Chroma Turnkey Test & Automation Solution Provider



17010 Application Note

How to Use Chroma 17010 for IEC 62660-1 Test Items

April, 2021

Chroma ATE Inc.

(1) Purpose

The IEC 62660-1 standard is an international test standard for lithium-ion secondary batteries in new energy vehicles, including battery electric vehicles (BEV) and hybrid electric vehicles (HEV). It serves to assess the performance of battery cells and its evaluation items include capacity (Ah), power density (W / I), energy density (Wh / I), storage life, and cycle life. Only battery cells that comply with the variety of indicators can be used in new energy battery pack design. This application note will focus on the relevant electrical tests introduced in the IEC 62660-1: 2010 standard, and explain how to implement the test plan using the Chroma 17010 charge and discharge test system.

(2) Equipment Requirements

IEC 62660-1 defines the accuracy of electrical equipment specifications as shown in *Table 1*. All equipment used in the testing process must meet these requirements. All models in the Chroma 17010 test solution can meet the voltage, current, and time specifications; the use of a compliant environmental chamber will ensure that the entire test meets all standard specifications.

Equipment	Test Item	Specification
	Voltage accuracy	<±0.1% F.S. Voltmeter resistance >1 MΩ/V.
Programmable charge and	Current accuracy	<±1% F.S.
discharge test equipment	Time accuracy	<±0.1% F.S.
	Temperature accuracy	<±2°C
Programmable chamber	-20°C ~ 45°C temperature control	<±2°C
Vernier caliper	Measurement accuracy	<±0.1%
Electronic balance	Measurement accuracy	<±0.1%
	Equipment Programmable charge and discharge test equipment Programmable chamber Vernier caliper Electronic balance	EquipmentTest ItemProgrammable charge and discharge test equipmentVoltage accuracyProgrammable charge and discharge test equipmentCurrent accuracyTime accuracyTime accuracyProgrammable chamber-20°C ~ 45°C temperature controlVernier caliperMeasurement accuracyElectronic balanceMeasurement accuracy

(3) Electrical Test Items

- 1. General charge conditions (refer to section 7.1 of IEC 62660-1)
- 1.1 Function: Unless otherwise specified in the standard, the battery cells should be charged as follows before electrical testing.
- 1.2 Charging procedure: Temperature adjustment (continuous >12hr, or >1hr with battery temperature change <1°C) → Full discharge with specified current (BEV uses 1/3C constant current, HEV uses 1C constant current) → Full charge (following the charging method specified by the manufacturer).</p>

Tip. Use Chroma's Battery Lab Expert (Battery LEx) to edit the charging procedure:



Figure 1 – Set DUT parameters in Battery LEx

Sub-re Proje	cipe / General cha act PJ1	arge condit	ions_8E	V		Descrip	ption 📧	C626	90_BEV					ŀ						
1000				Setting									Ci	flo-h					-	
step	Mode	18A0	VIVO	P(W)	R(0)	T(*C)	Range	Of=0	NAN.	win	PWI1	0(65)	FISABI	0(%)	THCC)	(0)	Time(s)	Goto	MISC	Time(5)
0.01.0	Chamber Cystrol	CC Dise	charge			1/30	-	1	C-ra	te set	ting c	urren	t con	dition			-			00 00 00 00 01 00
2	Common Rest	-			-	42	-		0.00			arren		ancioni	_	1.1	D.V.			0.V.0
3	CC Discharge	300	-		-	25	Auto	13		3	-					1.2				00.00.00.00.10
4	CC-CV Charge	-1/5C	4.2			25	Aute	10	1/20C		·					1.1				00.00.00.00.10
- 9	Common Reat	-		1.4	- 54	25	1	13	-		-	1.4-3	2(4)	243		111	D. V.			0. V.
	+																			

Figure 2 – General charging C-rate method to set current

- 2. Capacity test (refer to section 7.2 of IEC 62660-1)
 - 2.1 Test procedure: General charge (refer to Section 1.1) → Temperature adjustment (0°C/25°C/45°C)
 → Capacity test (Table 2 shows the current).
 - 2.2 Verification items: Record the capacity changes at different temperatures.

The capacity test is often used in the initial test stage to define the reference capacity of the battery cell under test as a reference datum for the subsequent current size and cut-off conditions. In order to facilitate the cut-off condition setup, the Q% of the capacity test step can be set to [S] to denote the reference capacity¹.

Tip. Use Chroma's Battery LEx to edit the capacity testing procedure:

Sub-re	cipe / Capacity m	easureme	nt_BEV	¥.		Denne	in F	08286	0 BEV					1					
evole	er Fai					Descrip	non E	:00200	U_DEV				C 1						
Step.				Second			102977-014	where we			200	0.04	C.U	1-01					Mag
	Mode	R(A)	A(X)	P(W)	R(0)	T(°C)	Range	Qt=0	- RAI	W(V)	P(W)	Q(Ah)	E(Wh)	Q(%)	LIGC)	{0}	Time(s)	Gold	and the second
1.1	Chamber Control	-	-	-		25	-	N.	-		-	-	-						
- 2	Conmon Rast	- ÷	÷			-25	1. i÷		-		-	-	-	-		5.2	D.V.		1.750
3	CIC Discharge	1/3C	-	-	-	25	Auto	DD	-	3						1.5			100
14	CC-CV Charge	1/5C	4.2	14		25	Auto	0	:1/29C	-						1.2.3	23 22		
5	Chartber Control	-	-		-	25	-	0	-	1 m		1.000			S	et Q	% refere	nce	
8	DC Discharge	1/3C				25	Auto	4	-	3	-			5	10	anac	ity		
													1			apue	ny		



Note 1. The [S] setting can cover SR, MR as the reference capacity; if you repetitively set [S], it will take the refresh step as the reference.

	Discharge C	urrent (A)
Temperature	BEV Application	HEV Application
O°C		
25°C	1/3 C	1 C
45°C		

- 3. SOC adjustment (refer to section 7.3 of IEC 62660-1)
 - 3.1 Test procedure: General charge (refer to Section 1.1) \rightarrow Rest \rightarrow SOC adjustment.

Tip. Use Chroma's Battery LEx to edit the SOC adjustment procedure:

Sub-re	cipe / Adjust SOC	_BEV_254	¢	1		Descrip	diana 🗖	0828	O REV					10					
rige	Ci Pai		-	Setting		Descrip		.00200	N_BEV				Cu	t-off					P
Step	Mode	I(A)	V00	P(W)	R(0)	T(*C)	Range	Qt=0	1(A)	W(V)	P(W)	Q(Ah)	E(svb)	0(%)	T1(*C)	[0]	Time(s)	Goto	MIS
1	Chamber Control	-	-	-	-	25	-	N.	-	-	-						-	-	1.00
2	Common Rest	-	-	1.4	-	25	-		-		-		141	1441		111	D.V.	_	175
3	CC Descharge	1/30	-	1.54	14	25	Auto	D	-	3	-				1	1.1			110
4	CC-CV Charge	1/50	4.2	-		25	Auto	TO	1/20C							1.1		-	15
5	Common Rest	-	-	-		25	-	1	-				1 - 1 T		1	1.1	D.V.		10
-0	CC Discharge	1/3C	-	-	-	-25	Auto	1	-					20		1.2			110
7	Convoin Rest	-	-	-	-	25	-	1					-		-	4.2	D.V.		1.000
					F	Reset t apaci	he cu ty to z	mul zero	ative at the	5		Ci 20	ut off 0% of	when refere	cumu ence c	ulati apa	ve capac city	ity>	
						peginr	ning	-	-	-		R	eferer apacit	ice ca y of S	pacity durin	/ = 9 ig th	Set the st le capaci	ep ty te:	st



- 4. Power test (refer to section 7.4 of IEC 62660-1)
 - 4.1 Test procedure:
 - [Step A] Mass measurement → Dimension measurement.
 - [Step B] SOC adjustment (20%/50%/80%) (refer to Section 3.1) → Temperature adjustment (45°C/25°C/0°C/-20°C) → Current pulse discharge (*Table 3* shows the current).
 - 4.2 Verification items: Record the power output capacity under different SOC& temperatures, and calculate the following parameters:
 - Power $P_d = U_d \times I_{dmax}$
 - P_{d} : power (W) U_{d} : measured voltage (V) at the end of the 10s pulse of I_{dmax} discharge I_{dmax} : maximum discharge current (A) as specified by the manufacturer
 - Power density per unit mass $\rho_{pd} = \frac{P_d}{m}$
 - ρ_{pd} : power density (W / kg) P_d : power (W)
 - *r*d. power (w)
 - m: mass of cell (kg)
 - Power density per unit volume $\rho_{\text{pvlm}} = \frac{P_{\text{d}}}{V}$
 - ho_{pvlm} : volumetric power density (W / I)
 - P_d: power (W)
 - V: volume of cell (I)
 - Regenerative power $P_c = U_c \times I_{cmax}$
 - *P*_c: regenerative power (W)
 - U_c : measured voltage (V) at the end of the 10s pulse of I_{cmax} charge I_{cmax} : maximum charge current (A) as specified by the manufacturer If P_c is an estimated value, it must be stated.
 - Regenerative power density per unit mass $\rho_{pc} = \frac{P_c}{m}$

 ρ_{pc} : regenerative power density (W / kg) P_c : regenerative power (W) *m*: mass of cell (kg)

Regenerative power density per unit volume ρ_{pvlmc} = P_c/V
 ρ_{pvlmc}: regenerative volumetric power density (W / I)
 P_c: regenerative power (W)
 V: volume of cell (I)

	Table 3	 – Charge and L 	Jischarge Curre	nt	
Application		Charge ar	nd Discharge C	urrent (A)	
BEV	1/3 <i>I</i> t	I _{max}			
HEV	1/3 <i>I</i> t	1 <i>I</i> t	5 <i>I</i> t	10 <i>I</i> t	I _{max}

Table 3 – Charge and Discharge Current

Tip. Use Chroma's Battery LEx to edit the power testing procedure:

