Dynamic Charge Acceptance of Lead Acid Batteries in Micro Hybrid Board Net. 12ELBC Istanbul – Session 4.

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Dynamic Charge Acceptance of Lead Acid Batteries in Micro Hybrid Board Net.

Overview

- Introduction to Axion Power
- Major Vehicle Changes Europe/US – 2020
- Micro/Mild Hybrid Testing
- VRLA Battery Test Results
- Description of the Axion ***PbC***® Battery
- ***PbC***® Battery Tests Results
- Conclusions

DCA of LA Batteries in Micro Hybrids.
Introduction to Axion and PbC® Battery.

AXION Manufacturing and R&D Facilities

- 50,000 sq. ft. New Facility
- 75,000 sq. ft. Mfg. Facility

DCA of LA Batteries in Micro Hybrids.

Major Vehicle Changes Europe/US – 2020.

EU CO_2 Reduction and US CAFE

Region	Date	% of Fleet	Requirement
US	NOW 2016 (Was 2020)	100	250 g CO_2/mi* (156 g CO_2/km)
Europe	2012	65	130 g CO_2/km**
Europe	2013	75	130 g CO_2/km**
Europe	2014	80	130 g CO_2/km**
Europe	2015	100	130 g CO_2/km**
Europe	Long term (2020?)	100%	95 g CO_2/km

*- Current US average fleet fuel economy = 20 MGP
- 250 g CO2/mi = 156 g CO2/km = 35.5 MPG
**-130 g CO2/km = 42.4 MPG

DCA of LA Batteries in Micro Hybrids.

Major Vehicle Changes Europe/US – 2020.

EU CO_2 Reduction and US CAFE

BRAND	VOLUME 1st Half-09 # Units	AV CO2 1st Half-08 (g/ km)	AV CO2 1st Half-09 (g/ km)	CO2 DIFF (g/ km)
FIAT	535,590	134.3	129.1	-5.2
MINI	65,559	133.9	129.7	-4.2
TOYOTA	358,982	146.5	132.9	-13.6
LANCIA	61,776	136.1	134.1	-2.0
PEUGEOT	500,880	138.5	134.5	-4.0
HYUNDAI	[illegible]	151.6	138.8	-12.8
CITROEN	[illegible]	141.7	138.8	-2.9
RENAULT	[illegible]	142.7	138.9	-3.8
FORD	664,582	148.4	140.4	-8.0
CHEVROLET	95,564	156.8	141.6	-15.2
SEAT	166,110	146.0	142.4	-3.6
SUZUKI	134,014	158.3	144.9	-13.4
HONDA	132,360	154.5	146.5	-8.0
KIA	128,296	153.4	148.9	-4.5
OPEL	434,218	150.5	149.5	-0.9
SKODA	[illegible]	149.3	149.9	0.7
MAZDA	[illegible]	161.4	151.2	-10.2
VAUXHALL	[illegible]	155.8	152.3	-3.5
DACIA	95,036	153.1	152.4	-0.6
VOLKSWAGEN	838,117	159.4	152.5	-7.0
BMW	285,023	160.7	158.4	-2.2
NISSAN	159,311	164.5	158.9	-5.6
AUDI	323,256	177.0	162.6	-14.4
MERCEDES	298,491	185.6	178.8	-6.8
VOLVO	99,726	180.4	179.0	-1.4
Total Volume / Average CO_2	6,976,634	152.3	146	-6.2

Have Major Problems Soon

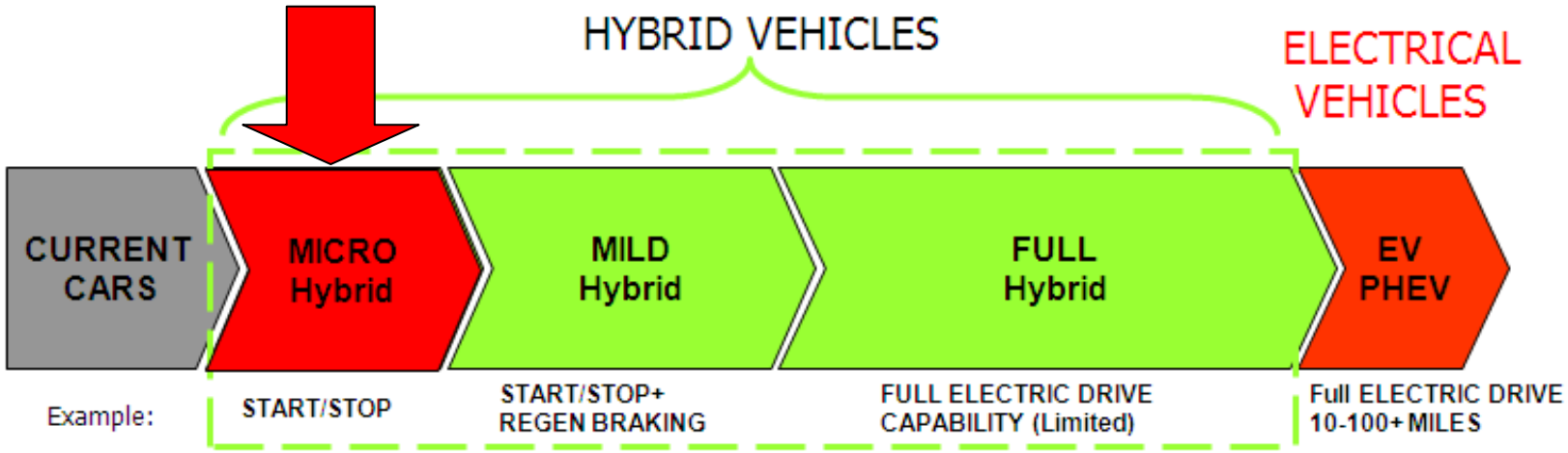
Have Major Problems Now

DCA of LA Batteries in Micro Hybrids.
Major Vehicle Changes Europe/US – 2020.

Motive Power Applications

Idle Start-Stop Vehicles:

- Estimated 10-18 million vehicles by 2016 (US and Europe)
- Drive by legislation
  - Europe: 130 gCO_2/km (42 mpg)
  - US: 250 gCO_2/mi (36 mpg)



DCA of LA Batteries in Micro Hybrids.
Major Vehicle Changes Europe/US – 2020.

Issues for Future Low Cost Micro/Mild Hybrid?

- **Early Start/Stop**
  - 12V System
  - Simple geared starter approach
- **Future Start/Stop**
  - 12+V System (but definitely below 60V)
  - Opportunity Charging
    - Need 100A (charge acceptance)
  - PbA only 5-10A (charge acceptance)
- **Supercaps, NiMH, and Lithium Ion**
  - DC-DC Converter (>$100)
  - Module Cost (>$250)
  - Significant integration costs
  - Cold temperature performance

DCA of LA Batteries in Micro Hybrids.
Major Vehicle Changes Europe/US – 2020.

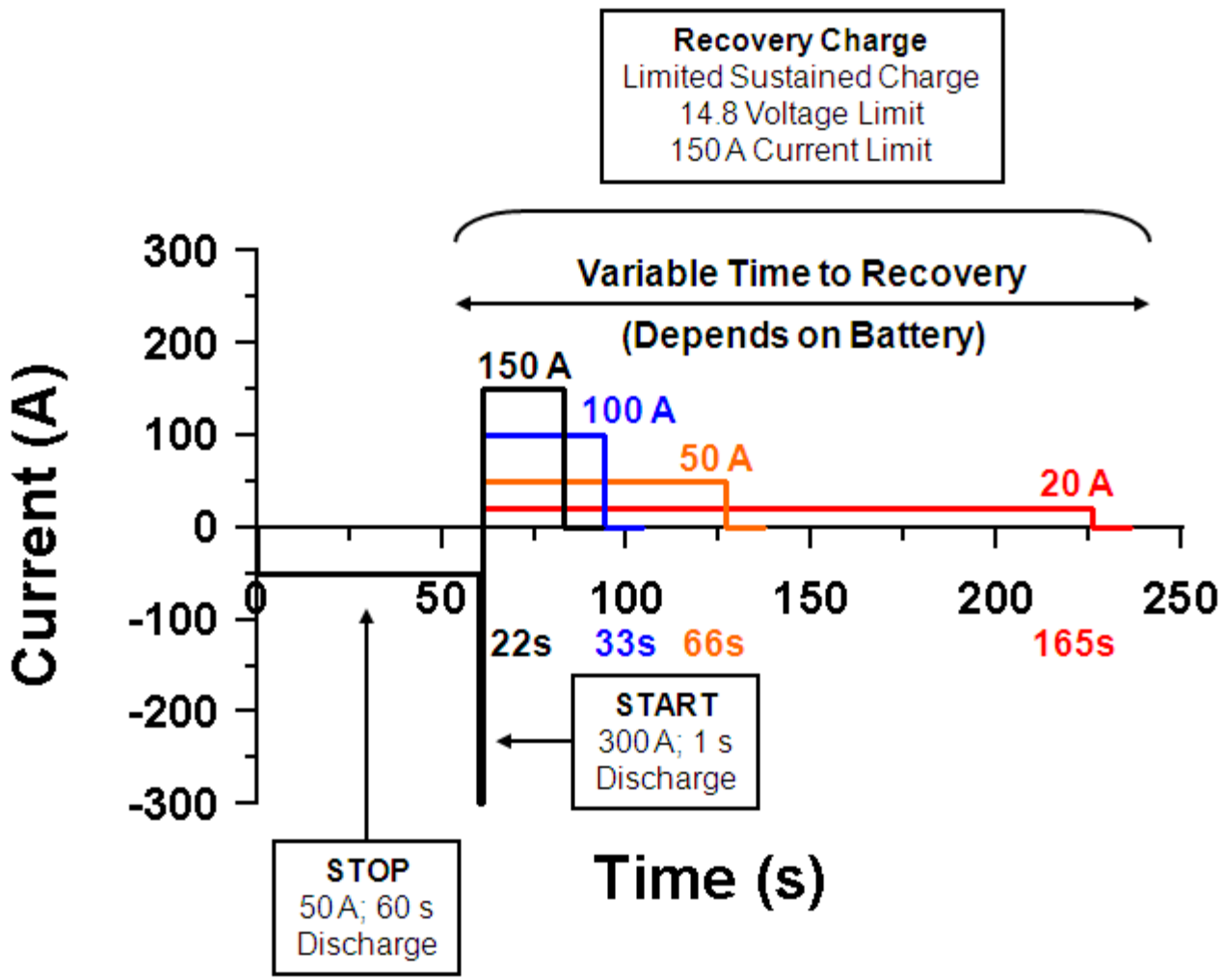
OEM focus on VRLA or improved flooded

- SOC difficult below 0°C
- Voltage drop-out during start
- 2 battery systems
- Current micro hybrid only 2-4% more efficient
- **HIGHER CHARGE ACCEPTANCE → 100+ Amps**
  - More frequent start/stop
  - More regenerative braking capability
  - 10% fuel efficiency improvement

