**Test Specification for Quick charge**

Project-ID: -

Sample phase: -

Supplier: -

Version:-

**Daimler Truck AG**

Confidential! All rights reserved. Reproduction and duplication of this document and utilization and communication of its content is prohibited, unless with permission from Daimler Truck AG.

Release and Version History

Table 1: Version history

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Version** | **Date** | **Change** | **Sections**  **/Test-ID** | **Author** | **Released** |
| 1.0 | 02.04.2024 | Creation of document. Document is based on former OAD-414 V2.2 (16.06.2023) | All | C. Subramanian;  T. Herdt |  |

**Table of contents**

[1 Aim of the document 3](#_Toc163035342)

[2 List of abbreviations 3](#_Toc163035343)

[3 List of references 4](#_Toc163035344)

[4 Test description 4](#_Toc163035345)

[4.1 Test equipment and setup 4](#_Toc163035346)

[4.2 General definitions for Quick Charge test 4](#_Toc163035347)

[4.3 Specific Description of the Test / Testplan 5](#_Toc163035348)

[5 Evaluation and reports 6](#_Toc163035349)

# Aim of the document

The aim of this test specification is to conduct testing on Li-Ion cells according to quick charge test procedure. The recorded data and calculated parameters leads to comparable, reproducible results in the various development stages during the cell qualification process between cell supplier, customer and test institutes.

# List of abbreviations

BOT Begin of Test

CNOM Nominal Cell Capacity

CRPT Cell Capacity of the latest RPT Procedure Test Cycle

Cx,y,CH Charge Capacity during RPT Procedure at Current x and Temperature y

Cx,y,DCH Discharge Capacity during RPT Procedure at Current x and Temperature y

CC Constant Current

CCCV Constant Current – Constant Voltage

CH Charge

CV Constant Voltage

DCH Discharge

Ex,y,CH Charge Energy during RPT Procedure at Current x and Temperature y

Ex,y,DCH Discharge Energy during RPT Procedure at Current x and Temperature y

EOL End of Life

EOT End of Test

ETP Cumulated Energy Throughput of whole Test

INOM Nominal Current (see section 4.2)

IRPT Current based on RPT capacity (see section 4.2)

n Number of CCCV Cycle Repetitions between RPT Procedures

OCV Open Circuit Voltage

Ri Internal Resistance as measured during RPT Procedure

RPT Reference Parameter Test, see DTC-O-5

SOC State of Charge (referenced to lates RPT capacity CRPT)

SOCstorage Defined SOC Condition for Cell Storage

SOHRPT State of Health (Current CRPT referenced to initial CRPT)

Tchamber Temperature of the Climate Chamber

Vdyn,min Minimum Allowed Voltage according to Operating Window (Under Load)

Vdyn,max Maximum Allowed Voltage according to Operating Window (Under Load)

η Efficiency

# List of references

[DTC-O-1] Testing Quality

[DTC-O-2] Measurement Data Specification

[DTC-O-3] Template for test reports

[DTC-O-4] Operating window cell

[DTC-O-5] RPTs for service life and environmental tests

[DTC-O-6] Cell jig handling manual

[DTC-O-7] Data tables for test reports

# Test description

This test is conducted as a part of performance test to determine the quick charge cycling profile of Li-ion cells.

## Test equipment and setup

* Climate chamber: **0 °C to 45 °C**
* DC-converter: **-**

Jigs and compression forces shall be applied as specified in component requirement specification or in cell specific handling manual according to DTC-O-6.

The test setup and all equipment shall be chosen based on the requirements. Additionally, the special requirements from DTC-O-1 concerning testing quality measures and allowable testing tolerance shall be met.

## General definitions for Quick Charge test

1. CNOM = xx Ah

Explanation: CNOM is the specified nominal cell capacity. It does not change throughout test duration.

1. CRPT = CRPT,X after cycle X

Explanation: CRPT is the reference CCCV discharge capacity of the latest RPT process. Therefore, CRPT is regularly updated throughout the test duration, whenever an RPT process is conducted.

1. Cx,y,DCH

Explanation: Cx,y,DCH is the discharge capacity of the CC process (without CV phase) at a current rate x and a temperature y.  
E.g. CC/3,25°C,DCH means the discharge capacity at 25 °C and a current rate of C/3.

1. SOC = *Qel* / CRPT  
   Explanation: The state-of-charge (SOC) of the battery cell is calculated based on the current electrical charge load of the cell referenced to CRPT. This is to be done even in case CRPT > CNOM (in contrast to definition 8).
2. SOHNOM = CC/3,25°C,DCH / CNOM

Explanation: The SOHNOM is calculated based on the latest CC/3,25°C,DCH capacity (from RPT process; only CC discharge capacity, without CV phase) referenced to the nominal capacity.

1. SOHRPT = CRPT / CRPT,0

Explanation: The SOHRPT is always calculated based on the latest RPT capacity referenced to the first RPT capacity.

