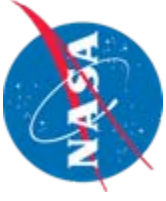




The Purpose of Generating Fatigue Crack Growth Threshold Data

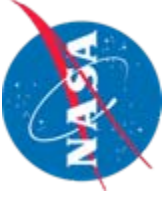
Scott Forth

NASA Johnson Space Center



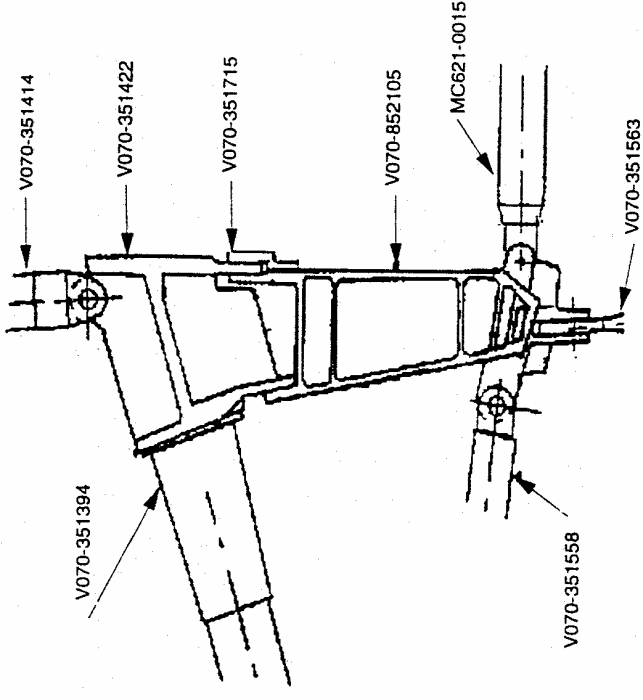
Overview

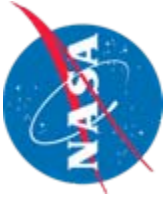
- NASA Applications
- Laboratory Data
- Summary



NASA Applications

- Space Shuttle Main Engine Thrust Structure
- Ti-6Al-4V Titanium
- High Cycle Fatigue
 - Launch Vibration
- Threshold used as design allowable
 - All ΔK values below ΔK_{th}

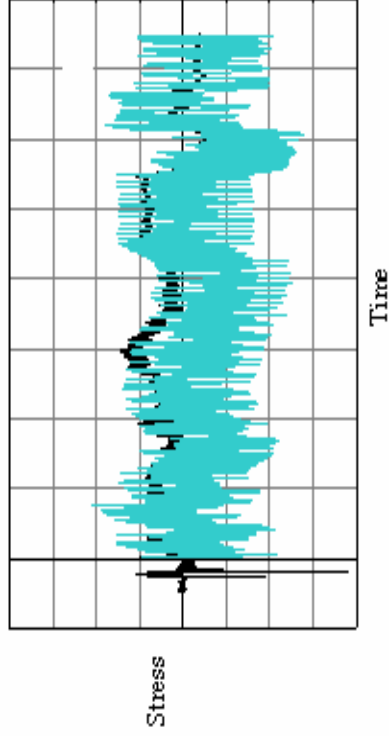
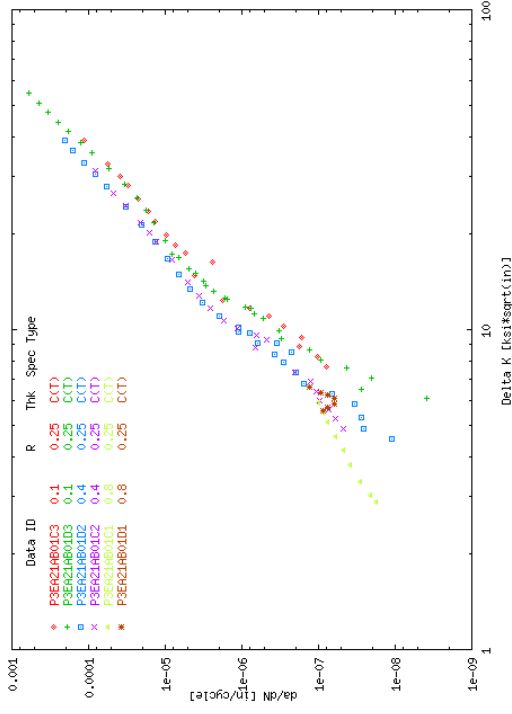


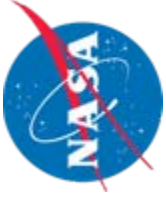


NASA Applications cont'

