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Hybrid Capacitor Assembly Qualification

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Overview

- **Background**

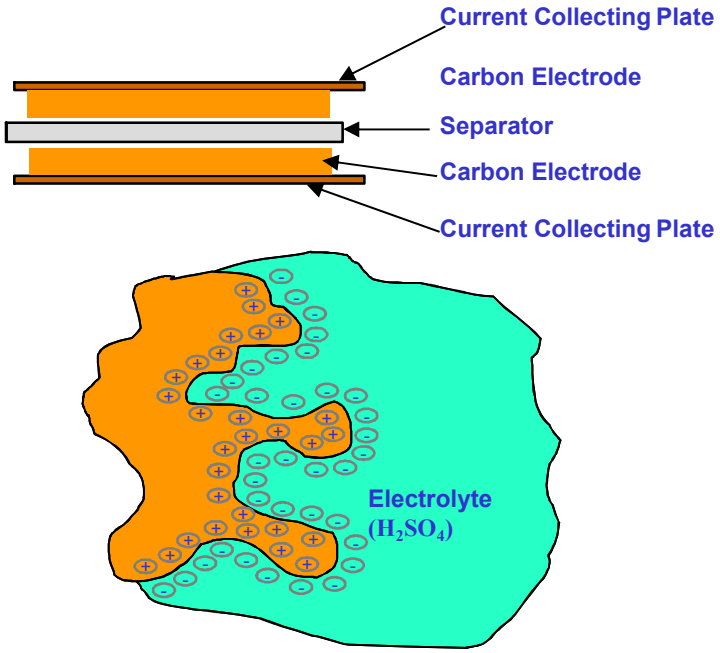
– Early 90ies Double Layer Capacitor Assemblies (DLCA) designed to Supply Interim Power for Flight Tests
– In 2002 Power Supply Temperature Range Changes from -30C to -55C
– Hybrid Capacitors Identified as Having Low Temperature Capability

- **Approach**

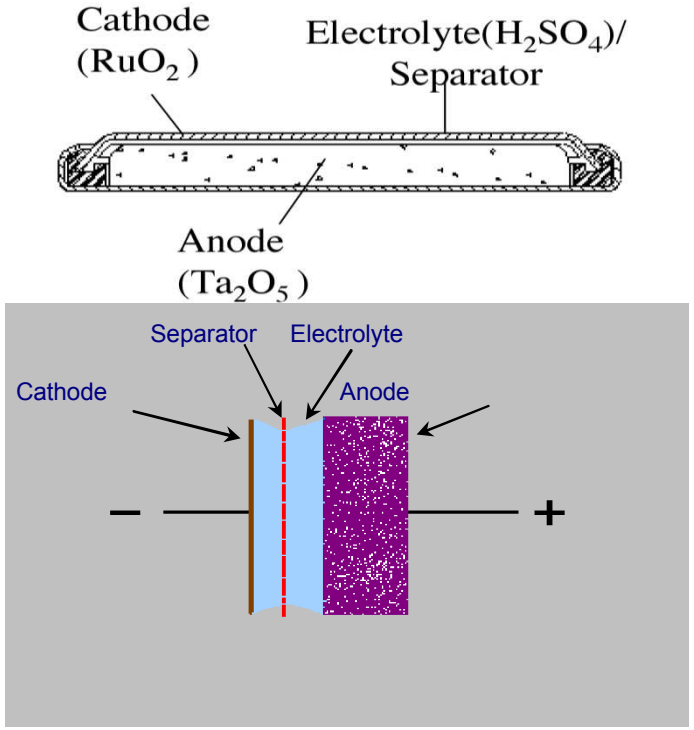
– Assess Capability of Hybrids to Meet Design Requirements
– Redesign of DLCA with Hybrids to Fit in Same Location
– Complete Qualification of Design to Meet All Requirements

Comparison of Old and New Technologies

Double Layer Capacitor



Hybrid Capacitor



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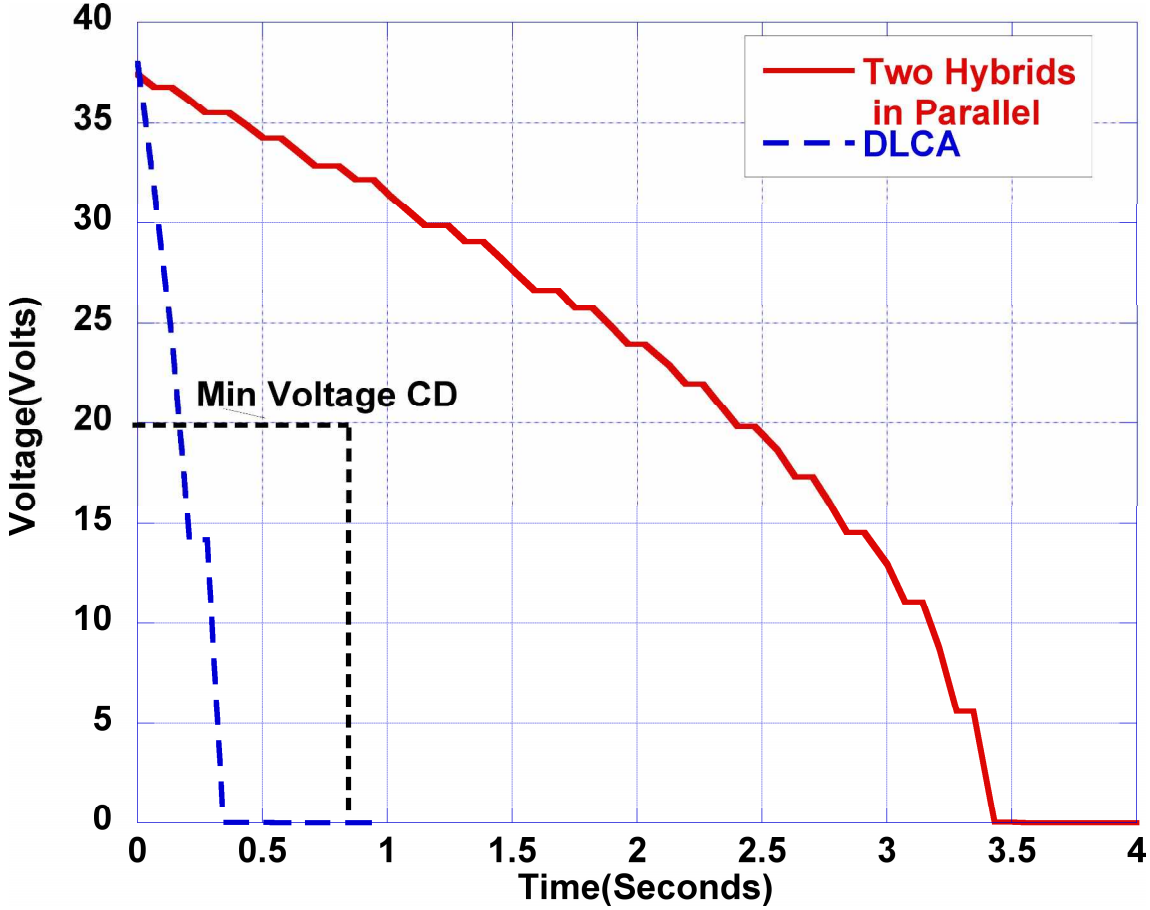
Comparison of Old and New Technologies Performance at -55C



