JCAA/JG-PP No-Lead Solder Testing Status

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Seattle, WA

JCAA/JG-PP Meeting
Melbourne, FL

September 21, 2004

Status

- Boeing Irving completed assembly of 205 test vehicles
- Vehicles distributed to testing sites on 7/19/04
- Testing
  - ✓ Boeing Seattle (thermal cycle*, thermal shock, vibration)
  - ✓ Boeing Anaheim (SIR*, electromigration*)
  - ✓ Rockwell-Collins (thermal cycle)
  - ✓ ACI (mechanical shock, salt fog)
  - ✓ Raytheon (combined vibration/thermal cycle)
  - ✓ Sandia (microsections*)

*Donated as work-in-kind

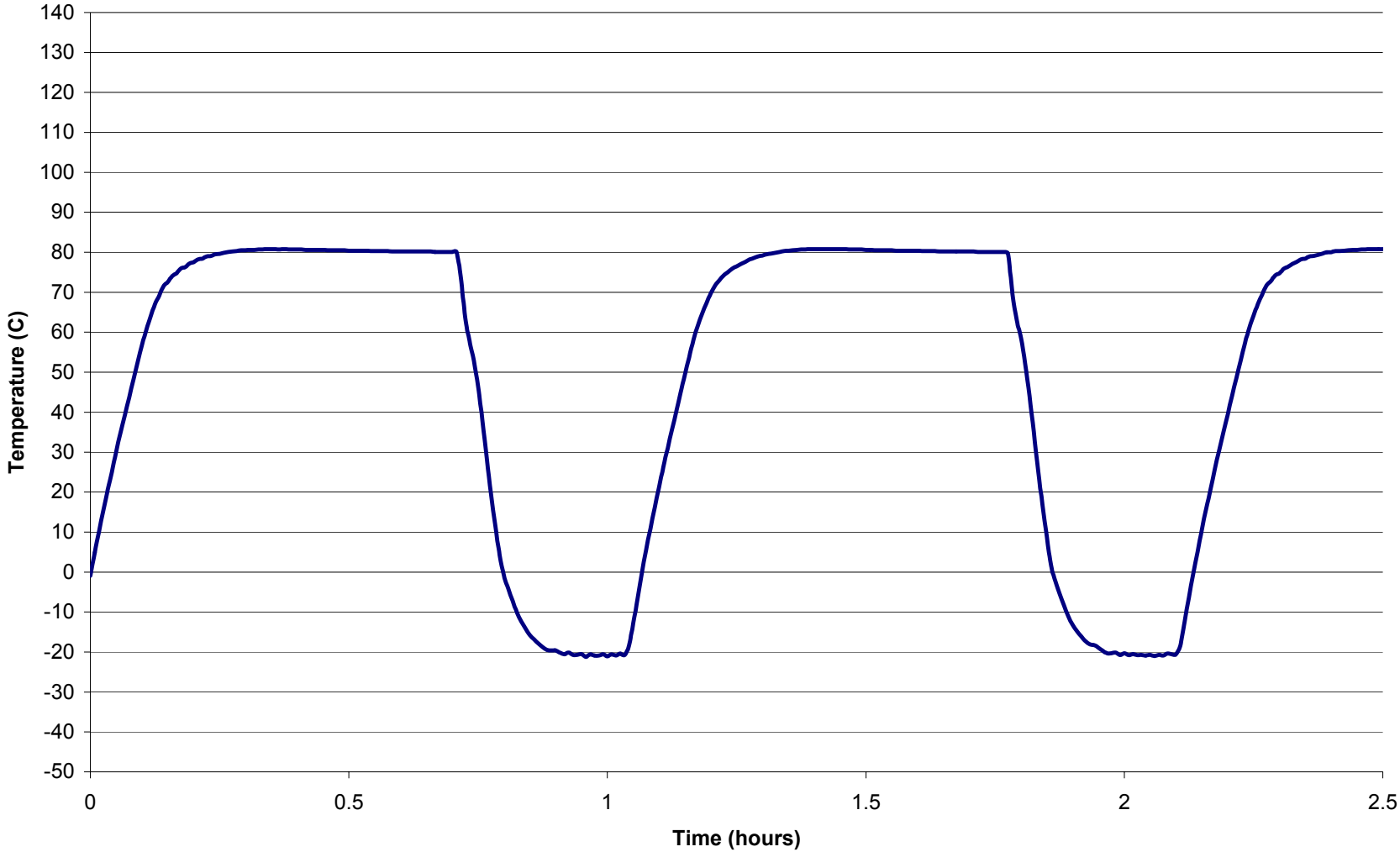
Boeing Testing (Seattle)

- **Thermal Cycle (15 test vehicles)**
  - ✓5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
- **Thermal Shock (30 test vehicles)**
  - ✓5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
  - ✓**(Reworked)** 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
- **Vibration (30 test vehicles)**
  - ✓5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
  - ✓**(Reworked)** 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi

Thermal Cycling - Boeing (-20°C to 80°C)

Thermal Cycle Chamber

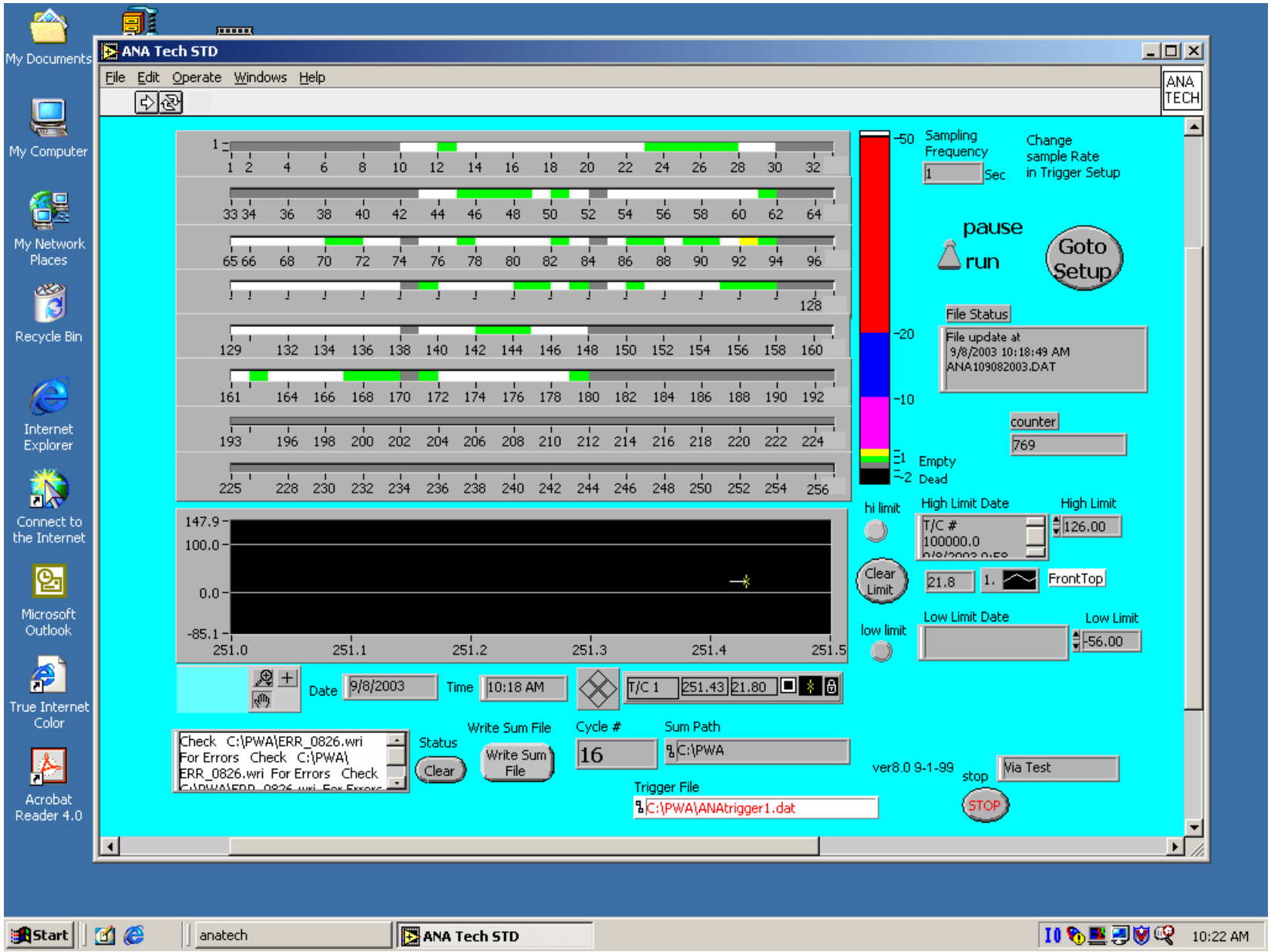
Thermal Cycle (-20°C to +80°C; Actual Board Temperature)
30 min. dwell (hot); 10 min. dwell (cold)



Anatech Event Detectors

Up to 4 can be controlled by one computer for a total of 1024 channels

Labview-based Data Collection Software



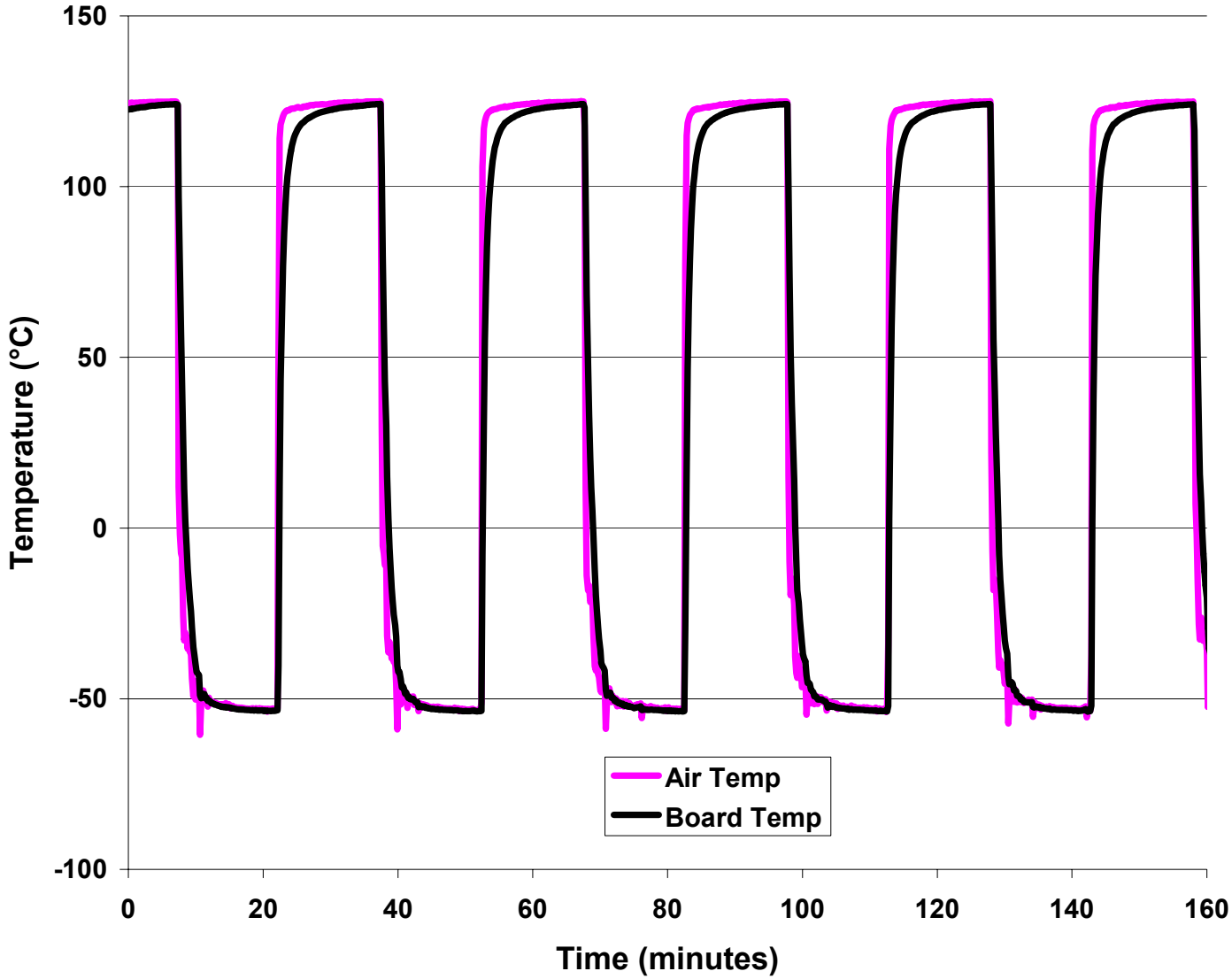
Thermal Cycling Status

- Wire bundles are being attached to the test vehicles.
- Testing should begin 9/25/04.
- Testing needs to be done to failure otherwise data is worthless for those that want to do modeling

