BS EN 50342-6:2015

BSI Standards Publication

Lead-acid starter batteries

Part 6: Batteries for Micro-Cycle Applications

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 50342-6:2015.

The UK participation in its preparation was entrusted to Technical Committee PEL/21, Secondary cells and batteries.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 83856 9

ICS 29.220.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 December 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50342-6

November 2015

ICS 29.220.20

English Version

Lead-acid starter batteries - Part 6: Batteries for Micro-Cycle Applications

Batteries d'accumulateurs de démarrage au plomb - Partie 6: Batteries pour applications micro-cycles

Blei-Akkumulatoren-Starterbatterien - Teil 6 : Batterien für Mikrozyklen-Anwendungen

This European Standard was approved by CENELEC on 2015-10-05. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Contents

Page

European foreword ... 4
1 Scope ... 5
2 Normative references ... 5
3 General ... 5
3.1 Designation of starter batteries ... 5
3.2 Condition on delivery ... 5
4 General requirements — Identification and labelling ... 5
5 General test conditions ... 6
5.1 Characteristics and abbreviations ... 6
5.1.1 Nominal capacity C_n ... 6
5.1.2 Cranking current I_{CC} ... 6
5.2 Syntax of test descriptions ... 6
5.3 Requirements for measuring equipment capability ... 8
5.3.1 Equipment requirements for the micro-hybrid test MHT (7.2) ... 8
5.3.2 Equipment requirements for the dynamic charge acceptance test DCA (7.3) ... 9
5.3.3 Water bath ... 9
5.3.4 Equipment for other tests, measuring instruments ... 9
5.4 Sampling of batteries ... 9
6 Test sequence ... 9
7 Inspections and test procedures ... 11
7.1 Charging of batteries ... 11
7.2 Micro-hybrid test (MHT) ... 11
7.2.1 Purpose ... 11
7.2.2 Procedure ... 11
7.2.3 Battery preparation ... 11
7.2.4 Micro-cycles ... 11
7.2.5 Check-up after cycling ... 12
7.2.6 Data evaluation ... 13
7.3 Dynamic Charge acceptance test (DCA) ... 13
7.4 Endurance in cycle test with 17,5 % depth of discharge (DoD) ... 17
7.5 Endurance in cycle test with 50 % depth of discharge (DoD) at 40 °C and preceded deep discharge ... 18
8 Requirements and battery performance levels ... 20
8.1 General ... 20
8.2 Tests to be passed (no performance differentiation) ... 20
8.3 Tests determining the micro-cycle performance level ... 21
Annex A (normative) Flow charts of DCA test procedure, 7.3 ... 22
Annex B (normative) Marking / Labelling of Batteries ... 26
Bibliography ... 27

Tables

Table 1 — Test steps ... 6
Table 2 — Description of columns ... 7
Table 3 — Acronyms and Symbols ... 8
Table 4 — Equipment requirements for the micro-hybrid test MHT ... 8
Table 5 — Equipment requirements for the dynamic charge acceptance test DCA ... 9
Table 6 — Test sequence ... 10
Table 7 — MHT – Battery preparation ... 11
Table 8 — MHT – Micro-cycle ... 12
Table 9 — MHT – Check-up after cycling ... 12
Table 10 — DCA – Pre-cycling ... 14
Table 11 — DCA – Charge Acceptance qDCA procedure ... 14
Table 12 — DCA – The DCA_{pp} procedure ... 15
Table 13 — DCA – The DCR_{ss} part ... 16
Table 14 — Endurance 17,5 % DoD – Cycling units ... 18
Table 15 — Endurance 50 % DoD – Deep discharge part ... 19
Table 16 — Endurance 50 % DoD – Cycling part ... 20
Table 17 — Requirements of tests to be passed ... 21
Table 18 — Requirements of tests determining the micro-cycle performance level M1…M3 ... 21

Figures

Figure 1 — Sub-phases of the DCRss part ... 17
Figure B.1 — Optional Start-Stop logo ... 26

European foreword

This document (EN 50342-6:2015) has been prepared by CLC/TC 21X “Secondary cells and batteries”.

