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Reply to Attn of: EB34 (04-89) April 8,1989

TO: EB34/J. Blanche

From: EB34/D. Jones

Subject: Tantalum Capacitor Vibration Test

A vibration test of axial-lead, solid tantalum capacitors was conducted to gain quantitative data to support staking requirements defined in NASA documents NHB 5300.4(3J) and NHB 5300.4(3K). The test was initiated to resolve the incompatibility between the previously mentioned documents and the .5 ounce weight requirement designated by NHB 5300.4(3A-1). Even though these parts have a long history of high-cycle fatigue failures of the leads, the available failure records often fail to identify case size and/or vibration level. This test was conducted under controlled conditions. The results support the need for staking axial-lead, solid tantalum capacitors regardless of case size.

Three identical 5"X7" printed wiring boards(PWB) were designed and populated with 96 axial-lead, solid tantalum capacitors. Each PWB held 8 of each case size. Wedgelock card retainers held the PWBs rigidly in position (see fig. 1). The location of capacitor groups would show any difference in amplification of vibration on the PWB. The capacitors were not staked, nor were they conformally coated since a .004" thick coating provides no structural support.

TABLE 1. TANTALUM CAPACITOR PARTS LIST

CASE SIZE	P/N(MIL-C-39003/1E)	LEAD DIAMETER(+.002)
A	-3003J	.020
B	-3024J	.020
C	-2981J -3012J	.025 .025
D	-3032J -6556	.025 .025

The test fixture was a 200 lb. magnesium cube with three orthogonally attached channeled brackets. The brackets were poisitioned in the X,Y,and Z planes so that each PWB would experience vertical vibration in its respective axis(see fig. 2). The test was run on a T 4000 shaker.

The PWBs were subjected to a series of random vibration test levels over the range of 3.5 to 49.32 GRMS in approximately 2 GRMS increments. The shape of the curve selected was the Shuttle Cargo Bay Equipment acceptance test criteria which has a composite of 6.1 GRMS. The PWB were vibrated for a duration of 120 seconds at each level. The vibrational input to the PWBs was controlled by an accelerometer mounted on the cube between the test articles(see fig. 2).

ACCEPTANCE TEST CRITERIA

	20 Hz	@ 0.01 g^2/Hz
20 -	80 Hz	@ +3 dB/oct
80 -	350 Hz	@ 0.04 g^2/Hz
350 -	2000 Hz	@ -3dB/oct
	2000 Hz	@ 0.007 g^2/Hz

All vibration test levels represent dynamic input directly to the PWBs. Discussions with vibration personnel in Structures and Dynamics Laboratory, and Bendix Guidance and Control Division indicate that board level vibrations will exceed box level inputs by a factor of three to seven depending upon the black box design. The axis perpendicular to the plane of the board is the most sensitive to vibration. The tantalum capacitor leads showed physical deformation at board input levels as low as 6.1 GRMS. C and D case capacitor leads(Z-AXIS) BROKE AT 11.99 GRMS. On the next run the same C and D case capacitors were torn completely from the PWB. The first A and B case capacitor failures were recorded at 17.97 GRMS. The B case capacitor broke both leads simultaneously and was catapulted completely from the PWB. A PWB could experience an input vibration of 18 GRMS with a box input vibration between 3 GRMS and 6 GRMS which is below the Shuttle Cargo Bay Equipment acceptance test level. Subsequent vibrations yielded many more lead breaks(see test data).