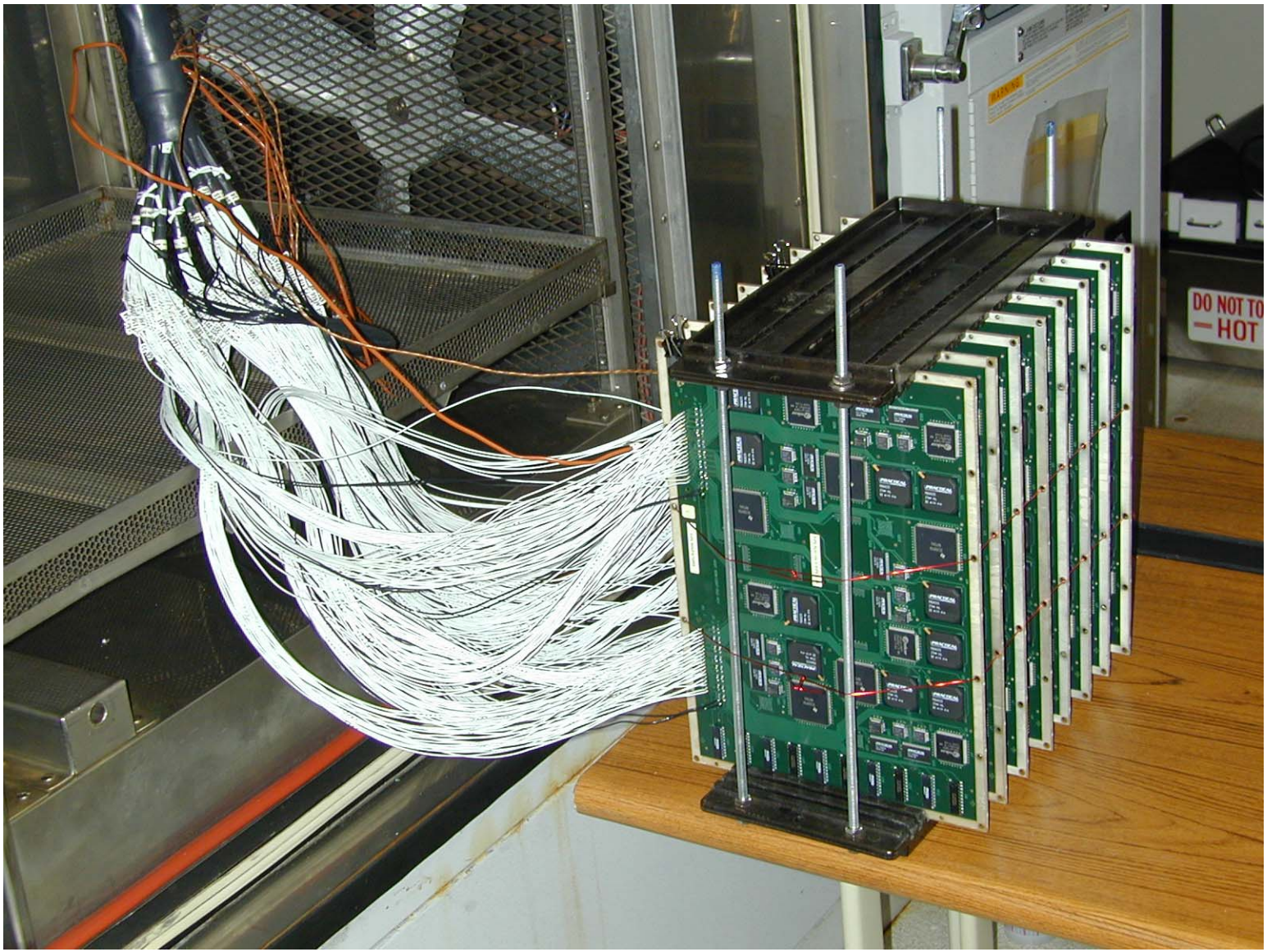
Thermal Shock - Boeing (-55°C to 125°C)

Thermal Shock Chamber
Capable of -70° to 200°C
Wired for 512 Channels

Thermal Shock Cycle (-55°C to 125°C,15 min. dwells)

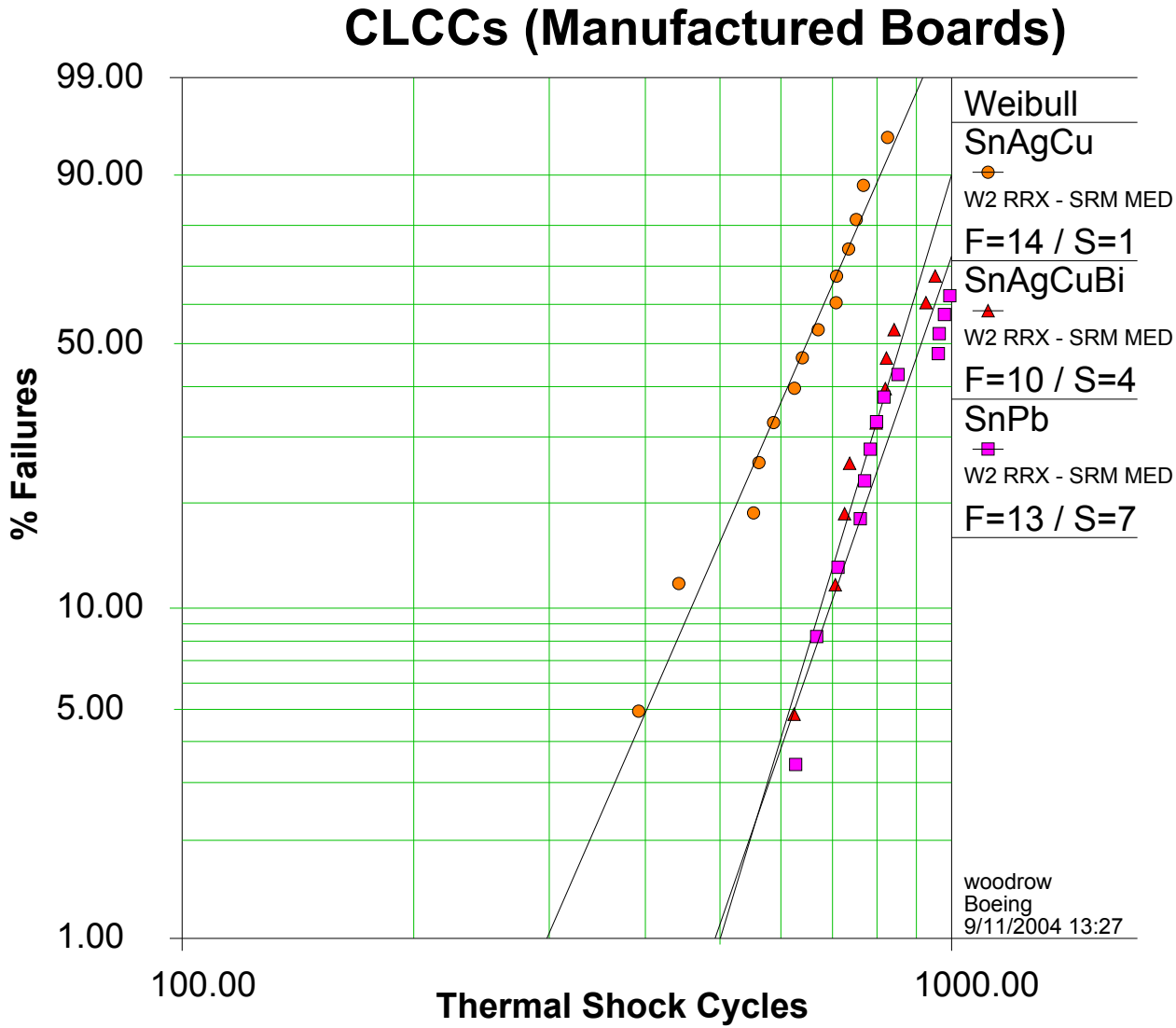


Test Vehicles Ready for Thermal Shock Test



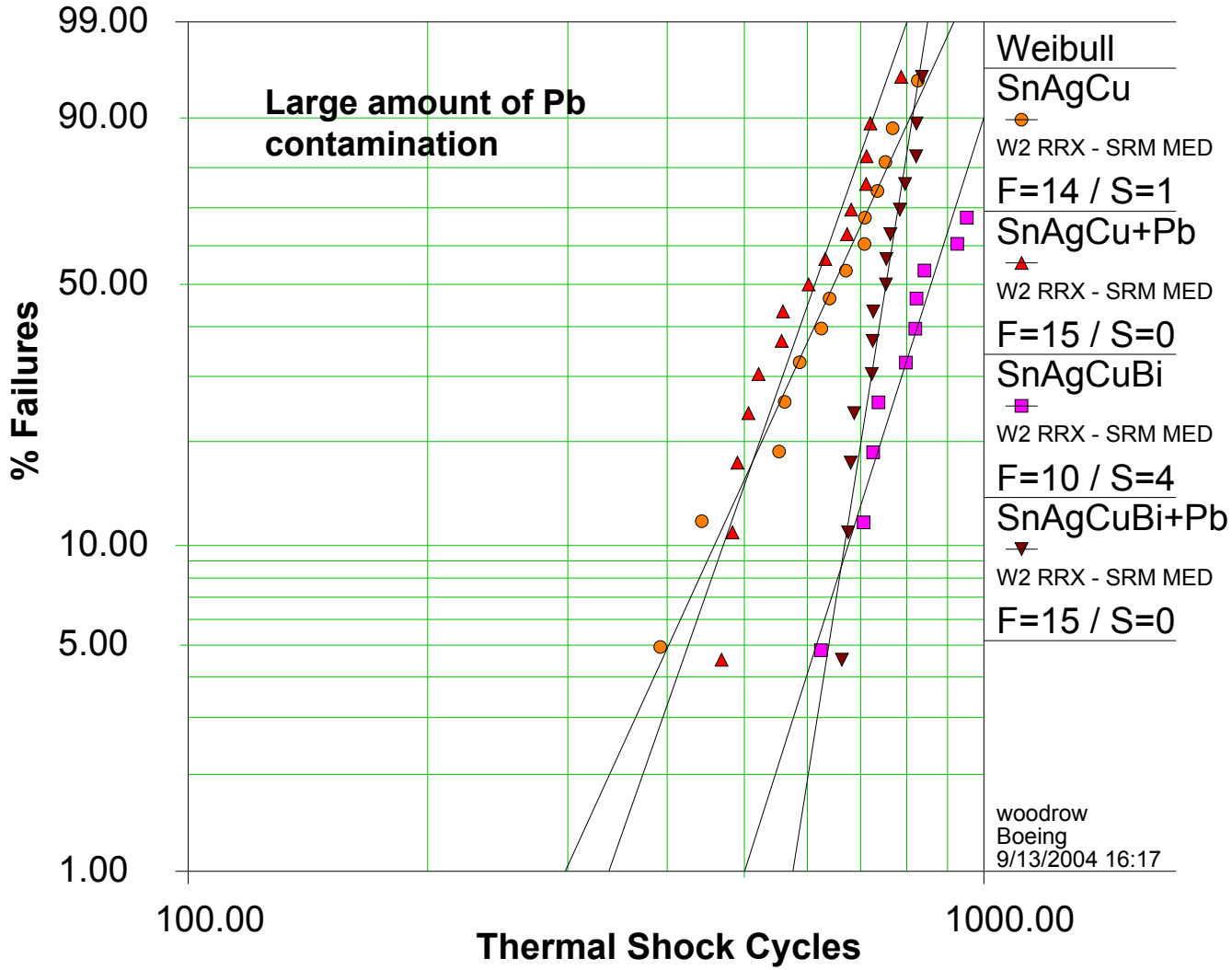
Thermal Shock Status

- Thermal shock testing divided into four batches
- First batch is complete (2-SnPb boards; 3-SAC boards; 3-SACB boards)
- Second batch should be complete on 9/24/04 (3-SnPb boards; 2-SAC boards; 2-SACB boards; chip resistors on BOC's)
- Third and fourth batches complete by end of 2004



