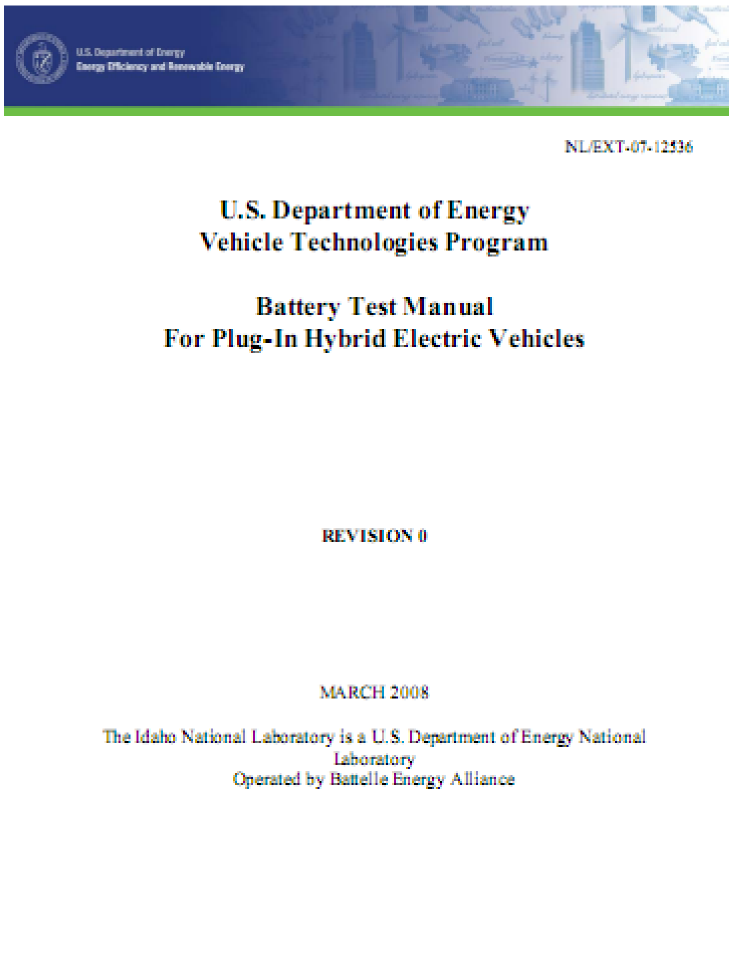
Comparison of the battery test protocols of China and USABC



NL/EXT-07-12536

U.S. Department of Energy
Vehicle Technologies Program

Battery Test Manual
For Plug-In Hybrid Electric Vehicles

REVISION 0

MARCH 2008

The Idaho National Laboratory is a U.S. Department of Energy National Laboratory
Operated by Battelle Energy Alliance

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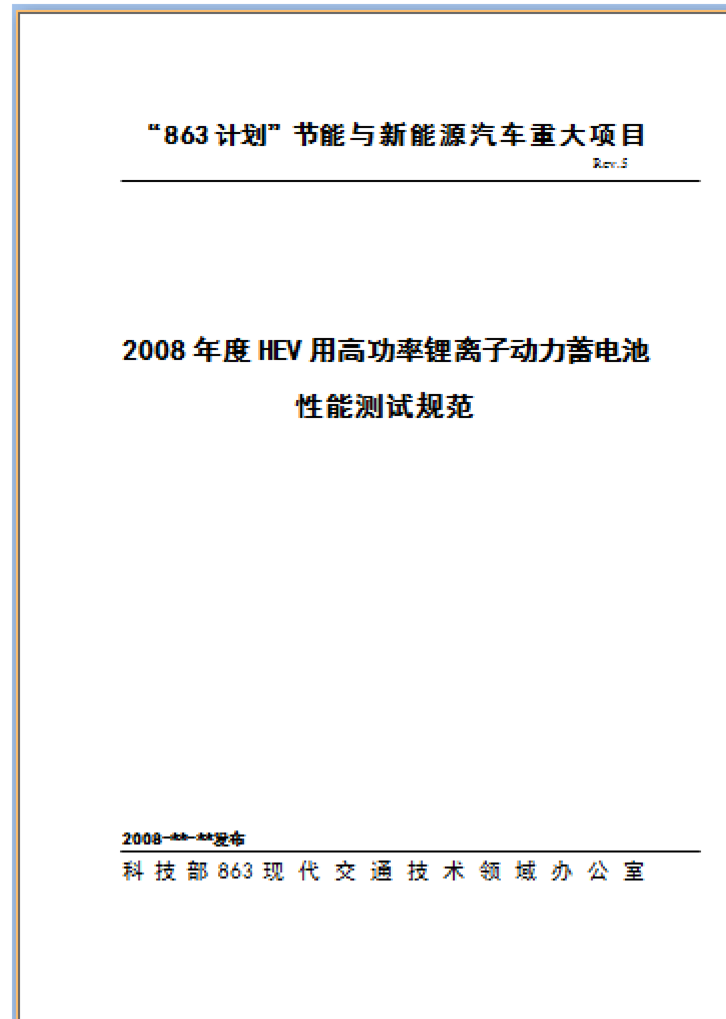