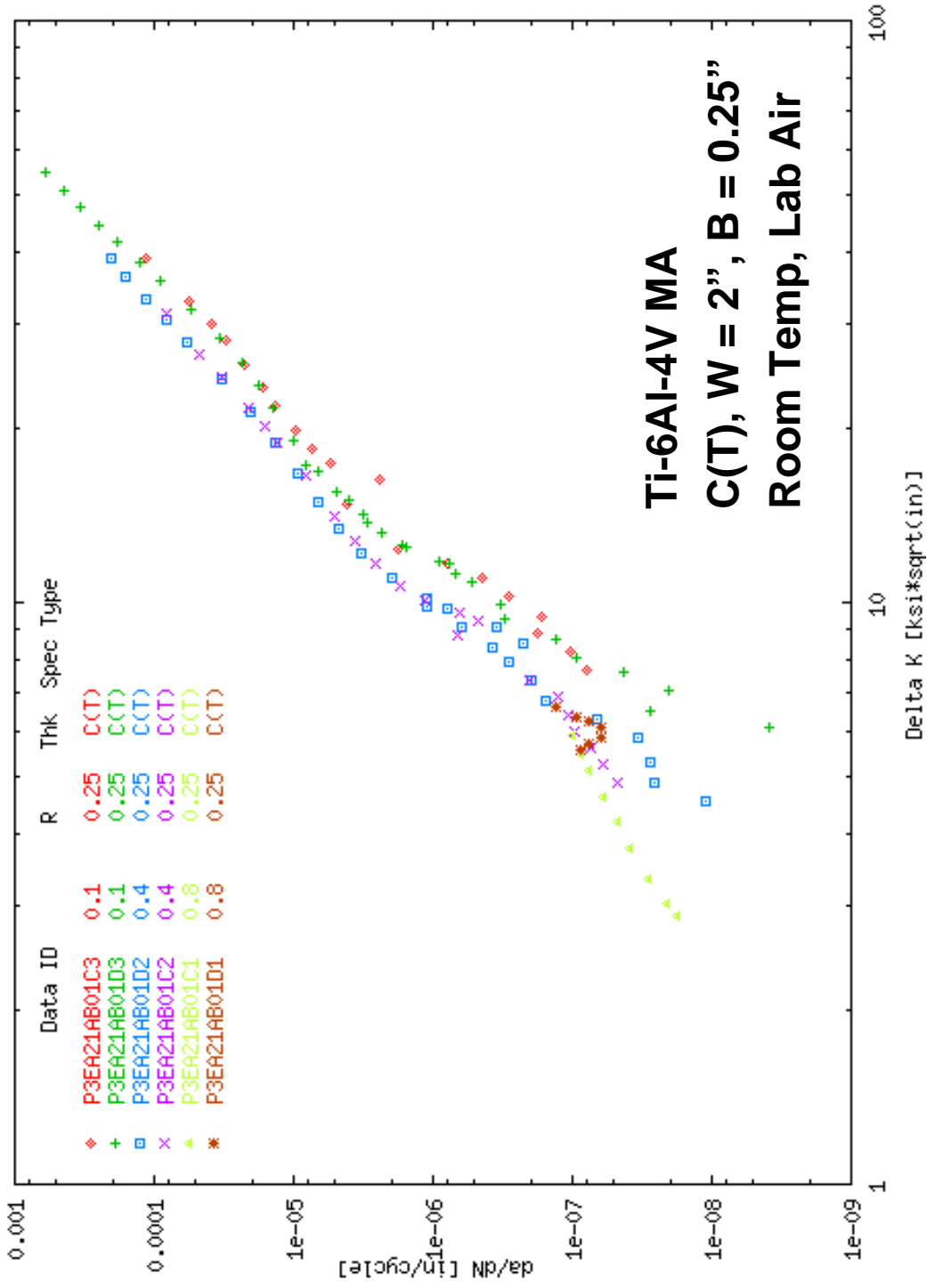
High Cycle Fatigue (HCF)
Components. Fracture
critical components
operating in a potential
HCF environment...

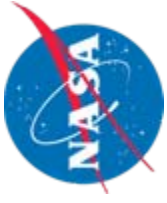
The metallic component is
acceptable if the
calculated HCF stress
intensity is below the
stress intensity factor
threshold for the metallic
material.





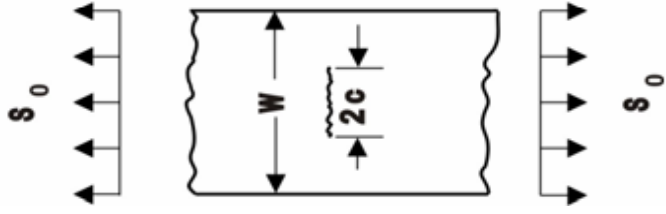
Design Threshold Data



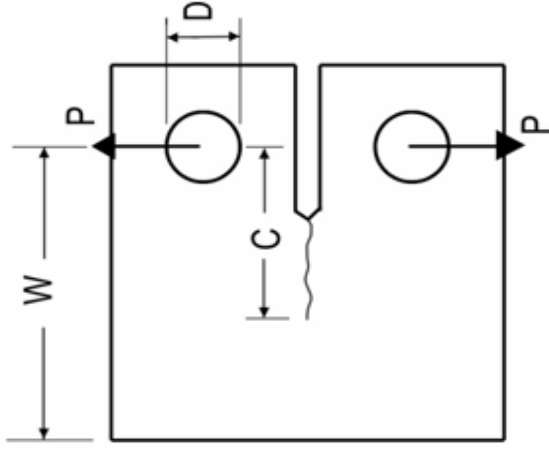


Recent Threshold Testing

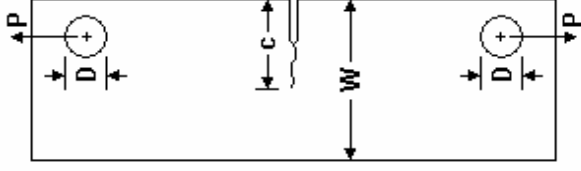
- Threshold testing completed on Ti-6-4 MA specimens to compare threshold values between C(T), ESE(T), M(T) & SM(T) designs