DCA of LA Batteries in Micro Hybrids.

Micro/Mild Hybrid Testing.

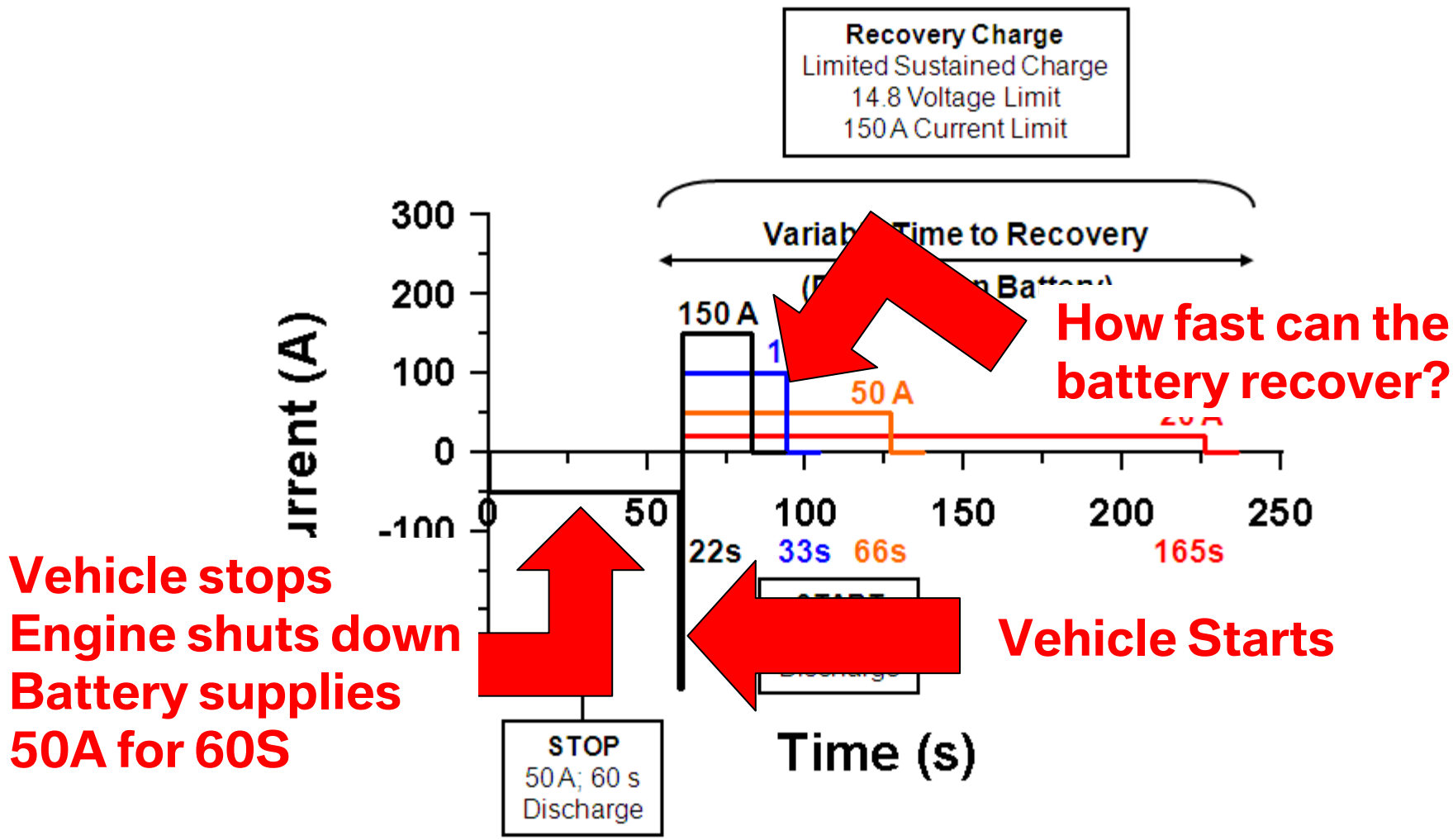
Dynamic Charge Acceptance Test Protocol



DCA of LA Batteries in Micro Hybrids.

Micro/Mild Hybrid Testing.

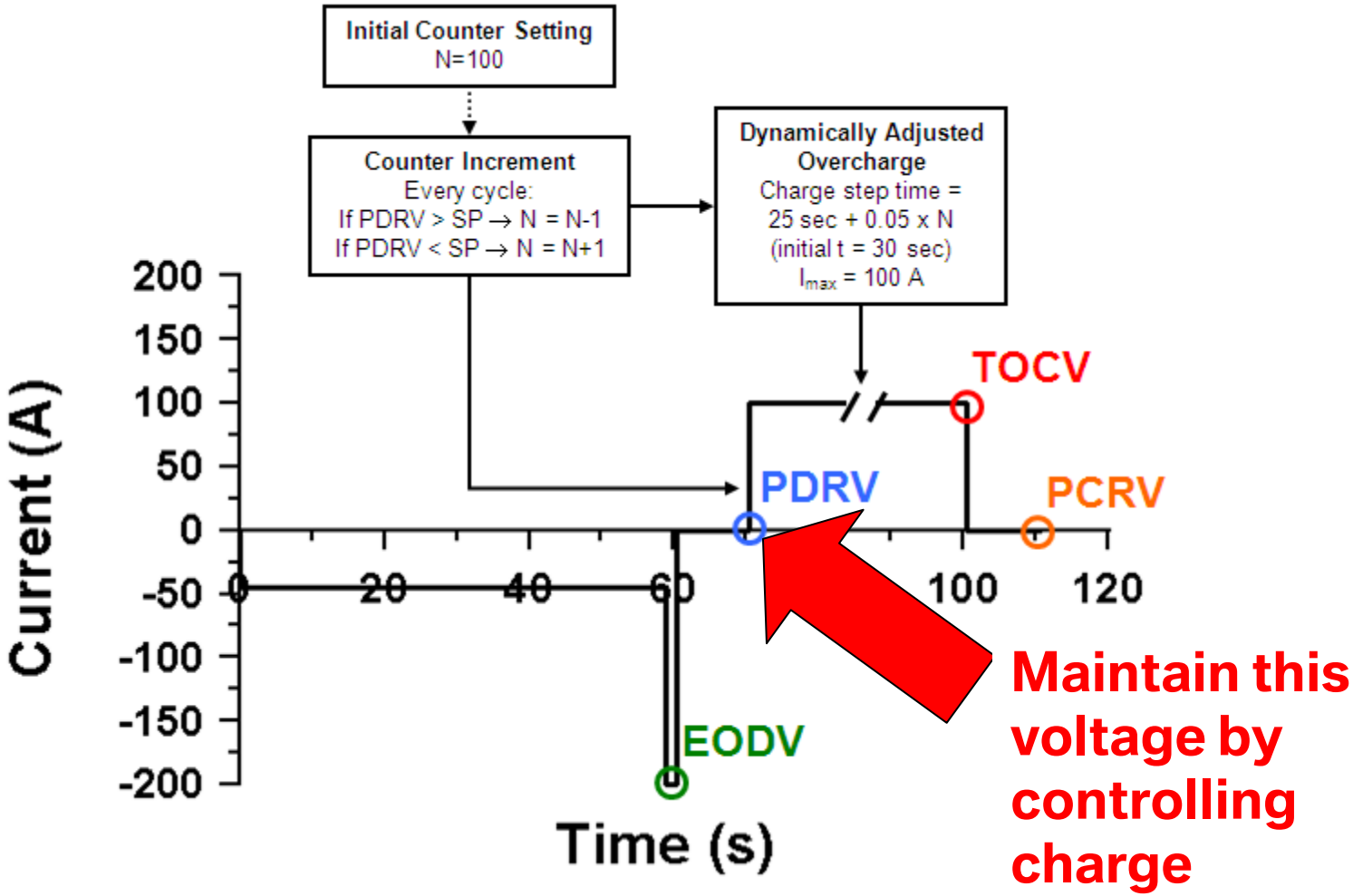
Dynamic Charge Acceptance Test Protocol



DCA of LA Batteries in Micro Hybrids.

Micro/Mild Hybrid Testing.

