



TM16-50% DOD test with low charging voltage

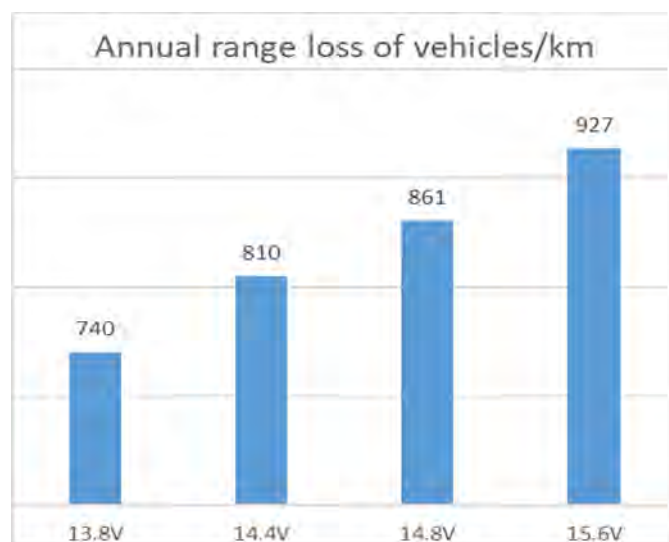
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Camel Group Co. LTD.



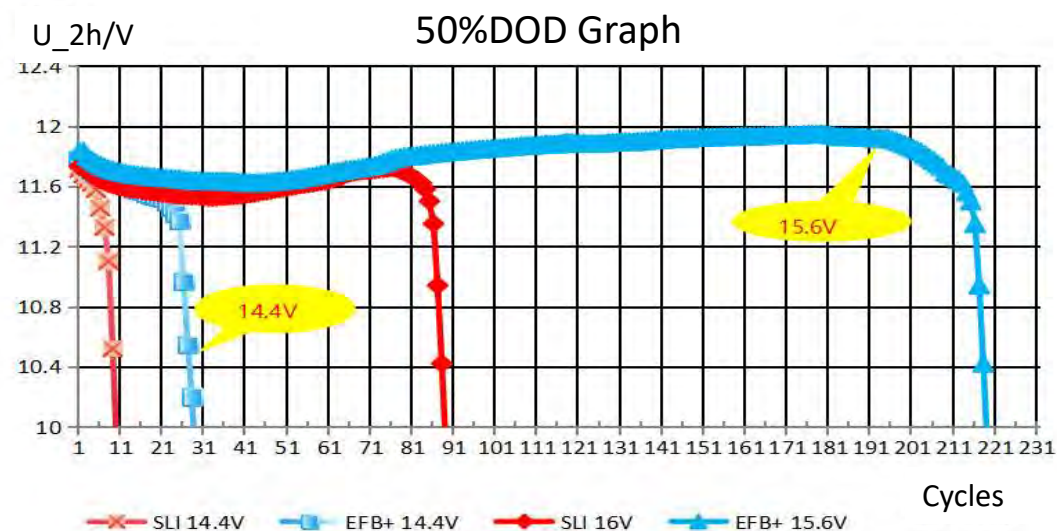
50% DOD test with low charging voltage

The impact of different DC-DC output voltages on energy and range losses

Voltage	13.8V	14.4V	14.8V	15.6V
Light load efficiency	79%	72%	68%	63%
power loss	4.0W	5.8W (+45%)	7.1W (+78%)	8.8W (+120%)
Daily energy loss increase	—	29Wh	50Wh	77Wh
Annual energy loss increase	—	10.5kWh	18.2kWh	28.1kWh



Kunping Yu and Zhen Tian, Camel Group, MAY 2026



1. In NEV, high-voltage power batteries charge low-voltage batteries through DCDC, but electrical energy is lost when passing through DCDC.

Generally, as the output voltage of DC-DC increases, the energy loss of each switching action significantly increases. When the load is light (15W), the switch loss can account for 60% - 70% of the total loss, so the negative impact of voltage rise on efficiency is particularly prominent in the float charging state.