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New Design For Hybrid Capacitor Assembly (HCA)

- Replace 3 DLC's in Series with 2 Hybrids in Parallel
- Maintain Same Curved Mounting Surface with decreased height and length

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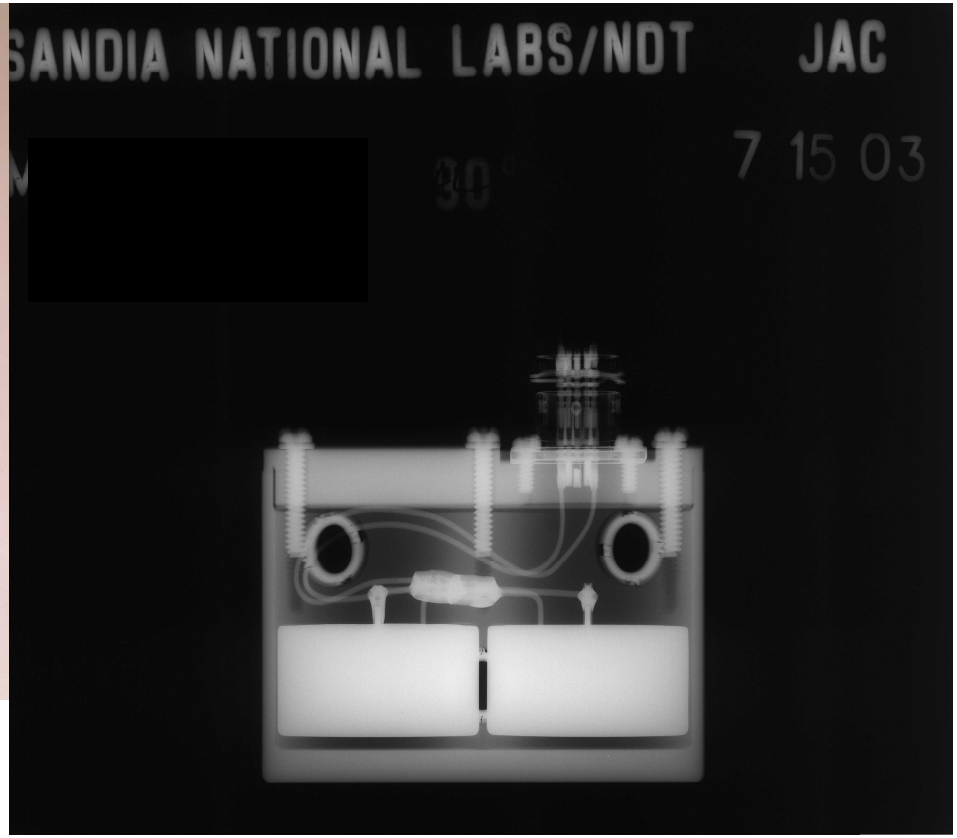
New Requirements for HCA

Requirement	DLCA	HCA
Charge Voltage	minimum of 33.5 volts and to a maximum of 34.5 volts	minimum of 37.5 volts and to a maximum of 38.5 volts
Output Power	7 watts	16 watts
Minimum Voltage	17.5 volts	21 volts
Time Above Minimum Voltage	2 seconds	0.85 seconds
Temperature Range	-30°C to +82°C	-55°C to +82°C
Environmental Requirements	Shock: 2000g's Linear Acceleration: 150g's Vibration: Random and Captive Carry	Shock: 2800g's Linear Acceleration: 240g's Vibration: Random and Captive Carry

Internal Design of Package



- Assembly ready for foaming. The lid will be screwed down to serve as top of mold for foam
- THQ3 Hybrids with 3 separators