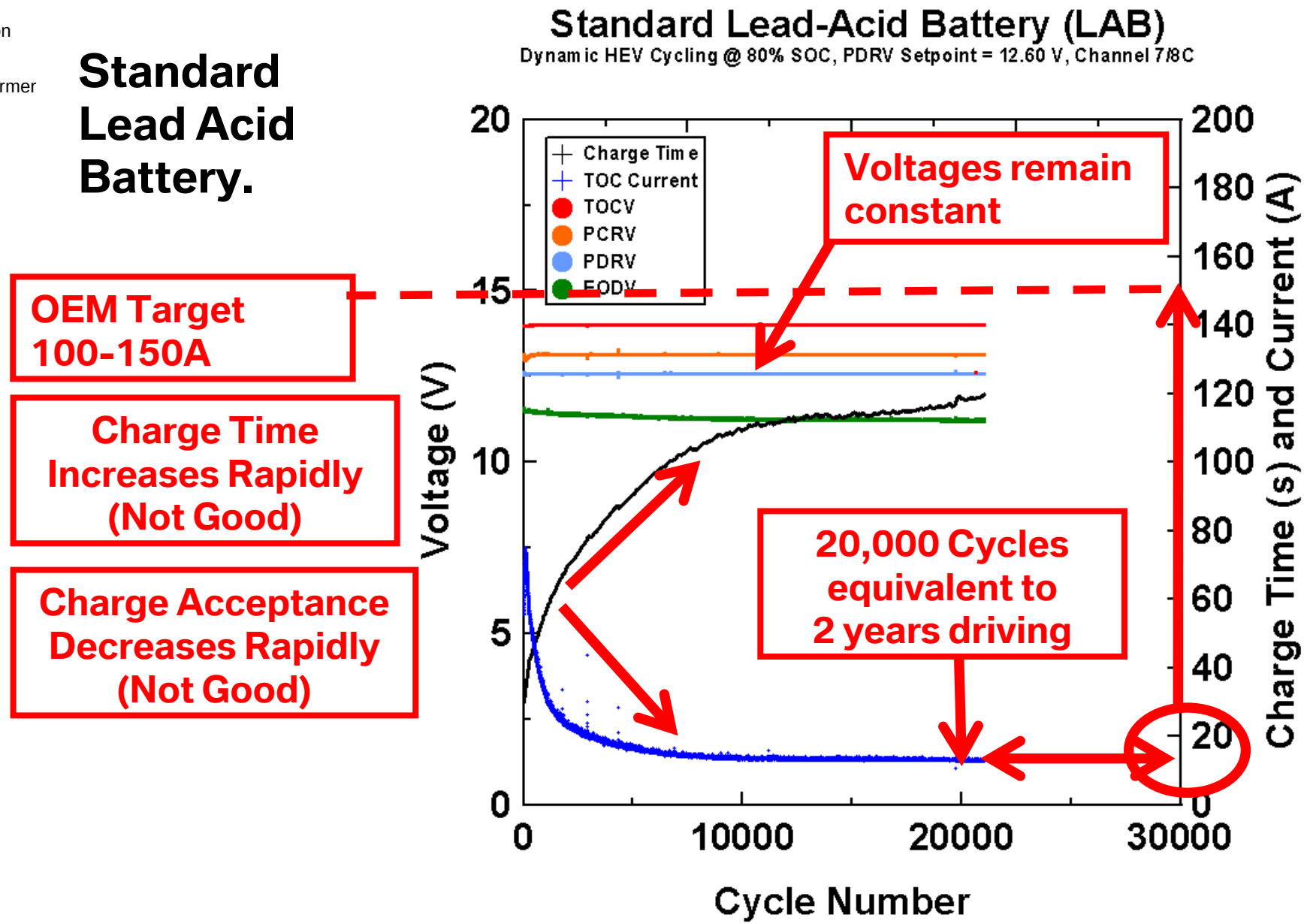
Dynamic Charge Acceptance Test Algorithm



DCA of LA Batteries in Micro Hybrids.

VRLA Battery Test Results.

Standard Lead Acid Battery.



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VRLA Battery Test Results.

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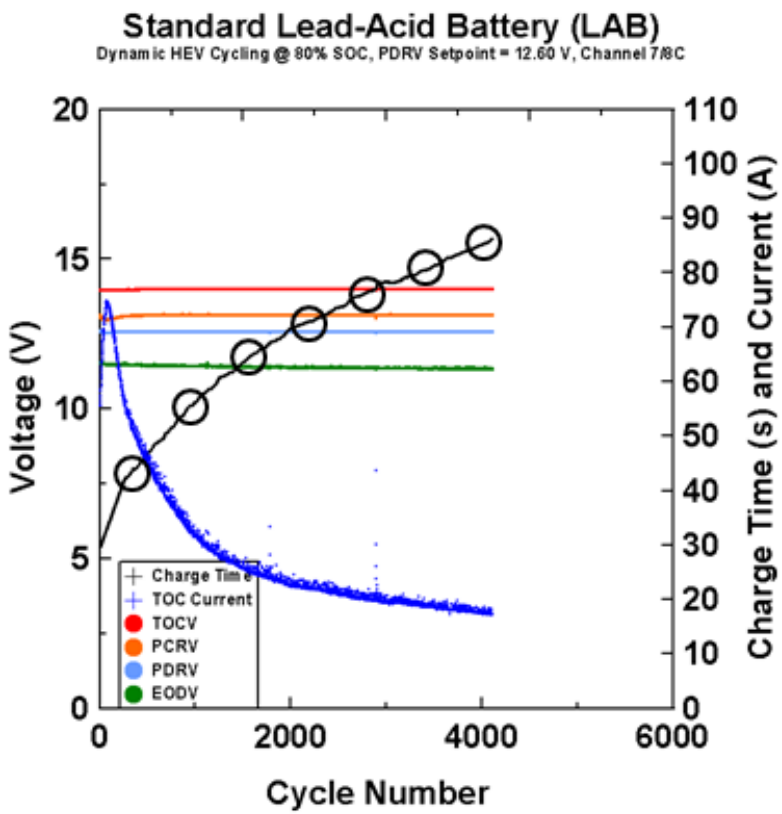
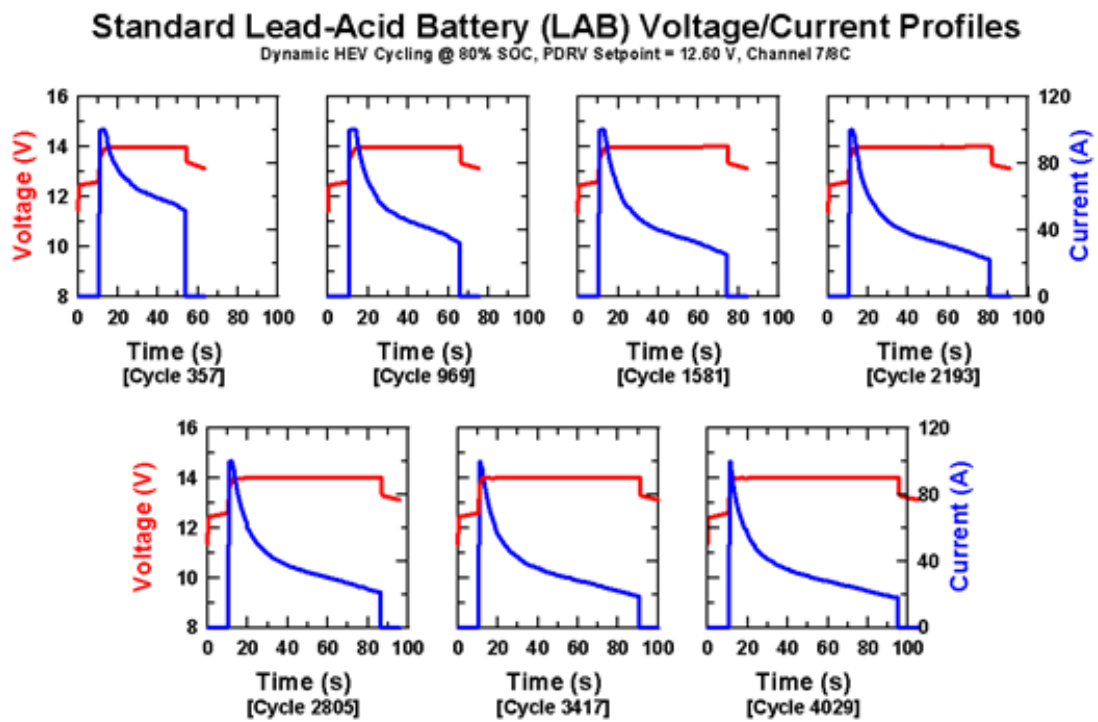




367 cycles: 44 seconds (I_{min}=51 Amps)