2. Pain point: Due to the charging voltage of AUX battery for NEV ranging between 14.0-14.4V, so each cycle is incomplete charging. The battery is in PSoc for a long time, and its capacity rapidly decreases after 10-30 cycles, The failure mode is acid stratification and plate sulfation, which leads to rapid degradation of the battery performance of conventional batteries in some NEVs. And frequent triggering of the SOC threshold for Smart Charging, loss of high-voltage battery power, affecting the range and life of the high-voltage battery.

50% DOD test with low charging voltage



Item	Flood-SLI method	EFB method	Flood-AUX recommended method
50% DOD	40 °C water bath: a. Discharge at $5 \times I_{20}$ for 2 hours. b. 16V charging for 5 hours - current limit of $5 \times I_{20}$; c. Continue cycling for a-b steps until the discharge voltage is below 10V.	40 °C water bath: a. Discharge at $5 \times I_{20}$ for 2 hours. b. 15.6V charging for 5 hours - current limit of $5 \times I_{20}$; c. Continue cycling for a-b steps until the discharge voltage is below 10V.	40 °C water bath: a. Discharge at $5 \times I_{20}$ for 2 hours. b. 14.4V charging for 5 hours - current limit of $5 \times I_{20}$; c. Continue cycling for a-b steps until the discharge voltage is below 10V.

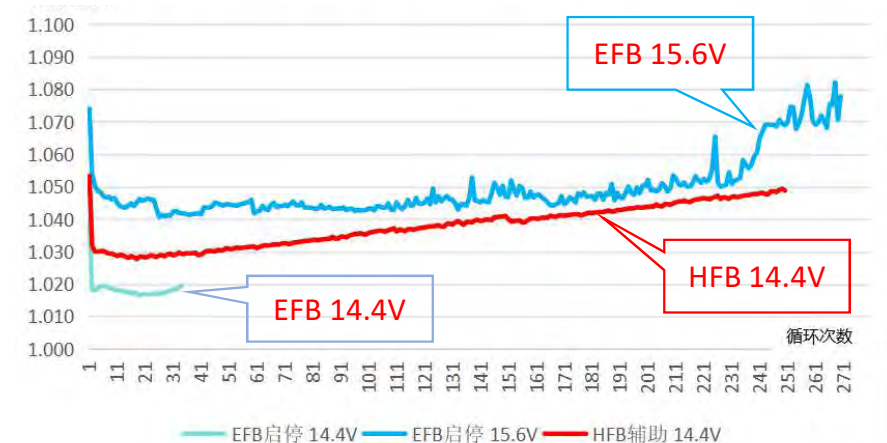
1. Therefore, for NEV, We suggest conducting aging tests based on the vehicle's charging voltage platform to effectively evaluate the performance of auxiliary battery cycling on the vehicle.

2. We conducted tests using this method, and improved the battery performance.

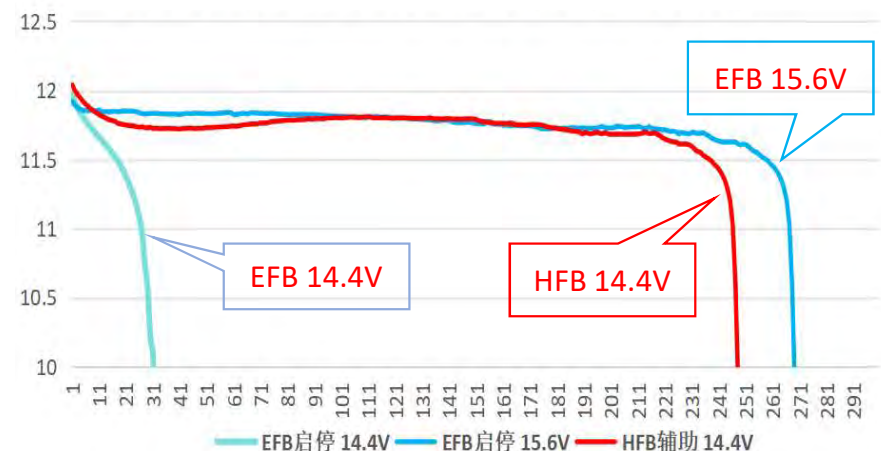
* The conventional EFB start stop battery has a charge efficiency of 1.04-1.06 at 15.6V, while the charge efficiency is lower than 1.02 at 14.4V. The HFB (newly developed Flood AUX battery by Camel) maintains a stable charge efficiency of 1.03-1.05 at 14.4V.