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-10-05
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2018-10-05

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

EN 50342, *Lead-acid starter batteries*, is currently composed of the following parts:

— *Part 1: General requirements and methods of test* [currently at Formal Vote stage];

— *Part 2: Dimensions of batteries and marking of terminals*;

— *Part 3: Terminal system for batteries with 36 V nominal voltage*;

— *Part 4: Dimensions of batteries for heavy vehicles*;

— *Part 5: Properties of battery housings and handles*;

— *Part 6: Batteries for Micro-Cycle Applications* [the present document];

— *Part 7: General requirements and methods of tests for motorcycle batteries* [currently at Formal Vote stage].

1 Scope

This European Standard is applicable to lead-acid batteries with a nominal voltage of 12 V, used primarily as power source for the starting of internal combustion engines (ICE), lighting and also for auxiliary equipment of ICE vehicles. These batteries are commonly called “starter batteries”. Batteries with a nominal voltage of 6 V are also included in the scope of this standard. All referenced voltages need to be divided by two for 6 V batteries. The batteries under scope of this standard are used for micro-cycle applications in vehicles which can also be called Start-Stop (or Stop-Start, idling-stop system, micro-hybrid or idle-stop-and-go) applications. In cars with this special capability, the internal combustion engine is switched off during a complete vehicle stop, during idling with low speed or during idling without the need of supporting the vehicle movement by the internal combustion engine. During the phases in which the engine is switched off, most of the electric and electronic components of the car need to be supplied by the battery without support of the alternator. In addition, in most cases an additional regenerative braking (recuperation or regeneration of braking energy) function is installed. The batteries under these applications are stressed in a completely different way compared to classical starter batteries. Aside of these additional properties, those batteries need to crank the ICE and support the lighting and also auxiliary functions in a standard operating mode with support of the alternator when the internal combustion engine is switched on. All batteries under this scope need to fulfil basic functions, which are tested under application of EN 50342-1:2015.

This European Standard is applicable to batteries for the following purposes:

- Lead-acid batteries of the dimensions according to EN 50342-2 for vehicles with the capability to automatically switch off the ICE during vehicle operation either in standstill or moving (“Start-Stop”);
- Lead-acid batteries of the dimensions according to EN 50342-2 for vehicles with Start-Stop applications with the capability to recover braking energy or energy from other sources.

This standard is not applicable to batteries for purposes other than mentioned above, but it is applicable to EFB delivered in dry-charged conditions according to EN 50342-1:2015, Clause 7.

NOTE The applicability of this standard also for batteries according to EN 50342-4 is under consideration.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50342-1:2015, *Lead-acid starter batteries — Part 1: General requirements and methods of test*

3 General

3.1 Designation of starter batteries

Regarding the designation of starter batteries, refer to EN 50342-1:2015, 3.2.

3.2 Condition on delivery

Regarding the condition on delivery, refer to EN 50342-1:2015, 3.3.

4 General requirements — Identification and labelling

The batteries shall be identified according to the legal demands within the European community.

NOTE The regulations of the battery directive 2006/66/EC and the amendment 2008/12/EC or their equivalent national laws need to be applied.

For detailed information about measurement and labelling EN 50342-1 shall be used.

In addition to the mandatory information defined in EN 50342-1:2015, 4.1 and Annexes A and C, the battery shall be marked with the micro-cycling performance level according to this standard (8.3).

For better identification and comparison of batteries under the scope of this standard, a special marking specified in Annex B shall be used by the battery manufacturer.

5 General test conditions

5.1 Characteristics and abbreviations

5.1.1 Nominal capacity C_n

Refer to EN 50342-1:2015, 3.4.2.