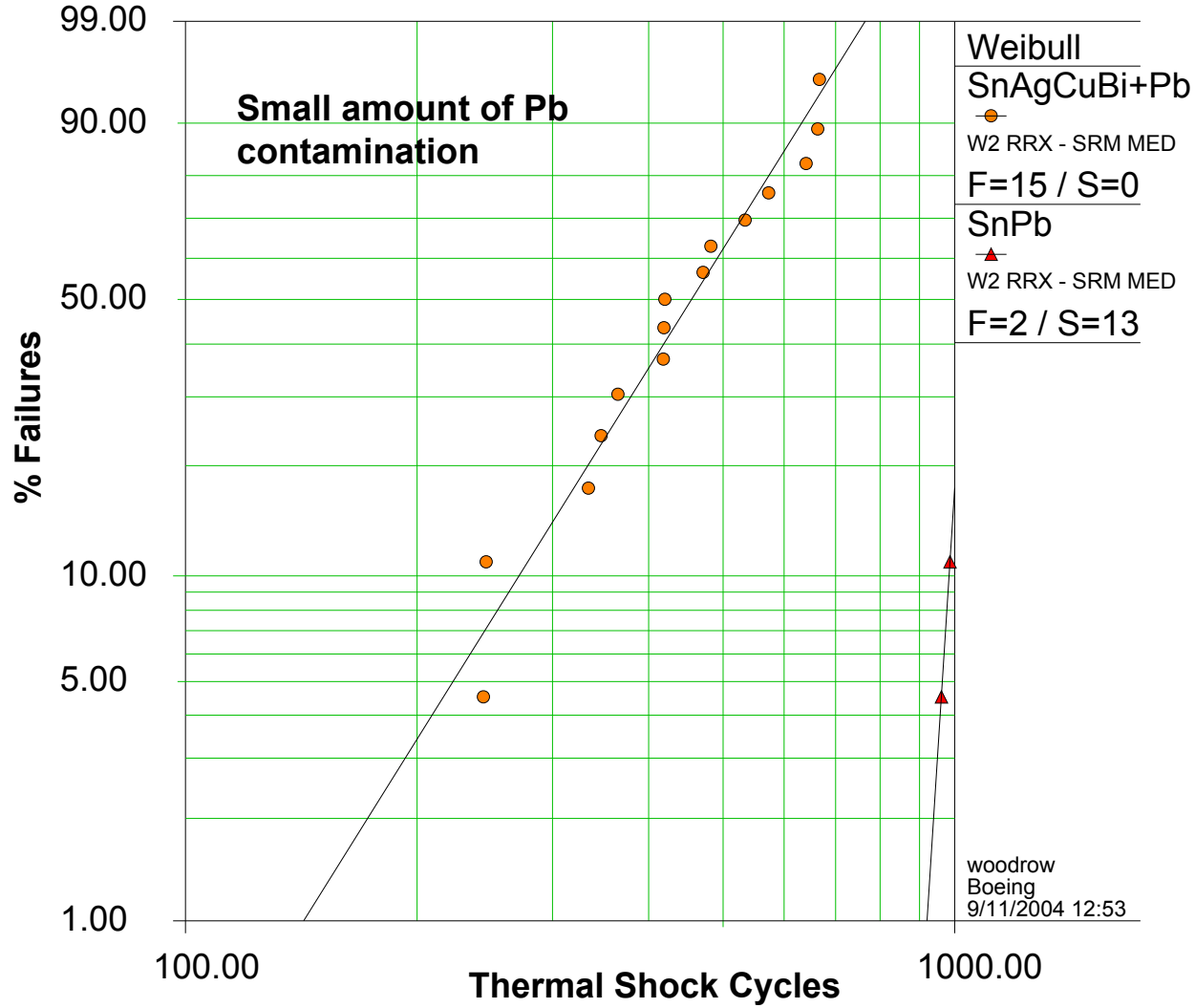
β1=5.4468, η1=692.9868, ρ=0.9882
β2=7.8529, η2=899.1317, ρ=0.9721
β3=6.8595, η3=963.3632, ρ=0.9571

CLCCs (Manufactured Boards)



β1=5.4468, η1=692.9868, ρ=0.9882
β2=7.1000, η2=645.7742, ρ=0.9546
β3=7.8529, η3=899.1317, ρ=0.9721
β4=15.7176, η4=771.2573, ρ=0.9642

TSOPs (Manufactured Boards)



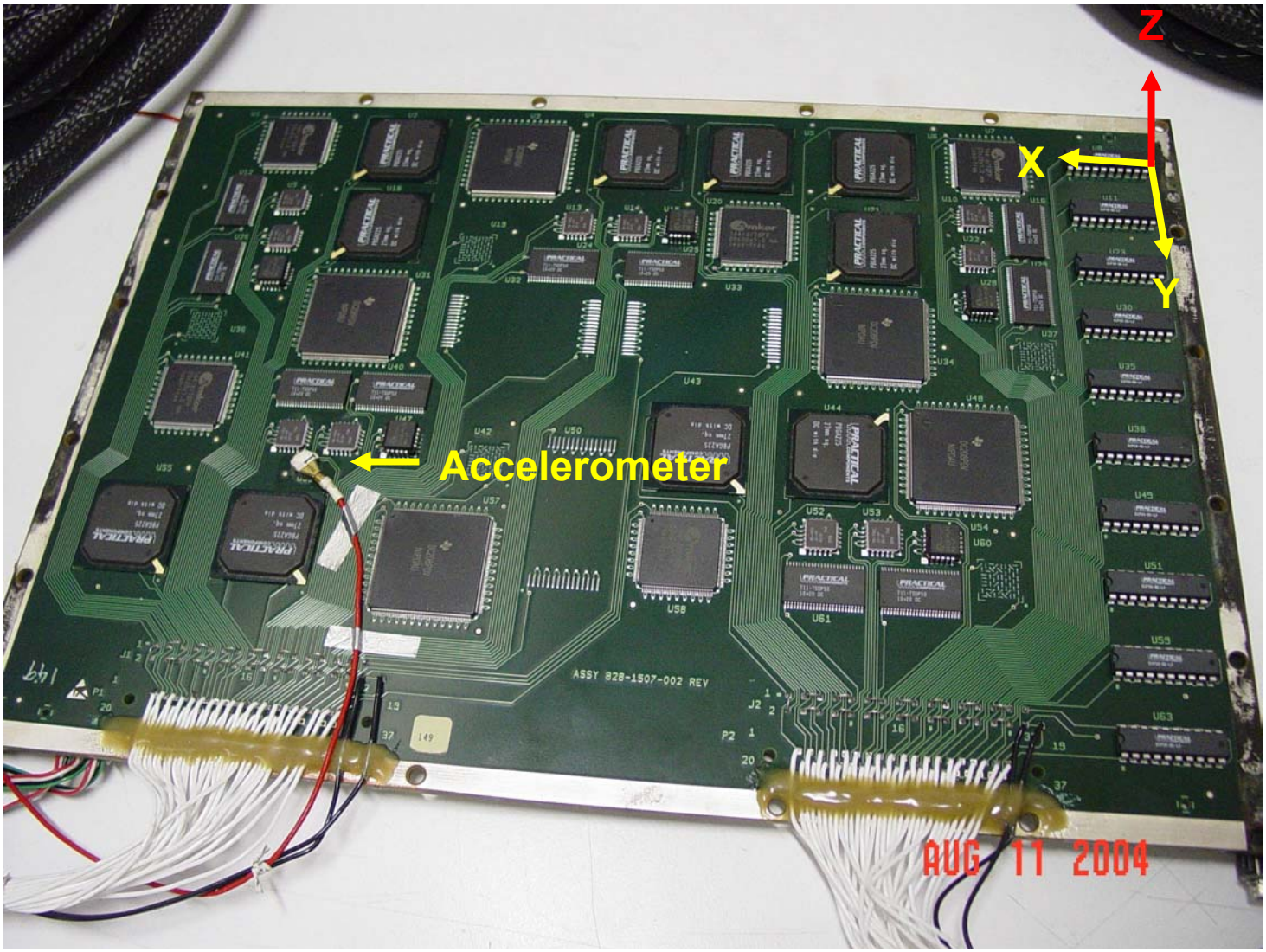
β1=3.6445, η1=503.3101, ρ=0.9802
β2=35.7899, η2=1047.2054, ρ=1.0000

Vibration - Boeing

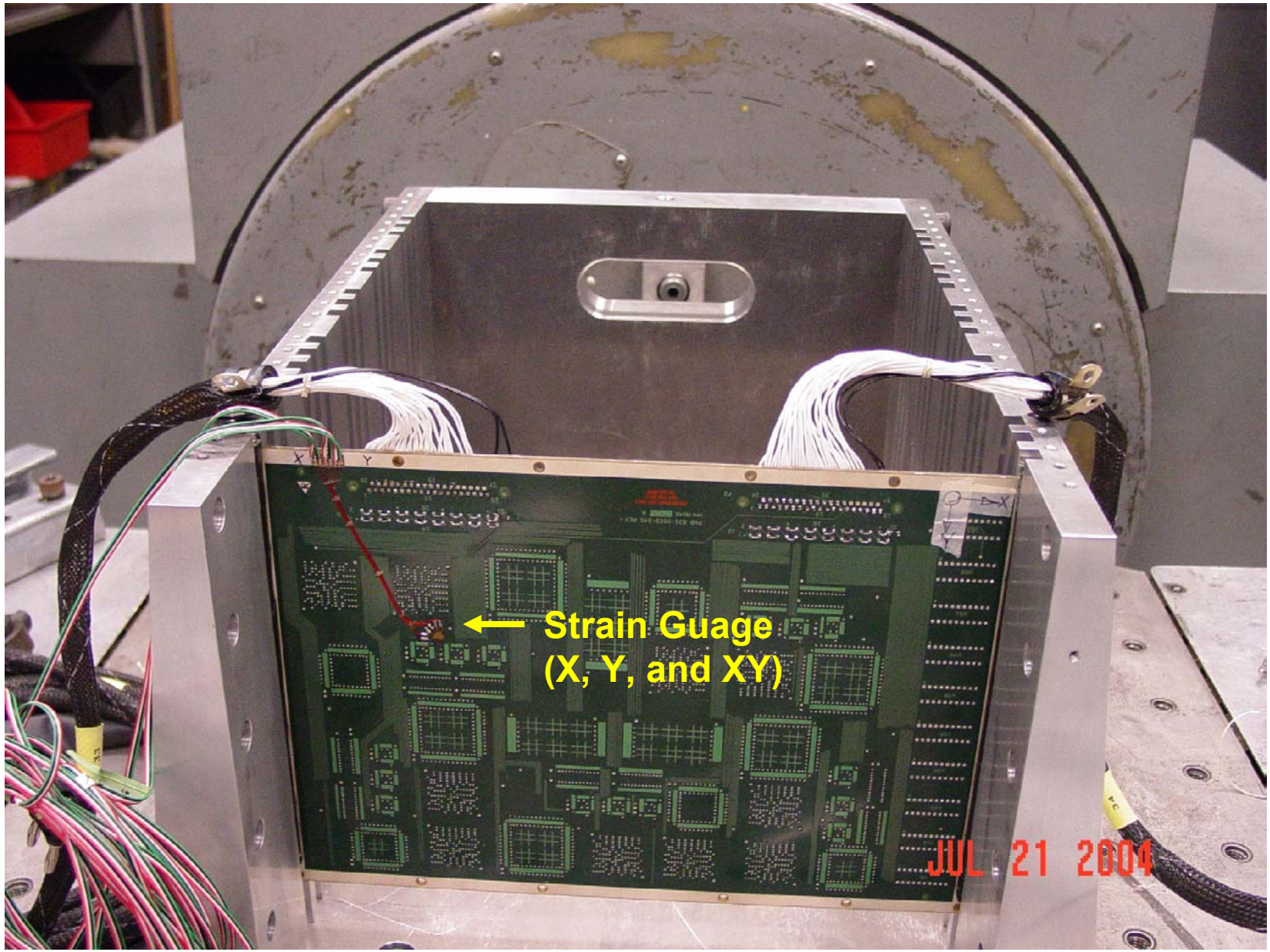
Pathfinder Board

- A “pathfinder” board was used:
  - ✓To verify that there were no problems with electronic noise, the fixture, or the wires
  - ✓A modal analysis was done using a laser vibrometer (maps mode shapes and identifies resonances)
  - ✓A strain gauge was mounted on the “pathfinder” board so that CALCE would have strain data for validation of their models