* The conventional EFB start stop battery can achieve over 240 cycles at 15.6V, while the simulated NEV charging voltage platform has only about 30 cycles at 14.4V. The HFB (newly developed Flood AUX battery by Camel) can achieve more than 240 cycles at 14.4V, which can be matched with the charging voltage platform of NEV.

Charge efficiency of 50% DOD at different charging voltages



U_{2h} of 50% DOD at different charging voltages



THANK YOU



VALUES

Integrity Diligence Thinking Innovation

VISION

**Build a century-old enterprise, be a globally
leading energy service provider**



Background and Problem

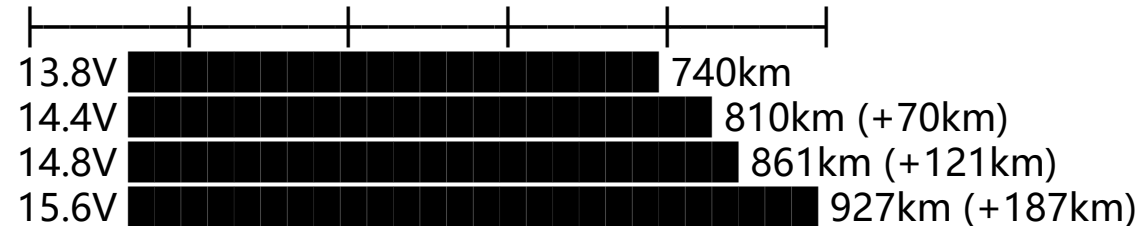


The impact of different DC-DC output voltages on energy and range losses

Voltage	13.8V	14.4V	14.8V	15.6V
Light load efficiency	79%	72%	68%	63%
power loss	4.0W	5.8W (+45%)	7.1W (+78%)	8.8W (+120%)
Daily energy loss increase	—	29Wh	50Wh	77Wh
Annual energy loss increase	—	10.5kWh	18.2kWh	28.1kWh

Annual range loss (km)

0 200 400 600 800 1000



* $P_{sw} \propto V_{out}^2$ — The output voltage of DCDC increases, and the energy loss of each switching action significantly increases;

* When the load is light (15W), the switch loss can account for 60% -70% of the total loss, so the negative impact of voltage rise on efficiency is particularly prominent in the float charging state.

* NEV reduce the DCDC output voltage from 14.8V to 13.8-14.4V, which can improve efficiency by about 7% -11% and reduce energy loss by about 50% under light load (sleep/float charging) conditions. As a 'zero cost software optimization', combined with millions of vehicle bases and annual accumulation, it has become a standard practice for energy efficiency design of electric vehicles.

* 15.6V description: The upper limit of the output voltage of the vast majority of on-board DCDC is 14.5V-15.4V. The switch loss at 15.6V is about 1.28 times that of 13.8V, which significantly increases the heating of the DCDC and affects its life, exceeding this value will trigger overvoltage protection and stop output. The calculated value of 15.6V is only used to reveal the trend of the impact of voltage rise on efficiency and does not represent the actual feasible operating point.