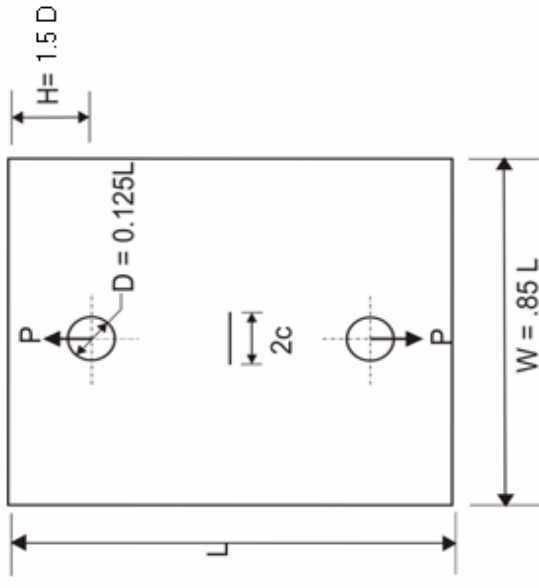
M(T)



C(T)



ESE(T)

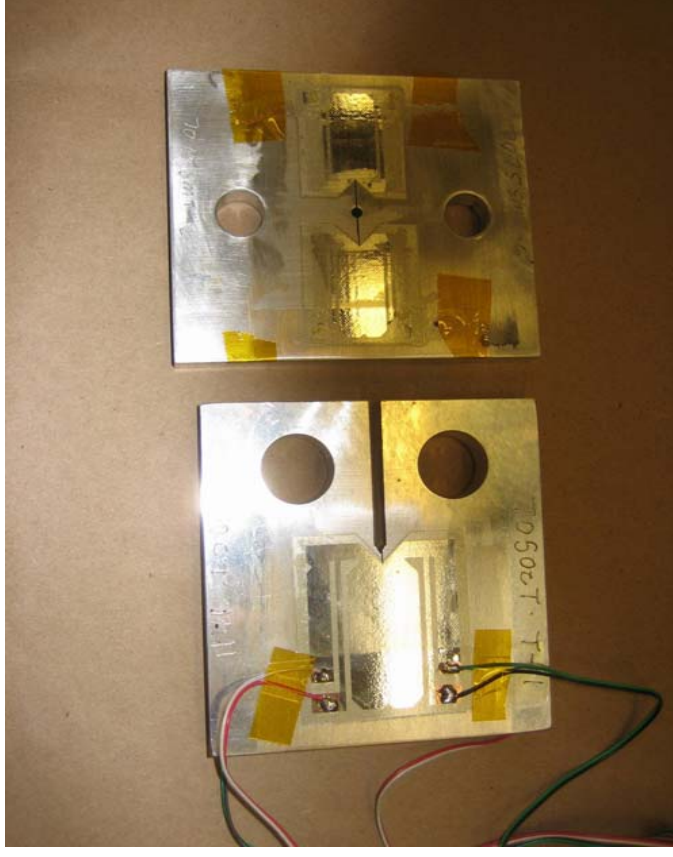


SM(T)

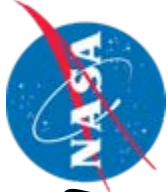
Short Middle Through Crack Specimen

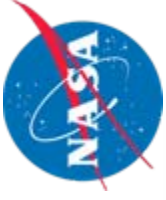
SM(T)

- Crack has less tendency to turn compared to the C(T) specimen
- Specimen has high stiffness - allowing high cyclic frequency
- Requires much less material than for an M(T) specimen.