“863 计划”节能与新能源汽车重大项目

Rev.5

2008 年度 HEV 用高功率锂离子动力蓄电池

性能测试规范

2008-**-**发布

科 技 部 863 现 代 交 通 技 术 领 域 办 公 室

Contents of test manual from USABC

No.	Test items	No.	Test items
1	Static Capacity	7	Thermal Performance
2	Hybrid Pulse Power Characterization Test	8	Energy efficiency
3	Charge-Sustaining Available Energy	9	Charge-Sustaining cycle life
4	Charge-Depleting Available Energy	10	Charge-Depleting Cycle life
5	Self-Discharge	11	Calendar life
6	Cold Cranking	12	Reference Performance

✓ The principal objective of Any test procedures is the comparison of the battery performance with battery targets for Plug-in hybrid electric vehicles

Contents of test manual from China

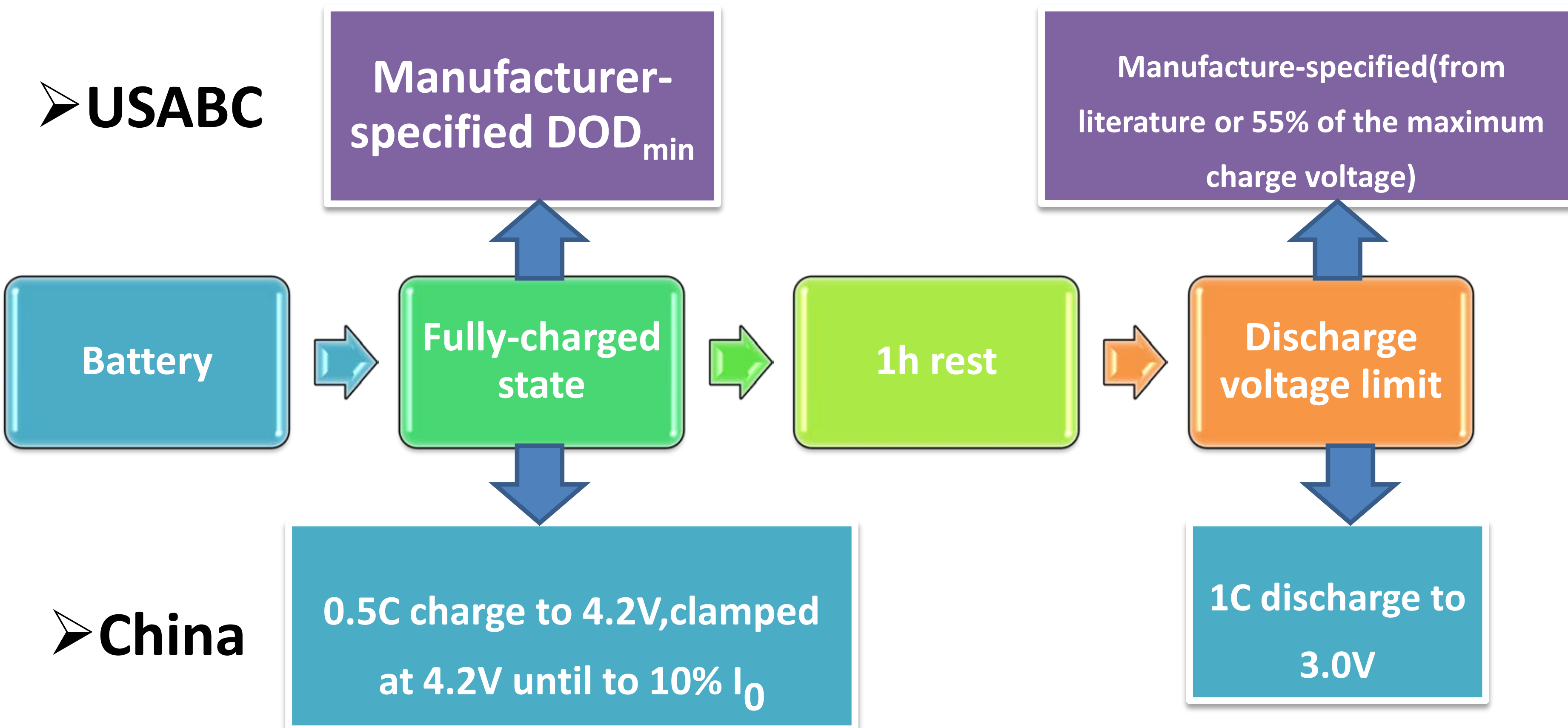
No.	Test items	No.	Test items
1	Basic Properties(appearance, Polarity, Weight and size)	5	Hybrid pulse test
2	AC resistance	6	Cycle life test
3	Capacity(20ºC,-20ºC,55ºC)	7	Self discharge
4	Power test	8	Safe test(Short circuit, Extrusion, Needle test, Drop test , High temperature test, Over charge or discharge)