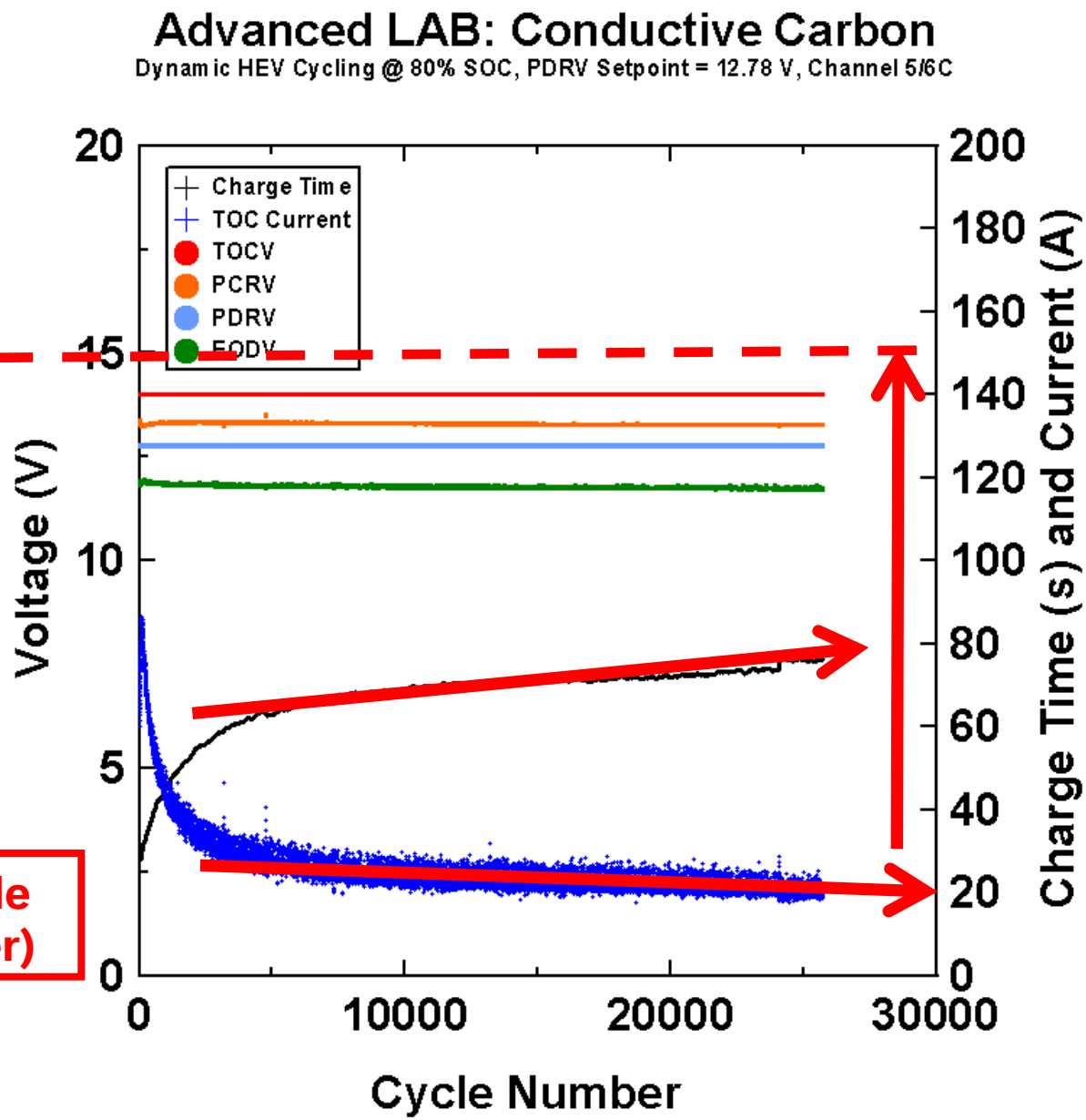
↓

4029 cycles: 85 seconds (I_{min}=18 Amps)

DCA of LA Batteries in Micro Hybrids.

VRLA Battery Test Results.

Advanced LAB with Cond. Carbon



OEM Target 100-150A

Slower increase in charge time (better)

Current decrease a little less than normal (better)

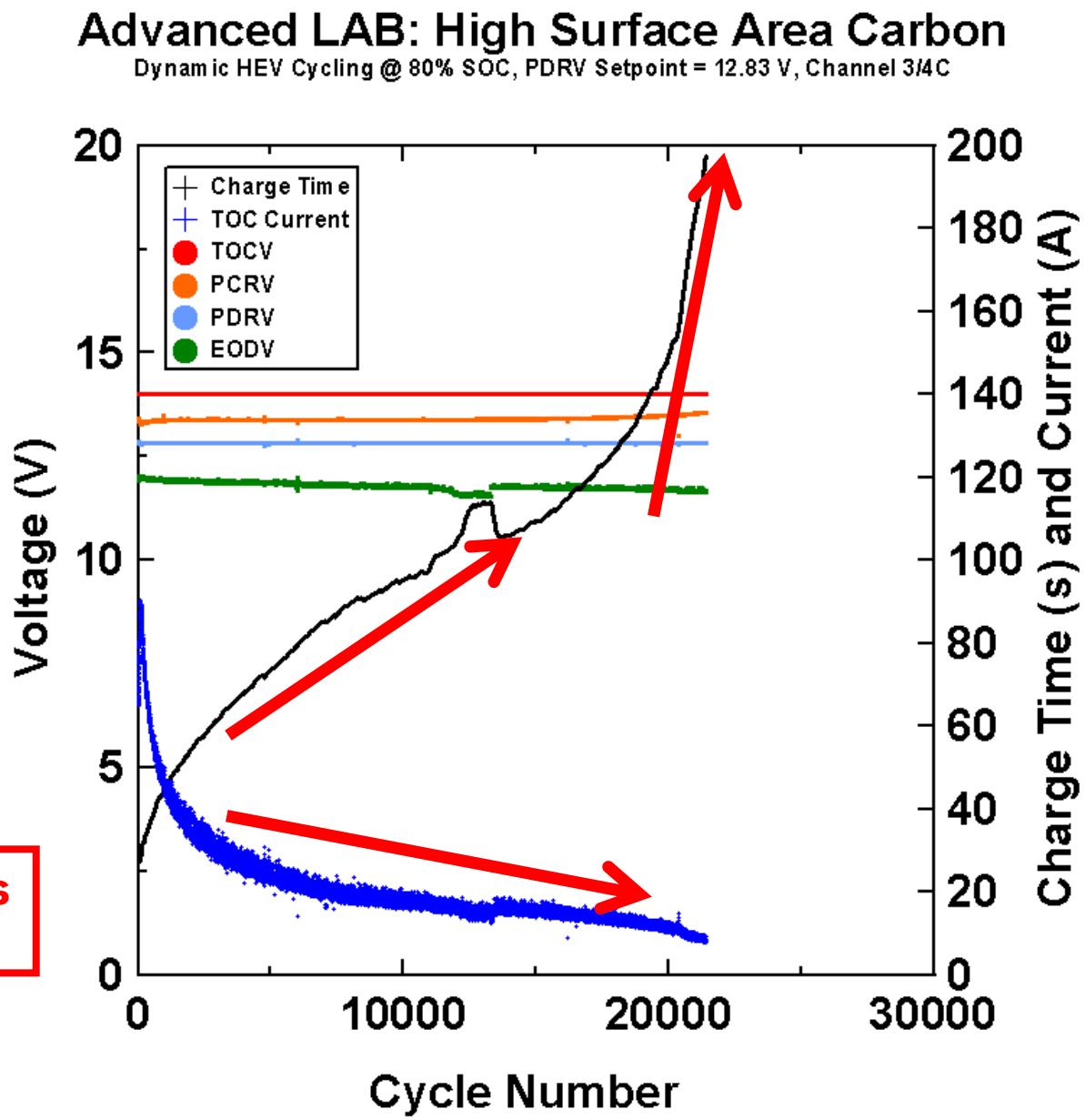
DCA of LA Batteries in Micro Hybrids.

VRLA Battery Test Results.

Advanced LAB with HSA Carbon

Hydrogenation of high surface area carbon when held at lead negative potential – BATTERY FAILURE!

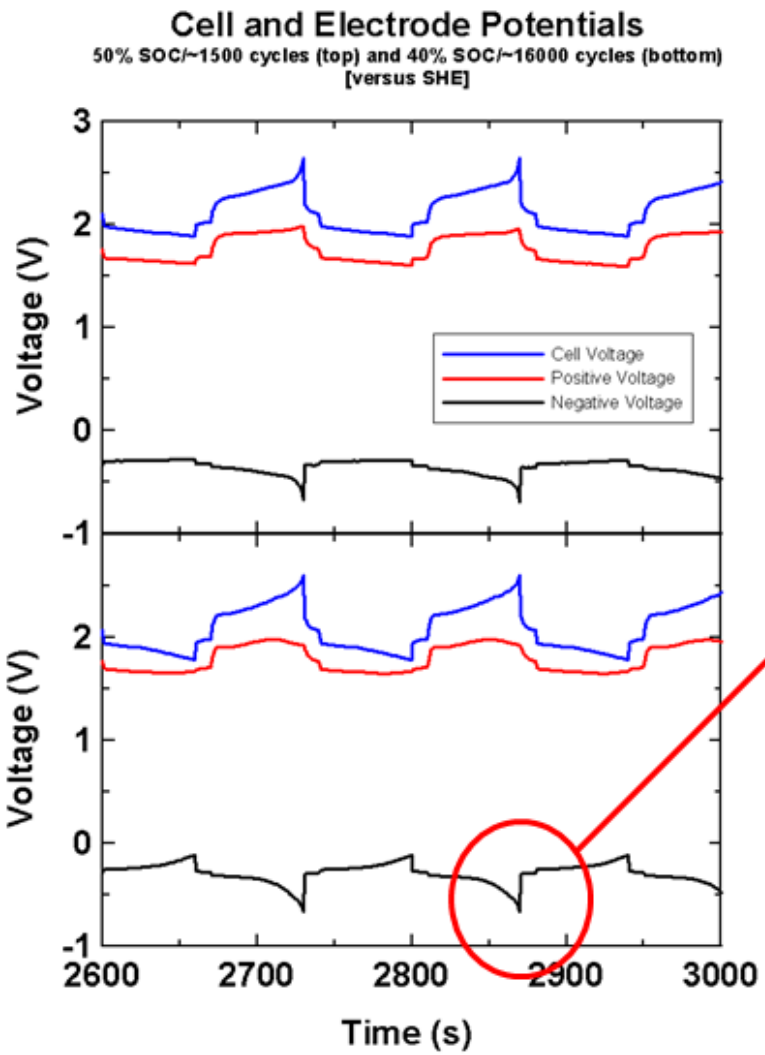
Normal Problems (Not Good)