Test Vehicle

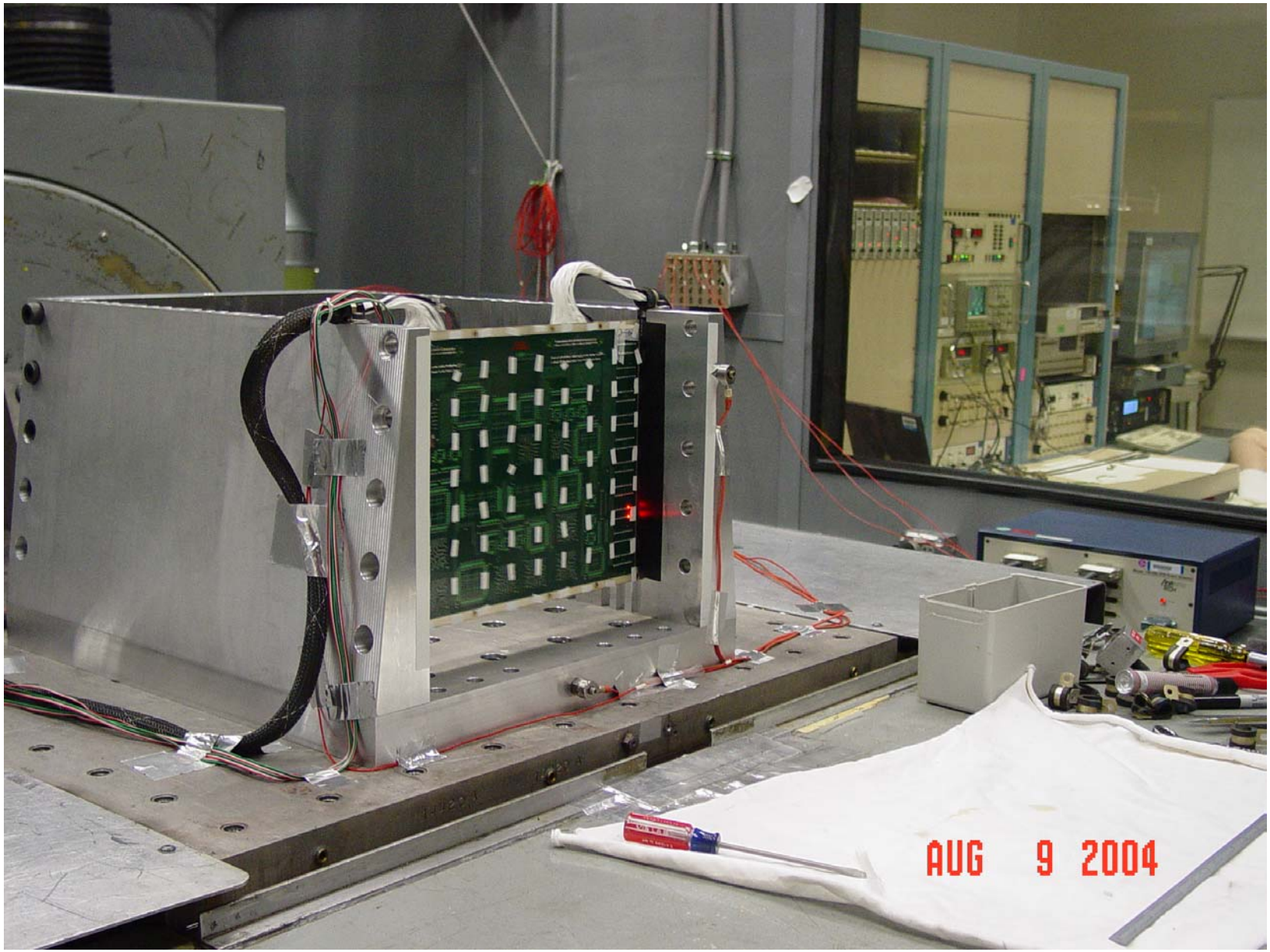


Strain data was taken for CALCE



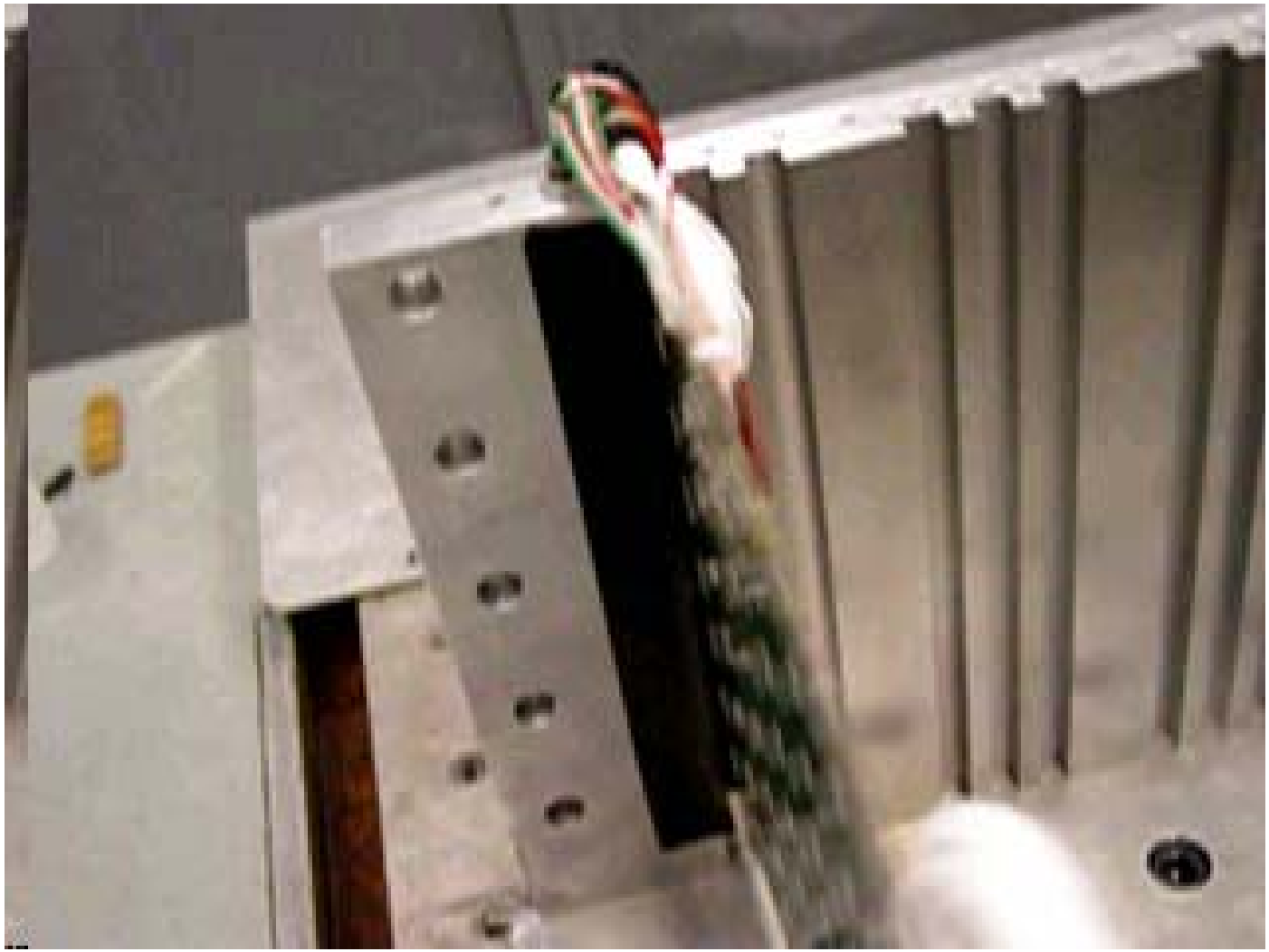
Laser Vibrometer System for Modal Analysis of Test Vehicle

Laser Vibrometer Measures Velocities, Accelerations, Displacements

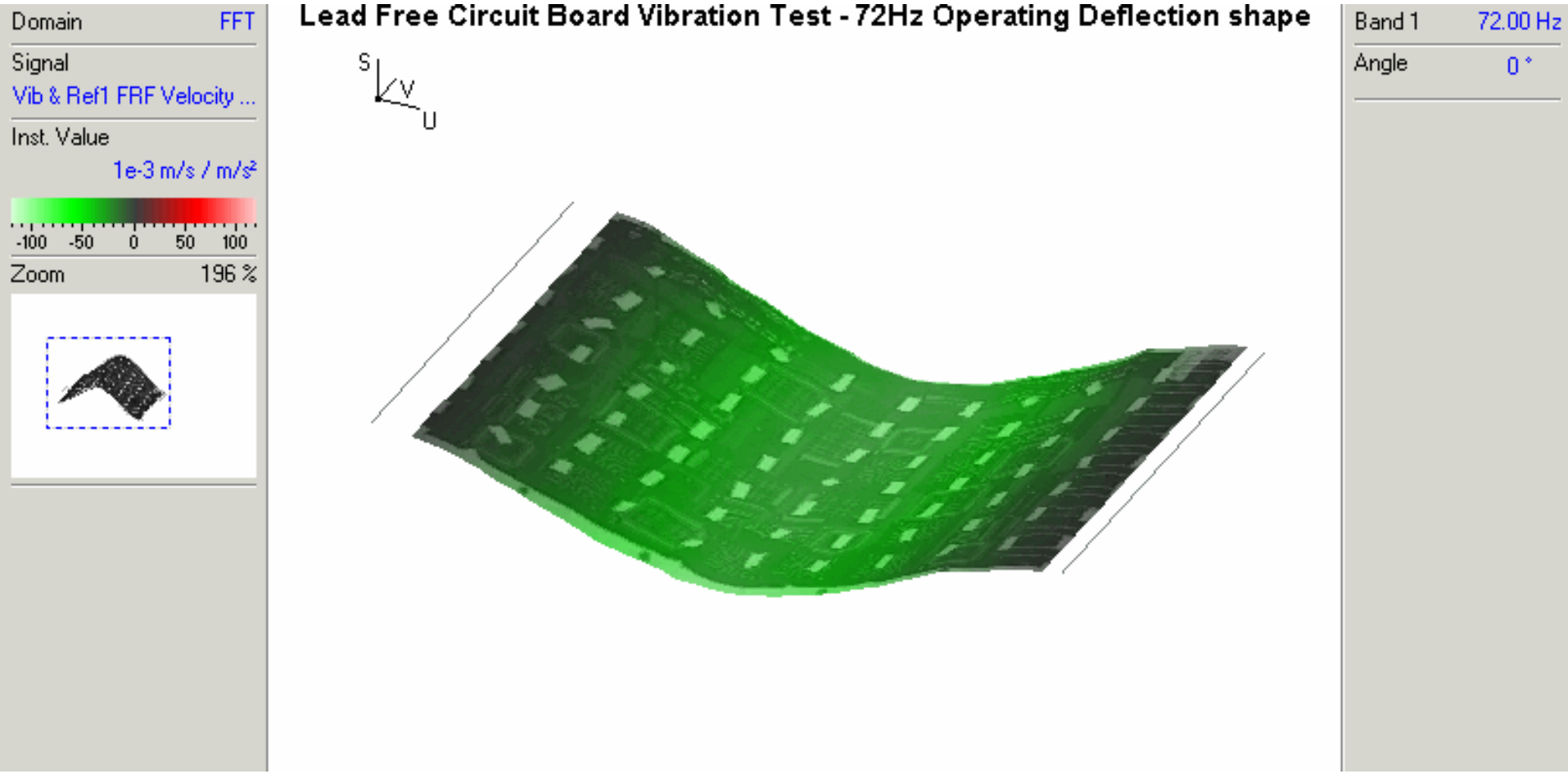


Laser Vibrometer

Pathfinder Test Vehicle in Z-Axis (16.0 Grms)