✓For single battery test and only detect the performance of the battery with no reference goals

Comparison of two method

USABC	Commen	China
• CS energy • CD energy • Cold Crank • Calendar life • Reference Performance	• Capacity • Hybrid pulse test • Cycle life test • Self discharge • Thermal Performance	• Basic Properties • AC resistance • Safe test

Capacity Test Method



- Same :test procedure and 1h rest before test
- Different :how to specify the DOD_{min} and DOD_{max}

Hybrid Pulse Test

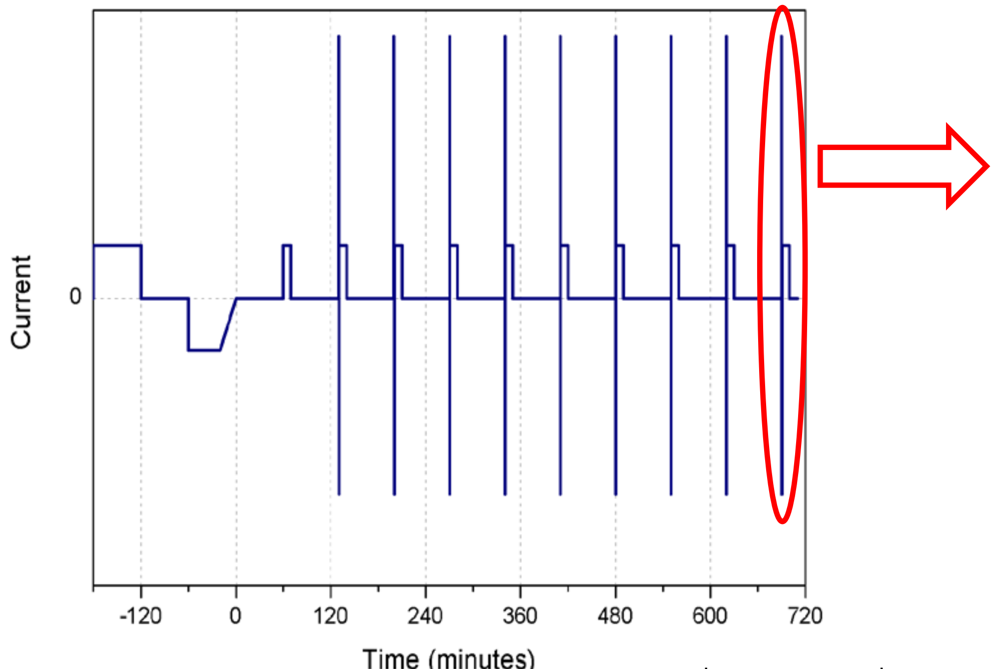
Intended to determine dynamic power capability over the device's useable voltage range using a test profile that incorporates both discharge and regen pulses.