X-Ray of Completed Assembly

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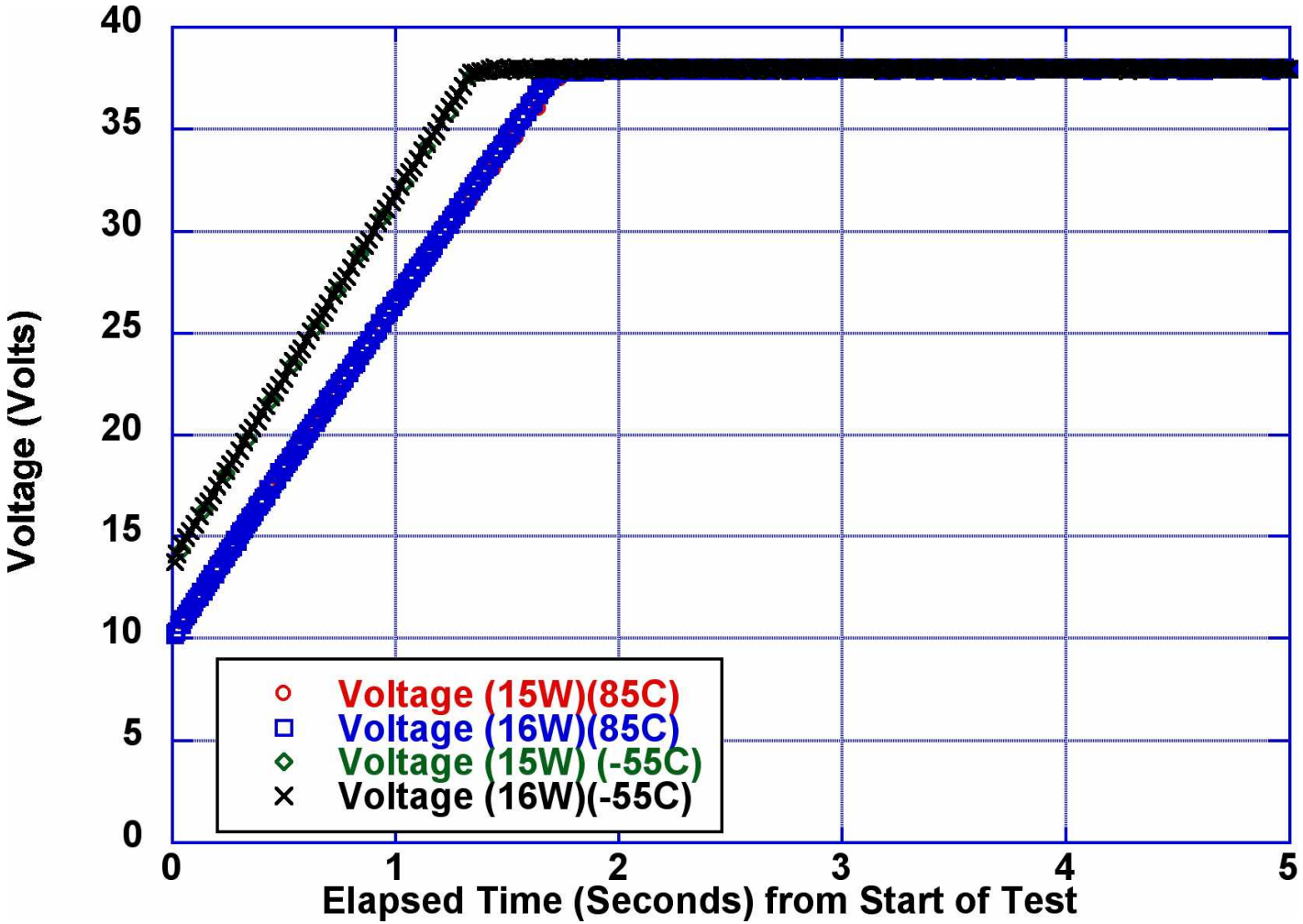
Qualification Testing (1)

Charging Requirement: The HCA is charged to a minimum of 37.5V and to a maximum of 38.5V with a current limit of 1.4A. Charging time shall not exceed 1 minute at temperatures ranging from -55C to +85C



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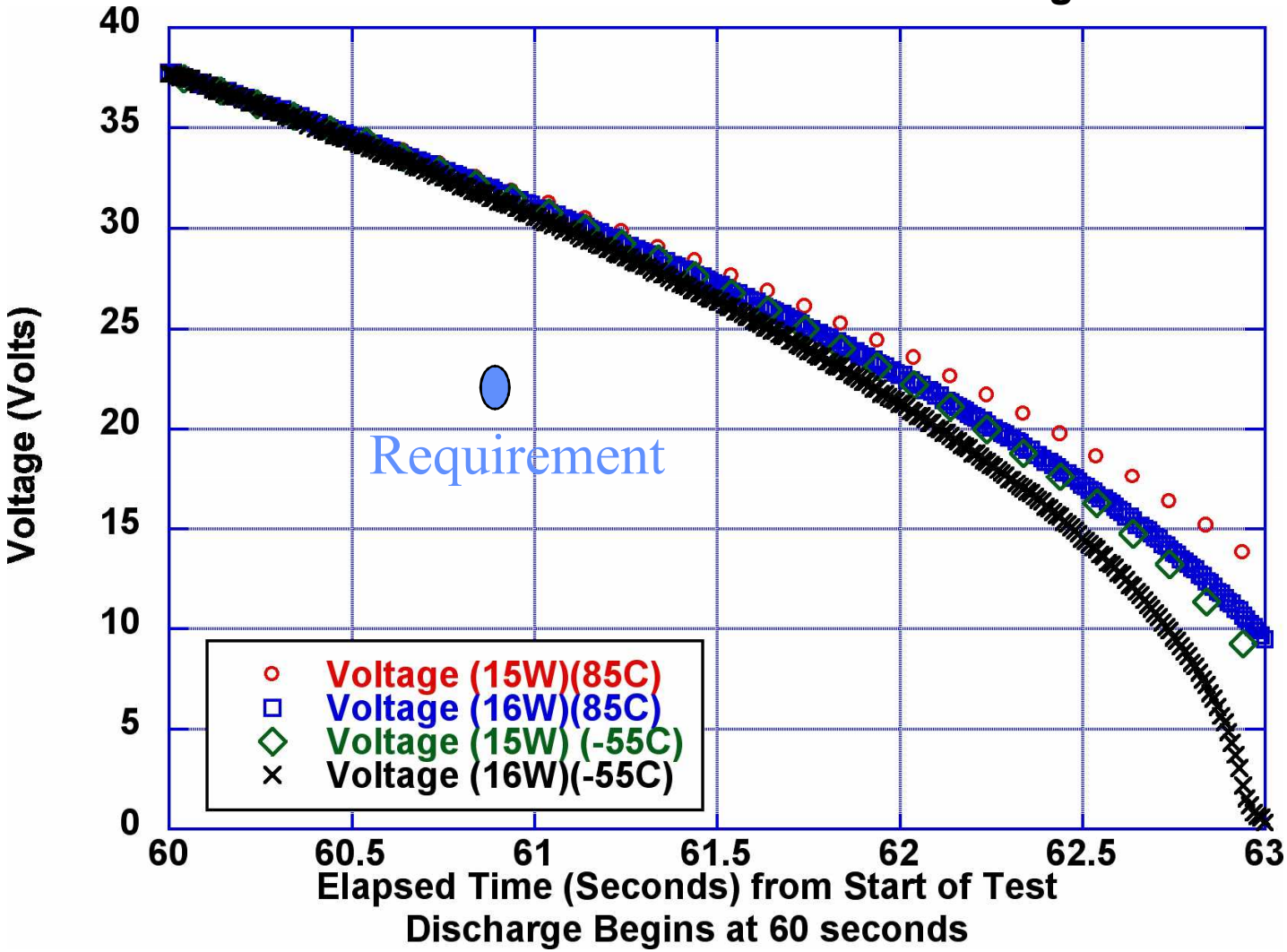
Qualification Testing (2)-Test Data

Discharging Requirement: The HCA shall provide 16 W of power for 0.85 seconds minimum with the initial charge of 37.5V minimum and shall remain above 20.1V during this time.