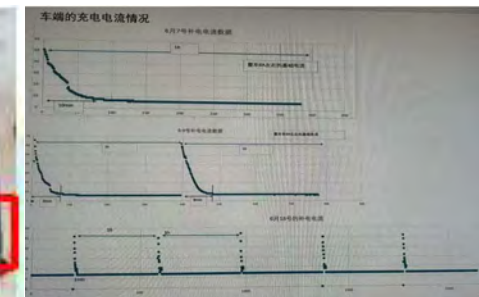
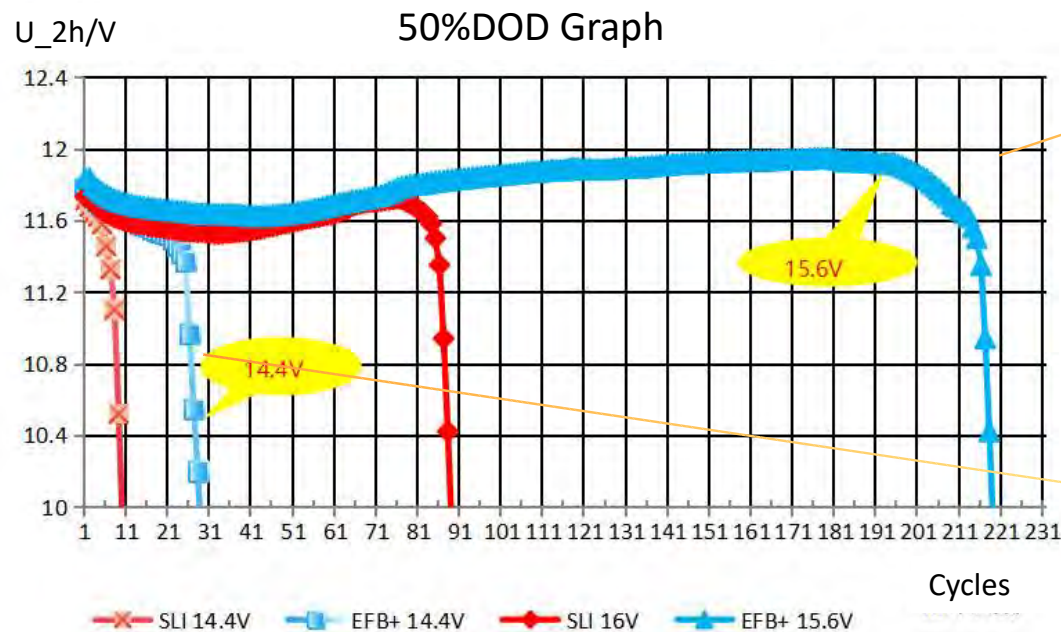


Background and Problem



Pain point: The 50% DOD cycle test for conventional SLI, EFB, and auxiliary batteries generally has a charging voltage of 15.6V/16V, with each unit in fully charged mode and a relatively high number of cycles. The main failure mode after the lifespan is the softening and detachment of the positive active mass.

However, the actual charging voltage of NEV is between 14.0-14.4V, and each unit is incomplete charging. After 10-30 cycles, the capacity rapidly decrease, and it remains in a PSoc for a long time. The failure mode is acid stratification and plate sulfation, which leads to rapid degradation of the battery performance of conventional batteries in some NEVs, and frequent triggering of the SOC threshold for Smart Charging, loss of high-voltage battery power, affecting the range and life of the high-voltage battery.





Recommended method



Recommended testing method for Flood auxiliary battery>>

Item	Flood-SLI method	EFB method	Flood-AUX recommended method
50%DOD	40 °C water bath: a. Discharge at $5 \times I_{20}$ for 2 hours. b. 16V charging for 5 hours - current limit of $5 \times I_{20}$; c. Continue cycling for a-b steps until the discharge voltage is below 10V.	40 °C water bath: a. Discharge at $5 \times I_{20}$ for 2 hours. b. 15.6V charging for 5 hours - current limit of $5 \times I_{20}$; c. Continue cycling for a-b steps until the discharge voltage is below 10V.	40 °C water bath: a. Discharge at $5 \times I_{20}$ for 2 hours. b. 14.4V charging for 5 hours - current limit of $5 \times I_{20}$; c. Continue cycling for a-b steps until the discharge voltage is below 10V.

For NEV, it is recommended to conduct a life cycle test based on the charging voltage platform of the entire vehicle to effectively evaluate the performance of the auxiliary battery in low-voltage charging cycles.