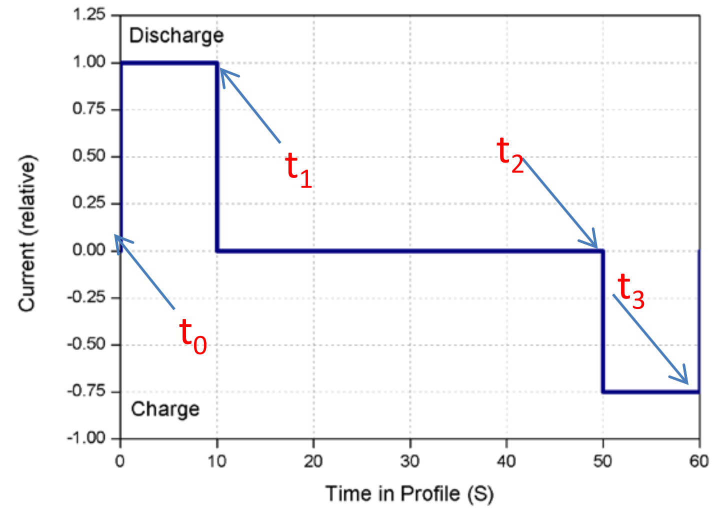
USABC → HPPC

✓ Performance characteristics to derive:

- Resistance
- Power Capability
- Charge-Sustaining Available Energy
- Charge-Depleting Available Energy
- Available Power

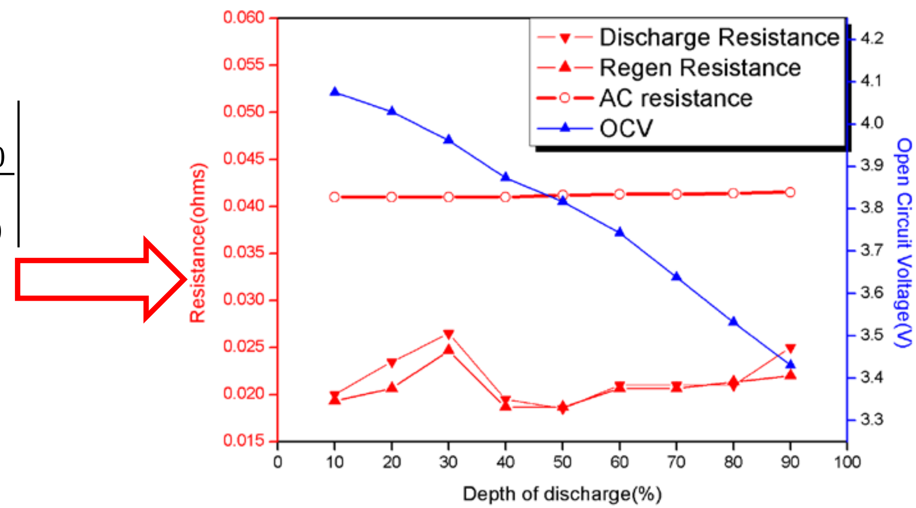
HPPC





$$\text{Discharge Resistance} = \frac{\Delta \text{V}_{\text{discharge}}}{\Delta \text{I}_{\text{discharge}}} = \left| \frac{V_{t1} - V_{t0}}{I_{t1} - I_{t0}} \right|$$

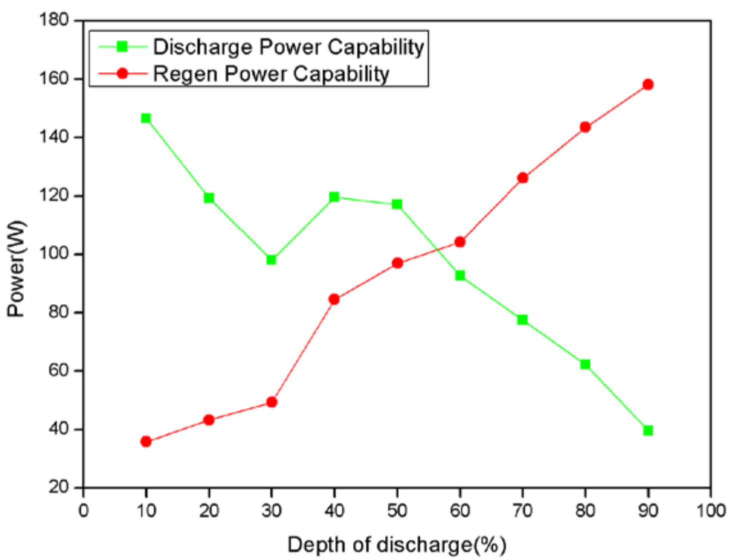
$$\text{Regen Resistance} = \frac{\Delta \text{V}_{\text{regen}}}{\Delta I_{regen}} = \left| \frac{V_{t3} - V_{t2}}{I_{t3} - I_{t2}} \right|$$