1. INOM = CNOM / h  
   Explanation: Currents INOM are always based on the nominal cell capacity (CNOM) and do not change throughout the test duration.
2. IRPT = CRPT / h if CRPT < CNOM

IRPT = INOM if CRPT ≥ CNOM

IRPT = INOM before conduction of any RPT procedure

Explanation: Currents IRPT shall generally be based on the capacity of the latest RPT procedure (CRPT). In case the measured value of CRPT is higher than CNOM, the currents of IRPT shall be calculated based on CNOM and therefore equal the current INOM. This is to prevent high currents outside of the specified operating window.  
Additionally, in case an IRPT current is to be applied on a fresh cell that has not experienced any RPT procedure so far, IRPT shall also equal INOM.

1. Current Derating  
   Explanation: Unless otherwise specified, the applied current shall be derated in case the currents violate the operating window at any SOC for a given temperature throughout the charging or discharging process.

## Specific Description of the Test / Testplan

Table 2: Quick charge cycling procedure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Step** | **Command** | **Parameter** | **Exit Condition** | **Comment** |
|  | **CYCLE-START-1** |  |  | **Pre-Cycle** |
|  | Set Temperature | *T* = 25 °C |  | Set temperature of climate chamber to 25°C |
|  | Rest |  | *t* > 30 min\* | Resting time for thermal relaxation of the cell.  \*Rest the cell for each Kelvin temperature difference (difference initial climate chamber temperature to set climate chamber temperature) 6 min, at least 30 min. |
|  | Discharge | *I* = INOM/3 | *V* < Vdyn,min | CC part of CCCV discharge |
|  | Discharge | *V* = Vdyn,min | *I* < 0.05⋅ INOM | CV part of CCCV discharge |
|  | Rest |  | *t* > 30 min |  |
|  | Charge | *I* = IRPT/3 | *V* > Vdyn,max | CC part of CCCV charge. |
|  | Charge | *V* = Vdyn,max | *I* < 0.05⋅ IRPT | CV part of CCCV charge |
|  | Set | Ah-Set = 0 |  | A fully charged cell is defined as 0 Ah. |
|  | Rest |  | *t* > 30 min |  |
|  | **CYCLE-END-1** | **COUNT = 1** |  |  |
|  | **CYCLE-START-2** |  |  | **CRPT Determination** |
|  | Discharge | *I* = INOM /3 | *V* < Vdyn,min | CC part of CCCV discharge |
|  | Discharge | *V* = Vdyn,min | *I* < 0.05⋅ INOM | CV part of CCCV discharge.  Determination of CRPT: Set CRPT to the combined CCCV capacity of steps 13 and 14. |
|  | Rest |  | *t* > 30 min |  |
|  | **CYCLE-END-2** | **COUNT = 1** |  |  |
|  | **CYCLE-START-3** |  |  | **Cycle for quick charging** |
|  | Charge | I = C/3\* | Ah-Set > -(1 - x).CRPT | C/3 charge for setting the start SOC to xx % based on *CRPT,* accordingto Table 3.  \*If necessary, derate the C-rate according to operating window. |
|  | Rest |  | *t* > 30 min |  |
|  | Set Temperature | T= xx°C |  | Set the temperature according to Table 3. |
|  | Rest |  | *t* > 60 min\* | Resting time for thermal relaxation of the cell.  \*Rest the cell for each Kelvin temperature difference (difference initial climate chamber temperature to set climate chamber temperature) 6 min, at least 60 min. |
| 1. s | Charge | I = Imax\*  P = Pmax\* | Ah-Set > -(1 - x).CRPT | Quick charge cycle to xx % end SOC based on *CRPT,* accordingto **Error! Reference source not found.**3.  \*Imax and Pmax has to be adjusted according to project specifications. Operating window shall not be violated. |
|  | Rest |  | *t* > 30 min |  |
|  | Set Temperature | *T* = 25 °C |  | Set temperature of climate chamber to 25°C |
|  | Rest |  | *t* > 60 min\* | Resting time for thermal relaxation of the cell.  \*Rest the cell for each Kelvin temperature difference (difference initial climate chamber temperature to set climate chamber temperature) 6 min, at least 60 min. |
|  | Discharge | *I* = INOM/3 | *V* < Vdyn,min | CC part of CCCV discharge |
|  | Discharge | *V* = Vdyn,min | *I* < 0.05⋅ INOM | CV part of CCCV discharge |
|  | Rest |  | *t* > 30 min |  |
|  | **CYCLE-END-3** | **COUNT = 1** |  | **Repeat CYCLE-3 according to required temperatures.**  **End of Measurement is reached, if quick charging test is conducted for all temperatures.** |

Quick charge profile

* The conditions of each profile are given in **Error! Reference source not found.**3.
* \*Imax, Pmax: The cell has to be operated within the operation window (given by the supplier) all the time.
* Pass criteria are specified in the given reference (see Table 3).

Table 3: Parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cycling Profile number** | **TSet / °C** | **Max. Charging Time** | **Start SOC** | **End SOC** | **Reference** |
| 1 | 0 | < 25 min | 10 | 80 | S-CRS-Cell-22006 |
| 2 | 25 | < 21 min | 20 | 60 | S-CRS-Cell-23954 |
| 3 | 40 | < 30 min | 30 | 90 | S-CRS-Cell-22004 |

# Evaluation and reports

All measuring data shall be provided according to measurement data specification DTC-O-2 as per the latest version.

Please provide plots as test report according to DTC-O–3.The data tables pertaining to plots shall be provided in excel format according to DTC-O-7.