5.1.2 Cranking current I_{CC}

Refer to EN 50342-1:2015, 3.4.1.

5.2 Syntax of test descriptions

The test description is given in tabular form. All test steps shall be carried out in a water bath according to 5.3.3 at the given temperature, if not stated otherwise.

The following definitions and acronyms are used:

Test steps:

Table 1 — Test steps

Acronym	*Test step*	*Description*
CHA	Charge	Battery to be charged with given parameters
DCH	Discharge	Battery to be discharged with given parameters
PAU	Pause	No charging or discharging but measurement of voltage as required. If the battery is connected to the test unit, there shall be no quiescent current.
RPT	Repeat	Instruction to repeat certain steps several times
CAS	Case of	Decision point leading to different actions dependent on the value of the reference variable

Description of columns:

Table 2 — Description of columns

<table>
<tr><th>Column text</th><th>Description</th></tr>
<tr><td>Structure</td><td>General explanation of test block</td></tr>
<tr><td>N°</td><td>Numbering of individual test steps</td></tr>
<tr><td>Step</td><td>Definition of test phase of individual step according to Table 1.
NOTE All steps in each table are numbered subsequently starting at “10” The next table of the same section starts at “20”, etc.
Example:
<table>
<tr><td>10</td><td>Action 1</td></tr>
<tr><td>11</td><td>Action 2</td></tr>
<tr><td>12</td><td>Action 3</td></tr>
<tr><td></td><td></td></tr>
</table>
<table>
<tr><td>20</td><td>Action 1</td></tr>
<tr><td>21</td><td>Action 2</td></tr>
<tr><td>22</td><td>Action 3</td></tr>
<tr><td>23</td><td>Action 4</td></tr>
</table>
</td></tr>
<tr><td>T</td><td>Duration of the individual step in days [d], hours [h] or seconds [s]</td></tr>
<tr><td>U [V]</td><td>Voltage in Volts to be maintained during the step.
In case of a “CHA” phase, this is the constant charging voltage to be given by the rectifier.
In case of a “DCH” phase, this is a cut off criteria at which the phase shall be stopped for the defined current.</td></tr>
<tr><td>I [A]</td><td>Current in Ampere to be maintained during the step.
In case of a “CHA” phase, this is a current limitation for this step.
In case of a “DCH” phase this is the constant discharge current to be given by the rectifier</td></tr>
<tr><td>Description</td><td>Explanation of individual test step</td></tr>
<tr><td>Data acquisition frequency</td><td>Recommended data acquisition frequency</td></tr>
<tr><td>Result of measurement of each step</td><td>Final result of the individual test step to be reported</td></tr>
</table>

Acronyms and symbols:

Table 3 — Acronyms and Symbols

Acronym or Symbol	*Description*	*Acronym or Symbol*	*Description*
C_e	Effective capacity [Ah]	I_c	Average charge current in DCA test after charge history [A]
C_n	Nominal capacity [Ah]	I_d	Average charge current in DCA test after discharge history [A]
C_{rch}	Recharged capacity [Ah]	I_r	Average charge current in DCA test during regenerative braking [A]
DoD	Depth of discharge [% of C_n]	Q_{CHA}	Charged capacity [Ah]
EOS	End of step	Q_{DCH}	Discharged capacity [Ah]
I_{CHA}	Charge current [A]	R_{dyn}	Calculated dynamic internal resistance [Ω]
I_{CC}	Discharge current for cranking[A]	R_i	Internal resistance [Ω]
I_{DCA}	Weighted normalized dynamic charge acceptance, measured in A per Ah nominal capacity C_n [A/Ah]	RC	Reserve capacity (discharge with a fixed current of 25 A to U = 10,5 V), used in DCA test, subsection 7.3
I_{DCH}	Discharge current [A]	t_{DCH}	Discharge time [s]
I_n	Nominal discharge current [A] I_n [A] = C_n [Ah] / 20 [h]	U_c	Charging voltage [V]