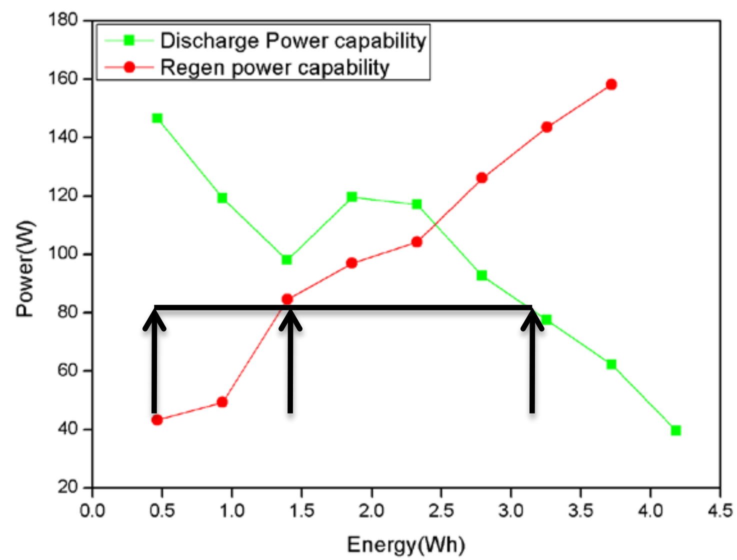


HPPC

$$\text{Discharge Pulse Power Capability} = V_{MIN}\frac{OCV_{dis} - V_{MIN}}{R_{discharge}} = V_{MIN} \bullet I_{dis}\frac{OCV_{dis} - V_{MIN}}{OCV_{dis} - V_{dis}}$$

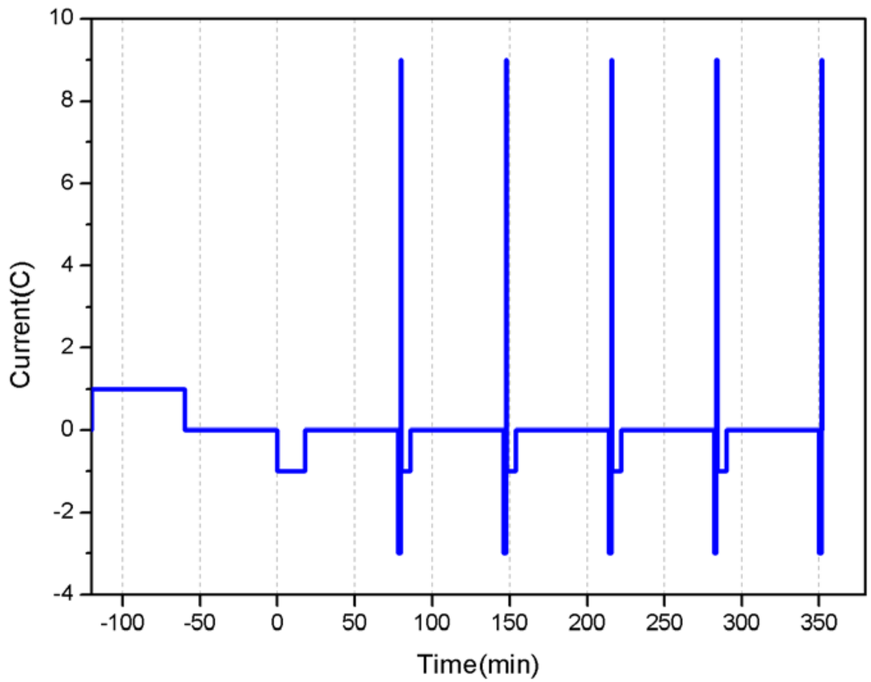
$$\text{Regen Pulse Power Capability} = V_{MAX}\frac{V_{MAX} - OCV_{regen}}{R_{regen}} = V_{MAX} \bullet I_{regen}\frac{V_{MAX} - OCV_{regen}}{V_{regen} - OCV_{regen}}$$