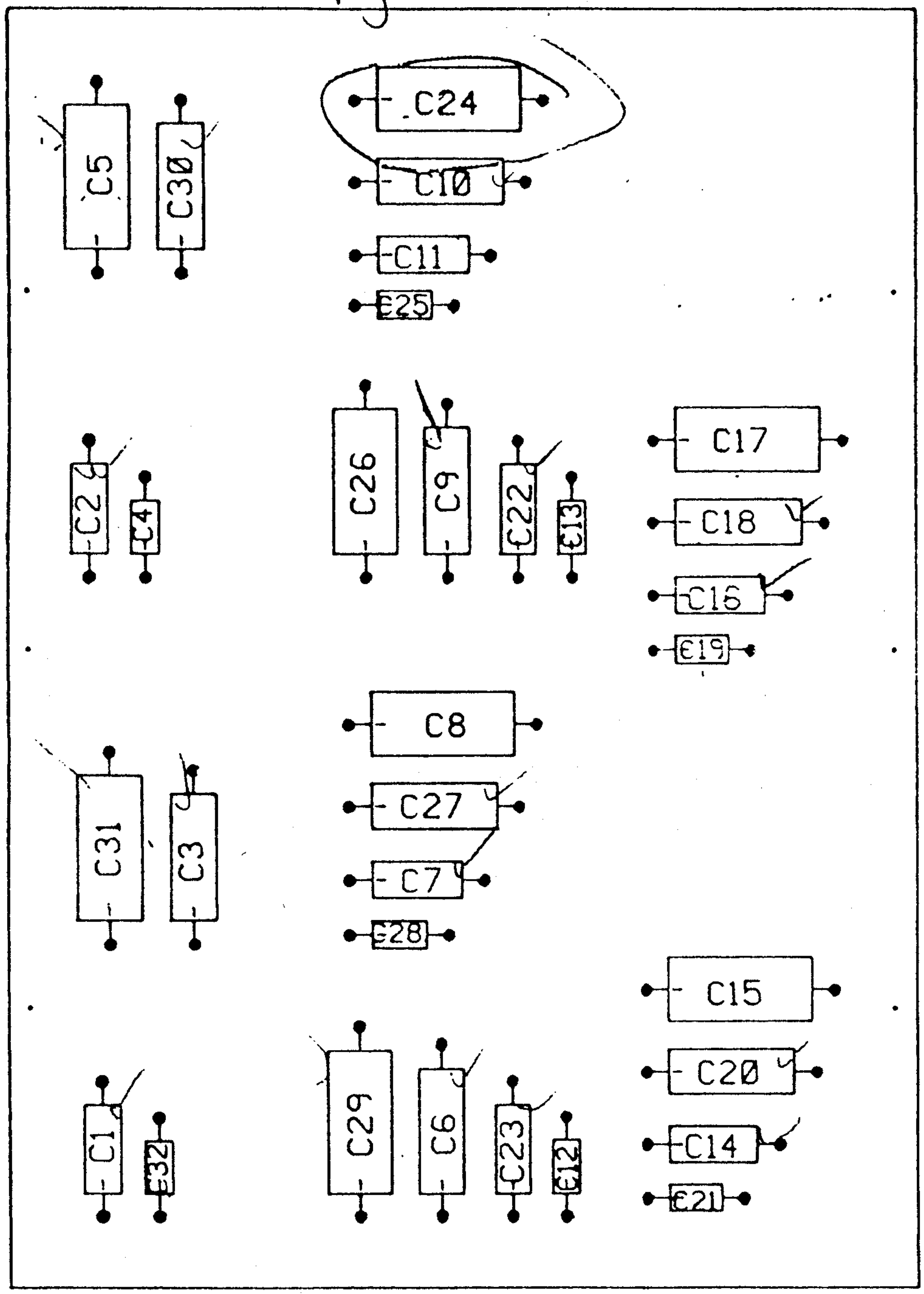
TABLE 2. FAILURE SUMMARY

	X-AXIS	Y-AXIS	Z-AXIS	
CASE SIZE				
A	0	0	2	
B	0	0	8	
C	3	5	8	
D	5	5	8	
	8	10	26	TOTAL BY AXIS
			44	TOTAL
			47.8%	FAILURE RATE

As theorized unstaked, axial-lead, solid tantalum capacitors fail under vibration. Not only is electrical continuity lost but shorting may also occur from loose parts on the PWB. The test data supports the staking requiremtns for all axial-lead, solid tantalum capacitors identified in NHB 5300.4(3J), section 3J602.4 and NHB 5300.4(3K), section 3K506.7. It is recommended that waivers and deviations to these requirements be disapproved.