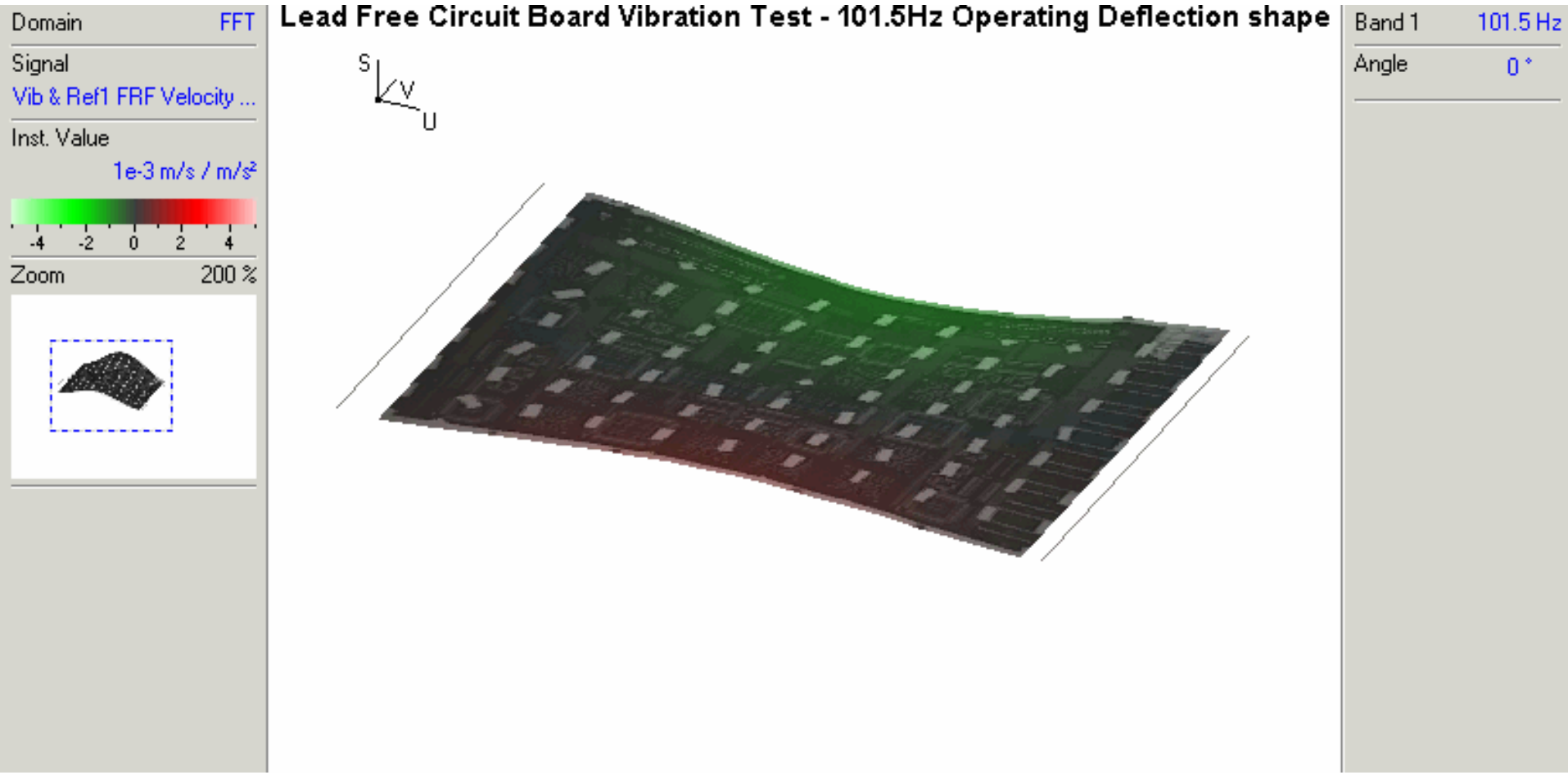


Operating Deflection Shape at 72 Hz

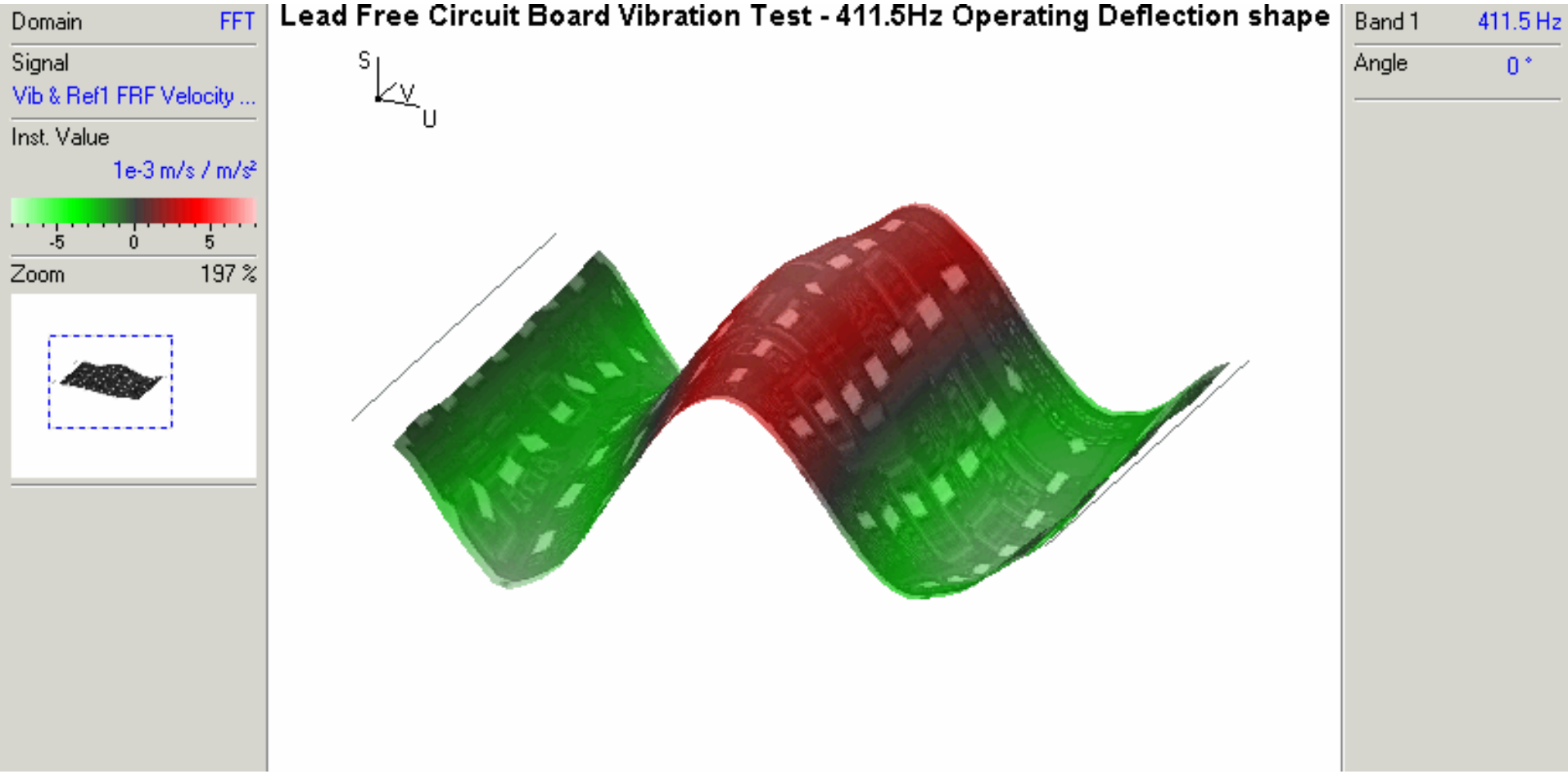


Boeing's prediction of first resonance was 80 Hz

Operating Deflection Shape at 101.5 Hz



Operating Deflection Shape at 411.5 Hz



Universal File Viewer - Animation

File Display View Vertical Format List Help

Prev | Mode List | Next

2: 76.9084 Hz
3: 101.0824 Hz
4: 165.5052 Hz
5: 209.5593 Hz
6: 222.4986 Hz
7: 241.8041 Hz
8: 252.3401 Hz
9: 362.9846 Hz
10: 410.2696 Hz
11: 427.1718 Hz

Component List

1: NONE
2: NONE
3: NONE
4: NONE
5: NONE

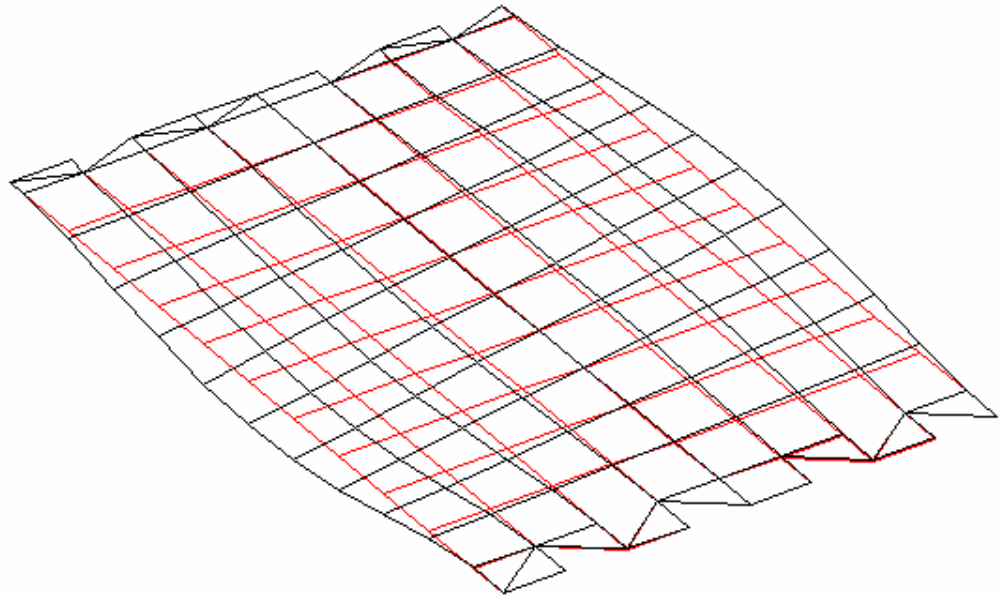
Label
Highlight
Pan
Rotate
Static
Realtime
RealtimeSync
Anotation

Mark

-10%	Amplitude	+10%
-10%	Scale	+10%
-10%	Speed	+10%
-10%	Smooth	+10%

Mode #3: 101.0824 Hz
Vib_Ref1 H1 Acceleration / Acceleration, ConjMAC= 0.985, MPC= 0.923
MPC 2 1 1 9.2313E-01