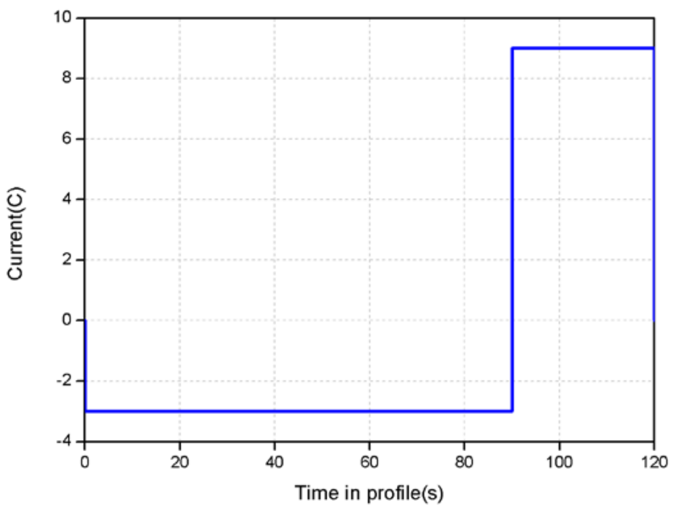




Results:CS available energy and power ,CD available energy and power

Pulse Power Test from China

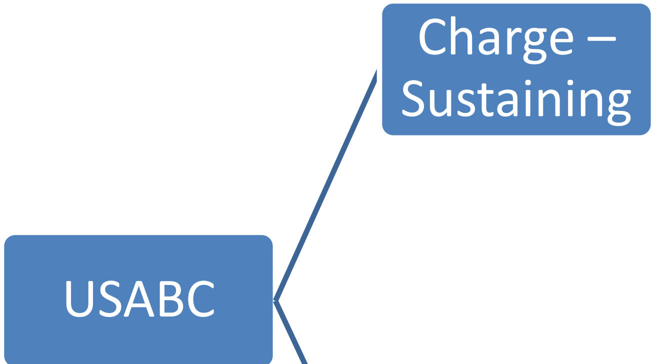


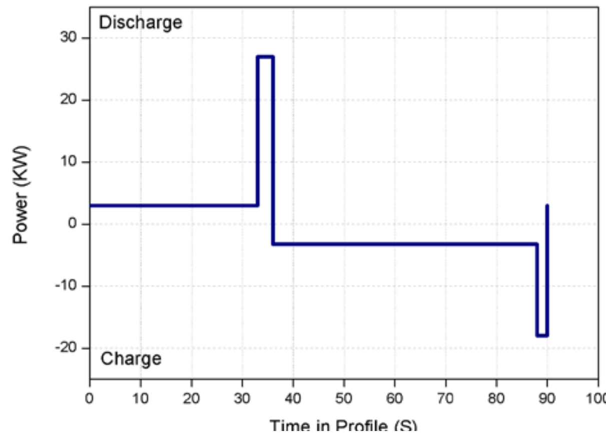


$$\text{Discharge Resistance} = \frac{\Delta V_{\text{discharge}}}{\Delta I_{\text{discharge}}}, (\Delta T = 5\,\text{sec})$$

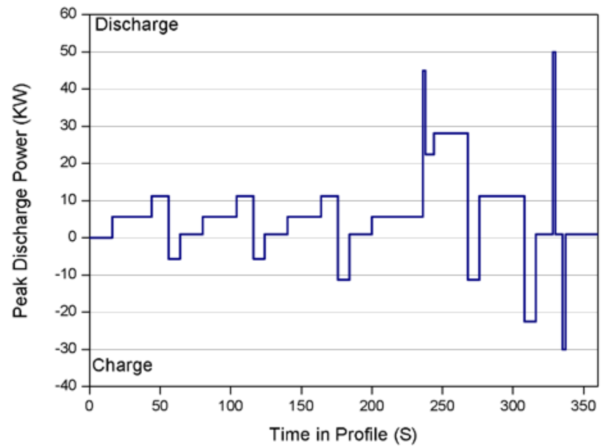
- Results:
  - Energy Efficiency
  - Discharge Resistance