5.3 Requirements for measuring equipment capability

5.3.1 Equipment requirements for the micro-hybrid test MHT (7.2)

Table 4 — Equipment requirements for the micro-hybrid test MHT

Parameter	*Range*	*Accuracy*	*Sampling rate*	*Sampling accuracy*
U_{CHA}	14…16 V	±0,04 V	10 ms	±0,01 V
I_{CHA}	0…100 A	±0,5 %	10 ms	±0,1 %
Q_{CHA}			10 ms	±1 mAh
U_{DCH}	6...14 V		10 ms	±0,01 V
I_{DCH}	0...300 A with 300 A t_{DCH} ≥ 1s every minute, transition time < 0,01 s	±0,5 %	10 ms	±0,1 %
Q_{CHA}			10 ms	±1 mAh

5.3.2 Equipment requirements for the dynamic charge acceptance test DCA (7.3)

Table 5 — Equipment requirements for the dynamic charge acceptance test DCA

Parameter	*Range*	*Accuracy*	*Sampling rate*	*Sampling accuracy*
U_{CHA}	14…18 V	±0,04 V	200 ms	±0,01 V
I_{CHA}	0…200 A	±0,5 %	200 ms	±0,1 %
Q_{CHA}			10 ms	±1 mAh
U_{DCH}	6...14 V		200 ms	±0,01 V
I_{DCH}	0...100 A	±0,5 %	200 ms	±0,1 %
Q_{CHA}			10 ms	±1 mAh

Computer controlled unit needed with the ability to use integrated charge balance (e.g. Q_{CHA} and Q_{DCH}) for terminating discharge steps. The software shall be able to output the information in the format of standard table calculation programs or special software to output tables or graphs.

5.3.3 Water bath

Refer to EN 50342-1:2015, 5.3.2.

5.3.4 Equipment for other tests, measuring instruments

Refer to EN 50342-1:2015, 5.3.1.

5.4 Sampling of batteries

Refer to EN 50342-1:2015, 5.1.

6 Test sequence

The test sequence is shown in Table 6.

The total number of 4 batteries shall be tested according to the test sequence of Table 6. The requirements of C_e capacity check and cranking performance test shall be fulfilled according to the requirements defined in EN 50342-1.

In addition, more batteries shall be tested according to EN 50342-1:2015, 5.4. Refer to the test sequence given there, with one exception:

- Test battery sample No. 4 undergoes a 50 % DoD test with preceding discharge. This test replaces the endurance cycling test defined in EN 50342-1:2015, 5.4, battery sample No. 1, which may be omitted.

Table 6 — Test sequence

No.	***Test Sequence***	***Test Procedure***	***Sample No.***			
			1	***2***	***3***	***4***
1	Initial charge prior to test	EN 50342–6:2015, 7.1	×	×	×	×
2	Capacity check C_e	EN 50342–1:2015, 6.1	×		×	×
3	Cranking performance test	EN 50342–1:2015, 6.2			×	
4	Capacity check C_e	EN 50342–1:2015, 6.1			×	
5	Cranking performance test	EN 50342–1:2015, 6.2			×	
6	Capacity check C_e	EN 50342–1:2015, 6.1			×	
7	MHT (micro-hybrid test)	EN 50342–6, 7.2	×			
8	DCA test	EN 50342–6:2015, 7.3		×		
9	Endurance test 17,5 % DoD	EN 50342–6:2015, 7.4			×	
10	Deep discharge 7 d	EN 50342–6:2015, 7.5.3				×
11	Rest time 1 to 4 days	EN 50342–6:2015, 7.5.4				×
12	Capacity check C_e	EN 50342–1:2015, 6.1				×
13	Cranking performance test	EN 50342–1:2015, 6.2				×
14	Endurance test 50 % DoD	EN 50342–6:2015, 7.5.5				×
15	High current discharge test, low T	EN 50342–1:2015, 6.3				×
16	Capacity check C_e	EN 50342–1:2015, 6.1				×

7 Inspections and test procedures

7.1 Charging of batteries

All tests shall commence with fully charged batteries. Refer to EN 50342-1:2015, 5.2.