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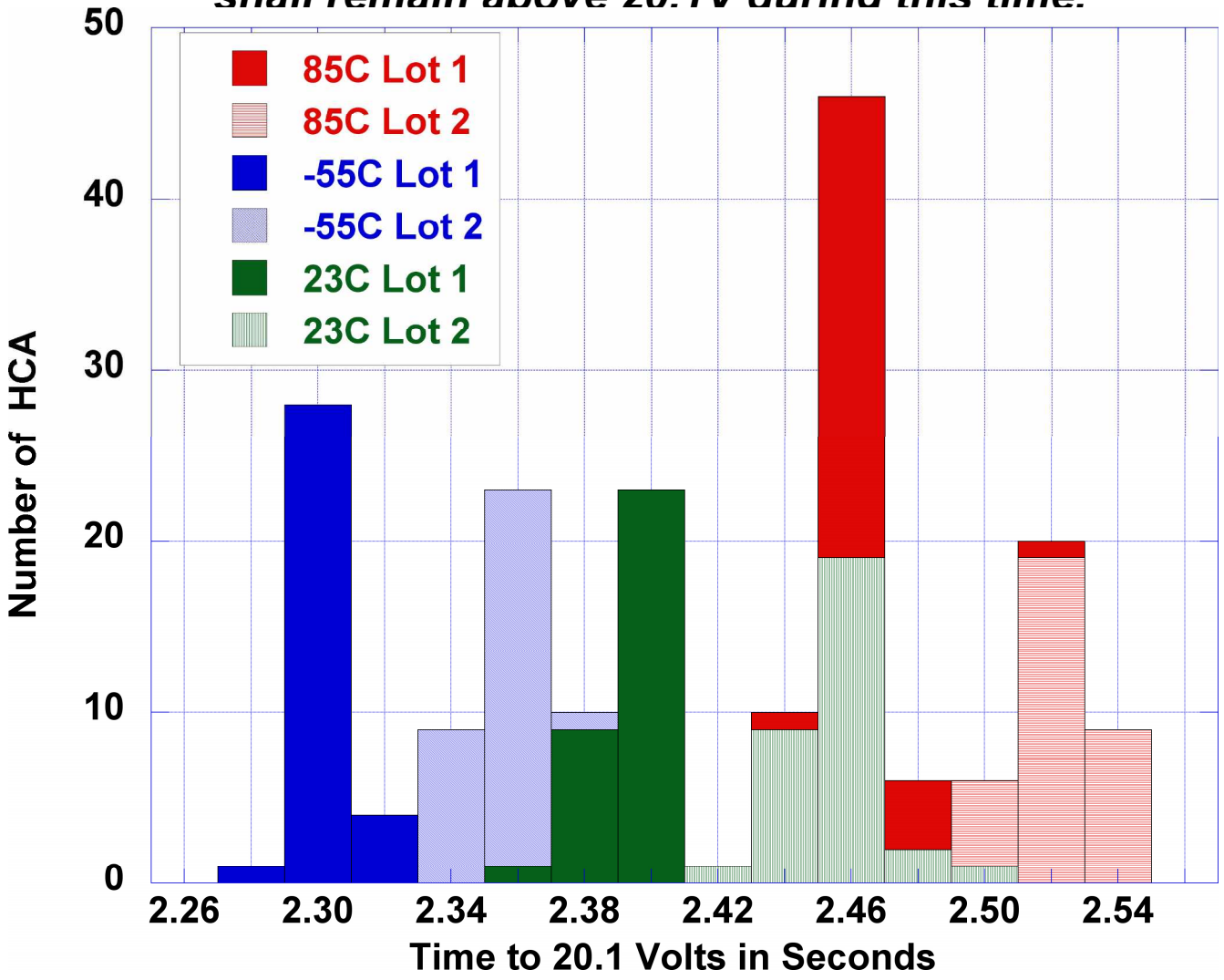
Qualification Testing (3)-Summary Data

Discharging Requirement: The HCA shall provide 16 W of power for 0.85 seconds minimum with the initial charge of 37.5V minimum and shall remain above 20.1V during this time.