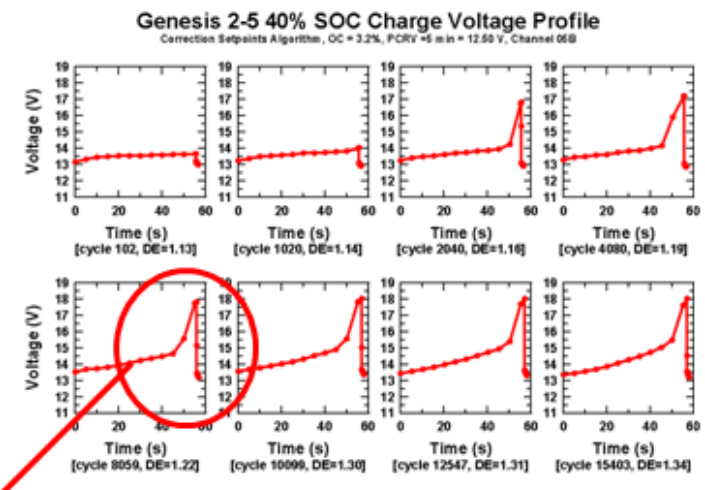


DCA of LA Batteries in Micro Hybrids.

VRLA Battery Test Results.

Reason for Failure of VRLA Batteries





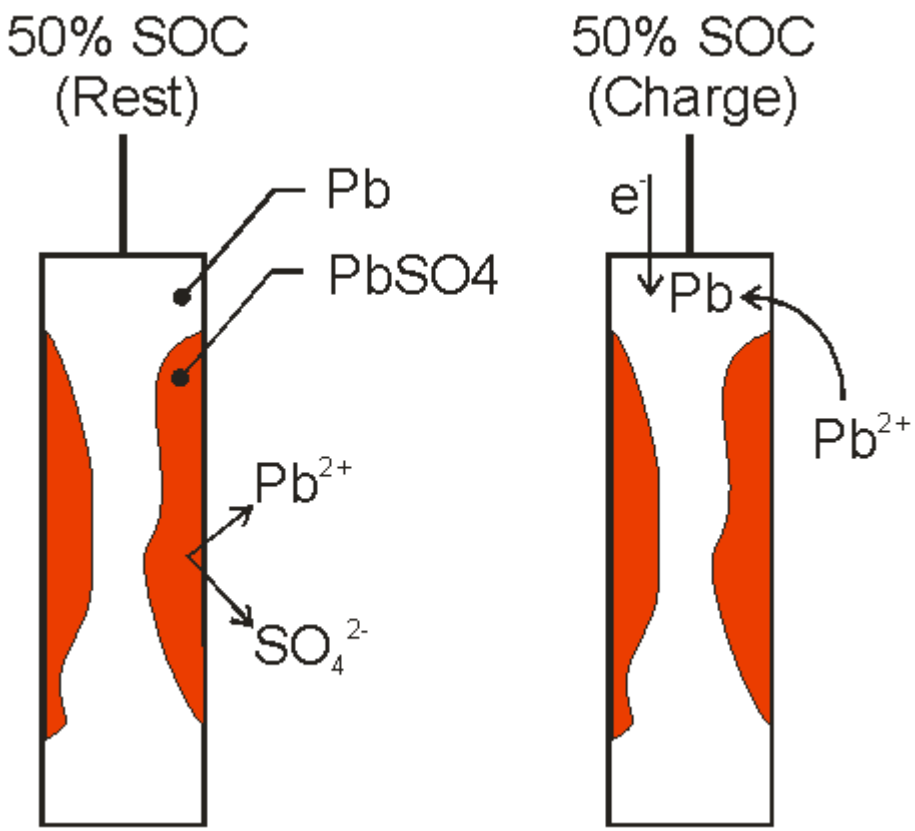
- Negative electrode cannot charge
- Polarizes
- Gases hydrogen

DCA of LA Batteries in Micro Hybrids.

VRLA Battery Test Results.

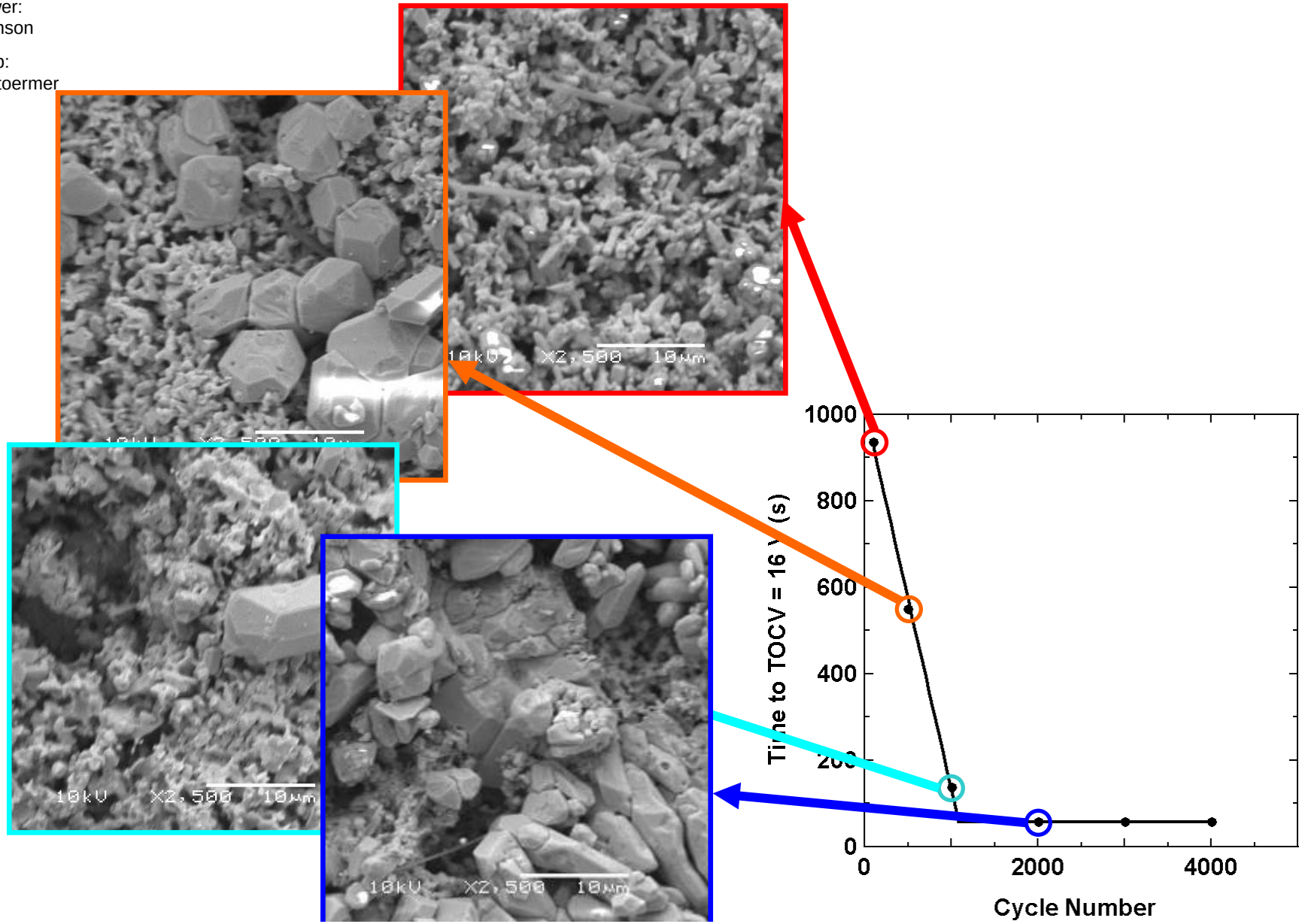
Inherent Charge Problem

- $PbSO_4$ must dissolve to provide Pb^{2+}
- Pb^{2+} can then be reduced back to Pb



DCA of LA Batteries in Micro Hybrids.

VRLA Battery Test Results.