Proj	Ref. Pat					Descrip	Xion E	C6296	0_8EV		_	_	_										
-	it.			Setting									, Qu	iof.								lensing.	
reads	Mode	1040	W90	PING	8(0)	T(*0)	Range	(Det)	-896		POVI	(Q(At))	E(WH)	-91%7	115/201	101	Time(e)	Gate	Mar.	Time(6)	-8890	6VI(V)	(.40
10	Charter Control		-	-		- 28	-	12	-	+	-	-			-		-			00 10 00 59 00			
2	Red	-	-	-	-	34	-	101	-		-	-	-	-			001258.00.00			00.00.00.01.00			
3	III Discharge	1000	-	-		22	4400	D	-		-						-00.00 88 18.00			00.00.00.00.10			
4	Red	-	-	-	-	29	-	0	-		-	-	-	-			00000,10.00.00			00.10.00.00.01.00			
1	Rest	+	-	-	-	.25	+.	10	-		-	-	-	-	-427		00.00 12 00.00			00 10 00 00 01 00			
5	ICC Charget	1100	-	-	-	28	-AAdm	0	-		-				100		30.02 89 10.00			00.00.00.00.10			
7	Red	-	-	-		- 25	-	101			-	-	-	-	- V.C.		00.08 12 80.00			68 68 50 51 68			
1	And		-	-	1.4	28	-				-	1.4	-		- 127	1.1	00.00.10.00.00			00.00.00.01.00			
+	CCDischarge	100	-	121	-	28	3400		-		-						00.08 88 10.00			18 18 80.00 18			
10.	Bast	-	-	-	-	- 28	-		-		-		-				00.02 13 30.00			68-58-80-91.08			
11	Real	-	-	-	-	25		0	_		-	-			+27		30.0111.00.00			00.00.00.01.00			
12	CC Charge	. 36		-		28	Auto	101	-								00.00.00.10.00			00 00 00 00 10			
10	Real	-	- 1	-	1.1	28		101	-		- 1	-	1.4	-			00.00 11.00.00			10 10 00 00 01 00			
14	(bid)	-	-	-		28	-	101			-	-			-17		30/08/18 81:00			48 88 60.01 08			
12	CC Discharge	30	-		-	28	Auto	01									00/00/00 10 10:00			00 00 00 00 10			
10	Reil	-	-	-		- 25	-	101	-		-	-	-				00/08/18/00:00			00.00.00.01.08			
17	Reat	-	-	1 m 1	-	28	-	181			-	1.00	-	-	-07		00.00 13:00.00			80.10.03.00.01			
10.1	CC Charge	32	-	-	-	25	Auto	01	-		-						10.0839.10.00			08.00.00.00.10			
19	Red		-	-		25	-	181				-		- 10-			00.02 10.50 00			00 10 00 00 01 00			
20	Rest		-	-	-	- 28		0	-		-	-		-	427		00-00-10-01.00.			80.10.08.03.03			
21	CC Decharge	- SC	-	1	-	- 25	-4400	0	1.		-			111	1.121		00 00 00 00 10 00			00.00.00.00.10			
22	Said	-	-		-	28	-	101	_		-	-					00.00.10.00.00			00-00-00-01-00			
23	And		-	-	-	21	-	0			-	-			27		00.00118.00.00			80 10:09 89 89			
24	CC Charge	10	-	+		- 26	4481	181									00.08.88 10.00			60.02.00.00.18			
2	Real	-		-	-	28					-	-	-	-			00.08118.00.00			90 10 00 00 01 00			
26	Sect		-	-		- 26	-	13	-		-	-	-		- 427		00100 12 81.00			80 10:03 20 20 80			
11	EC Dacharge	100	- 1	-	1.0	25	-A480	161	1.								00-08-88-11-00		P(A)-	00 00 00 00 10			
28	10-61	-	-		1	28	-	101	-		-		-				00/08/18 00:00			90 10:08 86:07			1
29	Real	-	-	-	-	28	-	101			-	-	-	-	-27		30.08 13 30.00			00 53 50 01 05			
50	SC Chierger	100	-	-		28	.4x000	0	-		-						00.06 22 11.00		Pod	08.09.09.00.18			
24	liest	-	-	-		28	-	181	-					-			10/08 12 81 00			10 10 10 10 10			-

Figure 5 – Edit sub-recipe power test in Battery LEx

	Plan Power Te	est		Descripti	00			Model	NMC 1	8650			Sava
414	Atain Day	1917)	Cut-off	1		
640	Main Rec	ape	1-max	V-max	V-min	P-max	(+) Q-max	(-) Q-mia	n Q-d	hg	Q-dchg	(+) E-	max
ET	Power Test_MR					-							
-				1	1	1	1	1				1	4
Main F	Recipe Power Te	est MR		Descripti	on								Save
Main Re	cipe Protection	Con Channel		account of a				_					
		10.00					(Q-			Cut-off		
No.	Sub-rec	tipe	Lines	Manne	11 min	R mar	(a) () mit	Tan	in (5)	ther.	O doba	and the	2275
			Pennan	C Section	36-uuu	P-man	((4) G-ma	el (e) dem	in 94	ng	-deniñ	1.10	C .
1	Adust SUC_BEV_25	50		Lising	Dattan	I Evin	combino	detruct	ura th		vieush		Y
• 2	Power test_BEV_25	¢		Using	Joaner	LEXS	combine	a struct	ure, in	e pre	viousiy	K	
3	Power test_BEV_45	3C		🙏 edite	d sub-re	ecipes	are used	etticien	tly to to	orm t	the		
				and the second second second									\circ
	Power test_BEV_00			Y requi	red pov	ver test	, and the	power	value	will b	e recoi	rded	9
5	Power test_BEV_00 Power test_BEV2	00		requi	red pov	ver test	, and the	power	value v	vill b	e recoi	rded	9
5	Power test_BEV_00 Power test_BEV_2	0C		in the	red pov e step re	ver test port.	, and the	power	value v	vill b	e recoi	rded	
s Sub-r	Power test_BEV_00 Power test_BEV2	oc est_BEV_2	25C	Description	red pov step re on IEC63	ver test port. 2660_BE	t, and the	power	value v	vill b	e recoi	rded	Save
Sub-r	Power test_BEV_20 Power test_BEV_20 recipe Power te	est_BEV_	25C Setti	Description	red pov e step re an 1EC63	ver test port. 2660_BE	t, and the	power	value v	vill b	e recor	rded	Save
Sub-r	Power test_BEV_00 Power test_BEV2	est_BEV_	25C Setti V(V) F	Description (W) R(C)	red pov e step re an 1EC63	ver test port. 2660_BE Range	t, and the	power	value v	vill b	e recoi	off Q(%)	Save
Sub-r	Power test_BEV_00 Power test_BEV2 recipe Power te Mode	est_BEV_	25C Setti V(V) F	Description	red pov e step re an 1EC6. 0 T(*C) 25	ver test port. 2660_BE Range	v Indithe	power	value v	o(Ah)	e recoi	-off Q(%)	5ave
Sub-r Sub-r	Power test_BEV_00 Power test_BEV2 recipe Power te Mode Chamber Control Rest	ICE	" 25C V(V) F -	Description	red pov e step re an 1EC62 0 T(*C) 25 25	ver test port. 2660_BE Range -	t, and the	yower	P(W)	0(An) -	Cut E(Wh)	-off Q(%)	5ave
Sub-r Sub-r	Power test_BEV_00 Power test_BEV2 recipe Power te Mode Chamber Control Rest CC Discharge	IC	25C Setti V(V) F	Description	red pov e step re an 1EC6 0 T(*C) 28 25 25 25	Range	t, and the	vw -	P(W)	0(An) -	Cur E(Wh) -	rded -off Q(%)	5ave
5 5 5 5 5 5 5 6 9 1 2 3 4	Power test_BEV_00 Power test_BEV2 recipe Power test Mode Chamber Control Rest CC Discharge Rest	ICA	25C Setti V(V) F 	Description	an IEC6.	Range Auto	t, and the	yower	P(W) - - -	0(An) - -	Cur E(Wh) -	rded	5ere 71(rC)
5 5 5 5 5 5 5 4 5	Power test_BEV_00 Power test_BEV2 recipe Power test Mode Chamber Control Rest CC Discharge Rest Rest	ICA	25C Setti V(V) F 	Description (W) R(C 	an IEC6. T(°C) T(°C) S S S S S S S S S S S S S	Range Auto	t, and the	yower	P(W) 	Q(An) - - -	Cur E(Wh) 	-otr -otr -(%) 	Save 71(°C) -
Sub-r Sub-r Shep 1 2 3 4 5 8	Power test_BEV_00 Power test_BEV2 recipe Power te Mode Chamber Control Rest CC Orscharge Hest Rest CC Charge	ICA ICA ICA ICA ICA ICA ICA ICA ICA ICA	25C Setti V(V) F 	Description (W) R(C 	an IEC6. T(*C) T(*C) 25 25 25 25 25 25 25 25 25 25	Range Auto Auto	t, and the	vvv	P(W) 	0(An) - - -	Cut E(Wn) 	-off Q(%) 	Save 71(°C) -
Sub-r Sbep 1 2 3 4 5 8 7	Power test_BEV_00 Power test_BEV2 recipe Power te Mode Chamber Control Rest CC Oscharge Rest CC Charge Rest CC Charge Rest	I(A) I(A)	25C Setti V(V) F 	Description	an IEC6 T(°C) T(°C) S S S S S S S S S S S S S	Range Auto Auto - Auto -	t, and the	yower	P(W) 	Q(An)	Cul E(Wh) 	-off Q(%) 	Save 71(°C) - v27

Figure 6 – Compose multi-level power test at 45°C/25°C/0°C/-20°C in Battery LEx

- 5. Energy test (refer to section 7.5 of IEC 62660-1)
- 5.1 Test procedure:

[Step A] Battery mass measurement \rightarrow Battery volume measurement. [Step B] Capacity test (refer to Section 2.1).

- 5.2 Verification items: Record the average voltage, energy density per unit mass, and energy density per unit volume. Use the channel report to calculate the average voltage and battery energy. Next, calculate the energy density per unit mass and the energy density per unit volume.
 - Average voltage $U_{avr} = \frac{U_1 + U_2 + \dots + U_n}{n}$

In the capacity test, obtain the average voltage value during discharge by integrating the discharge voltage over time and dividing by the discharge duration. Use the following method to easily calculate the average voltage: note the discharge voltages $U_1, U_2, ..., U_n$ every 5s from the start of the discharge, voltages that cut off the end of discharge voltage in less than 5s are discarded.

 Energy density per unit mass W_{ed} = C_d × U_{avr} W_{ed}: electric energy of cell (Wh)

 C_d : discharge capacity (Ah) at 1/3 l_t (A) for BEV or 1 l_t (A) for HEV

 U_{avr} : average voltage during discharging (V)

$$o_{\rm ed} = \frac{W_{\rm ed}}{\dots}$$

 p_{ed} : mass energy density (Wh/kg) W_{ed} : electric energy of cell (Wh) m: mass of cell (kg)

Energy density per unit volume ρ_{pvlmd} = ^{Wed}/_V
 ρ_{evlmd}: volumetric energy density (Wh / I)
 W_{ed}: electric energy of cell (Wh)
 V: volume of cell (I)

6. Storage test (refer to section 7.6 of IEC 62660-1)

6.1 Charge retention test (refer to paragraph 7.6.1 of IEC 62660-1)

- 6.1.1 Test procedure: SOC adjustment (50%) (refer to Section 3.1) → Capacity test C_b → SOC adjustment (50%) → Temperature adjustment (45°C ±2°C) → Rest 28 days → Capacity test C_r.
- 6.1.2 Verification items: Calculate the charge retention rate.
 - Charge retention ratio $R = \frac{Cr}{Cb} \times 100\%$
 - R: charge retention ratio (%)
 - Cr: capacity of cell after storage (Ah)

 C_b : capacity of cell before storage (Ah)

Tip. Use Chroma's Battery LEx to edit the storage testing procedure:

	Main R	ecipe Storage t	est_MR		De	scription										Save	
Μ	ain Reci	ipe Protection															
	Nia	Cub reai												Cut-off			
	INU.	Sub-reci	pe	I-ma	ax V	-max	V-min	P-ma	x	(+) Q-max	(-) Q-m	nin (Q-chg	Q-dchg	(+) E	-max	(-)
	1	Capacity measurement	nt_BEV														*
Þ	2	Adjust SOC 50%_BE	V_25C														
	3	Capacity measurement	nt_BEV														Ξ
	4	Adjust SOC 50%_BE	V_25C														
	5	Storage_45C															
	6	Capacity measureme	nt_ 28day_B														-
-								_								Þ	
	Sub-re	ecipe Adjust SC	DC 50%_	BEV_25	C De	scription	IEC62	2660_BE	V							Save	
Γ	Stop			1	Cotting										· · · · · · · · · · · · · · · · · · ·		
	Step			· · · · ·	Seung									Cu	t-off		
		Mode	I(A)	V(V)	P(W)	R(Ω)	T(°C)	Range	Qt=0	I(A)	V(V)	P(W)	Q(Ah)	Cu E(Wh)	t-off Q(%)	T1(°C)	{
۱×	1	Mode Chamber Control	I(A) 	V(V) 	P(W)	R(Ω)	T(°C) 25	Range 	Qt=0	I(A) 	V(V) 	P(W) 	Q(Ah) 	Cu E(Wh)	t-off Q(%)	T1(°C) 	}
•	1	Mode Chamber Control Common Rest	I(A) 	V(V) 	P(W) 	R(Ω) 	T(°C) 25 25	Range 	Qt=0 ☑	I(A) 	V(V) 	P(W) 	Q(Ah) 	Cu E(Wh) 	t-off Q(%) 	T1(°C) 	}
•	1 2 3	Mode Chamber Control Common Rest CC Discharge	I(A) :1/3C	V(V) 	P(W) 	R(Ω) 	T(°C) 25 25 25	Range Auto	Qt=0	I(A) 	V(V) 3	P(W) 	Q(Ah) 	Cu E(Wh) 	Q(%)	T1(°C) 	- III
•	1 2 3 4	Mode Chamber Control Common Rest CC Discharge CC-CV Charge	I(A) :1/3C :1/5C	V(V) 4.2	P(W) 	R(Ω) 	T(°C) 25 25 25 25 25	Range Auto Auto	Qt=0	I(A) :1/20C	V(V) 3 	P(W) 	Q(Ah) 	Cu E(Wh) 	L-off Q(%) 	T1(°C)) {
• 	1 2 3 4 5	Mode Chamber Control Common Rest CC Discharge CC-CV Charge Common Rest	I(A) :1/3C :1/5C 	V(V) 4.2 	P(W) 	R(Ω) 	T(°C) 25 25 25 25 25 25 25	Range Auto Auto 	Qt=0	I(A) :1/20C 	V(V) 3 	P(W) 	Q(Ah) 	Cu' E(Wh) 	t-off Q(%) 	T1(°C)	• • • • • • • • • • • • • • • • • • •
► 	1 2 3 4 5 6	Mode Chamber Control Common Rest CC Discharge CC-CV Charge Common Rest CC Discharge	I(A) :1/3C :1/5C :1/3C	V(V) 4.2 	P(W)	R(Ω) 	T(°C) 25 25 25 25 25 25 25 25 25	Range Auto Auto Auto	Qt=0	I(A) :1/20C 	V(V) 3 	P(W) 	Q(Ah) 	Cut E(Wh) 	t-off Q(%) 50	T1(°C)	- III

Figure 7 – Use sub-recipe to compose charge retention test in Battery LEx

Big Node KA V/V P/W/V R(D) T(C) Range Otio XA V/V P/W/V Q(N) T(C) Range Otio XA V/V P/W/V Q(N) T(C) Q(N) T(C) Q(N) T(C) Q(N) Q(N) T(C) Q(N) Q(N) T(C) Q(N) Q(N) Q(N) T(C) Q(N) Q(N) Q(N) Q(N) Q(N) Q(N) Q(N) Q(N) Q(N)		tep t t z t	Mode				the second s									- C1	6.0W						
1 Destar Central - - - 23 -		t 1 2 1			a i i i	W90	PON	80	T(*C)	Ranne	Ctri0	3543	10.900	2000	COLANIC	Erwhi	0(%)	THON	505	Time(s)	Getti	Misc	Timetoo
2 Commit Nest - - - 25 - <t< td=""><td></td><td>2 4</td><td>Charteer Corb</td><td></td><td></td><td></td><td></td><td>-</td><td>25</td><td></td><td>1</td><td></td><td>-</td><td></td><td>Contract.</td><td></td><td>145.04</td><td></td><td>1.65</td><td>College)</td><td></td><td></td><td>00.00.00.01</td></t<>		2 4	Charteer Corb					-	25		1		-		Contract.		145.04		1.65	College)			00.00.00.01
3 GC Decharge 1/3C 25 Adia 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 - 3 </td <td></td> <td>-</td> <td>Common Hest</td> <td></td> <td></td> <td>-</td> <td>-</td> <td>-</td> <td>25</td> <td>-</td> <td>181</td> <td></td> <td></td> <td>-</td> <td></td> <td>-</td> <td>-</td> <td></td> <td>1.1.1</td> <td>0.V.</td> <td></td> <td>1</td> <td>0.V</td>		-	Common Hest			-	-	-	25	-	181			-		-	-		1.1.1	0.V.		1	0.V
4 05-CV Charge 15C 4.2 - 25 Adls 1000 -		3 (4	oc Dechwge	-10	ic i	-	-	-	25	Auto	0	-	2	1.000					16.3			1.00	00.00.00.00
S Develop Center -		4 1	CC-CV Charge	- 1/	c	42		-	25	Auto	101	1/20C	-	-					1.1		_		00.02.00.08
# OC Discharge 10C - - 28 Aue 27 - 3 - * Misc-Formula	a	f. [1	Charleer Contr	ut		-			-25	1.00		-		-	1.00	-		-					00.00.00.01
Mise-Formula Set Variable End Condition Set Variable		1	00 Decharge	-17	0	-		-	25	Auto	1	-	3	-	_					1		700	00.00.00.00
Set Variable				Set Varia	ble E	nd Con	dition																
# VOLT LOOP1 LOOP1 Measured data Operators Condition Cursit 7 8 9 # Time(sec) * * Cursit 6 6 # Time(sec) * * Cursit 6 6 # * * * * Cursit 1 2 3 # * * * * * VARXX 0 *				Set Vari	sble			•							CT (48	Gtotal		P(W)				
Measured data Operators Condition CURR 7 8 9 # Time(sec) == =				12											VO	σ	LOOP	t	LOOP2				
Dim -				10+	Neas	ured da (sec)	vta	Opera	tors C	ondition					CUR	RR	7	8 9	•				
2114 - UNRXX 0 .					- 20	en :										(h)	4	5 0					
WRXX 0															EUV	m)	+	2. 1					
International Account						÷									- VAR	xxe	0						
Set Variable at End of step ms GVAR ()				Set Van	able at	End	of step	•	_	ms					GV	4A)				
Update												aptate	Dele	tte .									
Mode Variable Expression Trigger Ti				10	de		Variable					1	Expressio	n				Tri	oper Tin	ne			
Est Variable GVAR G(Ab) P End of sh				Set Vari	1010	-	GVAR:	QIAh	-									Er	nd of site	P			

Figure 8 – Use variable functions to record discharge capacity in Battery LEx

Sub	recipe / Capacity n	easureme	re zed	V_BEV			-															
Pr	oject PJt.					Descri	ption 🖷	C626	60_BEV	5.												
1120				Betting									.0	fol					1.53			anply
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1	Contract Next	11.0	-	-	-	苔	1.44	10		1.1	-		-	-			0. V			0. V.		
1	CC Decherge	100	-	-		25	Auto	0		- 7	1.4				-					00.00.00.00.10		
	CC-CV Charge	162	4.2	-	-	- 25	Ave	0	1/202	-	-	-	_		-	1.1		_	1.00	68 08 38 58 10		
	Charibar Control	-	-		-	20		19	-	-	-	-	-		-		-	-		00-00-00-01-00		
	CC Discharge	(00		-	-	20	Auto	N.		- 2	-	-	_		-		THE R. LANSING MICH.	-	-	80 26 88 88.19		
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		1.1				_				-							and a second					
		G	Mode let Variable		VARUE N	QUARS	GVAR	3		Equ	uaion				Th Er	ager Tr d of ah	ne -					
		10.0			Use and	varia reco	ables ord th	to ne r	calcu esult	ulate s in t	the o	charg eport	je ret	entio	on ra	te,						

Figure 9 – Calculate the charge retention ratio (%)

- 6.2 Storage life test (refer to paragraph 7.6.2 of IEC 62660-1)
- 6.2.1 Test procedure:
 - [Step A] Battery mass measurement → Battery volume measurement.
 - [Step B] Capacity test (refer to Section 2.1) → Power test (refer to Section 4.1) → SOC adjustment (BEV to 100%, HEV to 50%) (refer to Section 3.1) → Temperature adjustment (45°C ±2°C) → Rest 42 days → Capacity test →→ Repeat [Step B] three times.
- 6.2.2 Verification items: Report the capacity, power density, regenerative power density, and retained capacity.

				40 W.84	criptori	Cycle	ine test_	DLV	ILC:	model		10 10001		_	28	ave
114	Hain Day												Cycle			
reo.	Main reed	cipe	+) E-max	(+) E-m	nin 🗌	E-chg	E-dchg		TC	4	Count	N. La		Time(s	s)	
1	Storage life test								F	-	3					
	1 x:		0						-		10	100			0	
Main C	locion Storago	life tect		The	storac	e life t	est is c	om	oleted	after	three r	uns ar	nd the	ġ.	- Y	
MGR1 1	tecipe Storage	me test	-	Cana	citya	nd nou	ver of t	hat	bree c	torag	a life to	arte ca	n he a	uari	ad d	N.
lain Ree	pe Protection			hulth	icity a		ver or u	net	nices	torag	emeu	ests ca	n be q	uen	euv	
- 53	10		0	Dyu	ie stel	repo	rt.	_	-0		_	_			-	
No.	Sub-rec	cipe	1-max	V-	max	V-min	P-ma	х	(*) Q-mai	(-)(2-min	Q-chg	Q-do	hg.	(+) E-max	
1	Capacity measurem	ent BEV	1						101022-0022			101104				
2	Power test BEV 25	50	I I r													
	A ALL COL CON	BEV/ 250		Using) the c	ombin	ied stru	uctu	re of B	attery	LEx, t	ne edit	ed sub)-		
3	ADUBT SOL 100% B	DE Y LON														
3	Adjust Temperature	or v_roc		recip	es can	be us	ed effic	cient	tly to f	orm tl	he she	lf life te	est.			+
3 4 5	Adjust Temperature Cabacity measurem	ent		recip	es can	be us	ed effic	cient	tly to f	orm tl	he shel	lf life te	est.			
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3 4 5	Adjust Temperature Capacity measurem	ent		recip	es can	be us	ed effic	ient	tly to f	orm tl	he she	lf life te	est.			
3 4 5	Adjust Temperature Capacity measurem	ent	250	recip	es can	be us	ed effic	cient	tly to f	orm ti	he shel	lf life te	est.			
3 4 5 Sub-r	Adjust Soc 100%	ent est_BEV_	25C	recip: Des	es can	be us	ed effic	v	tly to f	orm tl	he shel	lf life te	est.		5	
3 4 5 Sub-r	Adjust Soc 100%	ent	25C	recip: Des	es can	be us	ed effic	v	tly to f	orm tl	he shel	f life te	est.		54	
3 4 5 Sub-t	Adjust Soc tobsel Adjust Temperature Capacity measurem	ent est_BEV_ I(A)	25C Se V(V)	Des P(W)	es can cription R(Ω)	be use IEC62 T("C)	ed effic	v v	P(W)	Q(Ah)	Le shel Cu E(Wh)	f life te t-off Q(%)	T1("C)	{O}	Sa	* *
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3 4 5 Sub-f Step 1 2 3	Adjust SOC 100%_1 Adjust Temperature Capacity measurem eclipe Power to Mode Chamber Control Rest CC Discharge	est_BEV_ 1(A) 	25C Se V(V) 	P(W)	es can cription R(Ω) -	IEC62 T(°C) 25 25 25	ed effic		P(W)	Q(Ah)	Cu E(Wh)	f life te	T1("C)	{0}	Sa Time(s — 00 12 00 01 00 00 01	* ave
3 4 5 Sub-t Step 1 2 3 4	Adjust SOC 100%_1 Adjust Temperature Capacity measurem eclipe Power to Mode Chamber Control Rest CC Discharge Rest	est_BEV_ 1(A) 	25C 25C 9(V) - - -	P(W) = = =	es can cription R(Ω) 	1EC62 T(*C) 25 25 25 25	ed effic		P(W) 	0(Ah) - -	Cu E(Wh) -	f life te	T1("C)	{O}	Se Time(s — 00.12.00.01 00.00.011 00.00.10.01	* 2VB) 0.00 0.00
3 4 5 Sub-t Step 1 2 3 4 5	Adjust SOC 100%_1 Adjust Temperature Capacity measurem Bode Chamber Control Rest CC Discharge Rest Rest	1(A)	25C Se V(V) 	P(W) P(W) - - - -	es can cription R(Ω) = = =	1EC62	Range		P(W)	Q(Ah) - - -	Cu E(Wh) - -	f life te t-off Q(%) 	T1("C) 	{O}	54 Time(s 00 12 00 01 00 00 00 11 00 00 10 01 00 00 10 01	* 3 3 0 00 0 00 0 00 0 00
3 4 5 Sub-t Step 1 2 3 4 5 6	Adjust SOC 100%_1 Adjust Temperature Capacity measurem Capacity measurem Mode Chamber Control Rest CC Discharge Rest Rest CC Charge	1(A)	25C Se V(V) 	P(W)	es can cription R(Ω) 	IEC62 T(°C) 25 25 25 25 25 25 25 25 25 25 25 25 25	Range		P(W) 	Q(Ah) - -	Cu E(Wh) - -	f life te	T1("C) 	{O}	Se Time(s 00 12 00 01 00 00 00 11 00 00 10 01 00 00 10 01 00 00 10 01	* 2V8 0 00 0 00 0 00 0 00 0 00
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Tip. Use Chroma's Battery LEx to edit the storage life testing procedure:

Figure 10 – Set the Battery LEx storage life test

- 7. Cycle life test (refer to section 7.7 of IEC 62660-1)
- 7.1 BEV cycle life test (refer to paragraph 7.7.1 of IEC 62660-1)
- 7.1.1 Test procedure:
 - [Step A] Capacity test (refer to Section 2.1) → Dynamic discharge capacity test C_D (Table 4 shows dynamic discharge profile A) → Power test at (25°C/45°C), 50% SOC (refer to Section 4.1).
 - [Step B] Temperature adjustment (45°C ±2°C) → General charge (refer to Section 1.1) → Discharge continuously according to the dynamic discharge profile A in Table 4 (until dynamic discharge capacity reaches C_D DOD 50%) → Single discharge according to the dynamic discharge profile B in Table 5 → Discharge continuously according to the dynamic discharge profile A in Table 4 (until dynamic discharge profile A in Table 5 → Discharge continuously according to the dynamic discharge profile A in Table 4 (until dynamic discharge capacity reaches C_D DOD 80%) → Continuously repeat [Step B] for 28 days, then a single repeat of [Step A] (battery performance check) → → Continuous cycling until the test cut-off condition.

Test cut-off conditions

The cycle life test shall be terminated when either of the following conditions is satisfied. Otherwise, repeat the test procedure.

Condition A – The test procedure is repeated 6 times.

Condition B – When any performance decreased to less than 80% of the initial value.

Condition C – During the test, the battery reached the upper temperature limit defined by the manufacturer.

7.1.2 Verification items: Battery life evaluation based on the overall charge and discharge capacity (throughput).

Step	Duration (s)	Ratio to test power (%)	Charge/discharge
1	16	0	
2	28	12.5	Discharge
3	12	25	Discharge
4	8	-12.5	Charge
5	16	0	
6	24	12.5	Discharge
7	12	25	Discharge
8	8	-12.5	Charge
9	16	0	
10	24	12.5	Discharge
11	12	25	Discharge
12	8	-12.5	Charge
13	16	0	
14	36	12.5	Discharge
15	8	100	Discharge
16	24	62.5	Discharge
17	8	-25	Charge
18	32	25	Discharge
19	8	-50	Charge
20	44	0	

Table 4 – Dynamic Discharge Profile A for BEV Cycle Test

Table 5 – Dynamic Discharge Profile B for BEV Cycle Test

Step	Duration (s)	Ratio to test power (%)	Charge/discharge
1	16	0	
2	28	12.5	Discharge
3	12	25	Discharge
4	8	-12.5	Charge
5	16	0	
6	24	12.5	Discharge
7	12	25	Discharge
8	8	-12.5	Charge
9	16	0	
10	24	12.5	Discharge
11	12	25	Discharge
12	8	-12.5	Charge
13	16	0	
14	36	12.5	Discharge
15	8	100	Discharge
16	24	62.5	Discharge
17	8	-25	Charge
18	32	25	Discharge
19	8	-50	Charge
20	44	0	

Tip. Use Chroma's Battery LEx to edit the BEV cycle testing procedure:

	Test	Plan Cycle life	test_BE	VIEC62	66 De	scription	Cycle	life test_	BEV	IEC	Model	NMC	18650		[Save	
	No	Main Desin												Cycle			
	INO.	Main Recip	e	+) E-max	(-) E-	min	E-chg	E-dchg		Time(s)	Count		Tir	ne(s)		
•	1	Cycle life test 2 BEV										1					*
•					-								-			•	Ŧ
				-	-												
	Main R	ecipe Cycle life t	test 2_B	EV	De	scription										Save	
Μ	ain Rec	ipe Protection															
															Loop		٦
	No.	Sub-recip)e	(+) E-1	max ((-) E-min	E-cho	E-d	icha	Tir	no(c)	Coto	- C(unt	Time	a(c)	
- -	4	le Wel e seference o C	251/	(.)	nax (() L mm	E ong	20	long		10(3)	0010		4		,(3)	-
		Cycele life test 2, REV	DEV											6			
	2	Cycle life test 2_BEV												0			-
•							_									•	
•	Sub-re	ecipe Initial perf	ormance	2_BEV	De	scription	IEC62	2660_BE	:V							Save	
	Sub-re	ecipe Initial perf	ormance	2_BEV	De	scription	IEC62	2660_BE	V					Cu	It-off	Save	
	Sub-re Step	ecipe Initial perfo	ormance	2_BEV	De Setting P(W)	scription R(0)	IEC62	2660_BE	V Qt=0	I(A)	V(V)	P(W)	Q(Ah)	Cu E(Wh)	It-off Q(%)	Save	1
	Sub-re Step	ecipe Initial perfo Mode	I(A)	2_BEV 5 V(V)	De Setting P(W)	escription R(Ω)	IEC62	2660_BE Range	Qt=0	I(A)	V(V)	P(W)	Q(Ah)	Ct E(Wh)	it-off Q(%)	Save	{
•	Sub-re Step	Chamber Control Rest	ormance I(A) 	2_BEV s V(V) 	De Setting P(W) 	R(Ω)	IEC62 T(°C) 25 25	2660_BE Range 	Qt=0	I(A) 	V(V) 	P(W)	Q(Ah) 	Ct E(Wh) 	it-off Q(%)	Save	{
•	Sub-re Step 1 2 3	Mode Chamber Control Rest CC Discharge	I(A) :1/3C	2_BEV s V(V) 	De Setting P(W) 	R(Ω)	T(°C) 25 25 25	2660_BE Range Auto	Qt=0	I(A) 	V(V) 3	P(W) 	Q(Ah) 	Ct E(Wh) 	It-off Q(%) 	Save	
•	Sub-re Step 1 2 3 4	Mode Chamber Control Rest CC Discharge CC-CV Charge	I(A) :1/3C :1/5C	2_BEV 5 V(V) 4.2	De Setting P(W) 	R(Ω) 	T(°C) 25 25 25 25 25 25	Range Auto Auto	Qt=0	I(A) :1/20C	V(V) 3 	P(W) 	Q(Ah) 	Ct E(Wh) 	It-off Q(%) 	Save	{ •
•	Sub-res Step 1 2 3 4 5	Mode Mode Chamber Control Rest CC Discharge CC-CV Charge Rest	I(A) :1/3C :1/5C 	2_BEV 5 V(V) 4.2 	De Setting P(W) 	R(Ω)	IEC62 T(°C) 25 25 25 25 25 25 25 25 25	Range Auto Auto 	Qt=0	I(A) :1/20C 	V(V) 3 	P(W) 	Q(Ah) 	Ct E(Wh) 	it-off Q(%)	Save T1(°C)	{ •
•	Sub-res Step 1 2 3 4 5 6	Mode Mode Chamber Control Rest CC Discharge CC-CV Charge Rest CC Discharge	I(A) :1/3C :1/5C :1/3C	2_BEV 5 V(V) 4.2 4.2 	De Setting P(W) 	R(Ω)	T(°C) 25 25 25 25 25 25 25 25 25 25	Range Auto Auto Auto	Qt=0	I(A) :1/20C 	V(V) 3 3	P(W) 	Q(Ah) 	Ct E(Wh) 	tt-off Q(%) S	Save	*
•	Sub-re Step 1 2 3 4 5 6 7	Mode Mode Chamber Control Rest CC Discharge CC-CV Charge Rest CC Discharge CC-CV Charge	I(A) :1/3C :1/5C :1/3C :1/5C	2_BEV (V(V) 4.2 4.2 4.2	De Setting P(W) 	Scription R(Ω) -	T(°C) 25 25 25 25 25 25 25 25 25 25 25	Range Auto Auto Auto Auto Auto	Qt=0	I(A) :1/20C :1/20C :1/20C	V(V) 3 3 	III P(W) 	Q(Ah) 	Ct E(Wh) 	Q(%) S	► Save	<
	Sub-re Step 1 2 3 4 5 6 7 8 8	Mode Mode Chamber Control Rest CC Discharge CC-CV Charge Rest CC Discharge CC-CV Charge CC-CV Charge	I(A) :1/3C :1/5C :1/3C :1/5C 	2_BEV s V(V) 4.2 4.2 4.2 	De Setting P(W) 	Scription R(Ω) -	IEC62 T(°C) 25 25 25 25 25 25 25 25 25 25 25 25	Range Auto Auto Auto Auto Auto Auto	Qt=0	I(A) :1/20C :1/20C :1/20C	V(V) 3 3 	III P(W) 	Q(Ah) 	Ct E(Wh) 	L-off Q(%) S	► Save	<
	Sub-re Step 1 2 3 4 5 6 7 8 9 9	Mode Chamber Control Rest CC Discharge CC-CV Charge Rest CC Discharge CC-CV Charge CC-CV CC-CV Charge CC-CV CC-CV CCC CC-CV CCCC CC-CV CCC CC-CV CCC CC-CV CCCC CC-CV CCCCC CC-CV CCCCCCC CC-CV CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	I(A) :1/3C :1/5C :1/3C :1/5C 	2_BEV s V(V) 4.2 4.2 4.2 4.2 	De Setting P(W) 	R(Ω) 	IEC62 T(°C) 25 25 25 25 25 25 25 25 25 25 25 25 25	Range Auto Auto Auto Auto Auto	Qt=0	I(A) :1/20C :1/20C :1/20C 	V(V) 3 	III P(W) 	Q(Ah) 	Ct E(Wh) 	L-off Q(%) S 	► Save	*

Figure 11 – Compose BEV cycle test sub-recipe 1 initial performance test & sub-recipe 2 cycle test

Edit the initial performance test for sub-recipe 1:

- 1944.00				Belling									- D	6 of					and and			iarspla
:0990	Mode	1840	700	Poto	(9)(0)	TCG	Hange	01-0	EAL	N(V)	P100	Q(At)	EDMb)	6(%)	TH'CI	100	Time(s)	Gate	Mar.	Time(s)	DIN .	dore
1.0	Charder Dontrol	-		-	-	25	-	N.	-	-		-	-							00.00.00.01.00		1.64
2	Real	-		- :	1	- 28	-	C.	-		: ->		1.4	-			00.1210.00.00			00.00.00.01.00		38
0.	OC Obsharge	100			-	29	448		-	2	-									90 00 00 00 00 10		
4	CE-CV Charge	180	-42	-	-	- 25	44.82	0	1/200	-										00.00.05.03.18		
	Rest		-	-	-	25	-		-		-	-		-			00.1238.88.88		7.04	00.00.00.01.00		
• •	CC Decharge	100	-	-	-	- 28	4185		-	8	-			- B - 1					FOG:	99 99 85 58 18		-
+ Linne																						
Chab.	OC Discharge																		Fun Bet Bet	chen: Variable: CWAR: C al: Eivid of Stap	WR-Q/	ni.