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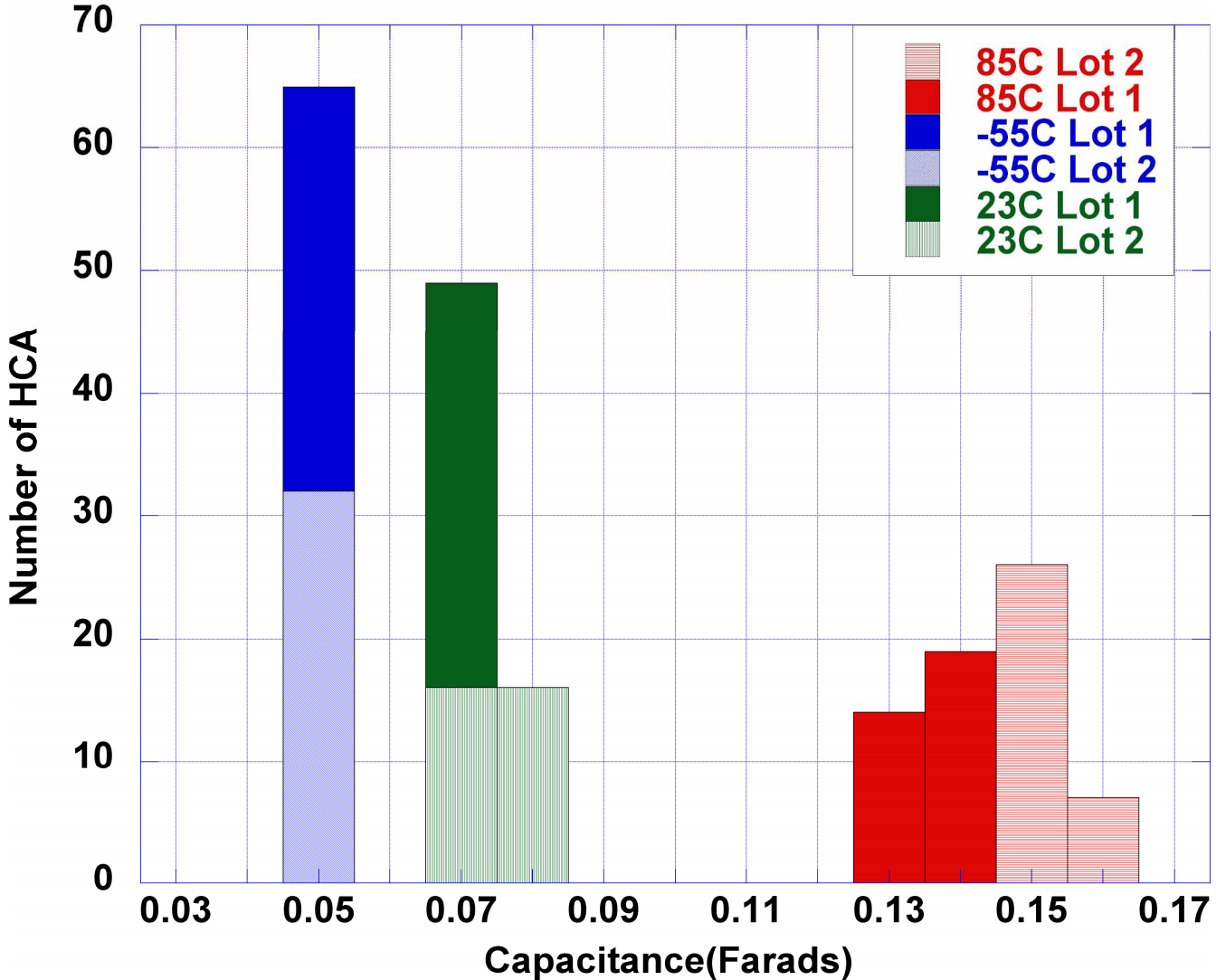
Qualification Testing (4)

ESR and Capacitance Requirements

	Temperature (°C)	Requirement
ESR	–55°	<0.070 ohms
	+23°	<0.030 ohms
	+85°	<0.030 ohms
Cap	–55°	>0.027 F
	+23	>0.047 F
	+85	>0.082 F

Summary of Capacitance Data Lots 1 &2

(>0.027@ -55C, > 0.047@23C, >0.082@85C)



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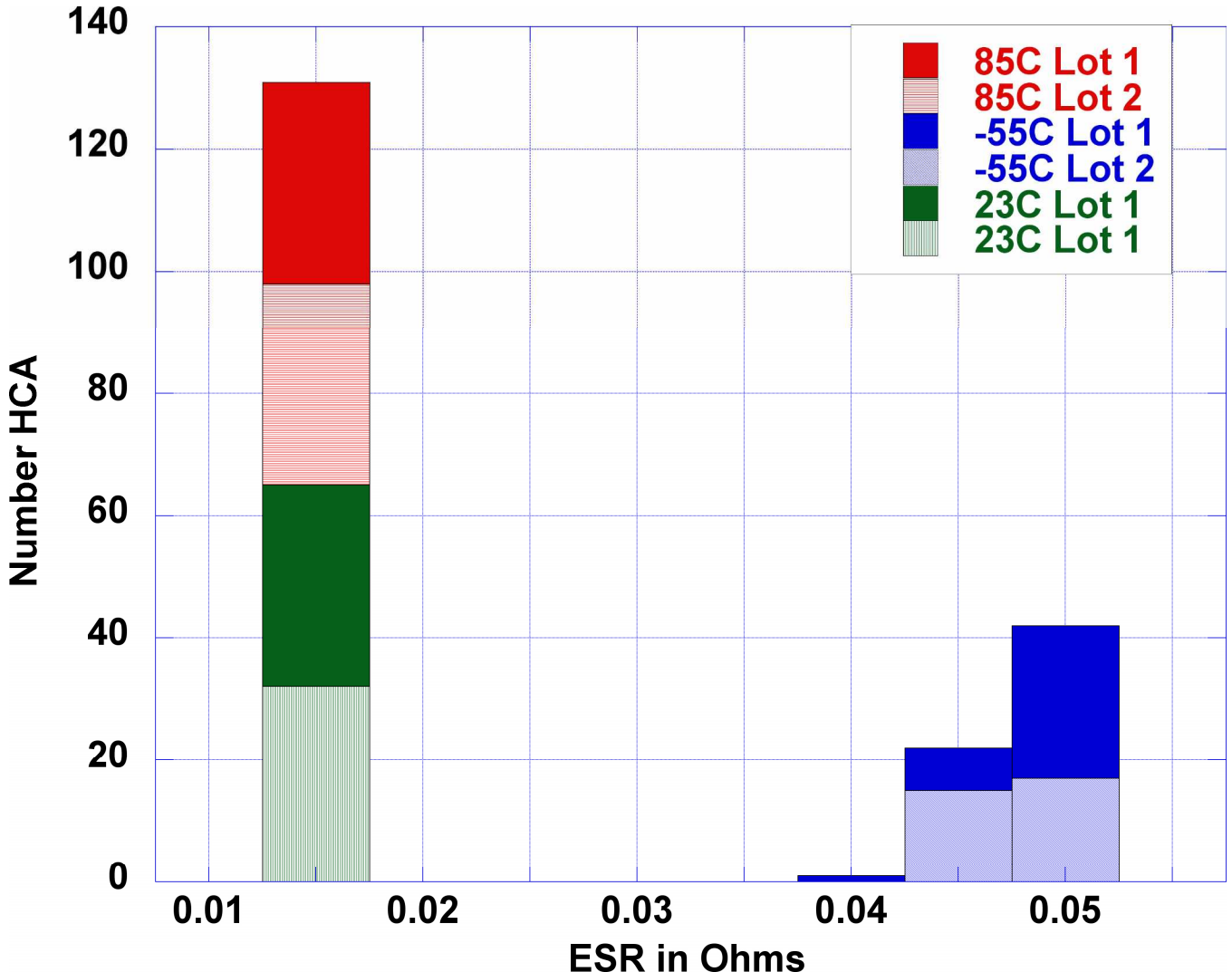
Summary of ESR Data
Lots 1 &2