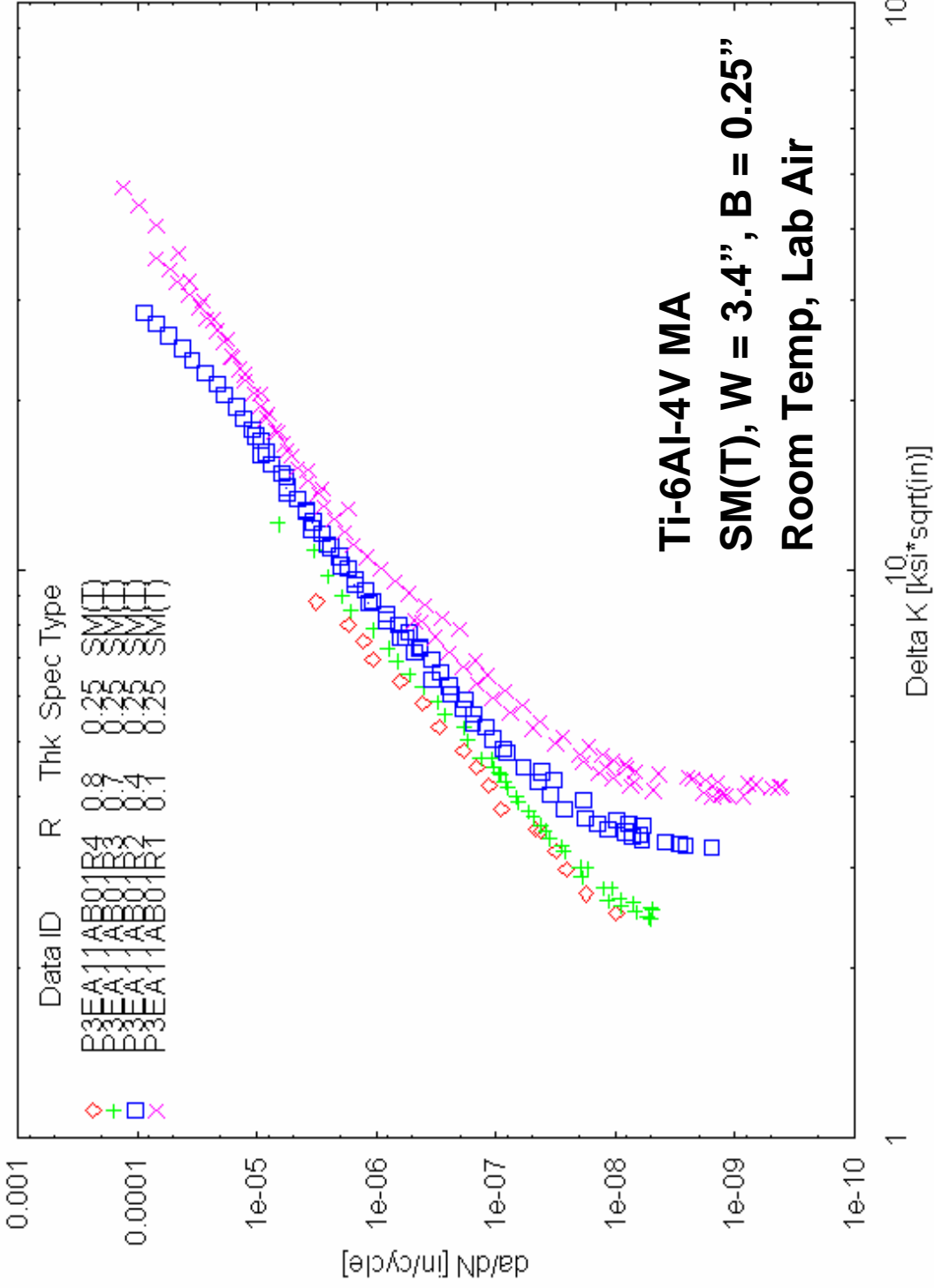


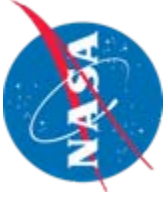
Comparison of $W = 3''$ C(T) specimen with $W = 3.4''$ SM(T) specimen.