Mode Shape at 101 Hz



Text Area

Text Field

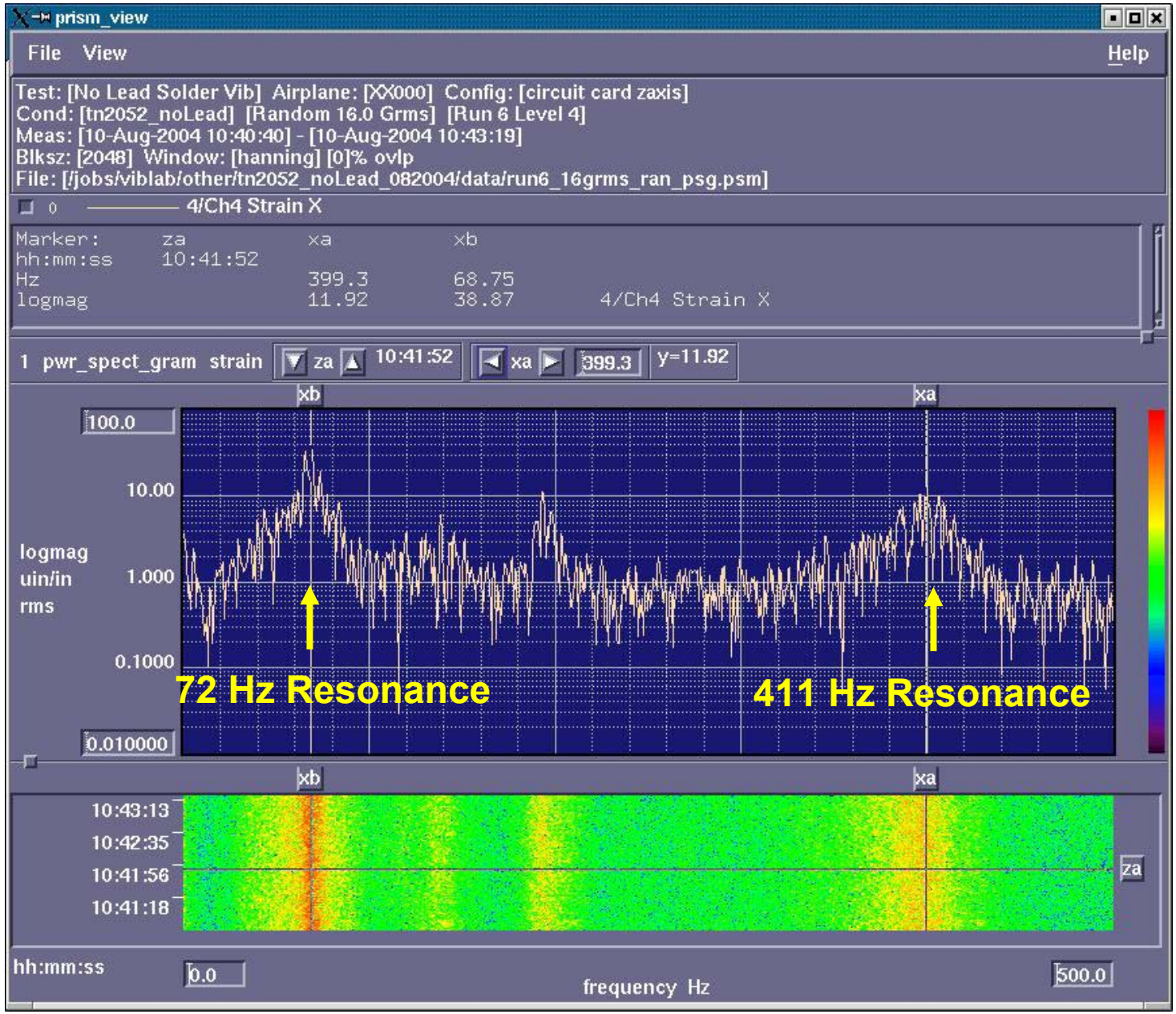
Unsigned Java Applet Window

Start | tn2052_no_lead_circuit_b... | Universal File Viewer - ... | 4:12 PM

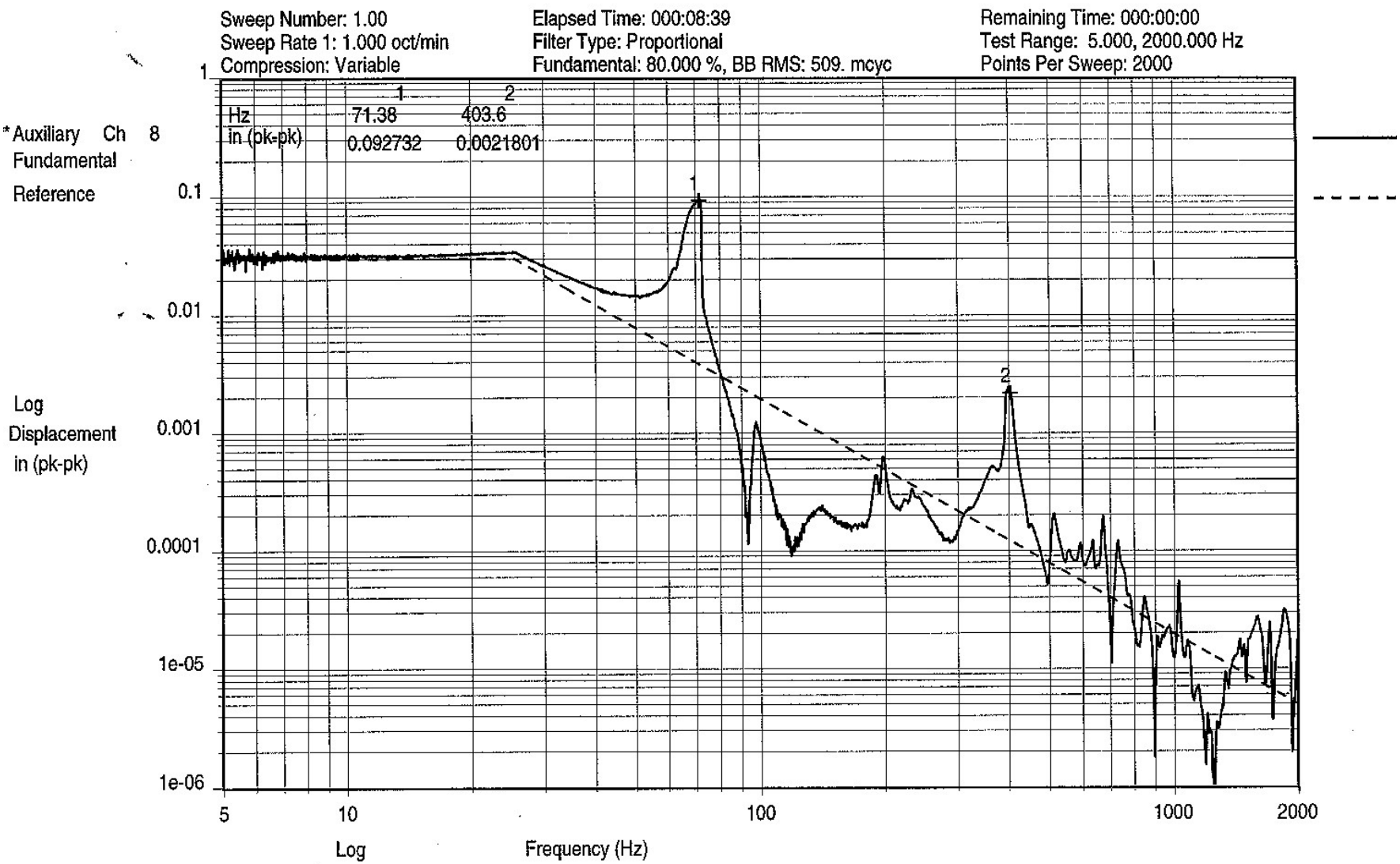
Strain Acquisition using Prism

Strain vs. Frequency

(the most strain is at 72 Hz)



Displacement vs. Frequency
(the most displacement is at 72 Hz)



Z RESPONSE, Board # 008

08:45:52
02-Sep-2004

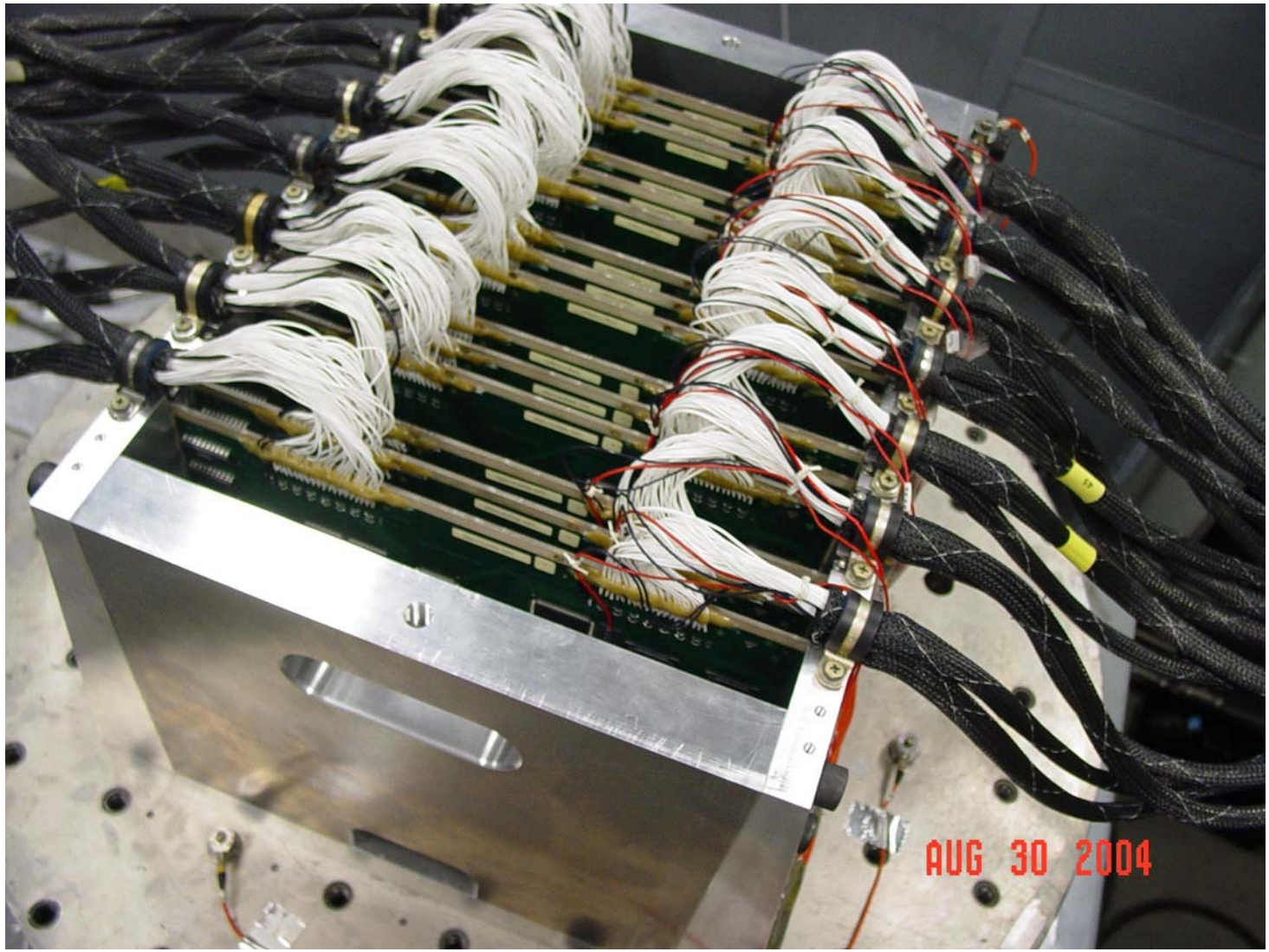
TN: 2052 No lead Circuit Board, 1st Set of 15 Boards
RUN#6 Z-Axis, SINE SWEEP 1.0 Gpk Operator:TDK

Sine Test Name: tn2052_NoLead_Circuit_bd.002

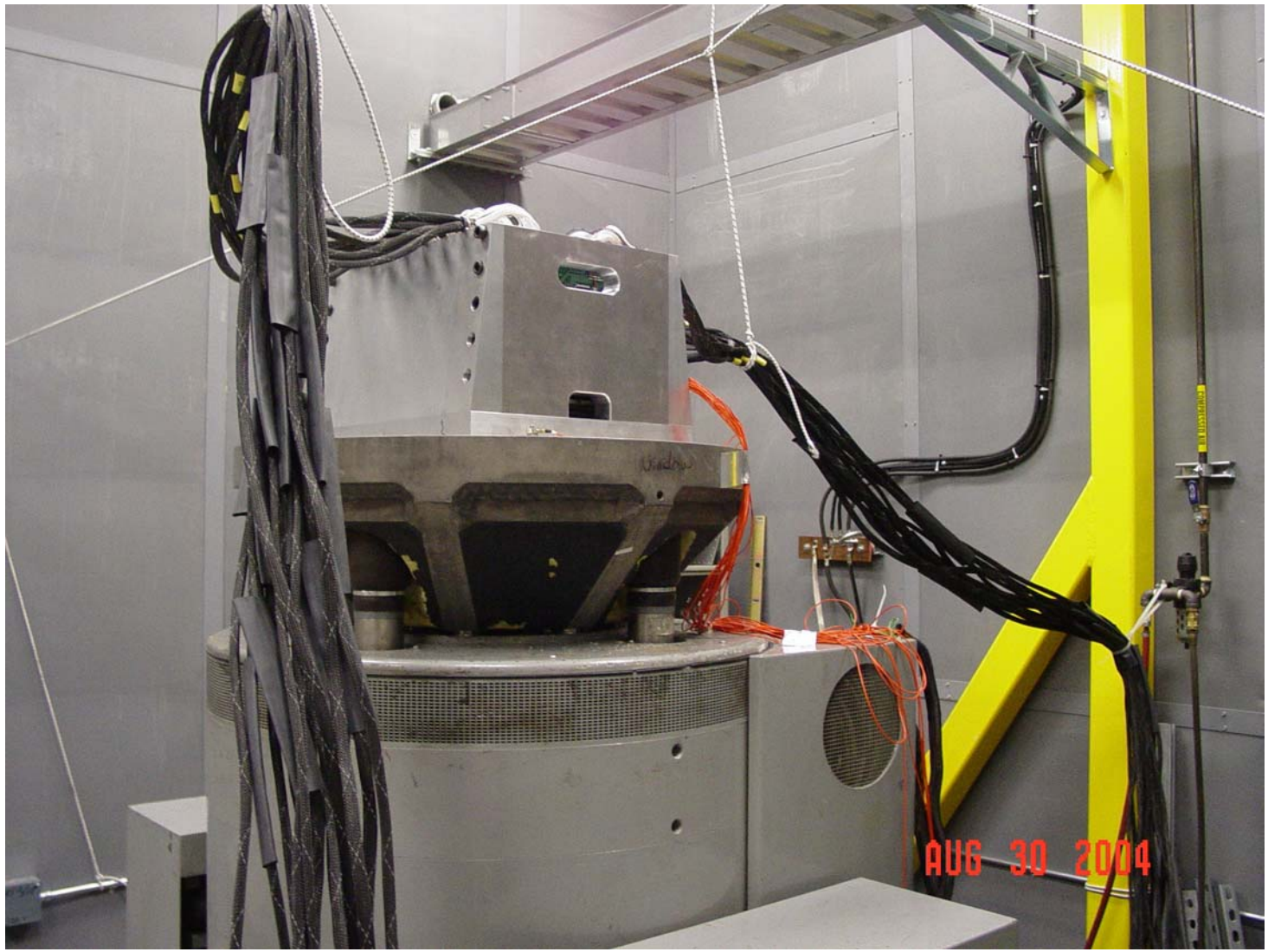
Vibration Test Status

- All “manufactured” and “rework” test vehicles have been tested
- Data needs to be reduced and put into a useable format