(>0.070@ -55C, > 0.030@23C, >0.030@85C)



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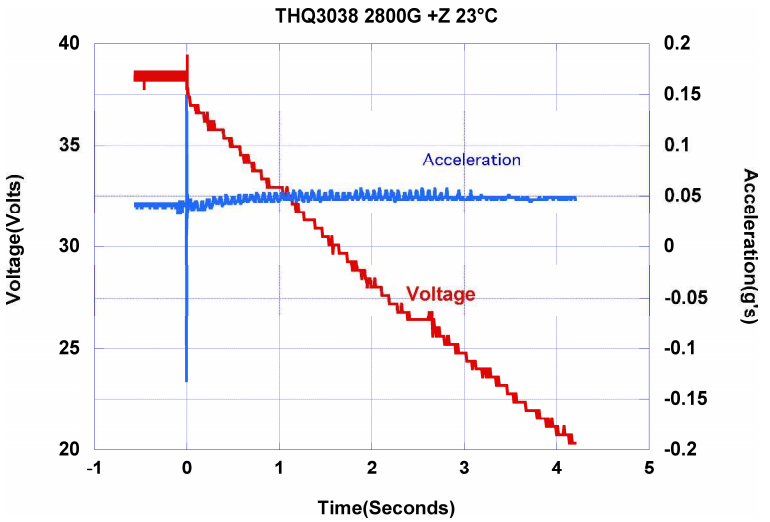
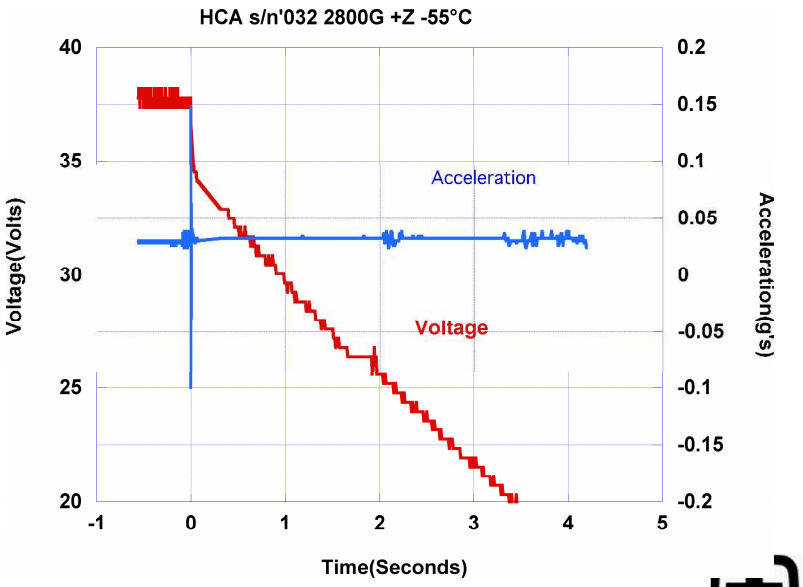
Environmental Test Requirements

Test Requirement @ -54°C, 23°C,and +74°C	Time	Axis
Transportation Vibration	2 hours	X,Y and Z
Captive Carry Random Vibration	20 minutes	X,Y and Z
Acceleration 240G's	>1 min	Y
Impact Shock 2800g's	milliseconds	X,Y and Z

Test Results

- Intial Tests on two parts resulted in drop outs in high g environment
- Proposed solution was to increase number of seperators to 3
- Tests on first hybrids and then 4 HCA passed requirements
- Four HCA passed all environmental tests
- No change in performance as result of environmental tests





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Life

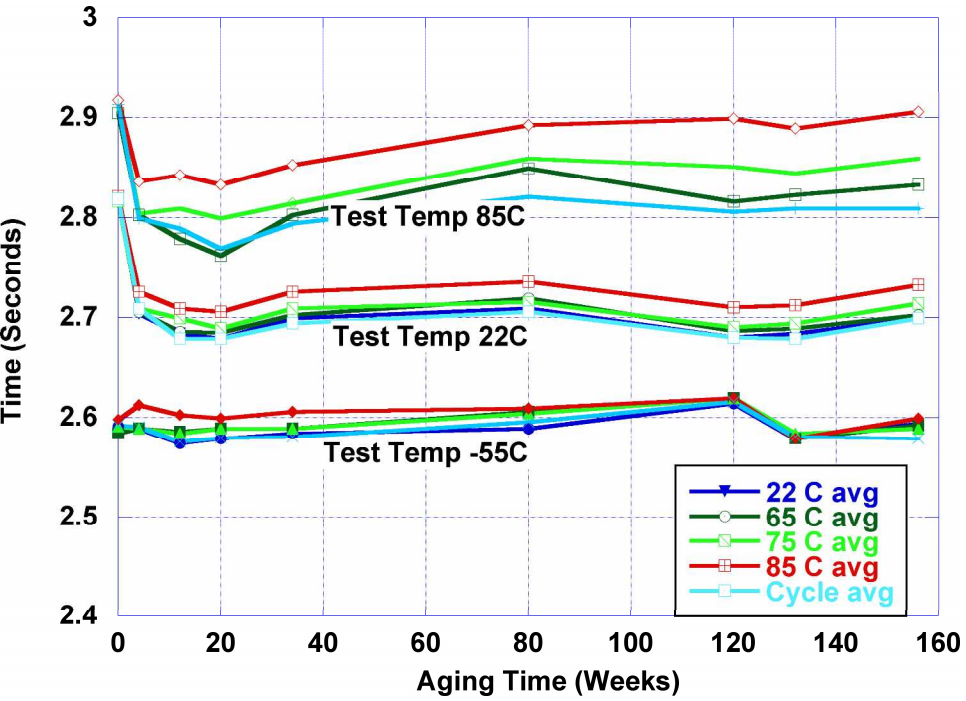
The shelf life of the HCA shall be at least seven (7) years while being stored in the shorted condition at room temperature

