**Test Specification for Internal Resistances**

**(BCC)**

Project-ID: -

Sample phase: -

Supplier: -

Version:-

**Daimler Truck AG**

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Release and Version history

Table 1: Version history

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Version** | **Date** | **Change** | **Sections**  **/Test-ID** | **Author** | **Released** |
| 1.0 | 15.03.2024 | Creation of document. Document is based on former OAD-371 V2.3 (05.01.2024) | All | C. Subramanian; T. Herdt |  |
| 1.1 | 24.01.2025 | Temperature control has been optimized, content of the table has been reorganized and one pulse has been removed | All | K. Talukdar, S. Bauknecht And T. Herdt |  |
| T.B.D | \_\_ | Ignore the discharge/charge pulses where the difference in current is less the 5%. |  |  |  |

**Table of contents**

[1 Aim of the document 3](#_Toc188866073)

[2 List of abbreviations 3](#_Toc188866074)

[3 List of references 4](#_Toc188866075)

[4 Test Description 4](#_Toc188866076)

[4.1 Test equipment and setup 4](#_Toc188866077)

[4.2 General Definitions for Internal resistance/maximal power 4](#_Toc188866078)

[4.3 Internal resistances 5](#_Toc188866079)

[4.4 Specific Description of the Test / Testplan 7](#_Toc188866080)

[5 Evaluation and reports 10](#_Toc188866081)

[6 Appendix 11](#_Toc188866082)

# Aim of the document

The aim of this test specification is to know internal resistance on Li-Ion cells according to a standardized 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

xcharge Multiplier for Applied Charging Current (“C-rate”)

xdischarge Multiplier for Applied Discharging Current (“C-rate”)

SOCset Supporting points of SOC to be tested

# 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 determines the internal resistances of the cell at different temperatures, SOC stages and pulse currents in charge and discharge direction.

## Test equipment and setup

* Climate chamber: **-20°C** to **45 °C**
* DC-converter: **2.2 C**

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 Internal resistance/maximal power

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.

## Internal resistances

Internal resistances are required for pulse times of **1, 10, 15, 20, 30 s** with the following parameters:

Table 2: Basic conditions/definition of parameters

|  |  |
| --- | --- |
| T1, 2, 3,… / °C | 25, 45, 10, 0, -10, -20 |
| SOCset / % (based on *Crpt*) | 100, 95, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, 0 |
| I1 | 0.1C |
| I2 | 0.5C |
| I3 | 1 C |
| I4 | 1\*Imax\* (cont.) |
| I5 | 1 \*Imax\* (pulse) |
| tpulse (total pulse time = longest single pulse time) | 30 s1 |
| Direction | Discharging and Charging |

**1**Within the total pulse time the current has to be constant (no derating). If this current is higher than the definition in operating window, a lower current value shall be defined to realize a constant current discharge/charge for the whole pulse duration.

* Imax is minimum of the allowed Imax, plating and Imax, thermal

Table 3: Pulse sequence in charge or discharge direction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Order | 1 | 2 | 3 | 4 | 5 |
| Pulse duration | 30 s | 30 s | 30 s | 30 s | 30 s |
| Discharge Direction Current | *-I1* | *-I2* | *-I3* | *-I4* | *-I5* |
| Charge Direction Current | *I1* | *I2* | *I3* | *I4* | *I5* |

* The pulse current starting at a specified SOC shall be constant over the complete pulse duration

Measurement of capacity at defined temperature X°C

Set temperature to 25°C and SOC 0% measured at X°C tmp

Set the temperature to 25°C to chrage the cell to 100% SOC

Loop 1: Pre cycles

Loop 3 : Pulse Test

Loop 4: Repeat outstanding or skipped SOC adjustment

Set temperature to X°C tmp

Loop 2: CRPT measurement

Loop 5: Adjust SOC steps (skip if SOC < SOC step) for discharge pulses

Loop 6: Discharge pulse sequence

Loop 7: Adjust SOC steps (skip if SOC > SOC step) for charge pulses

Loop 8: Charge pulse sequence

Figure 1: Test loops scheme.