	10000			Deting		- Andrew	I was not		STOLEN.		T DOWN	STATISTICS.	0	148				1	40.00	14 Mar 10		lampie
1.1106	Mode	1940	WW)	POW	RIDI	TCH	Rangé	Ot-D	AAP.	999	PUN	: 0(Ah)	#XWH1	:0(%)	11(51)	101	Terretori	Gots	No.	Time(x)	dAXA3	40
	CS-CV Charge	100	4.2	-	-	28	Auto	1	1000	+	-									00-00-00-00-10		1.4
100	Chariber Control	-	-			28	-	E	-			+1					-			00 10:00:00:00		-12
10	Rasi			- 1	-	25	-	1	-		-	-	1.1	- 1		1.1	00.12:00:00.00		1000	00-00-00-01-00		
A	Waterbrief analy	-		-		28	(1444)		-	43		-							700	\$8.28.18.02.18		
						_	(m.,	_		_	_	_	_	_								
7970.	Waveform P. IECK Stat Point 1. End P Charge None	2580_Cvd Point 20: T charge No	e_test_Tat ime intervi rite:	sle_3 #(5); ; Ratk	a t														Fat Set	clien Variable QUAR o at End of Step	NAR-QA	stal.

Figure 13 - Store the initial test dynamic capacity of sub-recipe 1 in the QVAR variable

1	10.00			Setting									OV.	6-pf								lanipki
1.000	Mode	8(4)	800	PON	RID.	7(*0)	Range	49+0	IDAY-	V(V)	Pt\$0	0000	actives.	00%1	THE	150	Teres(X)	Gate	Mape	Tyne(b)	20040	(ANT)
1.11	CC Discharge	301	-	-		28	Auto	10	-	- 3										00-00-00-04-10		
12	CC-CV Overse	30/	4.2	-		- 25	Auto	0	10280		-									10 10 00 00 10		
11	Comics Real	-		-	-	25	-	10	-			-		-			0.9			0.V.		
. 34	CC Dwdierys	300	-	-	-	28	Auto	1	-		-			50						101020-0110		
. 15	to Deside the DD	100		-	-	- 25	449	0	-		-						10.00.00 10.00			88.82.83.95.15		
18	Red		-	-	-14	. 25	-	0	-		-	+	-	-			00.00.10.00.00			00100000130		10
17	Aver		-	-	-	.25		0	-		-	-	-		-07		50 00 10 00 08			88.03 62 01 36		
10	CC Darge	301	-	-		25	Auto		-		-						00:00:00 10:00			00.00.00.00.10		
18	Red	+		-		38	+	0	-		+	+	-	-			60.00 10.00.00			50.00.01.01.00		
21	Rest.	-	-	-		- 25	1.4	0	-			+	-	-	-07		00.0010.00.00			88 88 88 81 51 56		1
21	OC Discharge	310	-	-	-	25	Auto	0	-		-						100:00:00 10:00			101010104.10		
	Real	-		-	4	25	-	0	-			-		-			00.0010.00.00			88.0388.0138		
23	Real		-	-	-	25	1.00	0	- 1		-	-	-	-	427		00.00.10.00.08			20.03.03.01.04		
24	CC Charge	310	-	-		- 25	Auto		-								00.00.00 10.00			88.00 81.01.10		
-25	Ret		-	-	-	- 28	-				-	+	-	-			00.00.10.00.00			00.50 00 01 30		1
38	Red		-	-	-	.25	1.00	0	-		-	-	-	-	427		00-00-10-00-08			62-22 62 01 26		
- 27	CC Discharge	-25			-	25	Auto	10	-		+				-		00.00.00 10.00			88-02-00-00.10		
28	Rest	+		-		- 28	+	0	-		-	+	-	-		1.1	60.00.10.00.00			88.08.61.01.50		
-28	Rest .	e.		+	-	21	1.00	G	-		-	+	-	-	-07		00-00:10-00-00			88 08 88 91 56		
38	OC Cherge	30	-	+	-	.25	Aite	0	-		-						00.00.00.10.00			10101010110110		
21	Real	-		-	-	- 25	-	0	-		-	-	-	-			00.00110.00.00			88 23 68 91 56		1.
12	Aug		-	-	-	28	-	0	-		-	-	-	-	- 120		00.00.10.00.00	-		00.00.00.01.00		
33	CC Discharge	86	-	-		25	Auto	161			-						99.00.20 19.00	-		00.00 00.00 10		
54	Red		-	-	-	25	-		-		-	-		-			33 80 10 33 88			100 00 00 01 at		
34	fant:	+	-	-	-	25	-		-		-	-		-	-477		00-00-10-00-00			00-00-00-01-00		
34	CC Charge	:50		-	-	-25	Auto	D	-		-						00.00.00.10.00			00.00-00.00.10		- 18
1 37	444	1.4	-	-	-	28		0			-		-				09-00-10-00-08			00.00.00.01.00		-11
38	Rest.	-	-	-		25	-	D-	- :		-	+		- :	-47		00.00.10.00.00			00.00.00.01.00		
• 28	CC Decharge	395		-	-	25	Add	0	-		-						00 00 00 10 00		P(4)	00.00.00.00.10		
- 40	Real	-	-	-	-	25	-	10			+	-		- :			00.0010.00.01			00:00:00:01.00		
41	And	-	-	-	-	25	-	D	-		-	-		-	427		98.99.10.01.00			00.00.00.01.00		1.5
62	CC Charge	192	-	-	-	28	Auto	1.01	-		-						00.00 20 10.00		Field	60.00.00.00.10		
+ 1															-							
	. OC Discharge																		For Def Var RR	uction laisle VARD 1 VAR . Set al End of S	iatoviout Res	•ou

Figure 14 – Sub-recipe 1 initial power test (25°C 50% SOC)

Test in stages. The data obtained from the initial performance test of sub-recipe 1 will be used in the editing of the cycle test in sub-recipe 2. For example, the power measurement value in sub-recipe 1 must be manually incorporated into the the output power calculation of the dynamic discharge profile A and the dynamic discharge profile B, and is used as a cut-off parameter for the cycle.



Edit the cycle test for sub-recipe 2:

Figure 15 – Set sub-recipe 2 dynamic discharge profile A to cycle until it is equal to DOD 50% of the initial dynamic discharge capacity C_D

-				Setting					in.			Sampling					Loop	12(1)			Reality	
Long.	Mode	RAP:	V/V	P(W)	R(0)	T(*C)	Range	010	0 0000	Time(a)	.280A)	aw(v)	6Q(Ah)	.dE(Wh)	1.1	Court	Time(s)	1.2	Court	Time(x)	toprogen.	
32	Rest.	-	+	-	-	48	-			00.00.00.01.00						-	-		-	-		
-3	CC Dackarge	1000	-	-	-	45	Auto			30.00 00.00 15						-		1	-	-		10
	CC-CV Charge	1:50	4.2	-	-	45	Auto			30.00.00.00 15						-			-	-		
8.	Rest		-		-	45		V.		90.90.00.01.00							-		-	-		
6	Wateform P #CK28	-	-	-	-	45	4480	10	900	00.00.00.00.10	-				1.8	1000			-	-	End Condition.	
7	Wavefores F : ECE26	-	-	1.41	-	45	Auto	10		00.00.00.00.10		_					-		-	-		Т.
8	Watehtm F: EC826		-		-		the second second				1	a.			-	1000	_		-	-	End Condition	
	Rest		+	-)ynar	nic d	isch	arg	e profile						-	÷.	1	10060	28.00.00.00.50		
390):	Waveform P : ECK Start Point: 1, End P Charge None Dra	2560_Cycl Ioint 20, T charge No	e_test_Tu: Vrse intervi me	ble_4 al(S) ; Rath	e 1		bev e	xec	uteo	1 I ume	_											

Figure 16 – Set sub-recipe 2 to perform dynamic discharge profile B once

-				Seting					1000			. 8	ampliesg					1.008	121.17			and and	
-246	Mode	8/43	WVO	\$P(W)	FRED).	T(*C)	Range	Q8-0 (1 Mape	Time(a	0. 4	(A)(A)	4W(V)	3Q(M)	AE(Who	1.5	Count	Time(z)	12	Count	Time(0)	Nacraer	
2	Real	-	-	-	-	42	-			00.00.00.0	01.00						-			-	-		
3	CC Decharge	(1/9C	-	-	-	45	Adt			00.00.00.0	00.10	(1) 1	D	min .	lingh			file	- 5	-	-		1
4	CC-CV Charge	1/52	4.2	-	-	40	Auto		1000	00.00.00.0	00.10	(1) 1	Dyna	mic c	aiscri	arg	e pro	me		-			
5	Real	-	-	-	-	-45	-	1		00.00.00.0	01.00	A fc	or BE	V cvc	le 10	00	times			-	-		
	Vieweform P : ECR28	+	-	-	-	41	Auto	0	100	00.00.00.0	00.92	care		, -				21		-	-	She Consten	
1	Waveform P ; #C626	-	-		-	40	Auto		-	00.00.00.0	00.10					-	-			-	-		
.8	Vavefore P EDS2E	-	1	-	1	48	Aute		Fill	00.00.00.0	00.10					- 8	1500			-	1.00	End Condito.	
. 9	See.	-	-		-	-46	14		TY	00 00 00 0	01.00						-	-	t	10000	29.00 00.00 0	E .	
																						-	£
tiniçi	Waveform P : IECS) Start Polot: 1, End P Charge None : Dia	2860_Cyd ² oint 20, T itharge No	e_lest_Tat ime intend ine	04_3 4(5), Rabi	et:					0	2) T	otal	O re	eache	s 809	% o	f the	dynan	nic	Fun End QVR	dios: Condition II Aro A julump	Gtotal >+ t≥ 9	
										0	apa star	city ting	and from	the on Qt	cut-o =0 pr	ff p	rofile ss st	e A cyc ep)	le				

Figure 17 – Set sub-recipe 2 dynamic discharge profile A to cycle until it is equal to DOD 80% of the dynamic discharge capacity C_D

-				Setting					(enco		THE R.	lampling :					Loop	12(1.1)			Bernett	
Simp	Mode	0.0846-0	V(V)	P(VI)	RIGI	T(*C)	Range	Qt=0	0	Time(3)	68(40	div(V)	aq(Ah)	AE(Wb)	1.5	Count	Time(a)	1.2	Count	Time(s)	popriari.	
2	Seal	-	-	-	-	41	-	11	1.00	00.00.00.01.00						-	-	-	+	-		٠
- 3	CC Decharge	/1/5/C	-	-	-	41	Apte	0	100	60.02.00.00.10						-	-	5	-	-	-	10
	CC-CV Charge	:1/92	42	-	-	45.	Auto	ū		00.00.00.00.10						-			-	-		
	Rest		-	-	-	45	-	12		00.00.00.01.00						-	-			-	and the second second	
. 8	Waveform P : ECR28	-	-	+	-	42	Auto	0	P00	00.00.00.00.10					1 B.	1000			-	-	Evel Candles	
1	Vieveform P: ECK26	-	-	-	-	41	Aste	12	1	00.00.00.00.10						+	+		+	+	1	
	Wavefore P #DE28	-	-	-	-	41	Auto		F00	00 00:00 00 10					11	1000			-	-	End Candles	
11.8	Real		-	-		41				00.00 90 91 80							-	18	10008	211010-10.00		+