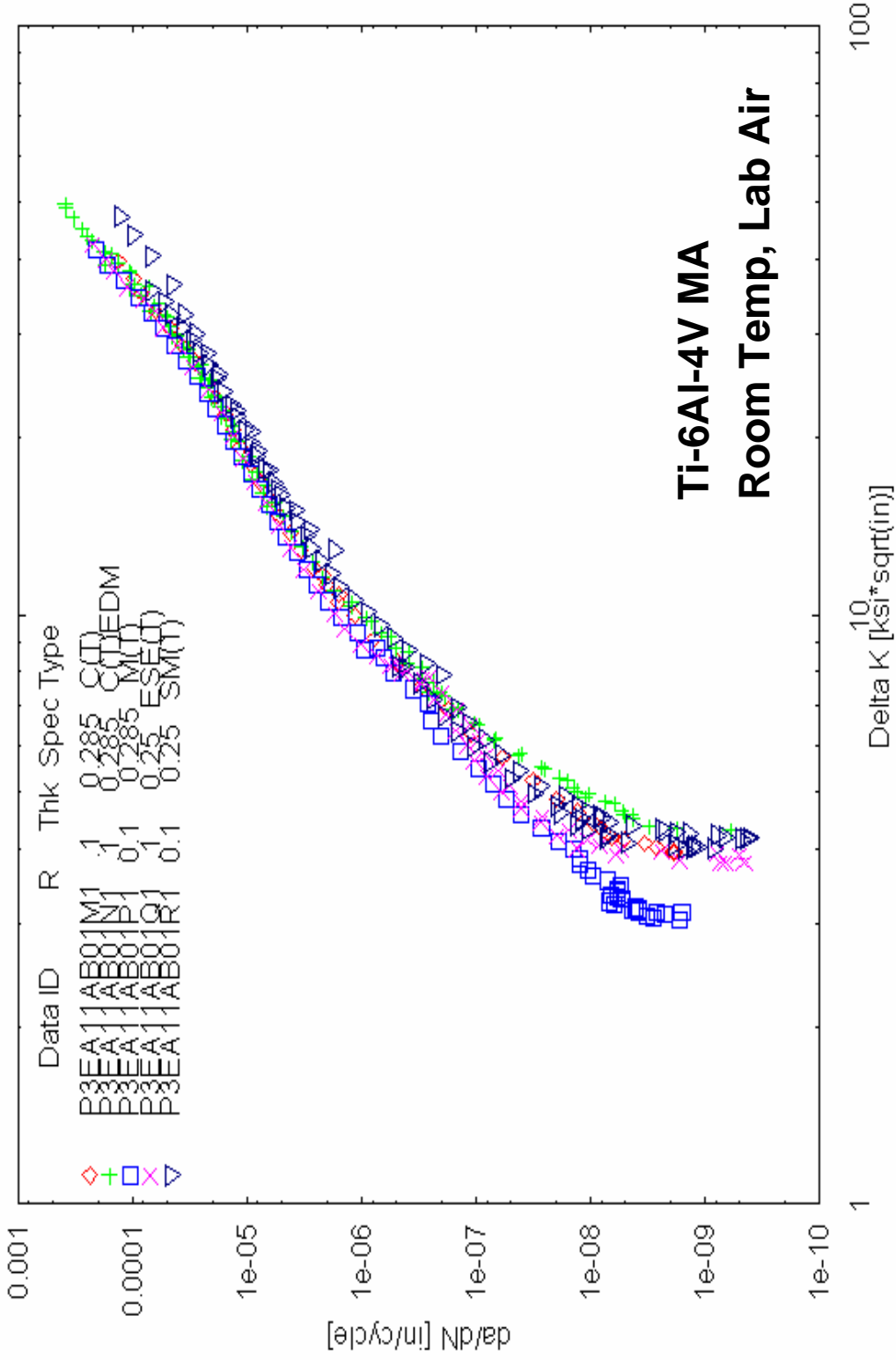


SM(T) Threshold Data

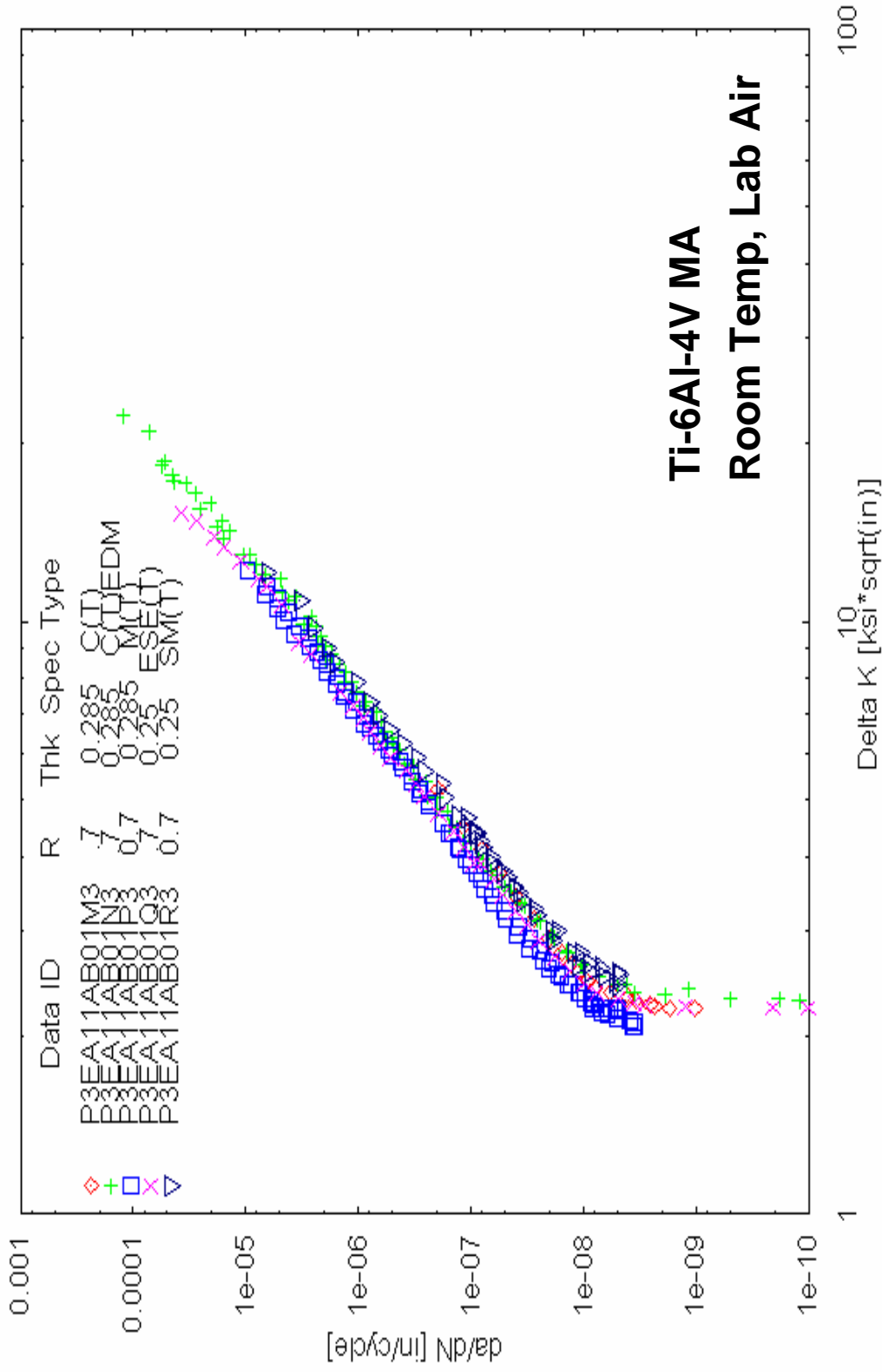
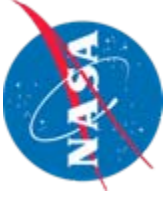