## Specific Description of the Test / Testplan

Table 4: Test procedure for the determination of internal resistances

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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* > 6 h |  |
|  | **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* > 6 h |  |
|  | **CYCLE-END-2** | **COUNT = 1** |  |  |
|  | **CYCLE-START-3** |  |  | **Resistances for different temperatures** |
|  | 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-START-4** |  |  | **CRPT,X°C Determination** **at specific temperature T1, 2, 3 …….** |
|  | Set Temperature | T = xx |  | Set temperature of climate chamber to T1, 2, 3….°C (see order Table 2). |
|  | 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.  Determination of Discharging Capacity at T1, 2, 3 ….. °C temperature to measure exact SOC at temperature X°C: Set C=C\_RPT,X°C to the combined CCCV capacity of steps 26 and 27. |
|  | Rest |  | *t* > 30 min |  |
|  | **CYCLE-END-4** | COUNT = 1 |  | n4 cycles of cycles of the capacity measurement step at any given temperature |
|  | **CYCLE-START-5** |  |  | **Charging cell at 25°C before performing pulses at specific temperature** |
|  | 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. |
|  | 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 |
|  | Rest |  | *t* > 30 min |  |
|  | **CYCLE-START-6** |  |  | **Discharge resistances for different SOC at given temperature** |
|  | Set Temperature | T = xx |  | Set climate chamber to T1, 2, 3, …(see order Table 2\*). |
|  | Rest |  | *t* > 60 min\* | Resting time for thermal relaxation of the cell.  \*Rest the cell for each Kelvin temperature difference 6 min, at least 60 min. |
|  | Discharge | *I* = INOM /3  V = Vdyn,min | *Ah-Set <* -X CRPT  I < 0.05⋅ INOM | Adjust the SOC of the cell to the required SOCset based on the capacity measured at specific temperature T1, 2, 3 …. and CRPT  \*Start at the highest SOC (see order Table 2\*).  If the actual SOC of the cell corresponds to a lower value than the required SOC stage (SOCset), then adjust the SOC of the cell to the next lower SOC stage (SOCset). |
|  | **CYCLE-START-7** |  |  | **Discharge LOOP for discharge pulses at given SOC** |
|  | Discharge | I = xx | t > *tPulse*  V < Vdyn,min  Ah-Set < -X *CRPT* | Discharge pulse according to pulse sequence (see Table 3)  \*Start with discharge pulse I1 (see order 2\*).  Do not apply a discharge pulse at 0 % SOC. |
|  | Rest |  | *t* > 60 min | Time step in an open circuit, no current flux. |
|  | **CYCLE-END-7** | **COUNT = n4** |  | **n4 cycles for the different pulses/currents at given SOC (see order, Table 2\*)** |
|  | **CYCLE-END-6** | **COUNT = n3** |  | **n3 SOC steps which were missed during the first run of cycle 6 shal be repeated after finshing cycle 5 once (after charge pulse test part)** |
|  | 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 |  |
|  | **CYCLE-START-8** |  |  | **Charge resistances for different SOC at given temperature** |
|  | Set Temperature | T = xx |  | Set climate chamber to T1, 2, 3, …(see order Table 2\*). |
|  | 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 30 min. |
|  | Charge | *I* = IRPT/3  *V* = Vdyn,max | *Ah-Set >* -X CRPT  *I* < 0.05⋅ IRPT | Adjust the SOC of the cell to the required SOCset based on the capacity measured CRPT,X°C at specific temperature T1, 2, 3 ….  \*Start @ the lowest SOC (SOCset) (see order Table 2\*).  If the actual SOC of the cell corresponds to a higher value than the required SOC stage (SOCset,), than adjust the SOC of the cell to the next higher SOC stage (SOCset,) . |
|  | Rest |  | *t* > 60 min\* | Resting time for thermal relaxation of the cell.  \*Rest the cell for each Kelvin temperature difference 6 min, at least 60 min. |
|  | **CYCLE-START-9** |  |  | **Charge LOOP for charge pulses at given SOC** |
|  | Charge | I = xx | *t* > *tPulse*  *V* > Vdyn,max  Ah-Set > 0 | Charge pulse according to pulse sequence (see Table 3).  \*Start with charge pulse I1 (see order 2\*).  Do not apply a charge pulse at 100 % SOC. |
|  | Rest |  | *t* > 60 min | Time step in an open circuit, no current flux. |
|  | **CYCLE-END-9** | **COUNT = n4** |  | **n4 cycles for the different pulses/currents at given SOC (see order, Table 2\*)** |
|  | **CYCLE-END-8** | **COUNT = n3** |  | **n3 SOC steps which were missed during the frist run of cycle 6 shal be repeated after finshing cycle 5 once (after charge pulse test part)** |
|  | **CYCLE-END-5** | **COUNT =n2** |  | **Please finish the pulses at remaining SOC in both discharge and charge directions. n2 cycles of charging steps for measurement of discharge resistance at given SOC** |
|  | 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. |
|  | **CYCLE-END-3** | **COUNT = n1** |  | **n1 cycles according to T (T1, 2, 3, …) stages**  **End of measurement is reached after carrying out the resistance measurements @ all SOCs and temperatures** |
|  | 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. |