End Loop2 after 28 days (preparation for a periodic inspection)



re ou r	oan Cycle ne	lest_bb	VIEC02	00	rescription	Cycle	ne test,	DCAR	CC N	IDDEI MINIC I	00000		3
1925	1000007		11								: Q	yche .	
THO.	Main Herce	·	+)E-max	(i)	E-mail	E-chg	E-ocho		Time(s)	Court		Time(s)	
	Curse the test 2 REV			-						1			
1	11070070070000000					- 1				1.00			
Maam R	ecipe Cycle life	test 2_E	BEV	100	escription								1.0
ain Red	pe Protection												
-										(a)		L.009	
125	000-1904	÷	(+)±-	max.	(-) E-mm	E-mg	- E-	grat	Tim	and Goto	Cour	1 7	time(s)
1	Index performance 2.5	EV.	1.000							Children and Children	the second		
	Cycle ife inel 2 BEV						-			-	1	1	
-							0			-0-	-	0	
-	1111 1 1000 (000000)		E. 10			1100400	- 6	i cvo	cles a	nd end the	e test		-
SUD-N	cipe Cycle life:	test 2_E	JEV	10	escription	IEC6;	100	0.54	10000	0	0.000	0	1.00
-			1000	leting.			Local V				Louis America	CONTRACT.	
out.	Mode	1040	. V00	Pph)	R(D)	T(*C)	Range	0000	C) (0)	Time(s) d	Goto Mean	Time(a)	Δ8(A)
10	Chamber Caritral		+	-	-	- 25	-	0	-	-		00.00.00.01.00	
11	Reat		100	-		25		V	1.1	00.12.00.00.00	1.00	30 00 00 01 88	
42	CC Discharge	:1/90	-	-	-	25	Auto	0	1.1			30.00.00.00.10	
13.	CC-EV Charge	150	4.2	-	-	25	Auto	0	1.1		1.00	80-06-80-98-18	
14	Real		-	-	-	25		0	11.5	10 12 10 00 00	- New Street	00 00:00 01 00	
18.	CC Discharge	1000	-	-	-	26	Auto	10		1950 (March 1960)	700	00 00 00 00 10	
18	Chamber Cantrol	-	-	-	-	28	-	01			-	86 80 00 01 88	
12	Rest		-		1	25	0	61		00 12 00 00 00		00 00:00:01 00	
10	OC Discharge		3	3					32.			80 00:00:00 10	
19	CC-CV Charge		ynam	nic c	apacit	y me	asur	eme	nt is	less than a	30%	80 00 00 00 10	
22	Reat	-	-	-	-	-		1 6 6 1		N V W W W		90 00 00 01 00	
21	Weinstein P. ECKOL	-		-		. 25	440	1	11.1		. 200	00 00 00 00 10	
				1	Mint-Facinate 1			-			-		
							_						
					Set Variation	End Coolifie	6						
					ited hashable						0.0044	10.04	P00
					1.0						10.7	10081	LOOP
					- C	Contraction of the	1000				Comm.	11 - 15 -	1.11
					PLA 150	CONT DO	Ope		nanue.		CURR		111
					114 11						(WW	4 9	1
											EMM	1 1 2	1111
						e-++					and the second second	the second house	
						- and the second							
					Our samples	e berein					2.9MB	14.	1
										times I from I			
										Conception of the second			
					-				1.00	Constant of Constant of Constant			

Figure 19 – Set cut-off conditions

7.2 HEV cycle test (refer to section 7.7.2 of IEC 62660-1)

- 7.2.1 Test procedure:
 - [Step A] Capacity test (refer to Section 2.1) \rightarrow Power test (refer to Section 4.1).
 - [Step B] General charge (refer to Section 1.1) → SOC adjustment (30%) → Temperature adjustment (45°C ±2°C) → Single measurement of lower limit switching voltage at the discharge-rich profile (refer to Table 6) → General charge (refer to Section 1.1)
 → SOC adjustment (80%) → Temperature adjustment (45°C ±2°C) → Single measurement of upper limit switching voltage at charge-rich profile (refer to Table 7).
 - [Step C] Temperature adjustment (45°C ±2°C) → General charge (refer to Section 1.1) → SOC adjustment (80%) → Repeated discharge through the discharge-rich profile (refer to Table 6) until it reaches the lower limit of the switching voltage → Repeated discharge through the charge-rich profile (refer to Table 7) until it reaches the upper limit of the switching voltage →→ Repeat for 22hr → Rest for 2hr →→→ Repeat every 7 days to measure power; repeat every 14 days to measure capacity →→→ Continue repeating [Step C] until either of the cut-off conditions is met.

Test cut-off conditions

The cycle life test shall be terminated when either of the following conditions is satisfied. Otherwise, repeat the test procedure.

Condition A – The test procedure is repeated for 6 months.

Condition B - When any performance decreased to less than 80% of the initial value.

7.2.2 Verification items: Report the number of profile implementations as in *Table 6* and *Table 7* and the number of times the switching voltage is reached. Finally, **evaluate the battery life based on the overall charge and discharge capacity (throughput).**

	Table e Bleenarge herri		
Step	Duration (s)	Current (A)	Charge/discharge
1	5	20	Discharge
2	10	10	Discharge
3	32	5	Discharge
4	20	0	
5	5	-15	Charge
6	10	-10	Charge
7	37	-5	Charge
8	20	0	
9	5	15	Discharge
10	10	10	Discharge
11	37	5	Discharge
12	20	0	
13	5	-12.5	Charge
14	7	-7.5	Charge
15	35	-5	Charge
16	42	0	

Table 6 Discharge-rich Profile for HEV Cycle Test

Table 7 Charge-rich profile for HEV cycle test

Step	Duration (s)	Current (A)	Charge/discharge
1	5	-15	Charge
2	10	-10	Charge
3	37	-5	Charge
4	20	0	
5	5	20	Discharge
6	10	10	Discharge
7	32	5	Discharge

8	20	0	
9	5	-12.5	Charge
10	7	-7.5	Charge
11	49	-5	Charge
12	20	0	
13	5	15	Discharge
14	10	10	Discharge
15	23	5	Discharge
16	42	0	

Tip. Use Chroma's Battery LEx to edit the HEV cycle testing procedure:

	Test I	t Plan Cycle life test_HEV IEC6266 Description Model NMC 18650 Save Main Recipe Imax V-max V-min P-max (+) Q-max (-) Q-min Q-chg Q-dchg (+) E-max (-) E Gycle life test_initia_HEV Imax V-max V-min P-max (+) Q-max (-) Q-min Q-chg Q-dchg (+) E-max (-) E Cycle life test_initia_HEV Imax V-max V-min P-max (+) Q-max (-) Q-min Q-chg Q-dchg (+) E-max (-) E Cycle life test_initia_HEV Imax V-max V-min P-max (+) Q-max (-) Q-min Q-chg Q-dchg (+) E-max (-) E Cycle life test_initia_HEV Imax V-max V-min P-max (+) Q-max (-) Q-min Q-chg Q-dchg (+) E-max (-) E Recipe Cycle life test_initia_HEV Imax (-) E-min E-chg E-dchg Time(s) Goto Count Time(s) 1 Initial performance3_HEV Imax (-) E-min E-chg E-dchg Time(s) Goto Count Time(s) Ima(s) Imax V-max (-) E 															
		Model NModel NMOdel NMOdel NMOdel NMODE Cut-off No. Main Recipe Cut-off T T Cut-off Cut-off NO. Sub-recipe Cut-off NO. Sub-recipe Cut-off Time(s) Golo Count Time(s) Golo Count Time(s) Golo Count Time(s) Golo Count Time(s) Cut-off Time(s)															
	N0.	Main Recip	e	I-max	V-	max	V-min	P-max	. (+) Q-max	(-) Q-min	Q-c	hg	Q-dchg	(+) E-	max	(-) E
Þ	1	Cycle life test_Initial_HE	V	1													
	2	Cycle life test_14day_H	IEV														-
•		-							-								Þ.
	Main R	ecine Cycle life	test Initia	al HEV	Dec	scription										Sau	10
	Within IX	ccipe Oycie ine	icoi_initic		DC	scription										34	C
M	ain Rec	Recipe Protection Loop No. Sub-recipe (-) E-min E-chg E-dchg Time(s) Goto Count Time(s) 1 Initial performance3_HEV															
	Nie	Recipe Protection No. Sub-recipe Image: Colspan="6">Image: Colspan="6">Loop 1 Intial performance3_HEV Image: Colspan="6">Count Count Time(s)															
	INO.	Recipe Protection Loop No. Sub-recipe (-) E-min E-chg E-dchg Time(s) Goto Count Time(s) 1 Initial performance3_HEV Image: Count															
•	1	Recipe Protection No. Sub-recipe (-) E-min E-chg E-dchg Time(s) Goto Count Time(s) 1 Initial performance3_HEV Initial performances Initial performances															
		Recipe Cycle life test_initial_HEV Description Save tecipe Protection															
•		Recipe Cycle life test_Initial_HEV Description Save tecipe Protection															•
		st Plan Cycle life test_HEV IEC6266 Description Model NMC 18650 save 0. Main Recipe Imax V-max V-min P-max (+) 0-max (-) 0-min Q-ddg (+) E-max (((-) 0-min Q-ddg (+) E-max ((-) 0-min Q-ddg (+) E-max (-) 0-min Q-ddg (-) 0-min Q-dgg (-) 0-min P-max <															
	Sub-re	Recipe Cycle life test_Initial_HEV Description Save ecipe Protection															/e
	01			Se	etting									Cut	-off		
	Step	Mode	I(A)	V(V)	P(W)	R(Ω)	T(°C)	Range	Qt=0	I(A)	V(V)	P(W)	Q(Ah)	E(Wh)	Q(%)	T1(°	C) {
F	1	Chamber Control					25		\checkmark								
	2	Rest					25										=
	3	CC Discharge	:10				25	Auto			3						
	4	CC-CV Charge	:1/5C	4.2			25	Auto		:1/20C							_
	5	Rest					25										_
	6	CC Discharge	:10				25	Auto			3				S		_
	/ 0	CC Discharge	:10				25	Auto			3						_
	9	Chamber Control	. 1/50	4.2			25	Auto		. 1/200							—
	10	Rest					25										-
	11	CC Discharge	·1/30				25	Auto									
																	- N

Figure 20 – Compose HEV cycle test main recipe 1 initial performance & main recipe 2 cycle test



Figure 21 – Architecture diagram for main recipe 1 initial performance test

entre				Setting									Cu	tof					1000
Stab	Mode	1040	VIV0	P(W)	-R(D)	T(*C)	Range.	Qt=0	RAD .	V(V)	P(W)	Q(Ah)	E(Wh)	Q(%)	T1("G)	(0)	Time(s)	Goto	MOC.
	Chantler Control	-	-	-	-	25	-	M		-	-	-	-						
2	Rest	-			-	25	-	0	-		-	-		-		1.3	0012:00:06.00		100
-3.	CC Discharge	30	-	-	-	25	Auto	0		3	-					11.31			100
4	CC-CV Charge	.1/50	4.2	-	-	25	Auto	EJ.	1/200							1.5			110
5	Hest				-	25	-	11			-		-			1.1	60.12.00.00.00		2,00
. е.	CC Descharge	31	-	-	-	25	Auto	0	-	3	-	-		5		101			F(n)