FIGURE 1

Fig. 1



TEST SETUP SKETCH

FIGURE 2 (a)

Vertical Axis 3 SPECIMEN Test

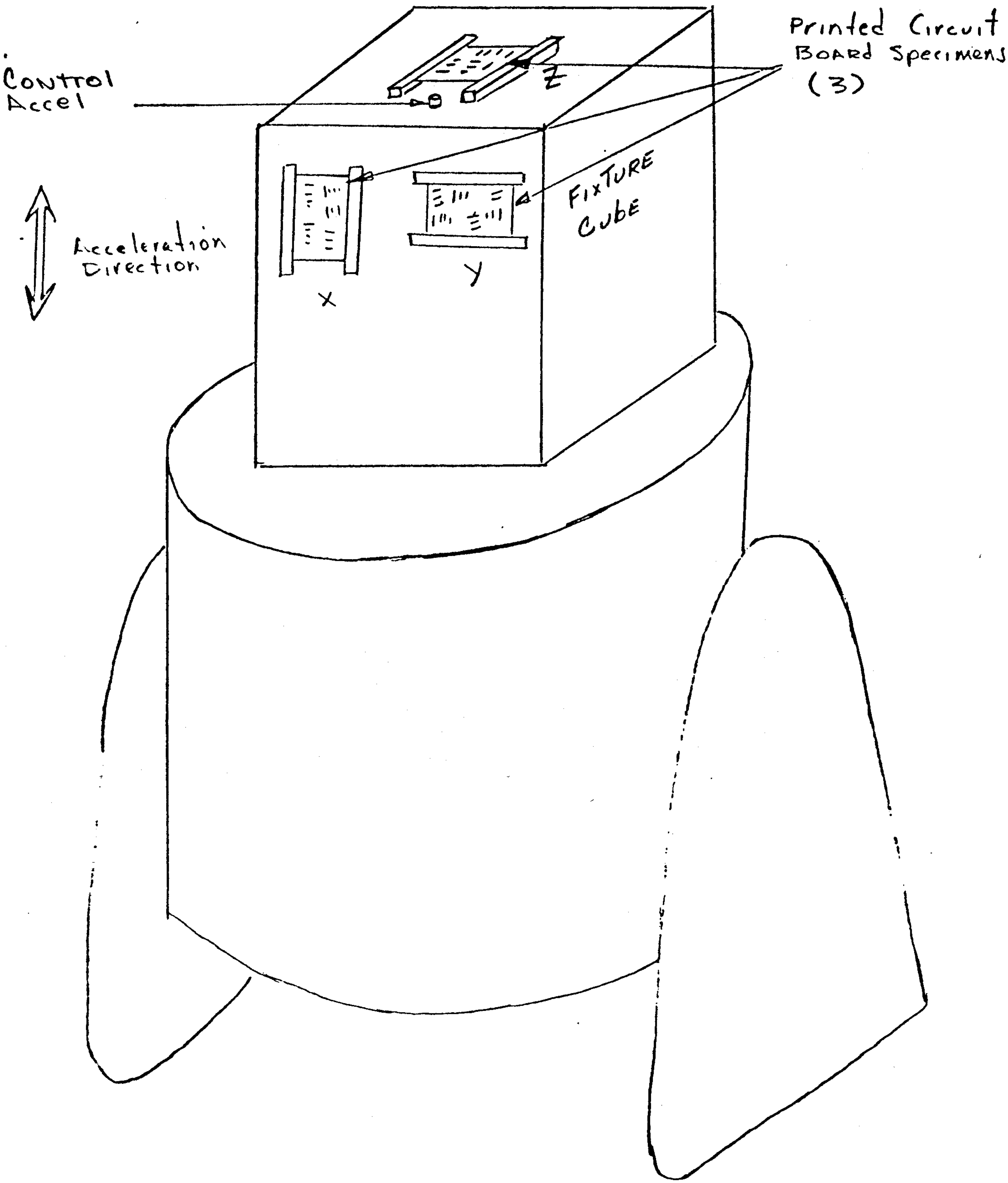


FIGURE 2 (b)