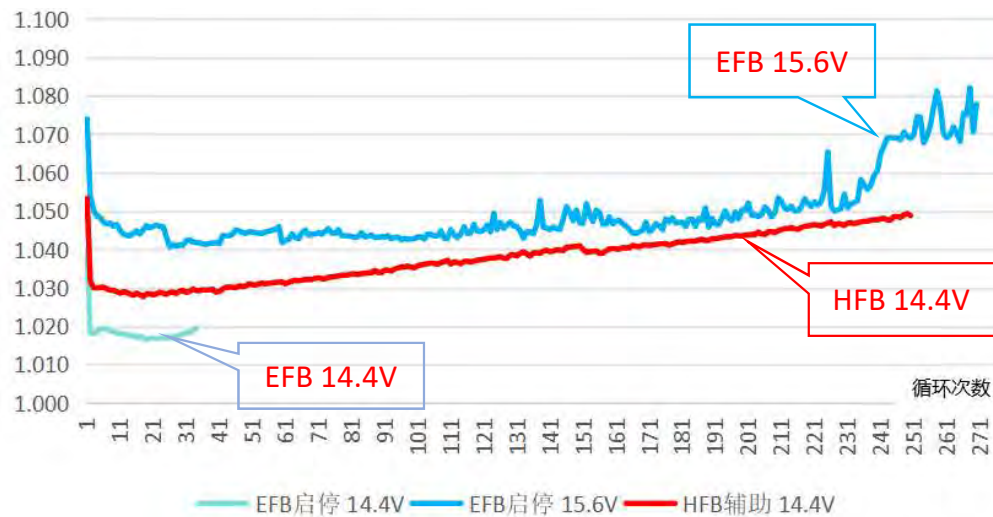


Recommended method

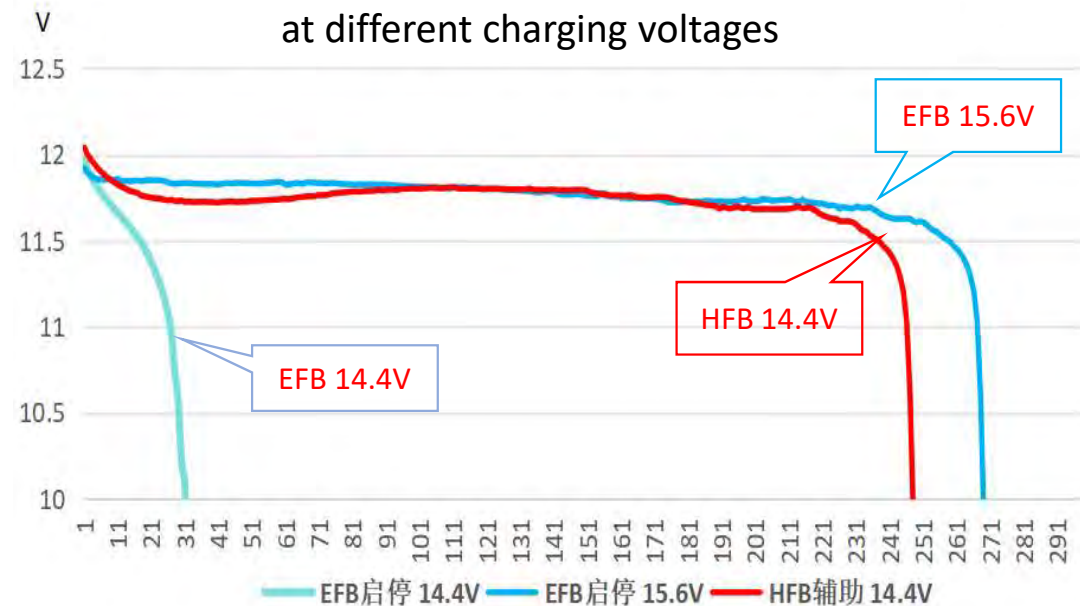


Camel recommended testing method Flood new energy auxiliary battery>>

Charge efficiency of 50% DOD
at different charging voltages



U_{2h} of 50% DOD
at different charging voltages



* The conventional EFB start stop battery has a charge efficiency of 1.04-1.06 at 15.6V, while the charge efficiency is lower than 1.02 at 14.4V. The newly developed Flood AUX battery by Camel maintains a stable charge efficiency of 1.03-1.05 at 14.4V.

* The conventional EFB start stop battery can achieve over 240 cycles at 15.6V, while the simulated NEV charging voltage platform has only about 30 cycles at 14.4V. The flood auxiliary battery (HFB) newly developed by Camel can achieve more than 240 cycles at 14.4V, which can be matched with the charging voltage platform of NEV.