEN

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	LATERAL VIB (CPS)	LONG. VIB (CPS)	RADIAL VIB (CPS)
ALUMINUM	70	210	82
LOCKALLOY	139	417	163
BERYLLIUM	190	170	223

PREPARED			S.Y.		3/76	NATURAL FREQUENCIES OF THE RADIATOR	TABLE 1
WRITTEN							
APPROVED							
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TABLE 2
LOWEST NATURAL FREQUENCY OF THE BIPS (CPS)

UPPER LOWER	1-1/2x1/16	1-1/2x1/8	1-3/4x1/16	2x1/16	2-1/4x1/8	3x1/8
1x1/16	A 38 L 74 B 101					
1x1/8	A 42 L 82 B 112	A 56 L 110 B 153				A 70 L 138 B 190
1-1/2x1/16				A 54 L 108 B 149		
1-3/4x1/16			A 55 L 106 B 146			
2x1/16				A 63 L 125 B 171		
2-1/4x1/8					A 84 L 165 B 227	

NOTE: (1) A = ALUMINUM
L = LOCKALLOY
B = BERYLLIUM

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TABLE 3
MATERIALS MECHANICAL PROPERTIES

	Density (lb/in. ³)	E (psi)	Y.P. (psi) @ 200°F
Aluminum	0.1	10×10^6	35,000
Lockalloy	0.076	30×10^6	30,000
Beryllium	0.067	50×10^6	46,000