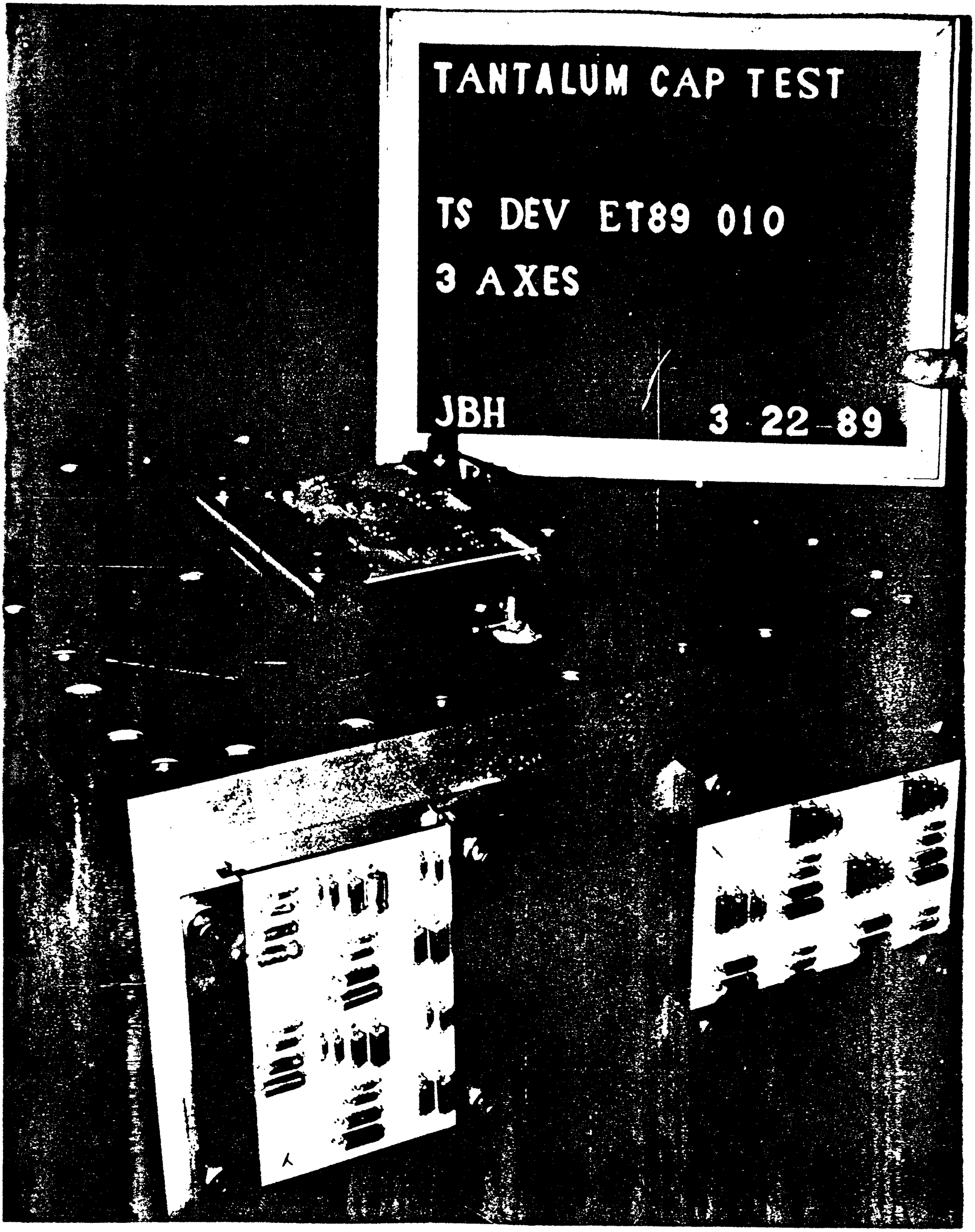


TABLE 3. FAILURE DATA

		COMPOSITE G LEVELS (TOTAL VIB. TIME IN MIN.)		
CASE	I/D	X-AXIS	Y-AXIS	Z-AXIS
A	C04			
	C12			
	C13			
	C19			
	C21			
	C25			28.04 (28)
	C28			17.97 (17)
	C32			
B	C01			49.32 (48)
	C02			35.73 (36)
	C07			17.97 (18)
	C11			34.42 (34)
	C14			40.50 (40)
	C16			37.75 (38)
	C22			31.94 (32)
	C23			31.94 (32)
C	C03	31.94 (32)		34.42 (32)
	C06		49.32 (48)	30.20 (30)
	C09	40.50 (40)		23.92 (24)
	C10		35.73 (36)	22.05 (22)
	C18		40.50 (40)	34.42 (34)
	C20		34.42 (34)	35.73 (36)
	C27		23.92 (24)	11.94 (12)
	C30	34.42 (34)		40.50 (40)
D	C05	17.97 (18)		22.05 (22)
	C08		13.99 (14)	11.94 (12)
	C15		15.90 (16)	22.05 (22)
	C17	37.75 (38)	23.92 (24)	31.94 (32)
	C24		30.20 (30)	15.90 (16)
	C26	34.42 (34)		17.97 (18)
	C29	23.92 (24)	19.91 (20)	19.91 (20)
	C31	17.97 (18)		28.04 (28)