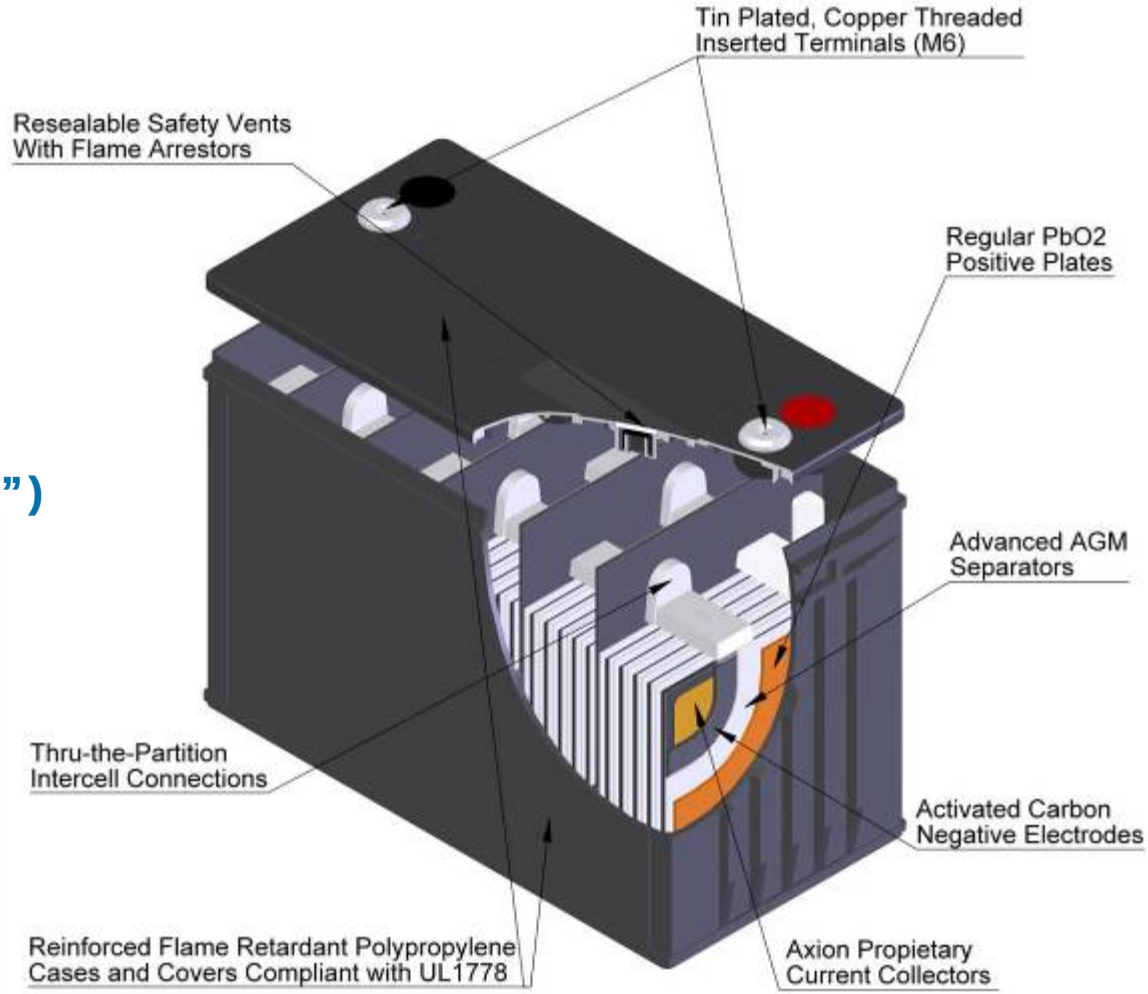
DCA of LA Batteries in Micro Hybrids.

PbC® Lead Carbon Battery.

Construction Principles.

Standard VRLA Cell ("Lead-Lead")

***PbC®* Cell ("Lead-Carbon")**



DCA of LA Batteries in Micro Hybrids.
PbC® Lead Carbon Battery.

PbC ® Batteries – Advantages and Availability

- 10x dynamic charge acceptance
- 5x increase in cycle life
- 80-90% round trip energy efficiency
- 30% less weight
- 25 Wh/kg

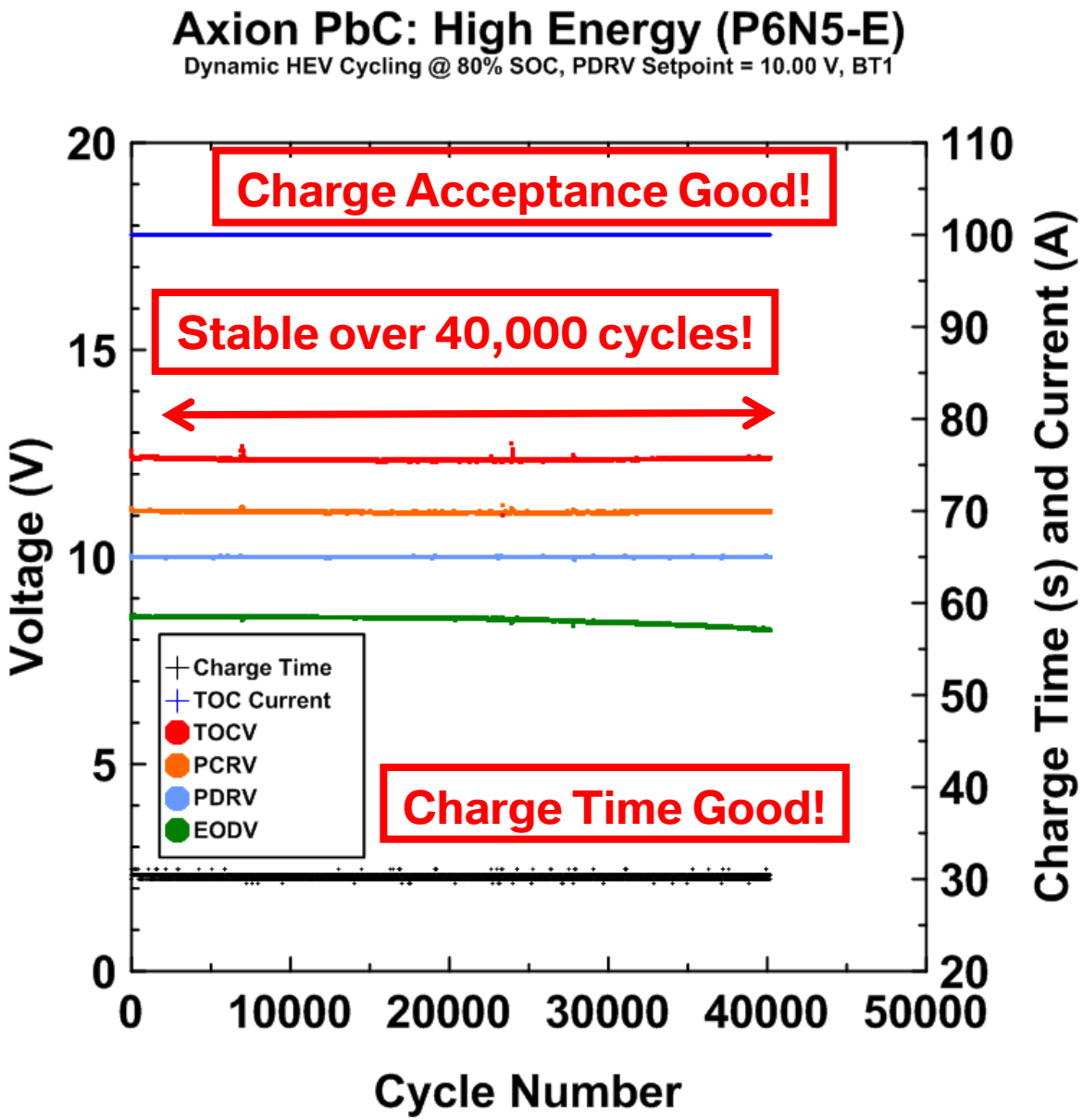
Product	BCI Group Size	Capacity (Ah)
PbC12V070	BTX7A	6
PbC12V450	24	50
PbC12V500	27	55
PbC12V600	30H	65
PbC12V750	30HT	80
PbV16V400	L5	40

DCA of LA Batteries in Micro Hybrids.

PbC® Battery Test Results.

PbC ª
DCAT Update:

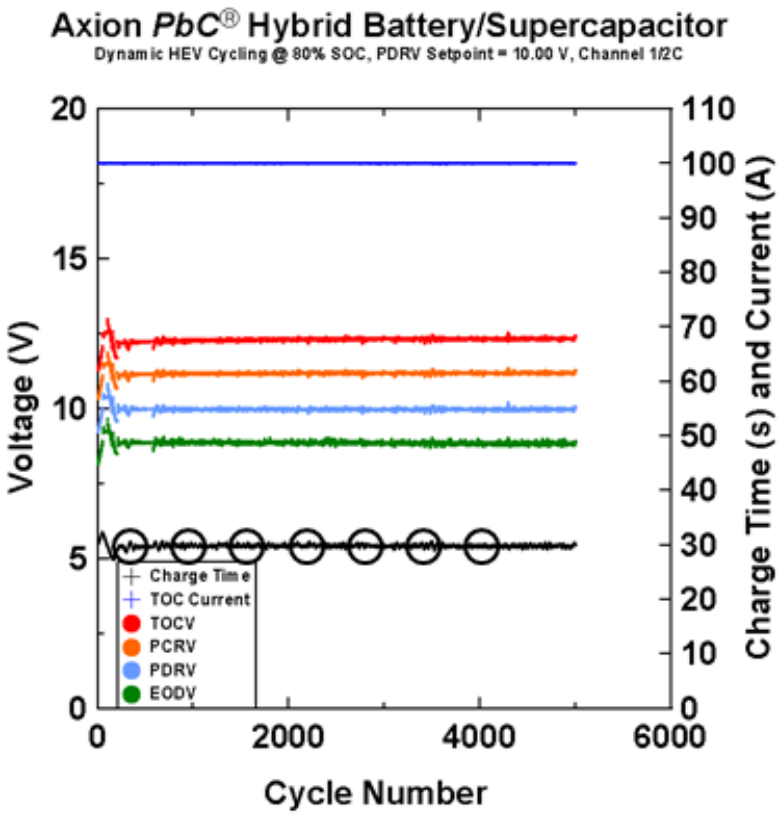
40,000+ cycles

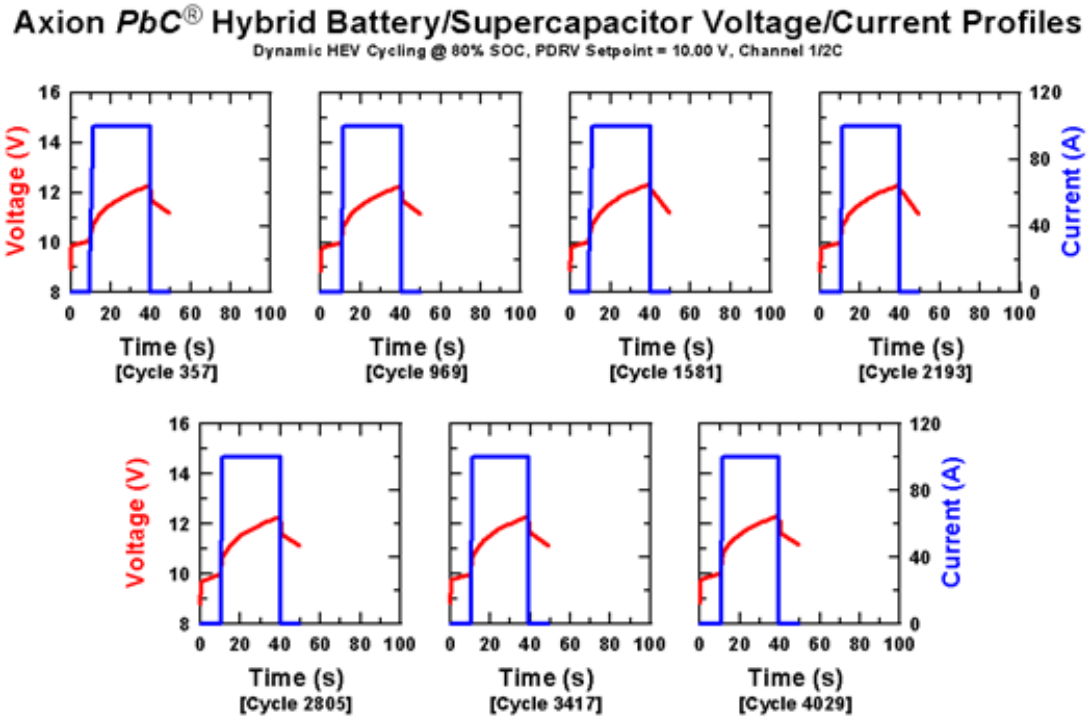


DCA of LA Batteries in Micro Hybrids.

PbC® Battery Test Results.

Details





367 cycles: 30 seconds (I_{min}=100 Amps)

↓

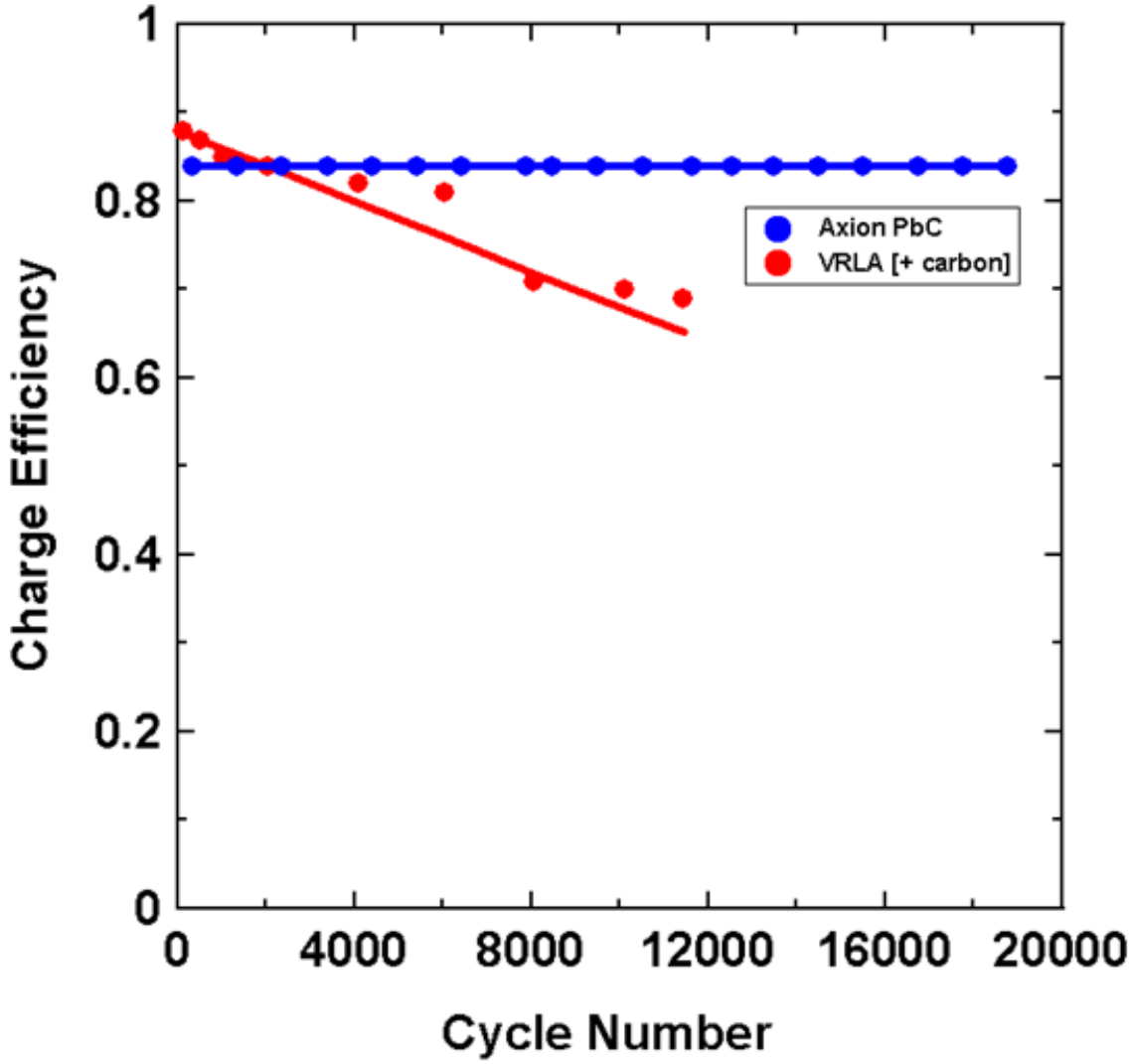
4029 cycles: 30 seconds (I_{min}=100 Amps)

DCA of LA Batteries in Micro Hybrids.

PbC® Battery Test Results.

PbC ª vs. VRLA Efficiency

- VRLA Efficiency drops to below 70% in only 8000 cycles
- ***PbC*** ® Efficiency >80% and stable



DCA of LA Batteries in Micro Hybrids. Conclusions.

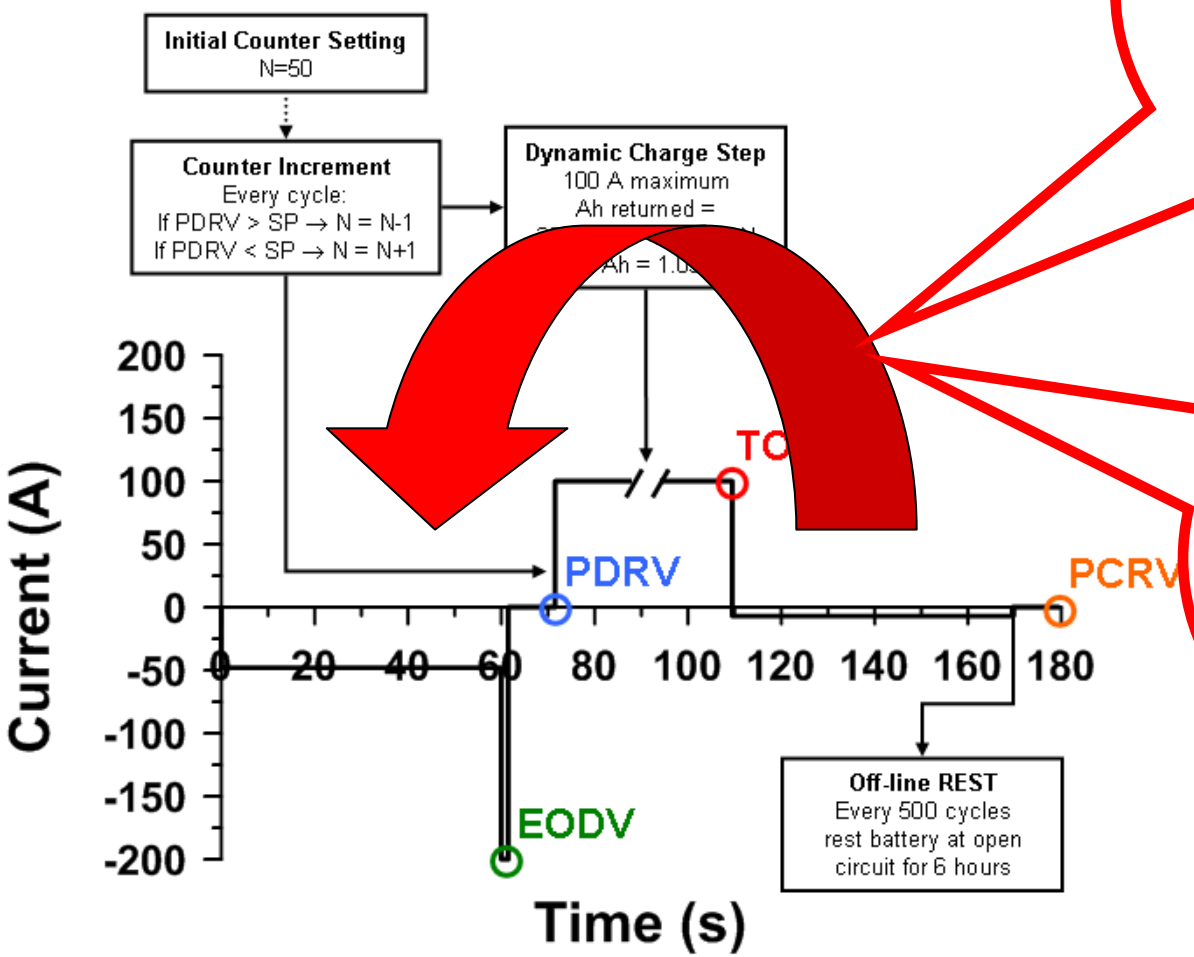
- **Idle start-stop systems will surpass non-ISS vehicles by 2015-16 world wide.**
- **VRLA batteries cannot respond with the necessary charge acceptance for ISS systems especially those that will evolve with opportunity charging (PSOC)**
- **Rapid growth of sulfate crystals in the negative electrode will be difficult to address in VRLA batteries itself**
- **Axion's *PbC*® battery is proving to be a good solution (both in performance and cost) when used in conjunction with a standard lead acid battery**

DCA of LA Batteries in Micro Hybrids.