Cycle life test





- ➢Verify stable operation at the selected SOC point before test
- ➢Reference performance test every 30000 cycles
- ➢Every profile : -6.2Wh

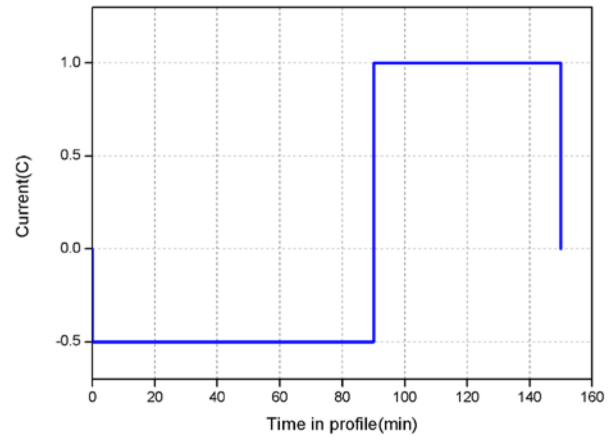


- ➢Start at 10%DOD Recharge every 5 cycles
- ➢Reference performance test every 2500 recharge
- ➢Every profile :545.6Wh

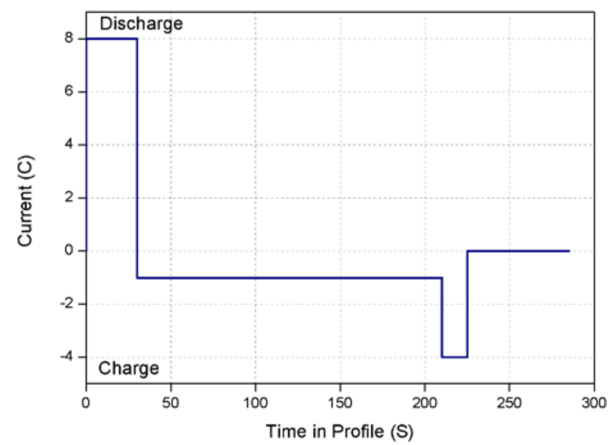
Cycle life test

China

- General cycle life
- Working condition cycle life



- ➢Charge to 20% DOD every cycle
- ➢Voltage:4.2V for charge and 3V for discharge
- ➢Reference performance test every 25 cycles



- ➢Start at 30% DOD
- ➢Repeat the test profile 100 times as a cycle
- ➢40%DOD 1 cycle , 50%DOD 2 cycles , 60%DOD 2 cycles , 50%DOD 2 cycles , 40%DOD 1 cycle , 30%DOD 1cycle

End-of-test condition: degradation of the battery capacity is more than 20%

Self discharge

$$\text{Self Discharge} = \frac{C_{\text{before test}} - (C_{\text{part1}} + C_{\text{part2}})}{\text{Stand Time in Days}}$$

	USABC	China
Capacity measurement	discharge use a constant scaled 10-KW rate to voltage limit(Wh)	discharge use 1C current to voltage limit(Ah)
Test condition	remove the CD available energy	full charged state
Test temperature	30 ^{o}C	20 ^{o}C and 55 ^{o}C
Nominal interval	7 days or interval yield capacity loss of more than 5%	28 days at 20 ^{o}C and 7 days at 55 ^{o}C

Capacity recovery: there must be no visible capacity loss before and after self discharge test

Thermal Performance

- **Laboratory cell level:**
  - **Characterize the performance as a function of temperature**
  - **Bound the likely constraints on thermal management**
- **System level:**
  - **Thermal management system design and behavior**

	USABC	China
Initial Fully Charge Temperature	30°C	20°C
Target Temperature	Not specify(-30 to +52°C)	-22°C and +55°C
Thermal Equalization Time	4-8h	16h at -22°C and 5h at 55°C
Test Content	capacity test Low HPPC test	capacity test Hybrid pulse test DC resistances
Objective	fraction of the CS Available power target	energy efficiency at various temperature

Calender life test

- Careful planning and analysis of calendar life tests are critical to estimation of battery life with high confidence.
- Calender life esimmates are necessarily based on accelerated test methods(High temperature)
- Achieve high rates of deterioration to minimize test time and cost
- Avoid introducing irrelevant failure modes at too high temperature

Interesting cooperation area

- The life accelerating test method.
- The safety performance evaluation grade definition
- Mechanism of safety