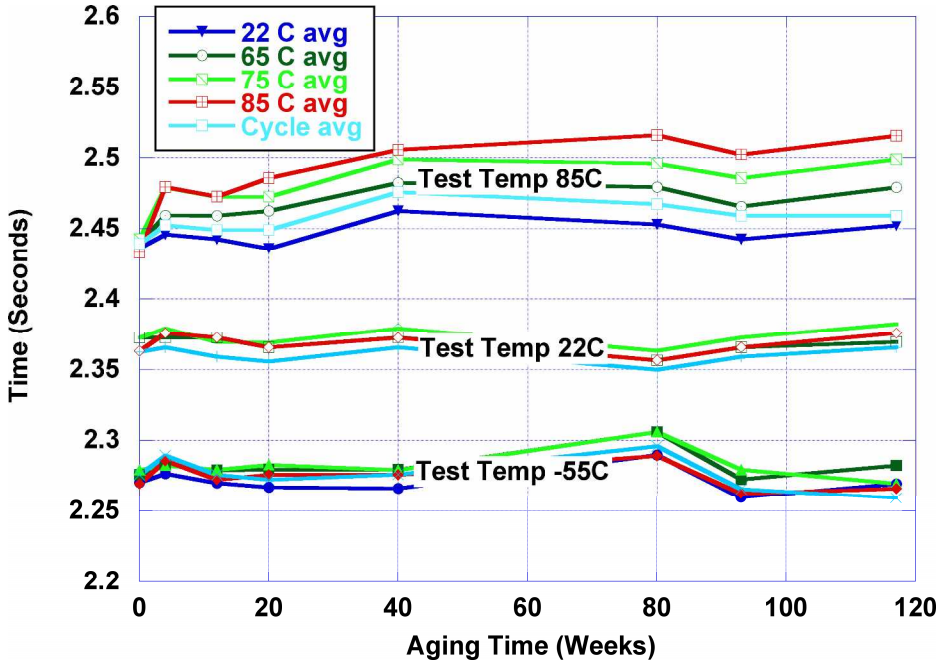
- **Age three each HCA's in temperature chambers at 65°C, 75°C, 85°C, cycle three and leave three as baseline samples at room temperature.**
- **Test these parts at intervals of about 1, 3, 5, 10, 15 and 24 months as per discharge requirements of time to 20.1 volts. (*The HCA shall provide 16 W of power for 0.85 seconds minimum with the initial charge of 37.5V minimum and shall remain above 20.1V during this time duration.)***
- **Test capacitance (cap) and equivalent series resistance (ESR) at intervals of about 1, 3, 5, 10, 15 and 24 months.**
- **Analyze data for changes/trends as a function of aging temperature or cycling.**

Test Results

- Two studies of 3 parts each were done because a welding problem was discovered in first set
- Data in from first study of parts still useful as will have data from at least one of pair of hybrids in HCA
- Plots are average of 3 HCA's except where data from only 1 part

Average time to 20.1 volts as a function of aging time and test temperature





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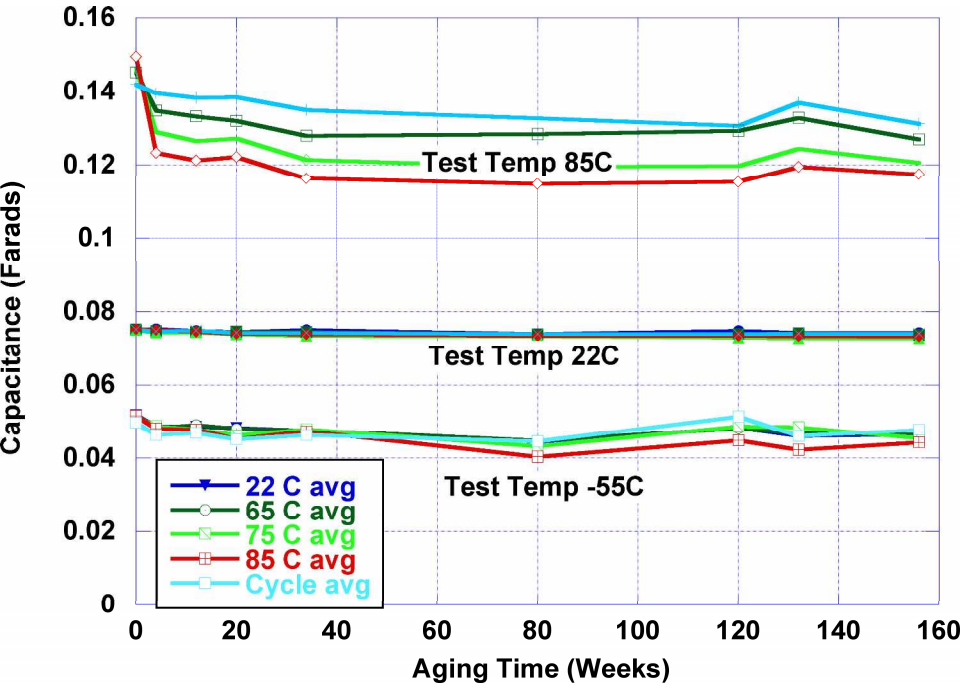
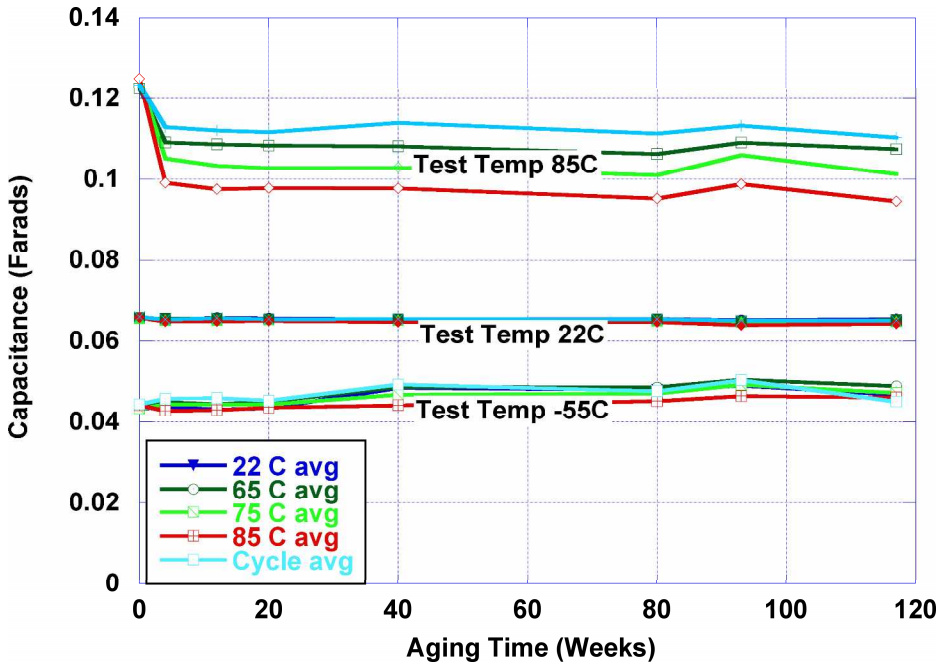
Capacitance as a function of aging time and test temperature