Figure 22 – Use the Q% function to set the reference volume

-				Setting	Lange at									l-it					1000			iam;
3000	100.00	100	WV3	P(W)	R00	1001	Range	GE+0	RIA1	WW2	POW	0(41)	E(WIII)	12(%)	Th(°C)	(0)	Time(a)	Ciono	Nec	Time(s)	(AKA)	1
34	CC Charge	306			- :	28	Auto.	T D T									00.00.00.10.00			00.00.00.00.10		
恒	Rem	-				-25	- :	0	-		-	+	-	+			10.00 10.00.00			35.10.00 00 01 8E		
10	Rest:		-	1.00	-	26	-	10			-	+	-	-	-425		00.00 10 85 00			88.00.00.01.88		
17	CC Discharge	÷t¢	-	-	-	-26	-Refts		-								UD 00 30 12 00			06:00:02:00:15		
18	Rest	-	-	-	-	25	-	101	-			-		-			00:00 10 25:00			95 15 20 00:00		
19	lles!	-	-	-	-	25	-	101				-		-	-27		80.00.12.88.00			00.00.02.01.85		
20	CE Charge	10				25	. AL82		-		-		1.000		1000		10 00 00 12 00			50.00.00.00.18		
21	Heat	-	- :		- :	25	-	101	. +-			-	:	-			00.00.10.05.00			00-00-00-01 28		
22	Rem		-		-	25	-	10	-		-	1		-	-31		10 00 10 85 00			00 00 00 01 8E		
27	CC Discharge	38	10.1	1.00		26	Auto	10			-						00.00/00 18.00			68:00.00.00.15		
24	Hest.	-	-	-	-	26	-		-		-	-	-	-			00.00 10 88.00			00.00.00.01.00		
25	ries:		-		-	- 25		0				-		-	-37		00:00 10:00 00			92.11200.00		
28	CC Charge	-50	-	-	-	. 25	.4481		-								10:00.00 15:00			00.00.00.00.16		
27	Resi	-	- :	: 		25			-		-	-		-			10:00 10:05:00			00.00.03.01.88		
28	Rest		- :			25					-	-	:	-	-21		00.00.10.05.00			00.00 00 01 26		
29	CC Discharge	100C :	-	-	-	25	Aste	10	1.		'.						10.00.00 10.00			00.00.00.00 fE		
30	Rest	1.0		1.00		26	-	10			-	+	-	+			00.00 10 95.00			00:00:00:01.88		
21	Rest		-		-	26			-		-	-	-	-	-41		10:00.10.88.00			00.00.00.01.05		
32	CC CRatge	:100	-	-	-	25	4400	10			-						80.00 20 18 00			00.00.00.08.18		
33	Rest	-	-	-	-	- 25	-		-			-	·	-			00.00.10 88.00			85.19.00.00		
34	Rest		- :			25			-		-	-	-	-	-07		10 00 10 55 00		1000	50,00,00,01,88		
125	CC Decharge	-	-		-	-	Auto	606									10.0030 15.00		100	0000.0038.10		
U.S.S.	1.					1.0	18										1000000000	-		1550-050-151		1
asia) 35	- CC Discharge																		Fut tiel Vari RR	ction able VAR02 VAR Set at End of 9	102=VDLT	-01



Otio				Setting									Ču	10.0					14.10		3	Bampi
Seeb	Mode	R(A)	V(V)	Pont	Ritti	T('C)	Hange	(2)=0.	1040	M(N)	Pisty	0(36)	EDMIN	Q(%)	11/127	(2)	Tansa(a)	Ganta	No.	Termino	.EXA3	- 40
40	Waveform1 806206	+		-	-	45	Add	12	-	+0	-	-	+						110	22-22-02-00-10		1.9
49	Disertier Control	-	-	-		25	-	12		-	-	-	+		-				124	00.10-20:00.00		
50.	Rest	-	-	-	-	25	-	0			-		-	- 10			89 12 59 00 00			10 10 00 01 01		
\$1	OC Diactorga	31.	-	-		25	Auto	0	-	3	-									01-00-33-35-56		
52.	CC-CV Divergel	1/62	4.2	-	-	36	Auts		10200	-	-									45 13 CK 05 11		
55	Rest	1.00				25	. 17	E3	-		-			100			98 12 96 99 00	-		001003030006		
54	CC Illecturgs	:10	-	-	-	35	4425	11	-		-			28						80-88-05-06.16		
55.	Chambar Control	1	-	-	-	45	-	1	-	-	-		+		-		1.00			88-88-88-01-00		TA
58	Hent	-		-	-	45.	-	11	-		-		-	-			88 12 00:00.00			88 88 66 01 05		
57	Western Class.			-		10	Aug .	X	-	-1	-		-						T(0)	88 28 60 00.10		
-							*								-							
	Waveform1 IEC628 Start Point 1, End P Charge None , Disr	it0_Dyde ont: 16, Ti therge No	_heat_Tabl me brietvi ne	N_B NG) , Runa	9														Fun Set	clium Variable QVAR C al: End of Slep	194R-Cik	ise.

Figure 24 - Use QVAR, GVAR variables to calculate the switching voltage



(2) If the voltage is higher than the switching voltage, the charge-rich profile cycle will be cut off



-				Setting					- Anti-			Sampling					1.000	1,201,13			1920.00
Bred	Mode	1040	WV0	P010	R(D)	T(*C)	Range	00-0	0	Timetal	:: 40(A)	(V/V)	30(40)	AE(Wh)	1.1	Count	Time(s)	12	Count	Time(0.)	roman
.1	Real	-	-	-	-		-	12		00.03.00.00.01						-	-	- 5	-	-	
2	Waveform1 @C6266	-	-		-	- 400	Auto		FDO	00.00.00.00.10					1.0	1000			-	-	End Condition
12	Waveford: \$CK064.		-				dist.	D	1993	00 00 00 00 10						7000			CONTRACT		Red Canadian
4	Heat	-	-	-	-	-		V.		00.00.00.00.01					-	-	-		10000	80.22 00 00 00	
5	Real	+		+	-		-	Ľ	1.500	00-00:00:01:00						-	-		-		
	-					-		1-1	.d			1/		-	_			-			
	Waveform I. IBC624 Start Point: 1, End P Charge None: , Dis	00_Cyde owt 10_D tharge No	_test_Tats inte intervis cie	e_6 4(5) Ratio	é)t									C	ycle	e test	22 <u>hr</u>	anc	the	n rest f	or 2 h

Figure 28 – Use L1, L2 to reach a 22hr operation cycle

Function: End Condition:If(V(V) H< OV#F 3.Jump to 5

N	ain Re	cipe Cycle life test_1	4day_HEV	Descript	ion							Save
Ma	n Recip	Protection										
	110	Sub racina			0	6					Loop	
	rep.	Subseche) E-max	(-) E-min	E-chi	E-dchg	Time(s)	G	oto	Count	Time(s)	
	. 1	Adjust SOC_HEV_45C	0	-	-		0	C I I	048	1		
I	2	Cycle life test4_HEV		Derform n			-9	Cycle te	ST	1000	07:00:00:00:00	
	3	Cycle Check P HEV	-0	fenorm po	ower mea	isurement	0	/ days		1.1		_
	4	Adjust SOC_HEV_45C	4	arter / day	stesting				_	1		12
	5	Cycle life test4_HEV	-				-			1000	07:00:00:00.00	
	6	Cycle Check_P_HEV	F	ower mea	asuremer	nt & capacit	/			t		1.00
	7	Cycle Check_Q_HEV	r h	neasurem	ent after	14 days				<u></u>		
*			t	esting		*********			844			



The overall operation time is long. We recommend that operators periodically intervene with the operation. For example, when executing a performance check for seven days, the personnel should confirm whether the power & capacity is lower than 80% of the initial state, or the overall operation reached 6 months.

- 8. Energy efficiency test (refer to section 7.8 of IEC 62660-1). Determine the energy efficiency of the battery by choosing one of 8.1 or 8.2 test methods.
- 8.1 Test for normal conditions (refer to paragraph 7.8.1.1 of IEC 62660-1)
- 8.1.1 Test procedure: Capacity test → Rest 4hr → Charge to SOC 100% → Rest 4hr → Capacity test → Charge to SOC 70% → Rest 4hr → Capacity test.
- 8.1.2 Verification items: Calculate the coulombic efficiency and energy efficiency.
 - Calculate the coulombic efficiency η_c (%) $\eta_c = \frac{Q_d}{Q_c} \times 100\%$ Q_d : discharge electric quantity (Ah) Q_c : charge electric quantity (Ah)
 - Calculate the energy efficiency η_e (%) $\eta_e = \frac{W_d}{W_c} \times 100\%$ W_d : discharge electric energy (Wh) W_c : discharge electric energy (Wh)

170	and Real		_			Destin	aan 🖻	06200	0_BEV				_	_									
144	4			letting .									() (64					land.			langing.	
	Mathe	1040	WW.		RG	T(*C)	Range	Q±0.	1040	- WV012	P(W)	G(4t)	-E0101	0(%)	T1000	101	Tirse(s)	Gold		Tinte(s)	- 60AL	£24(3/)	4904
1	Chaiter Tiretol	-	-	-	-	25	-	×.	-	-	-	-	-		-		- 1			00.00.00.01.00			1
- 3	Rest			-	-	15	- 100	0	-			-	-				881206-00-00			30-00-00-01-00			
3	OC Discharge	1996	"	-		.25	448		-	(4)	-									80 00.00 (08.10)			
	OC-CV Charge	150	12276	-	-	28	Auto	0	10200	-	-									30-00-00-00.00			
1	Real		· · · ·			25		0	-				-	-			1012.0006.00			98.90.08.61.89			
	000 Sector (S	100	-	-	-	- 25	Auto		-	-18	-			1						86.00.00.05.10			
1	Real	1.00		-	-	25			-				+	3-6 L			89.04109.00.00			80.00.00101.00			
- 8	CC-CV Charge	:1(5)2	.120%	-	-	25	AUD			-	-			180			81103-46-46-80		PIN	88.90.05.68.10			1
	Rest	-		-	-	25	-	0	-			-	-	14		1.1	23/04/02/06 00			99-90-08-01-89			
11	DC Dectrarge	:100	-	-	-	25	App	0	-		-								Ppti	30.00.00.03.13			
11	Heal	1.1	0.00	-	-	25	-	0	-		-		-	-			80.94.05.98.80			00.00100.01.00			
- 62	CC-CV Charge	-tiNC	102%	-	-	25	- Auto	0						78			81.03.40.40.00		P(n)	20.00.00.08.10			
11	Rest	-	-	-	-	- 15	-	0	-		-	-	-	-		1.1	10 04:00 00 00			80.00.00101.00			
14	OC Destherps	1000		-	-	- 15	Auto:		-	:148									P10	80.00.00.08.02			
13	Rest	-		-	-	. 15	-		-		-		-				88.9008.81.90		F00	88.90.00.01.85			
	14																						1.14
lain.								ň. – – – – – – – – – – – – – – – – – – –															
214	Aest																		Fur Set at 1 Set at 1 Set at 1 Set at 1 Set	ktilon Variazila: WAROS Esidior Stepi Variazile: WARIO End of Bitep Variazile: VARITZ End of Bitep Variazile: VARITZ End of Bitep	SARTI-V SARTI-V SARTI-V	WIDZAWN HIDDAWR IRDOARR HIDDAARD	73, 544 13, 544 15, 544 27, 544

Tip. Use Chroma's Battery LEx to edit the performance testing procedure:

Figure 30 – Calculate the variables of coulombic efficiency and energy efficiency of the general test

8.2 Temperature test (refer to paragraph 7.8.1.2 of IEC 62660-1)

- 8.2.1 Test procedure: Temperature adjustment (25°C) → General charge → Rest 16 ~ 24hr → [Temperature adjustment (-20°C/0°C/45°C)] → Rest 4hr → Capacity test → Charge to SOC 100% → Rest 4hr → Capacity test.
- 8.2.2 Verification items: Calculate the coulombic efficiency and energy efficiency.
 - Calculate the coulombic efficiency η_c (%) $\eta c = \frac{Q_d}{Q_c} \times 100\%$ Q_d : discharge electric quantity (Ah)

Q_c: charge electric quantity (Ah)

• Calculate the energy efficiency η_e (%) $\eta_e = \frac{W_d}{W_c} \times 100\%$ W_d : discharge electric energy (Wh) W_c : charge electric energy (Wh)

Tip. Use Chroma's Battery LEx to edit the temperature testing procedure:

Evol	et PJH			<u>k</u>		Desco	itian IB	C620	0_BEV													
- China				Setting									Ċ	lat.					in the second		9	ample
Sub	Mode	8A3	VIVI.	#0W3	RGD.	T[*C]	Ratps	01-0	LLAD.	VIV3	P(W)	(Q(Ab))	£1(070)	U(N)	11/01	909	TITNEGUI	Gato	mar.	Time(x)	ANN.	dur
	Charter Centrel	-	-		-	21	-	N.	-	-	-	-	-		-		- 11			00 92 88 81 88		- +
z.	Reat	-	-	-		21	-	10	_		-	-					00.18.00.00.08			88.18 00 22 00 21 38		
1	CC Discharge	1/30	:	+		28	Adte			:2										90 00 00 00 10		
4	CC-CV Charge	1/50	4.2	-	1.4	21	Adt	0	1/00C	-	-					1.1				00.00.00.00.18		
2.	Diakter Centrel	-		-		-20	-	TO	-	-	-	-			-		-			00 00 00 01 00		
	Real	-		-	-	-20	-	0	-		-	-		-		1.1	00.16.00.50.01			00.00.01.01.00		
1.	CC Discharge	1/30		-	-	-23	Add	0	-	3				5		12.37				00.00.00.00.10		
8	Rest	- W.S.		-	-	-29	-	10	-		-	-	-			1.2	00.94 09.93 89			00.00.00.01.00		
	CC-CV Charge	1/50	4.2	-	-	-20	Aite	10			-			188			01.03.46.40.00		9161	00.02.00.52.15		
10	Real	-	-	-		-20	-	10	-		-	-					00/04/00/00.00			00.00.01.01.00		
11	CC Discharge	1/30	-	-	-	-29	Auto	TO	-		-								F(c)	90.00.00.00.10		
TE	Feed 1	-			-	- 28	-	TO:				·		-			8000002186		F(4)	100 DC 20 TT 24		
1.0	Chakter Cuttlel	-				25	-	1	-	-	-	-	-				-			00.00.00.01.00		
14.	Real	-	-	-		25	-	0	-		-	-		-		1.1	0016-00.00.00			00.01.01.01.00		
15	CC Discharge	NAC	-	-	-	- 25	Auto			- 1	-									90.90.80 23.18		
18.	CC/CV Eharge	1/52	4.2	+	-	21	Auto	121	1000	-	-					1.2				00.00.00.00.10		
17	Chamber Control		-	-	-	8.	-	0	1.00	-	-	-	-		-	-				30 50 52 21 88		
10	Rest	-	-	-	-	E	-	0	-		-	-	-	-			0010.00.90.90			00-00-88-81-88		
10	CC Discharge	1/20	-	+	-		Aste	0	-	- 1	-			- E -		1.1				00-30-88-88-18		
28	Fieal	-		+	1.00	в.		0	-			-	-	-		1.2	00.04.00.00.00			00.00 00 01 00		
21	CC-CV Charge	100	4.2	-	1.4	E -	Acto	0		14	-			(00			01:02:40:40:01		PIA)	00 00 00 00 18		
22	Rost	-		-			-	10	-		-	-				1	00.04.00.00.01			00.00.00.01.00		14
10							10															+
880	Reot																		Fun Bat Vati	dion: able VARde VARd	09-io-Ro	

Figure 31 - Calculate the variables of coulombic efficiency and energy efficiency of the temperature test

- 8.3 Battery test for BEV application (refer to paragraph 7.8.2 of IEC 62660-1)
- 8.3.1 Test procedure: Capacity test (refer to Section 2.1) → Rest 4hr → 2C charge to SOC 80% → Rest 4hr → Capacity test.
- 8.3.2 Verification items: Calculate the coulombic efficiency and energy efficiency.
 - Calculate the coulombic efficiency η_{c1} (%) $\eta_{c1} = \frac{Q_{d1}}{Q_{c1}} \times 100\%$ Q_{d1} : discharge electric quantity (Ah) Q_{c1} : charge electric quantity (Ah)
 - Calculate the energy efficiency η_{e1} (%) $\eta_{e1} = \frac{W_{a1}}{W_{c1}} \times 100\%$ W_{d1} : discharge electric energy (Wh) W_{c1} : discharge electric energy (Wh)

Tip. Use Chroma's Battery LEx to edit the testing procedure:

1211				Skitting			141						Q	to!				_		_		anging-	
200	Mode	NM.	Vov3	P(W)	ROL	T(*C3	Range	(0)-0)	NA0	V(V).	P(W)	Q5482	E(Wh)	19/96	111105	105	Time(s)	(Loto	Mar.	Time(II)	0141	0/10	aquer
1	Chartleer Control		-	-	-	25	-	12	-	-	-	-	-							00 50 00 01 35			1.4
1	Red	0.000	-	-	-	.15		0	-			-	-	-			visit that show that the			100.003 00.01.00			
5.	CC Discharge	1000	· · · ·	-	-	28	Auto	0		3	-									06 80 90 06 18			
4.	CC-DV Charge	1960	42	-	-	25	.848	0	1.DVC	-	-									00 00 00 00 12			
. 5	Rest		-	-	-	25		0	+		-	-					10.0110.00.00			10.03.00.01.18			
	CC Descharger	3/32		14	-	.25	445	0	1	- 3				- 8						00-00-00:00:15			
Τ.	Red	12-2-22	-	+	-	-25	+	0	+		-		-				00:04 \$0.00.08			00-00-00-01-00			1.1
	EC Charge	15	-	-	-	- 16	Auto	13	-	1.1	-			-81					£00	100.0030.0018			
	Red	-	-	+	-	25	-	D.	+		-		-	-			90.04.00.00.08			00-00-00-01-38			
10.1	CC Discharge	-104	-			- 15	Auto	0	1	1									100	08.33(00.00.18)			
11	Test	-	-	-	-	-28	-		-		-	-	-	-			00.00.001.08		700	00 00 00 00 01 28			
1		_	_		_			1		_									-				18

Figure 32 – Use variables to calculate the coulombic efficiency and energy efficiency of the battery test for **BEV** applications

- 8.4 Battery test for HEV application (refer to paragraph 7.8.3 of IEC 62660-1)
- Test procedure: Same as energy test (refer to Section 5.1). 8.4.1
- 8.4.2 Verification items: Calculate the charge electric energy, discharge electric energy, and energy efficiency.
 - Calculate charging energy and discharging energy (Wh)

$$W_{\rm C2} = \frac{I_{\rm c1}U_{\rm c1} + I_{\rm c2}U_{\rm c2} + \ldots + I_{\rm cn}U_{\rm cn}}{3600}$$

*I*_{cn}: charge current value at n point of measured intervals (A)

Ucn: charge voltage value at n point of measured intervals (V)

$$W_{d2} = \frac{I_{d1}U_{d1} + I_{d2}U_{d2} + \ldots + I_{dn}U_{dn}}{3600}$$

Wd2: discharge electric energy (Wh)

Idn: discharge current value at n point of measured intervals (A)

Udn: discharge voltage value at n point of measured intervals (V)

Calculate the energy efficiency η_{e2} (%) $\eta_{e2} = \frac{W_{a2}}{W_{a2}} \times 100\%$

Wd2: discharge electric energy (Wh) W_{c2} : charge electric energy (Wh)

Pto)	ect PJI					Descrip	itian IE	C6266	V.BEV														
s:11)				Setting .									C)	hoff					(A. 4)	1	- Berr	neeng.	
SND	Note:	144	100	#(00)	6(0)	FITCH:	Range	01-0	8/40.	MOVE -	P(0)	-0(49)	-E(WH)	0(%)	THICS.	105	Tirreco)	Golo	MERC	Termina an	AL A	00/45	3004
1	Charles Control	-	'	+	-	-45		13	+	-	-	-	-		-		-			10/20 20 21 20			- 9
	Rest	-		-	-	.45	-	11	-		-		-	-			00/12/00/00/08			10:01 88:01.00			
	CC Oecharge	1152	-	-	-	45	Auto	121	-		-						00 10 00 10 00			10.00.01.00.10			
18	Rest	-		-	-	45	-	10	-		-	-	-	-			00.00.10.00.00			00.08.88.01.08			
11	Rast		-	-	-	45	-		-		-		-	-	-27		00.08110.00.08			100.00103.01.00			
12	CC Change	181312		-	-	45	Auk/				-						00.00.0010.00			100 000 00:000 10			
15	Past	1.04		-	~	-45	-		~		-		-	-			00.08 10.00.08			10000-00-01-00			
14	Rest	1.44	1. 1. 1.	-	-	- 45	1.1		241		-	-	- 2- 1	-	-27		00/08/10/00 08			00.00.00.01.00	-		
12	CC Decharge	10	-	-	1.2	45	Aut.	0	-		-						00.08.80.10.08			100.00.00.00.10			
16	#est	-	-	-	1.2	45	-		-		-	-	-			1.1	00.08 10.00.08			10.00 00 01.00	_		
17.	Reat	-	-	-	-	-45	-		-		-		-	-	-27		00.00.10.00.08			10.05.03.01.00			
18	CC Charge	tC	-	-	-	45	inds.		1		-					1	00.018.88 10.08			100.08.83.00.10	_		
13	Rest	-	-	-	1.5	- 40	-		-		-		-	-			00.08 10.00.08			10.00.01.01.00			
31	Paul	1.1		-	-	45		10	-			-	-		-37		00.08 10:00:08			80:00 88:01.00			
23	CC Ownferge	-30	1	-	-	-45	Auto		-		1.4						00 88 80 10 08			10.00.01.00.11			
21	Reaf			-	-	45	-	10	-				-	-			00.08 10.00.08			10.10.00.01.00			
23	Rant			-	12	45	-	0			-		-	121	-07		00.00.10.00.06			10.00.01.01.00			
24	CC Charge	sc	-	-	-	45	wate	10			-						00.00.00.00			100-048-800-00-18			-
21	Rest			-	12	45	-	D	-		-		-	-			00.08.10.00.08			10.00.00.01.00			
28	Rest			·		- 45	-	10	-		-	-	-		-47		00.08 10:00.08			100/00 00 01:00			
27	CC Discharge	.180	-		-	45	Water.	10	-		-						00.01101.00			00.08.99.00.10			
28	Ret	1.44	1			- 65 -	1	10	-		1.10	100		-			00.00 10.00.00			00.00 00.01.00			
29	Retd		-	-	-	45		10	-		-	-	-	-	-		00.00 10.00.00			100.00 00.01.00			
38	CC Charge	2811		-	-	- 45	ingle .	10	-		-						00103010.00			10:00 01:00 18			
31	Rest	11-1-1	· :	-	-	45	-	101	-		-		-	-			00.00.10.00.00	2		00.08-09.01.00			
32	Finat	-	-	-	-	-45	+	10	-		-	-	-	-	-47		99.08-10.00.06			100.00 00:01:00			
11	CC Decharge	IN:		-	-	- 45	: Watte	0	-		-				I Desired		00.08.83.10.08		100	100.008.00.00.18	_		
34	Funt	-	-	-	-	45	-		-		-	-	-	-			00/00/10/00:08			80.00.00.01.00			
34	Rippi		-	-	-	45	-	0	-		-	-	-	-	-47	1	00.08 10.00.08			100.00.00.01.00	_		
38	CC Charge	380	-	-	-	-45	- Auto	10	-								00.06.89.10.08		100	10.00.03.00.10	-		
317.	Past		-	-	-	- #6	-	10			-	-	-	-		100	00.08.10.00.09			10.00.01.01.00	_		

Tip. Use Chroma's Battery LEx to edit the testing procedure:

Figure 33 – Select Qt=0 before the power test to cut off the report and accumulate charge/discharge energy from step 9.

The Battery LEx step report automatically records the accumulated energy values of charge energy (W_{c2}), discharge energy (W_{d2}) across steps. These can be used to calculate the energy efficiency η_{e2} (= discharge energy / charge energy).

(4) References

[1] IEC 62660-1: 2010

[2] Chroma 17010 Battery Cell Charge & Discharge Test System Software Instruction Manual