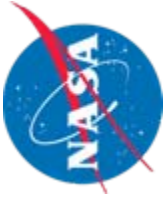


Effect of Specimen Geometry on $R = 0.1$ Threshold



Effect of Specimen Geometry on $R = 0.7$ Threshold



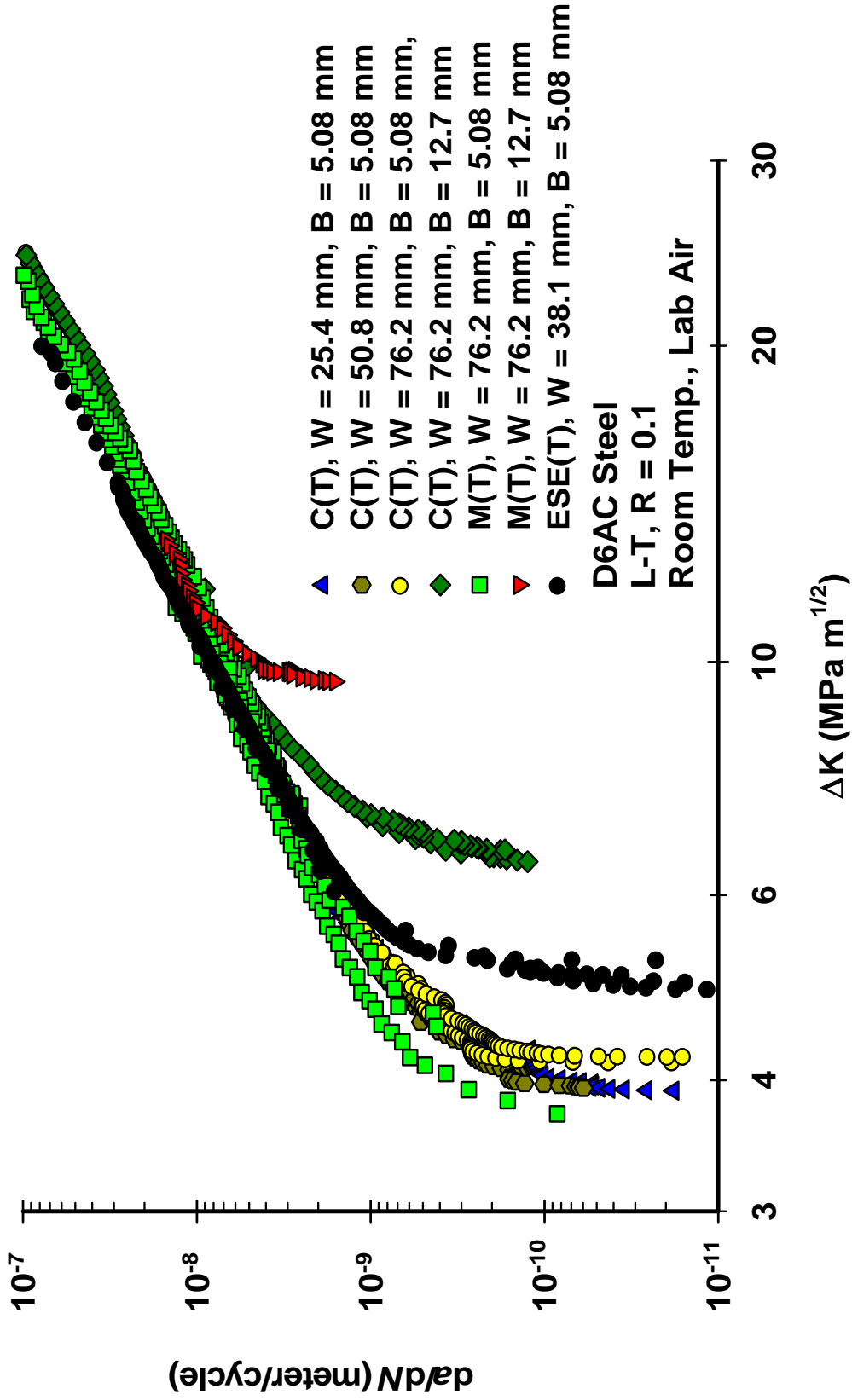


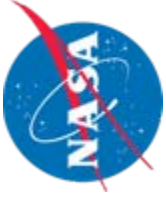
Ti-6Al-4V MA Thresholds

R Value	Specimen Type	ΔK_{th} (ksi in ^{1/2})
0.1	C(T)	6.0
	M(T)	3.1
	ESE(T)	3.9
	SM(T)	4.1
0.7	C(T)	2.4 / 2.1
	M(T)	2.0
	ESE(T)	2.1
	SM(T)	2.2