7.2 Micro-hybrid test (MHT)

7.2.1 Purpose

This test checks the ability of a battery to provide the power to restart the engine after frequent stop phases, its ability to recover state of charge afterwards and the aging effects due to shallow pulse loads.

7.2.2 Procedure

During the entire test procedure, the battery shall be placed into a water bath at 25 ± 2 °C, according to 5.3.3. The micro-hybrid test is divided into three sections:

a) Battery preparation (set SoC to 85 %, 7.2.3)

b) Micro-cycles (7.2.4: 80 units with 100 cycles each = 8 000 cycles in total)

c) Check up after cycling (7.2.5)

7.2.3 Battery preparation

The battery shall be discharged to 85 % of nominal capacity according to Table 7.

Table 7 — MHT – Battery preparation

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
Set battery SoC to 85 %	10	DCH	3 h	> 10,5	C_e / 20	Discharge to 85 % of C_e	25		Q_{DCH}
	11	PAU	min 12 h max 60 h			Relaxation	25	EOS	U(EOS)

7.2.4 Micro-cycles

This high-rate cycling test often leads to an internal battery temperature significantly higher than 25 °C. This means the charging voltage of 14,0 V (step 21) is in line with typical vehicle operation parameters.

The micro-cycle test has a fixed depth of discharge of 2 % C_n. The charge time in step 21 (Table 8) and the discharge time in step 22 depend on the nominal capacity C_n of the battery and shall be calculated and rounded to nearest integer value in seconds according to:

$$t_{DCH}[s] = \frac{(0{,}02\ C_n[Ah] - 0{,}083\ Ah)}{48\ A} \cdot 3\,600\ \frac{s}{h}$$

Table 8 — MHT – Micro-cycle

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
Micro-cycle sequence	20	PAU	10 s			Relaxation	25	EOS	U(10s)
	21	CHA	1 + t_{DCH} [s]	14,0	100	Charge	25	EOS	I(EOS), Q_{CHA}(EOS)
	22	DCH	t_{DCH} [s]		48	Low rate discharge step	25	EOS	U(EOS), Q_{DCH}
	23	DCH	1 s	> 9,5	300	High rate discharge step	25	EOS	U(EOS), Q_{DCH}, R_{dyn}
	24	RPT				Run steps 20–23 100 times			
	25	PAU	12 h			Storage and cooling down after cycling	25	EOS	U(EOS)
	26	RPT				Run steps 20–25 80 times			

The dynamic internal resistance R_{dyn} shall be calculated from the load voltages of steps 22 and 23 of Table 8 according to:

$$R_{dyn}[\Omega] = \frac{U\left(EOS\right)_{48\ A}[V] - U\left(EOS\right)_{300\ A}[V]}{\left|48\ A - 300\ A\right|}$$

7.2.5 Check-up after cycling

The check-up procedure shall be performed according to Table 9 within 60 h after the end of the micro-cycling part (step 26 of Table 8).

Table 9 — MHT – Check-up after cycling

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
Check-up sequence after cycling	30	DCH		> 10,5	I_n	Remaining C_e capacity	25		C_e
	31	CHA	24 h	U_c	$5 \cdot I_n$	Charge	25		Q_{CHA}
	32	DCH		> 10,5	I_n	C_e capacity	25		C_e
	33	CHA	24 h	U_c	$5 \cdot I_n$	Charge	25		Q_{CHA}

7.2.6 Data evaluation

The following data evaluations shall be performed.