BACKUP

Special Modifications to the mDCAT.

Opportunity Charging and Service Lifetime



Charging right after discharging very beneficial because lead sulfate never gets a chance to form

Opportunity charging would delay charging. Move 7A discharge between discharge and charge

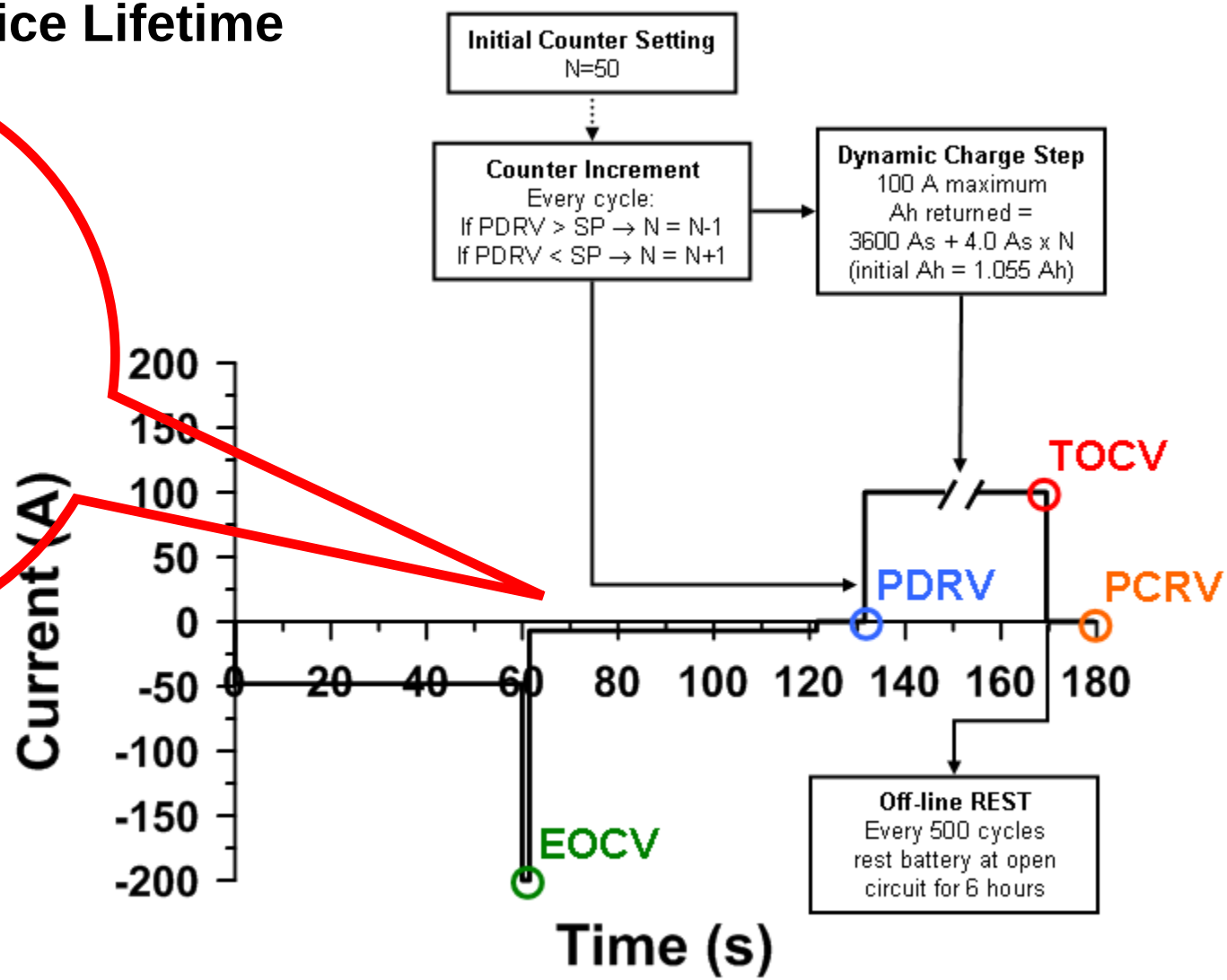
DCA of LA Batteries in Micro Hybrids.

BACKUP

Special Modifications to the mDCAT.

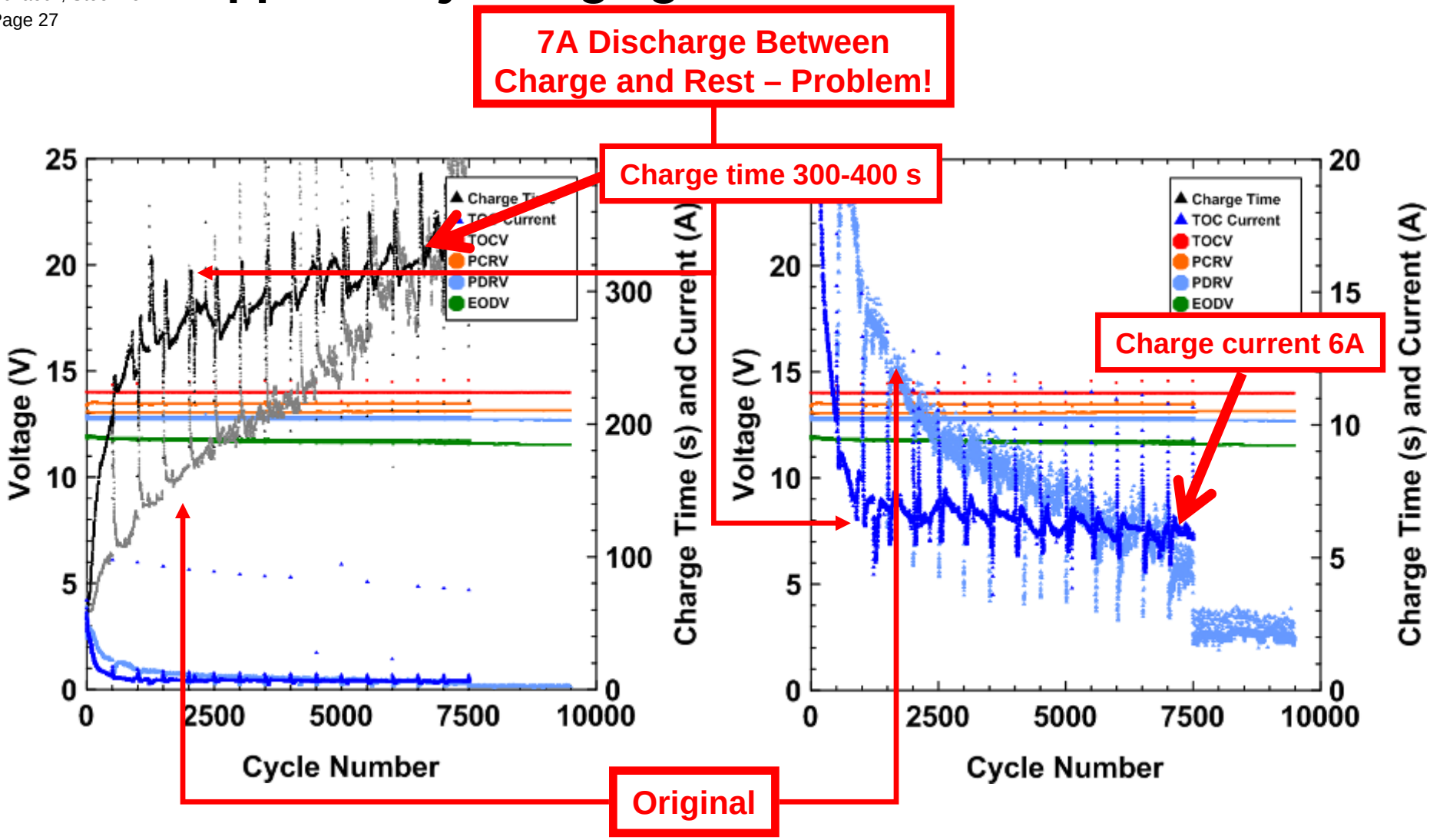
Opportunity Charging and Service Lifetime

Vehicle prevents charging during acceleration period. Increases power engine but allows $PbSO_4$ to form on negative.



DCA of LA Batteries in Micro Hybrids.

BACKUP

Special Modifications to the mDCAT.

Opportunity Charging and Service Lifetime