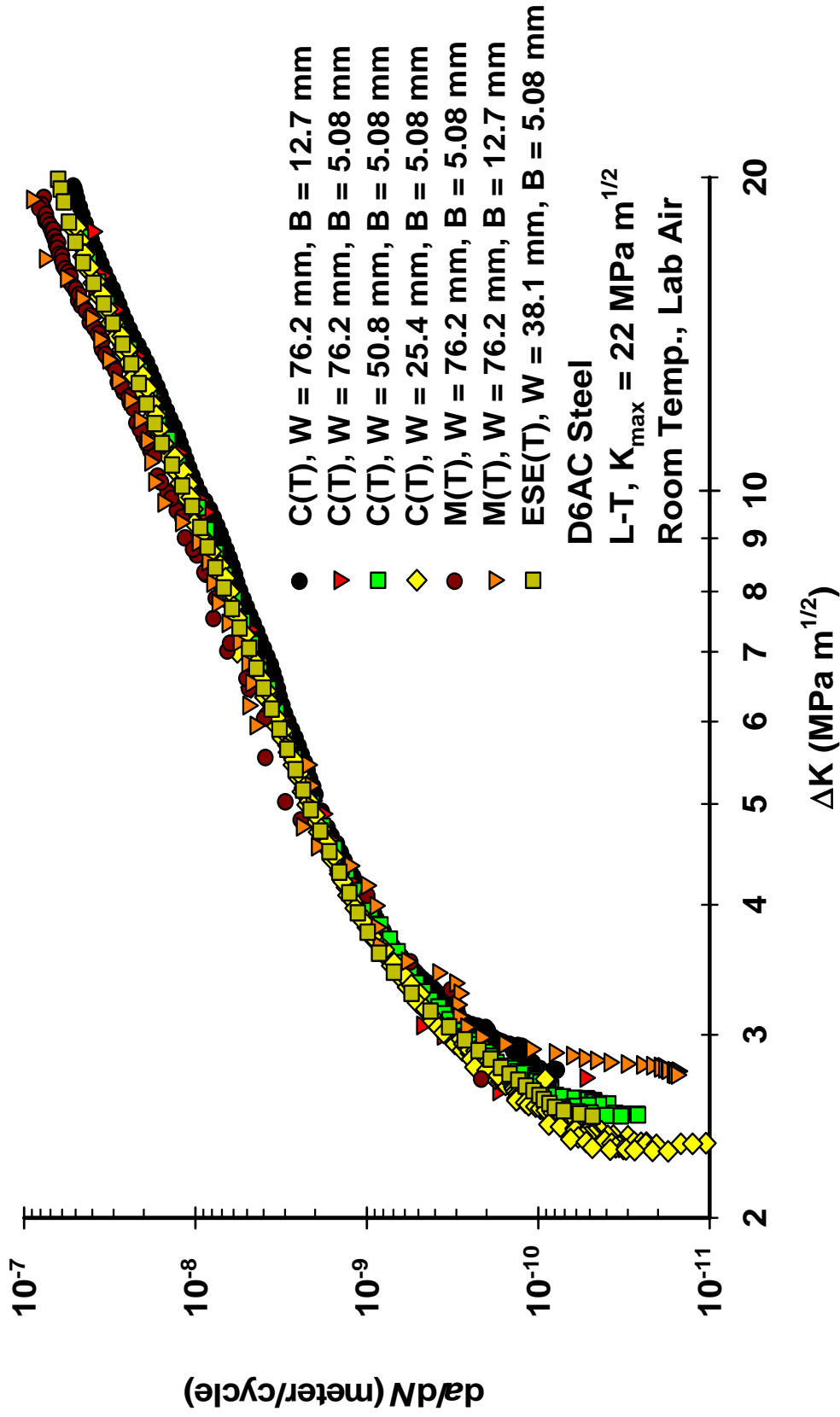


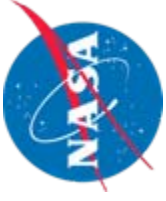
Specimen Configuration Effects



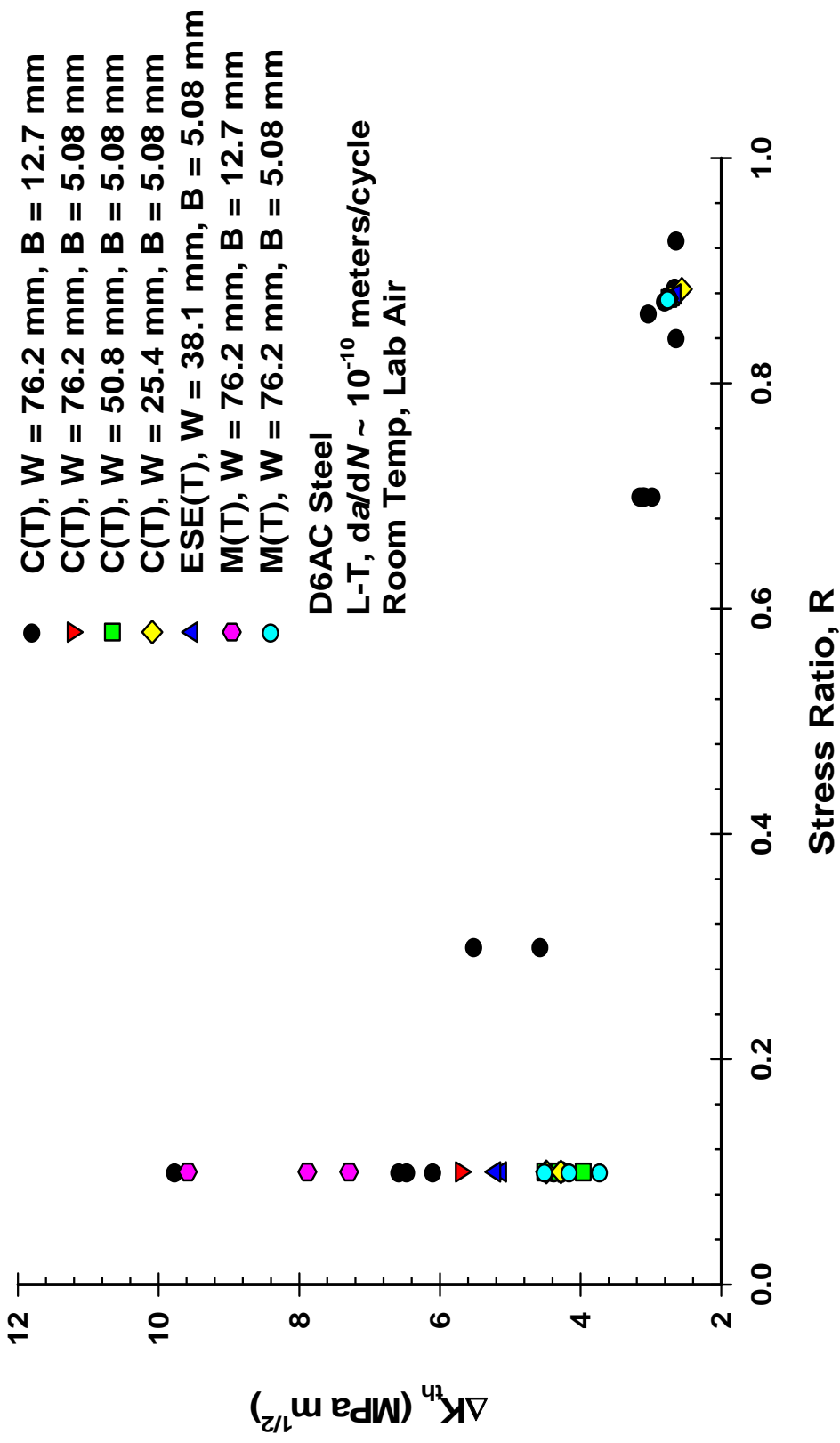


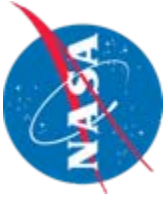
Constant K_{max} Data



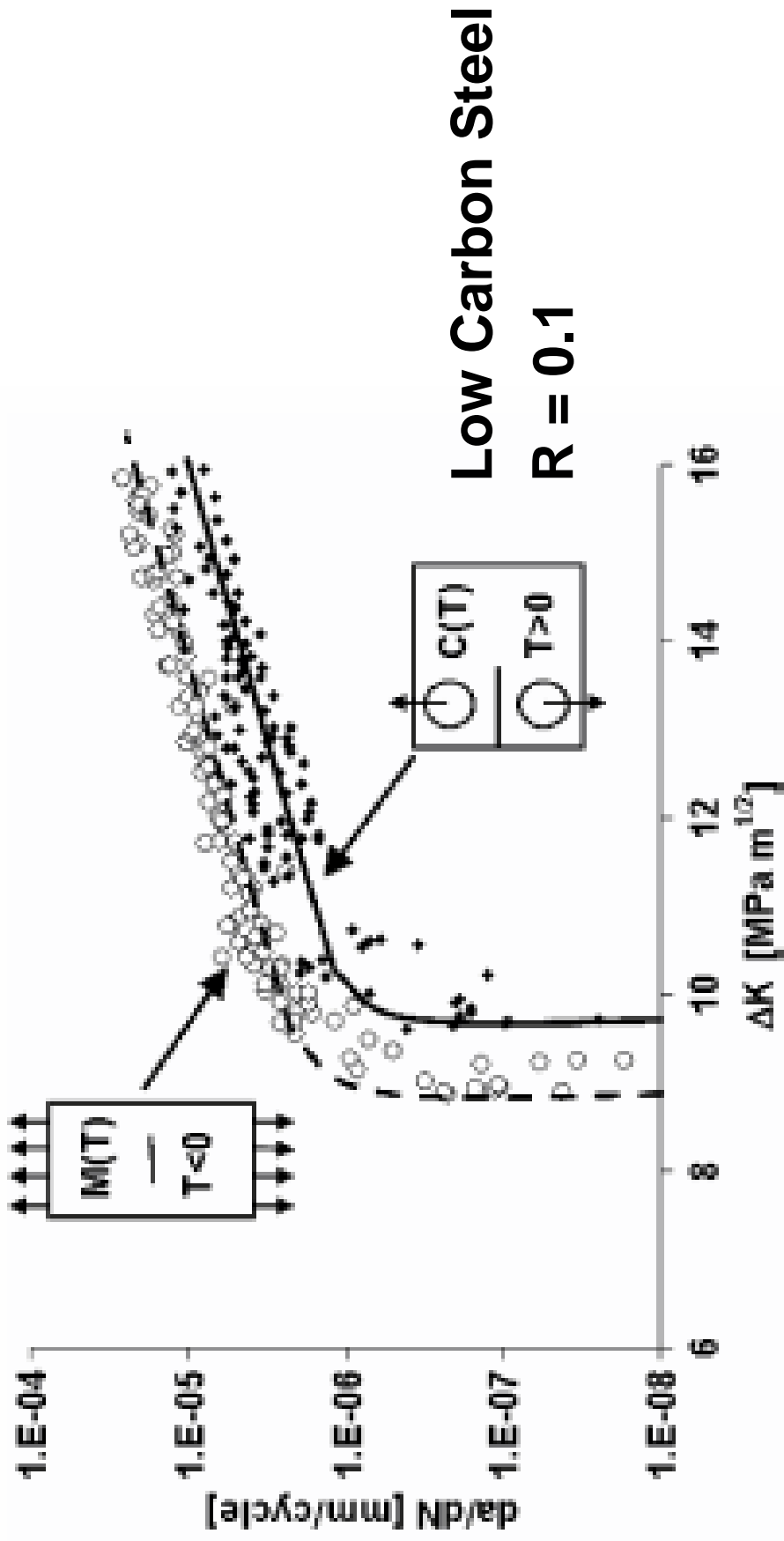


Specimen Configuration Effects at Threshold





Specimen Configuration Effects at Threshold





Summary

- Test data shows that different width and thickness C(T), M(T) and ESE(T) specimens generate different thresholds
- Structures designed for “infinite life” are being re-evaluated
 - Threshold changes from 6 to 3 ksi in^{1/2}
 - Computational life changes from infinite to 4 missions
- Multi-million dollar test programs required to substantiate operation
- Using ASTM E647 as standard guidance to generate threshold data is not practical
- A threshold test approach needs to be standardized that will provide positive margin for high cycle fatigue applications