Data from cycling:	Mean R_{dyn}	Average of the R_{dyn} values of every block of 100 cycles
	Normalized mean R_{dyn}	The mean R_{dyn} values shall be normalized to the value found for the first block of 100 cycles for each battery (step 22 and step 23 of Table 8)
	Minimum $U(EOS)_{300A}$	Minimum value of the end of discharge voltages of the 300 A discharge step of every block of 100 cycles (step 23 of Table 8)
	U(EOS)	EOS voltage of each 12 h rest phase (step 25 of Table 8)
Data from check-up:	Remaining C_e	According to line 30 of Table 9
	C_e	According to line 32 of Table 9

7.3 Dynamic Charge acceptance test (DCA)

7.3.1 Purpose:

Batteries in Start-Stop applications shall be recharged in a short time frame to maintain energy balance during vehicle operation. To determine the dynamic charge acceptance capability therefore is necessary to differentiate between batteries suitable for Start-Stop and for standard applications. This test shall check the ability of a battery to adsorb current peaks at different SoC after charging or discharging operation as well as after simulated Start-Stop and regenerative braking operation. It shall indicate the decrease of dynamic charge acceptance under conditions of micro-cycle applications.

7.3.2 Procedure:

7.3.3 During the entire test procedure, the battery shall be placed into a water bath at 25 ± 2 °C, according to 5.3.3. This test consists of three consecutive parts:

- Pre-cycling (7.3.4)
- Charge acceptance tests qDCA delivering I_c and I_d (7.3.5 – 7.3.8)
- DCR_{ss} micro-cycling part delivering I_r (7.3.9 – 7.3.11)

The final result is calculated according to 7.3.12 by using results I_c, I_d and I_r. Flow charts of the test procedures are depicted in Annex A of this document.

Abbreviations used in this section:

- DCA – dynamic charge acceptance;
- qDCA – quick DCA test;
- DCA_{pp} – DCA pulse profile;
- DCR_{ss} – dynamic charge acceptance real world Start-Stop.

7.3.4 Pre-cycling shall be defined according to this scheme:

Table 10 — DCA – Pre-cycling

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*Data acquisition frequency*	*Result of measurement of each step*
Pre-cycling	10	DCH		> 10,5	25	RC discharge	EOS	RC capacity
	11	CHA	24 h	U_c	$5 \cdot I_n$	Recharge voltage for flooded / VRLA	EOS	Ah recharged End of charge current
	12	PAU	1 h			Relaxation		
	13	DCH		> 10,5	25	RC discharge	EOS	RC capacity
	14	CHA	24 h	U_c	$5 \cdot I_n$	Recharge voltage for flooded / VRLA	EOS	Ah recharged End of charge current
	15	PAU	1 h			Relaxation		
	16	DCH		> 10,5	$1 \cdot I_n$	C_e discharge	EOS	C_e Calculate: $C_{rch} = C_e – 0,2 \cdot C_n$
	17	CHA		U_c	$5 \cdot I_n$	Recharge voltage for flooded / VRLA		Stop recharge when C_{rch} [Ah] is reached

7.3.5 The charge acceptance qDCA procedure shall be defined according to the scheme of Table 11. The DCApp procedure used in steps 21 and 27 is defined in Table 12.

Table 11 — DCA – Charge Acceptance qDCA procedure

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*Data acquisition frequency*	*Result of measurement of each step*
Charge acceptance tests qDCA	20	PAU	min 20 h max 72 h			Rest phase	EOS	OCV
	21	DCA_{pp}				DCA_{pp} procedure acc. to 7.3.6	EOS	I_c = integrated charge / 200 s
	22	CHA	12 h	U_c	$5 \cdot I_n$	Recharge voltage for flooded / VRLA	EOS	
	23	CHA	4 h	18,0 / 14,8	$0,5 \cdot I_n$ / $5 \cdot I_n$	Recharge voltage for flooded / VRLA	EOS	
	24	PAU	1 h			Rest phase	EOS	
	25	DCH	2 h		I_n		EOS	
	26	PAU	20 h			Rest phase	EOS	
	27	DCA_{pp}				DCA_{pp} procedure acc. to 7.3.6	EOS	I_d = integrated charge / 200 s
	28	DCH	2 h		I_n		EOS	
	29	PAU	min 12 h max 72 h			Rest phase	EOS	

Step 23: For flooded batteries, a combination of constant voltage (CV) and constant current (CC) charging (with “unlimited” voltage) is applied. The given voltage limit of 18 V is meant as a safety limit.