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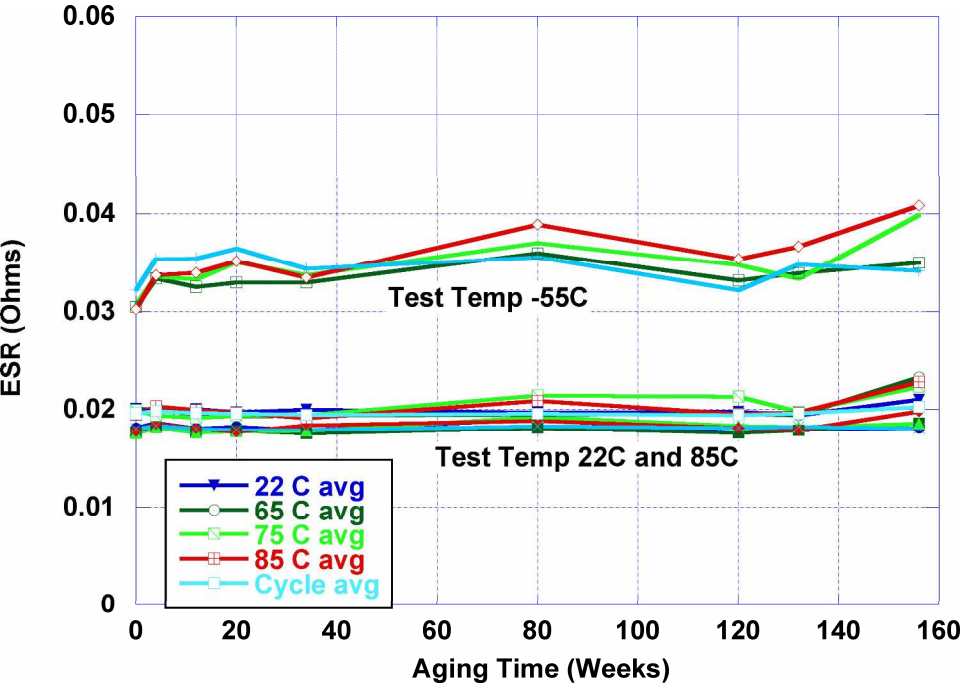
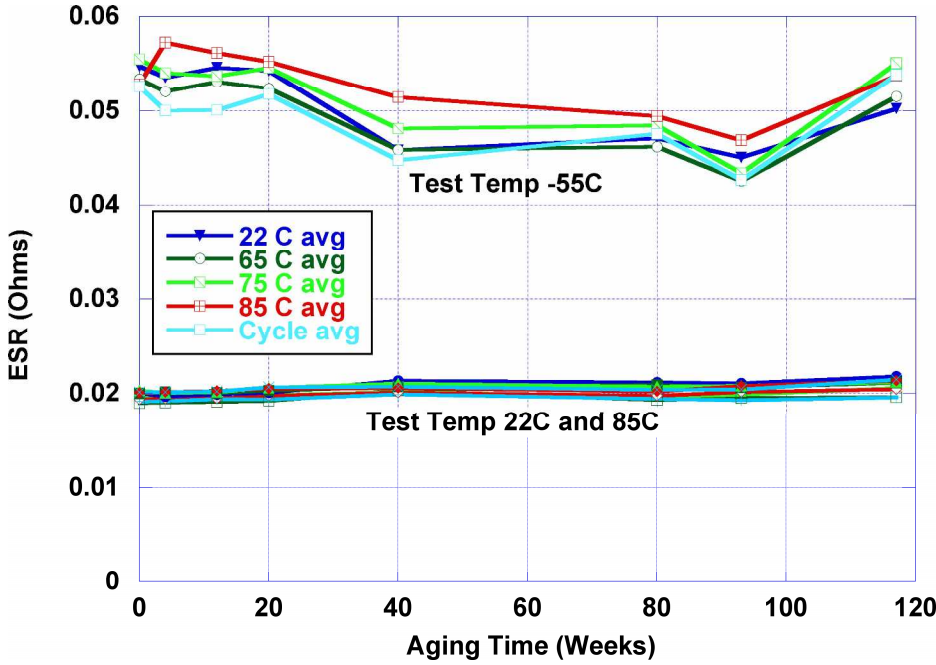
ESR as a function of aging time and test temperature





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Summary Life Studies Data

- Temperatures to 85C do not appear to degrade the performance of the HCA
- Metal Oxides most likely require higher temperatures to provide activation energies
- Expect HCA to be stable for required 7 years and beyond

Summary

HCA are qualified for use as interim power in flight tests