# 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.

# Appendix

Table 2\*: Stepwise defined paramets

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tset / °C** | **SoCRPT, Set / %** | **I/A** | ***tpulse*/ s** | **CH/DCH** | **No. of cycles** |
| 25 | 100 | 0.1C | 30 | DCH | 1 |
| 25 | 100 | 0.5 | 30 | DCH | 1 |
| 25 | 100 | 1C | 30 | DCH | 1 |
| 25 | 100 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 100 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 90 | 0.1C | 30 | DCH | 1 |
| 25 | 90 | 0.5 | 30 | DCH | 1 |
| 25 | 90 | 1C | 30 | DCH | 1 |
| 25 | 90 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 90 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 80 | 0.1C | 30 | DCH | 1 |
| 25 | 80 | 0.5 | 30 | DCH | 1 |
| 25 | 80 | 1C | 30 | DCH | 1 |
| 25 | 80 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 80 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 70 | 0.1C | 30 | DCH | 1 |
| 25 | 70 | 0.5 | 30 | DCH | 1 |
| 25 | 70 | 1C | 30 | DCH | 1 |
| 25 | 70 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 70 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 10 | 0.1C | 30 | CH | 1 |
| 25 | 10 | 0.5 | 30 | CH | 1 |
| 25 | 10 | 1C | 30 | CH | 1 |
| 25 | 10 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 10 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 25 | 20 | 0.1C | 30 | CH | 1 |
| 25 | 20 | 0.5 | 30 | CH | 1 |
| 25 | 20 | 1C | 30 | CH | 1 |
| 25 | 20 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 20 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 25 | 30 | 0.1C | 30 | CH | 1 |
| 25 | 30 | 0.5 | 30 | CH | 1 |
| 25 | 30 | 1C | 30 | CH | 1 |
| 25 | 30 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 30 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 25 | 40 | 0.1C | 30 | CH | 1 |
| 25 | 40 | 0.5 | 30 | CH | 1 |
| 25 | 40 | 1C | 30 | CH | 1 |
| 25 | 40 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 40 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 25 | 95 | 0.1C | 30 | DCH | 1 |
| 25 | 95 | 0.5 | 30 | DCH | 1 |
| 25 | 95 | 1C | 30 | DCH | 1 |
| 25 | 95 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 95 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 15 | 0.1C | 30 | DCH | 1 |
| 25 | 15 | 0.5 | 30 | DCH | 1 |
| 25 | 15 | 1C | 30 | DCH | 1 |
| 25 | 15 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 15 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 5 | 0.1C | 30 | DCH | 1 |
| 25 | 5 | 0.5 | 30 | DCH | 1 |
| 25 | 5 | 1C | 30 | DCH | 1 |
| 25 | 5 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 25 | 5 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 25 | 5 | 0.1C | 30 | CH | 1 |
| 25 | 5 | 0.5 | 30 | CH | 1 |
| 25 | 5 | 1C | 30 | CH | 1 |
| 25 | 5 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 5 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 25 | 15 | 0.1C | 30 | CH | 1 |
| 25 | 15 | 0.5 | 30 | CH | 1 |
| 25 | 15 | 1C | 30 | CH | 1 |
| 25 | 15 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 15 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 25 | 95 | 0.1C | 30 | CH | 1 |