G LEVEL	CAP ID	VIB TIME	DESCRIPTION
3.481		2	ALL is well (AIW)
5.025		4	(AIW
[illegible]43		6	(AIW) Few Beads
7.[illegible]36		8	(AIW)
9.[illegible]62		10	
11.94	C27/C C8/D	12	Broke at solder joint (Z-axis) " " " " "
13.79	C27/C C8/D C8/D	14	2nd Break closer to body } Z-axis " " at solder joint Broke at body (Y-axis)
15.90	C15/D ? C24/D	16	Broke at body (Y-axis) " " " (Z-axis)
17.97	C7/E C15/D C28/A C26/D C5/D C31/D	18	Both breaks at solder joints (Z-axis 2nd Break at closer to body (Y-axis) One break at solder joint [illegible] (Z-axis Break at body (Z-axis) Break at body (X-axis) " "

G LEVEL	CAP ID	VIB TIME	DESCRIPTION
19.91	C8/D	20	2nd Break at body (y-axis)
	C29/D		Breaks at body + solder joint (y-axis)
	C24/D		" " " " " (z-axis)
22.05	C15/D	22	Breaks at body + solder joint (z-axis)
	C10/C		Breaks at solder joints (z-axis)
	C5/D		Broke at body (z-axis)
23.92	C17/D	24	Broke at solder joint (y-axis)
	C27/C		Broke at body (y-axis)
	C29/D		Broke at body (x-axis)
	C5/D		2nd break lead at bend (z-axis)
	C9/C		Broke at body (z-axis)
26.03	C9/C	26	2nd Break at solder joint (z-axis)
	C5/D		" " " " " (x-axis)
	C31/D		" " " " " (x-axis)
28.04	C17/D	28	2nd Break at solder (y-axis)
	C27/C		" Break at solder "
	C21/D		Break at solder (y-axis)
	C25/A		1st Break at solder (z-axis)
	C31/D		Break at body (z-axis)

G LEVEL	CAP ID	VIB TIME	DESCRIPTION	
30.20	C24/D	30	2nd Break in lead (y-axis)	
	C6/C		1Break at solder + body (z-axis)	
31.94	C23/B	32	Breaks at body	z-axis ✓
	C22/B		" " " + solder	z-axis
	C17/D		" " " "	z-axis
	C3/C	-	Break at body	x-axis
34.42	C3/C	34	Break at body, + solder	z axis
	C16/C		Break at [illegible] at body	z-axis
	C3/C		Break lead	x-axis
	C26/D		Break at body	x-axis
	C20/C		Break at solder	y-axis
	C11/B		Break in lead	z-axis
	C30/C		Break at body	x-axis
35.73 →	C26/D	36	2nd Break	x-axis
	C10/E ✓			y-axis
	C2/E		Break at body + lead	z-axis
	C30/C		Break at body	z-axis
	C31/E		Break at solder	z-axis

G LEVEL	CAP ID	VIB TIME	DESCRIPTION	
37.75	C20/C	38	2nd Break in lead	(z-axis)
	C17/D		Break at body + solder	(x-axis)
	C16/B		Break in bend	(z-axis)
40.5	C30/C	40	1st Break at bend	(x-axis)
	C18/C		Break at bend	y-axis
	C30/C		2nd Break at bend	z-axis
	C16/B		Breaks at Both [illegible]	z-axis
	C14/B		Break at body	z-axis
	C9/C		Break at body	x-axis
48.8/47.2[illegible]	C14/B	[illegible]	2nd Break at body	z-axis
	C9/C		2nd Break Broke lead	x-axis
	C1/B		1st Break at body	z-axis
	C[illegible]/C		Break at body	y axis

f. Resonance uncovered