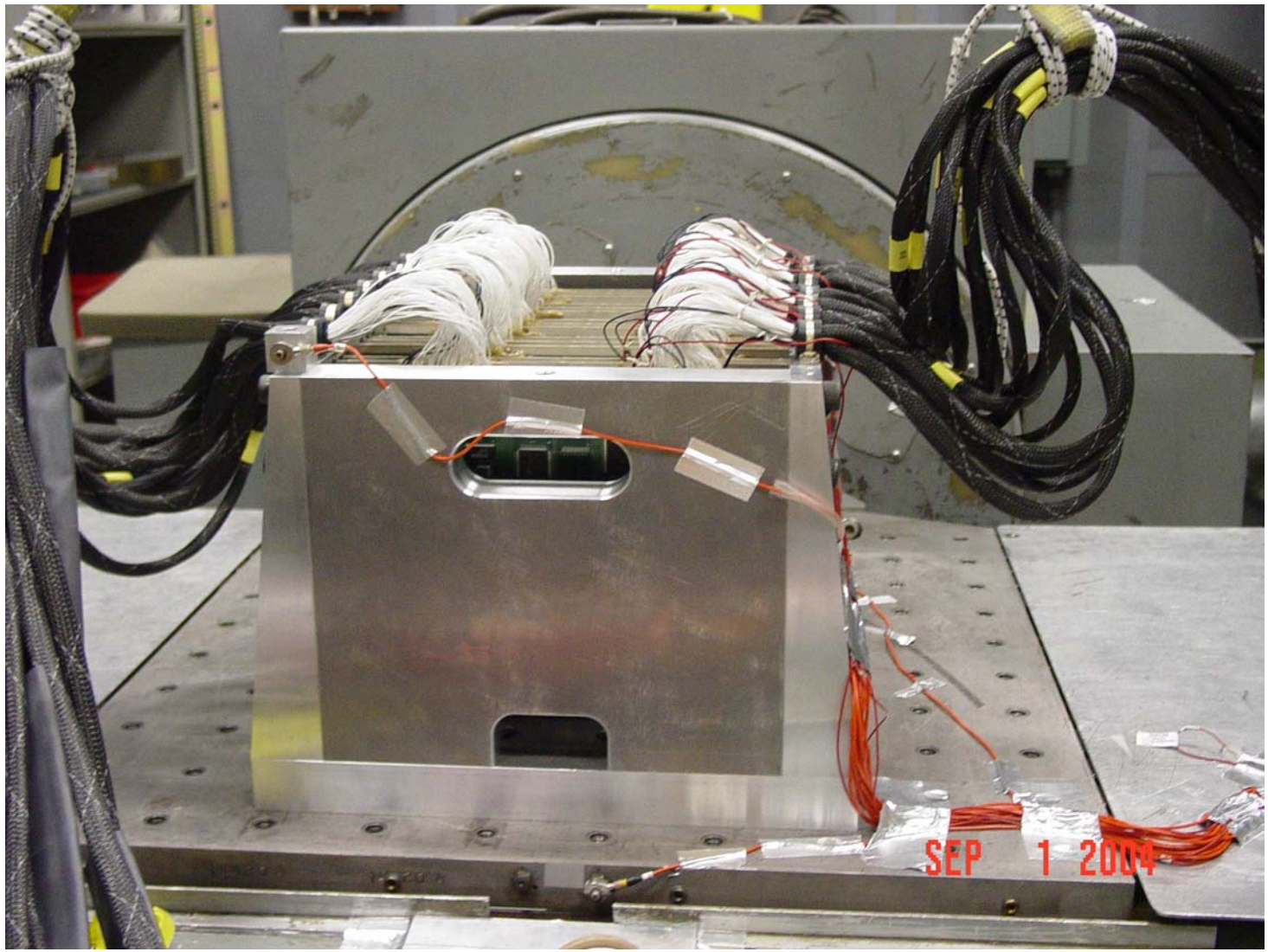
Test Vehicles in Fixture



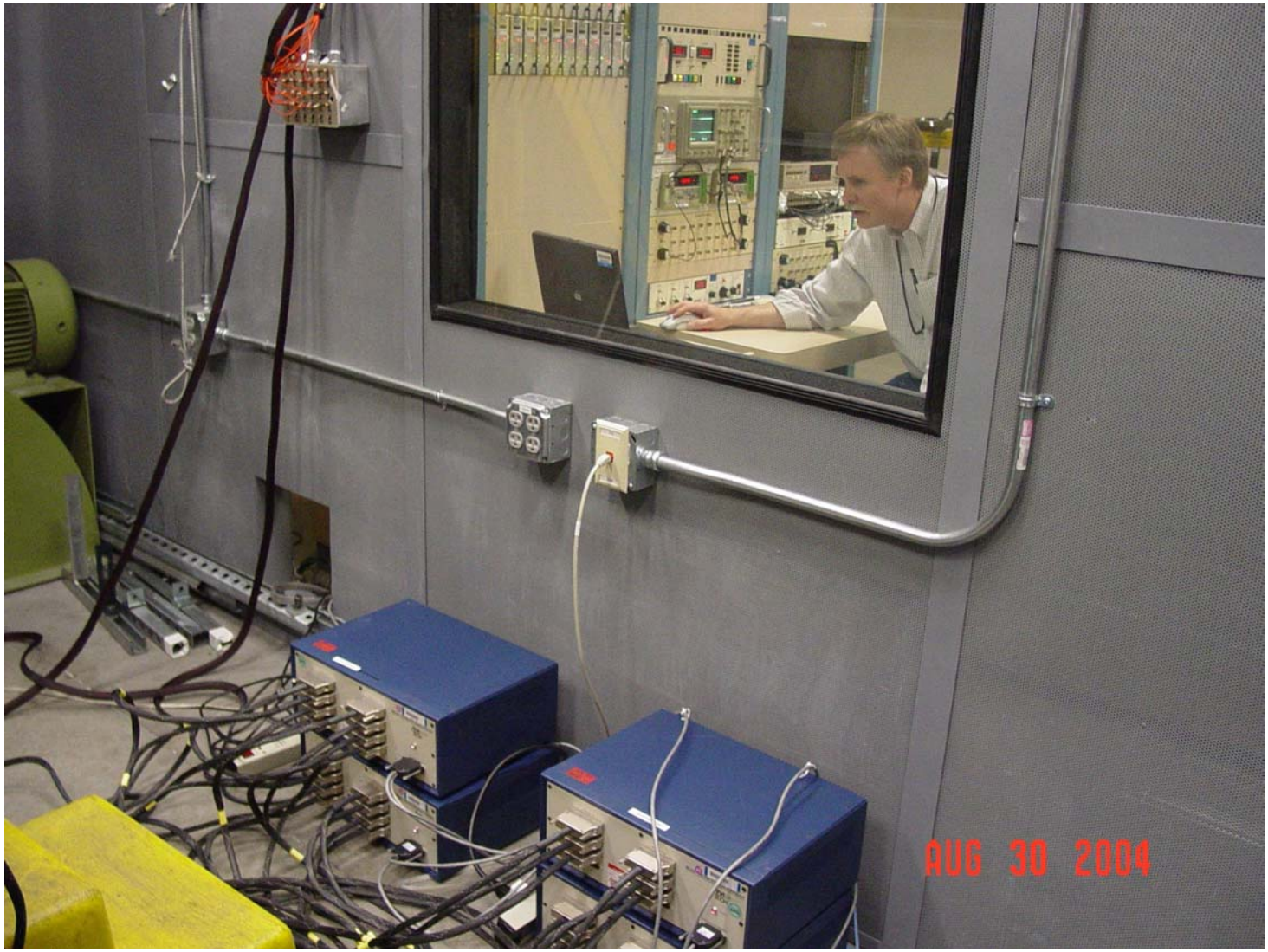
Vibration Table (Y-axis)

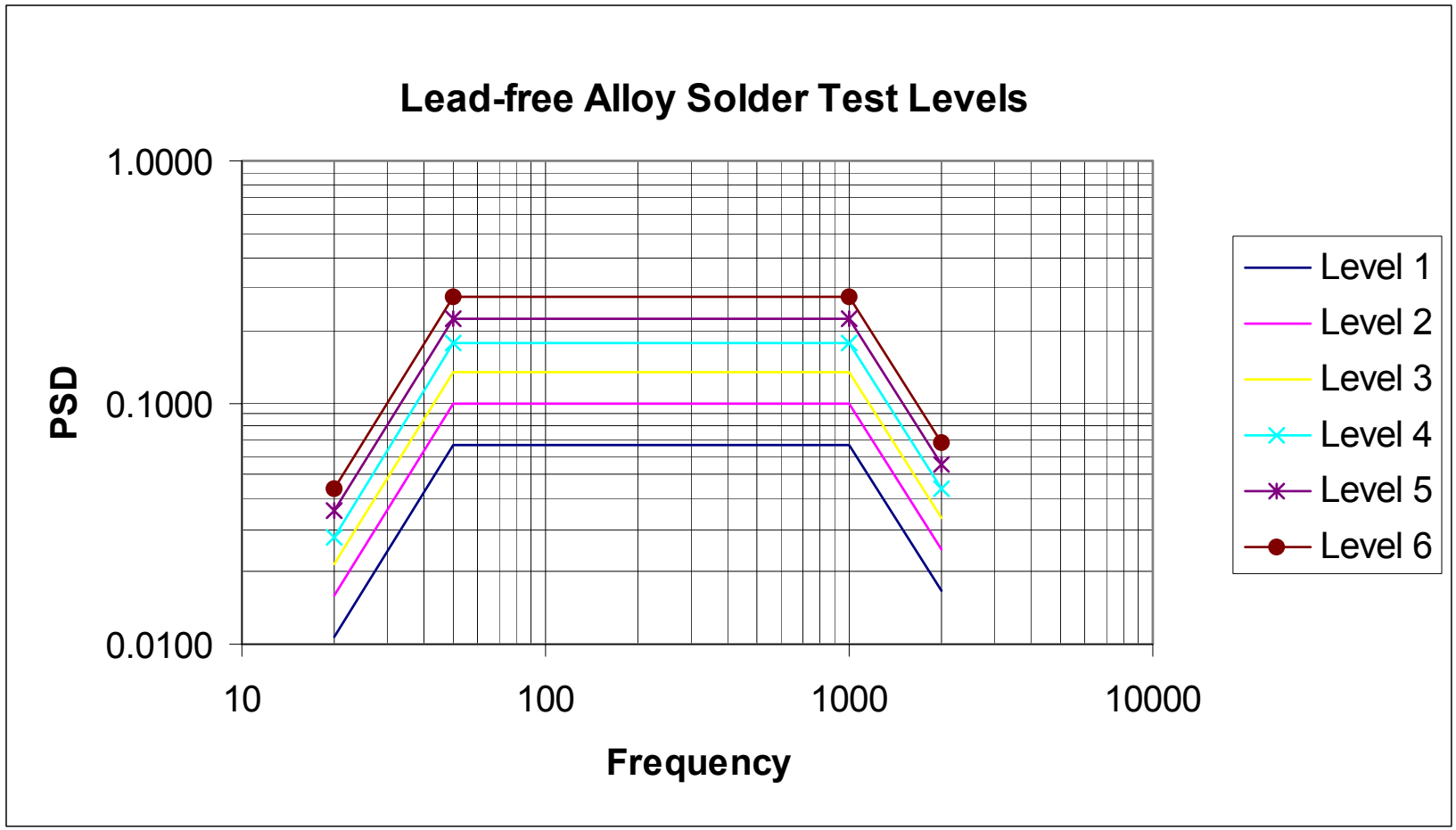


Vibration Table (Z-axis)