| 25 | 95 | 0.5 | 30 | CH | 1 |
| 25 | 95 | 1C | 30 | CH | 1 |
| 25 | 95 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 25 | 95 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 100 | 0.1C | 30 | DCH | 1 |
| 45 | 100 | 0.5 | 30 | DCH | 1 |
| 45 | 100 | 1C | 30 | DCH | 1 |
| 45 | 100 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 100 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 90 | 0.1C | 30 | DCH | 1 |
| 45 | 90 | 0.5 | 30 | DCH | 1 |
| 45 | 90 | 1C | 30 | DCH | 1 |
| 45 | 90 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 90 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 80 | 0.1C | 30 | DCH | 1 |
| 45 | 80 | 0.5 | 30 | DCH | 1 |
| 45 | 80 | 1C | 30 | DCH | 1 |
| 45 | 80 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 80 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 70 | 0.1C | 30 | DCH | 1 |
| 45 | 70 | 0.5 | 30 | DCH | 1 |
| 45 | 70 | 1C | 30 | DCH | 1 |
| 45 | 70 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 70 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 20 | 0.1C | 30 | CH | 1 |
| 45 | 20 | 0.5 | 30 | CH | 1 |
| 45 | 20 | 1C | 30 | CH | 1 |
| 45 | 20 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 20 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 30 | 0.1C | 30 | CH | 1 |
| 45 | 30 | 0.5 | 30 | CH | 1 |
| 45 | 30 | 1C | 30 | CH | 1 |
| 45 | 30 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 30 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 40 | 0.1C | 30 | CH | 1 |
| 45 | 40 | 0.5 | 30 | CH | 1 |
| 45 | 40 | 1C | 30 | CH | 1 |
| 45 | 40 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 40 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 50 | 0.1C | 30 | CH | 1 |
| 45 | 50 | 0.5 | 30 | CH | 1 |
| 45 | 50 | 1C | 30 | CH | 1 |
| 45 | 50 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 50 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 95 | 0.1C | 30 | DCH | 1 |
| 45 | 95 | 0.5 | 30 | DCH | 1 |
| 45 | 95 | 1C | 30 | DCH | 1 |
| 45 | 95 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 95 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 15 | 0.1C | 30 | DCH | 1 |
| 45 | 15 | 0.5 | 30 | DCH | 1 |
| 45 | 15 | 1C | 30 | DCH | 1 |
| 45 | 15 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 15 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 5 | 0.1C | 30 | DCH | 1 |
| 45 | 5 | 0.5 | 30 | DCH | 1 |
| 45 | 5 | 1C | 30 | DCH | 1 |
| 45 | 5 | 1\*Imax\* (cont.) | 30 | DCH | 1 |
| 45 | 5 | 1 \*Imax\* (pulse) | 30 | DCH | 1 |
| 45 | 5 | 0.1C | 30 | CH | 1 |
| 45 | 5 | 0.5 | 30 | CH | 1 |
| 45 | 5 | 1C | 30 | CH | 1 |
| 45 | 5 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 5 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 15 | 0.1C | 30 | CH | 1 |
| 45 | 15 | 0.5 | 30 | CH | 1 |
| 45 | 15 | 1C | 30 | CH | 1 |
| 45 | 15 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 15 | 1 \*Imax\* (pulse) | 30 | CH | 1 |
| 45 | 95 | 0.1C | 30 | CH | 1 |
| 45 | 95 | 0.5 | 30 | CH | 1 |
| 45 | 95 | 1C | 30 | CH | 1 |
| 45 | 95 | 1\*Imax\* (cont.) | 30 | CH | 1 |
| 45 | 95 | 1 \*Imax\* (pulse) | 30 | CH | 1 |