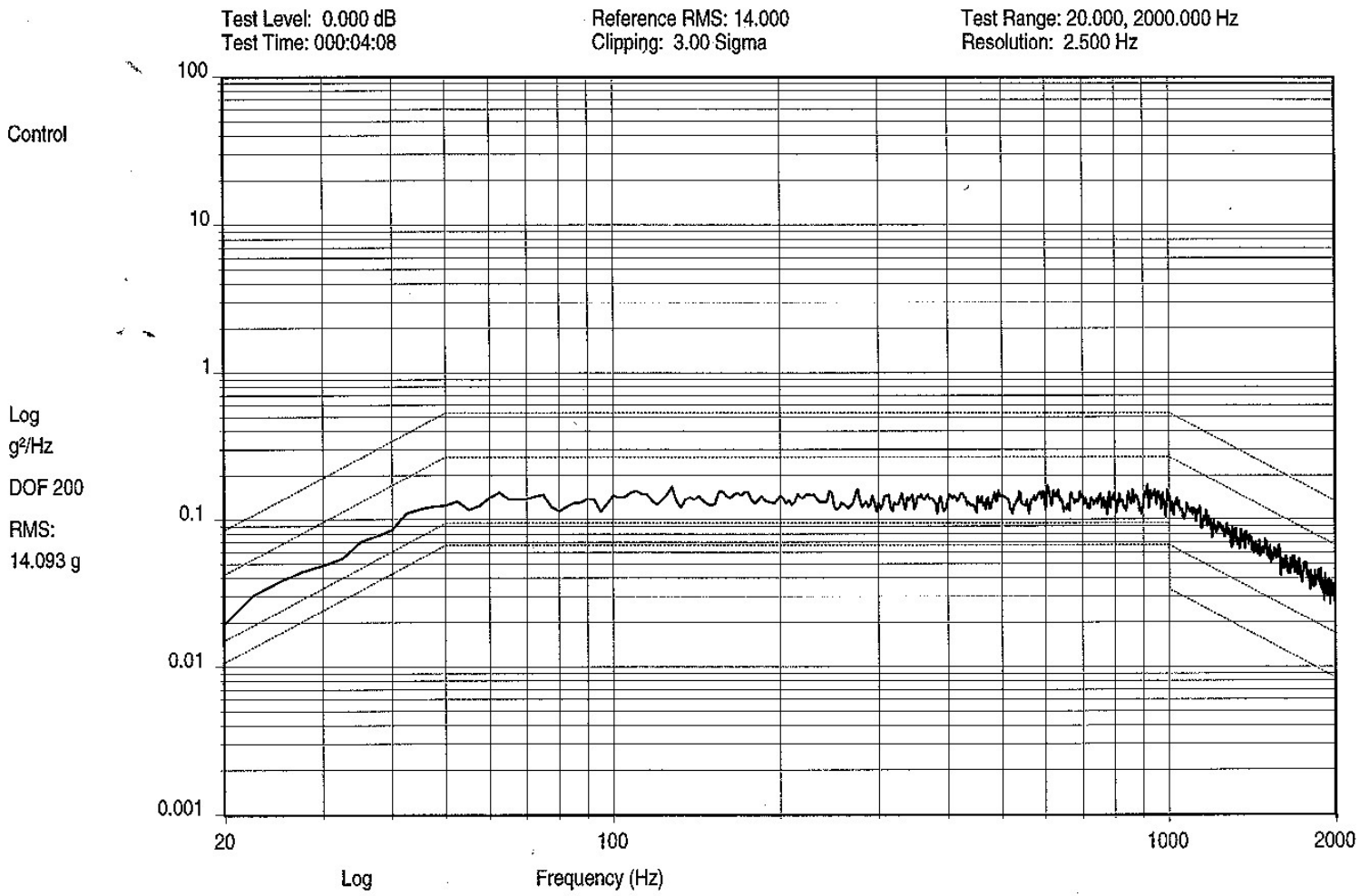


Anatech Event Detectors

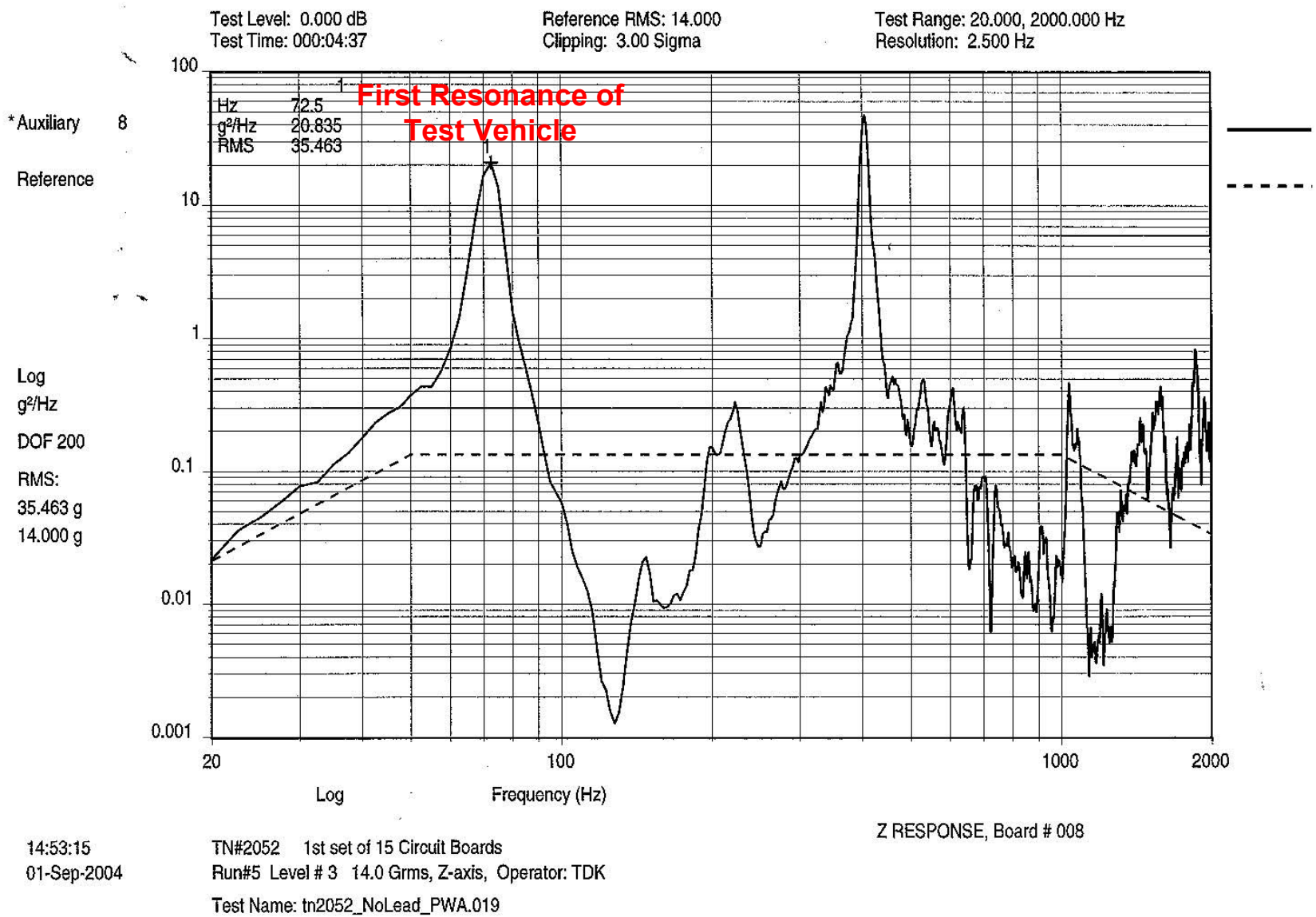



Lead-free Alloy Solder Test Levels
1.0000
0.1000
0.0100
PSD
10
100
1000
10000
Frequency
Level 1
Level 2
Level 3
Level 4
Level 5
Level 6

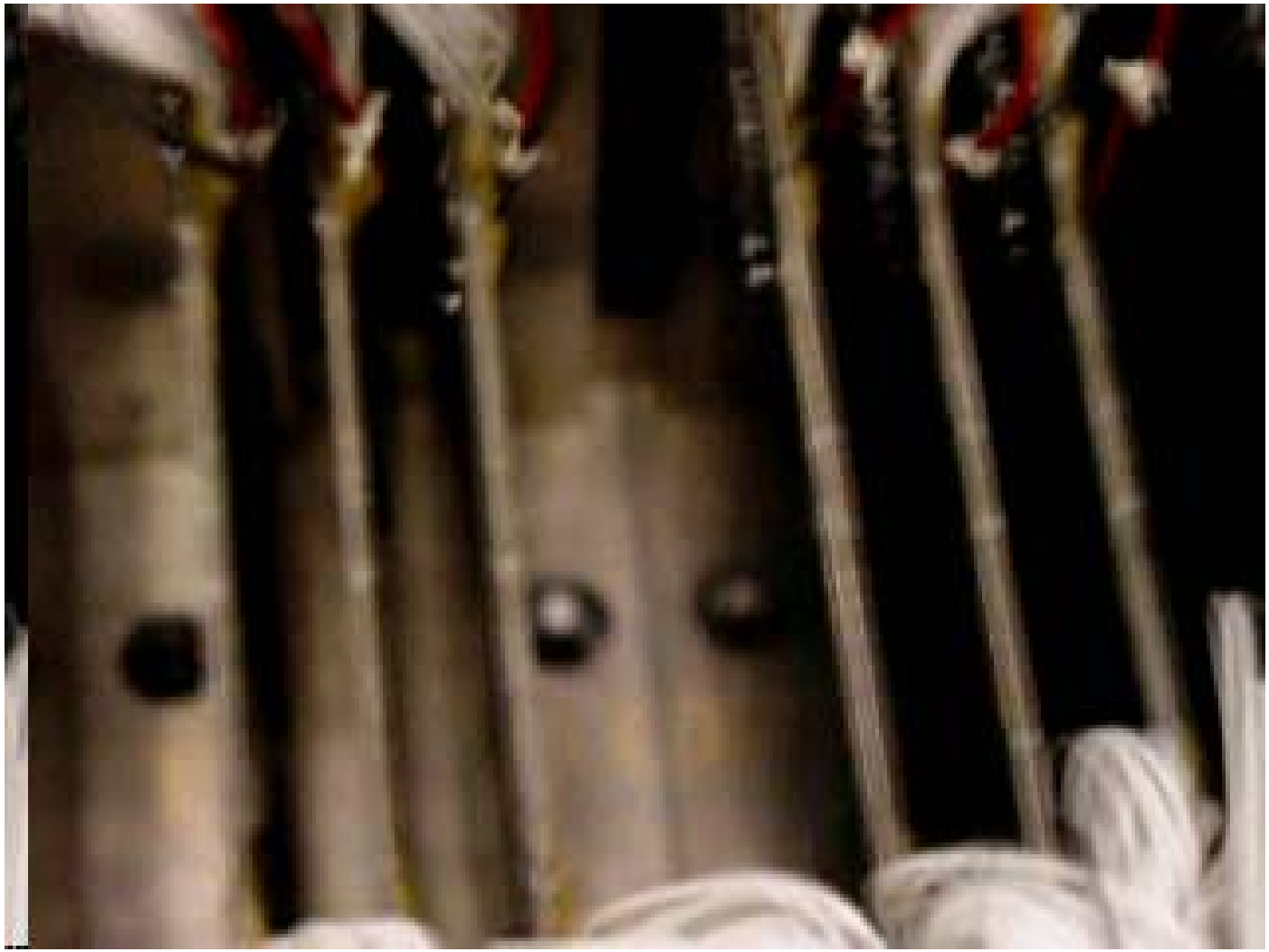
Accelerometer Measurement of Input into Test Vehicle



Accelerometer Measurement of Test Vehicle Response



Test Vehicles in Z-Axis (20.0 Grms)



	Test Level	% of Components Failed (Manufactured Boards)
Y-axis	**9.9 Grms**	0
X-axis	**9.9 Grms**	0
Z-axis	**9.9 Grms**	7.6
Z-axis	**12.0 Grms**	18.0
Z-axis	**14.0 Grms**	29.3
Z-axis	**16.0 Grms**	39.3
Z-axis	**18.0 Grms**	47.0
Z-axis	**20.0 Grms**	55.6
Z-axis	**28.0 Grms**	68.8

U52 CLCC (Manufactured Boards)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
76	SAC/SAC	60	60	60	60	44				
79	SAC/SAC	60	60	60	60	60	17			
77	SAC/SAC	60	60	60	60	60	60	4		
78	SAC/SAC	60	60	60	60	60	60	32		
75	SAC/SAC	60	60	60	60	60	60	37		
114	SACB/SACB	60	60	60	60	60	60	26		
115	SACB/SACB	60	60	60	60	60	60	60	59	
117	SACB/SACB	60	60	60	60	60	60	60	60	14
118	SACB/SACB	60	60	60	60	60	60	60	60	35
116	SACB/SACB	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	37		
9	SnPb/SnPb	60	60	60	60	60	60	60	31	
6	SnPb/SnPb	60	60	60	60	60	60	60	60	5
8	SnPb/SnPb	60	60	60	60	60	60	60	60	21
5	SnPb/SnPb	60	60	60	60	60	60	60	60	24

U8 PDIP (Manufactured Boards)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
77	SAC/PdNiAu	60	60	5						
76	SAC/PdNiAu	60	60	60	34					
78	SAC/PdNiAu	60	60	60	60	1				
79	SAC/PdNiAu	60	60	60	60	60	3			
75	SAC/PdNiAu	60	60	60	60	60	60	18		
115	SnCu/PdNiAu	60	60	60	60	60	27			
114	SnCu/PdNiAu	60	60	60	60	60	60	26		
116	SnCu/PdNiAu	60	60	60	60	60	60	28		
117	SnCu/PdNiAu	60	60	60	60	60	60	60	1	
118	SnCu/PdNiAu	60	60	60	60	60	60	60	17	
8	SnPb/PdNiAu	60	60	14						
5	SnPb/PdNiAu	60	60	20						
6	SnPb/PdNiAu	60	60	20						
7	SnPb/PdNiAu	60	60	22						
9	SnPb/PdNiAu	60	60	60	8					

U43 BGA (Manufactured Boards)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
79	SAC/SAC	60	60	5						
77	SAC/SAC	60	60	6						
75	SAC/SAC	60	60	10						
76	SAC/SAC	60	60	23						
78	SAC/SAC	60	60	60	10					
116	SACB/SAC	60	60	7						
114	SACB/SAC	60	60	16						
117	SACB/SAC	60	60	20						
115	SACB/SAC	60	60	32						
118	SACB/SAC	60	60	51						
6	SnPb/SnPb	60	60	54						
5	SnPb/SnPb	60	60	60	3					
8	SnPb/SnPb	60	60	60	16					
9	SnPb/SnPb	60	60	60	16					
7	SnPb/SnPb	60	60	60	20					

U5 BGA (Rework Boards)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
180	SnPb/SAC	60	60	6						
153	SnPb/SAC	60	60	8						
156	SnPb/SAC	60	60	8						
155	SnPb/SAC	60	60	9						
157	SnPb/SAC	60	60	10						
183	SnPb/SAC	60	60	11						
185	SnPb/SAC	60	60	11						
154	SnPb/SAC	60	60	13						
184	SnPb/SAC	60	60	13						
182	SnPb/SAC	60	60	18						
50	SnPb/SnPb	60	60	30						
47	SnPb/SnPb	60	60	59						
43	SnPb/SnPb	60	60	60	5					
49	SnPb/SnPb	60	60	60	15					
46	SnPb/SnPb	60	60	60	27					

U4 Reworked BGA (Rework Boards)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
153	SAC/SAC	60	60	4						
154	SAC/SAC	60	60	6						
155	SAC/SAC	60	60	6						
156	SAC/SAC	60	60	6						
157	SAC/SAC	60	60	7						
180	SACB/SAC	60	60	3						
185	SACB/SAC	60	60	4						
183	SACB/SAC	60	60	5						
182	SACB/SAC	60	60	8						
184	SACB/SAC	60	60	10						
50	SnPb/SnPb	60	60	6						
49	SnPb/SnPb	60	60	8						
43	SnPb/SnPb	60	60	17						
46	SnPb/SnPb	60	60	19						
47	SnPb/SnPb	60	60	22						

Data Sharing

- Vibration test data will be shared with the U of Maryland (CALCE)
- CALCE will use the test data to help validate their vibration fatigue computer models