Steps 21 and 27: The average charge currents I_c and I_d are calculated according to 7.3.7 and 7.3.8. Please note that both I_c and I_d are charge currents, the index “c” or “d” means “charge history” or “discharge history”.

7.3.6 The DCA_{pp} procedure (steps 21 and 27 of Table 11) shall be defined according to this scheme:

Table 12 — DCA – The DCA_{pp} procedure

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*Data acquisition frequency*	*Result of measurement of each step*
DCA_{pp} procedure	30	CHA	10 s	14,8	$33,3 \cdot I_n$	Charge pulse	EOS	Increment I_c or I_d by amount of charge ΔQ_i
	31	PAU	30 s			Rest phase		
	32	DCH			$20 \cdot I_n$	Discharge		Stop discharge when ΔQ_i [Ah] is reached (x = 1..20)
	33	PAU	30 s			Rest phase		
	34	RPT				Run steps 30 to 33 20 times		

7.3.7 The average charge current for the 20 pulses after preceded charging step 17 (I_c) is calculated from the integrated amount of charge over all pulses, divided by the total charge time (Table 11, step 21):

$$I_c[A] = \frac{\int_{I>0} Idt}{200\ s} = \frac{\sum_{i=1..20} Q_i}{200\ s}$$

NOTE Usually Q_i is calculated by the test bench and returned in units of Ah. I_c is calculated from the sum of the charged Ah values of the 20 steps by multiplying it with 3 600 s/h and dividing the result by 200 s.

7.3.8 The average charge current for the 20 pulses after preceded discharge step 25 (I_d) is calculated from the integrated amount of charge over all pulses, divided by the total charge time (Table 11, step 27):

$$I_d[A] = \frac{\int_{I>0} Idt}{200\ s} = \frac{\sum_{i=1..20} Q_i}{200\ s}$$

NOTE Usually Q_i is calculated by the test bench and returned in units of Ah. I_d is calculated from the sum of the charged Ah values of the 20 steps by multiplying it with 3600 s/h and dividing the result by 200 s.

7.3.9 For the DCR_{ss} test part, a resistor combination shall be connected across the battery terminals, consisting of a parallel connection of two E96 (1 %) resistors, each with minimum rated power dissipation of 0.25W, and each of which comes closest to 75000 Ω·Ah, divided by C_n. Verify and document the resistance of the parallel combination. Example: For C_n = 80 Ah, use two parallel resistors of 931Ω each, which – within the E96 series – comes closest to 75 000/80 Ω = 937,5 Ω, so that the total resistance of the combination of both resistors in parallel is 466 Ω in this example.

For Ah balance control during *DCR*ss, a modified Ah counter is used: The counter is set to zero in the beginning before connecting the resistor. It sums charged and discharged Ah by the test bench assuming a charge factor of 1 and compensates for the Ah drain by the external resistor (simulated key-off load) by calculating. The formulas are given in Annex A and in Table 13.

7.3.10 The DCR_{ss} part shall be defined according to this scheme:

Table 13 — DCA – The DCR_{ss} part

Structure	*N°*	*Step*	*T*	*U [V]*	*I [A]*	*Description*	*Data acquisition frequency*	*Result of measurement of each step*
DCR_{ss} cycling part	40	Connect the resistors						
	41	PAU	12 h			Correct Ah_balance by −0,45 % of C_n	1/h	
	42	DCH	30 s		$1 \cdot I_n$	Vehicle activation		
	43	DCH	3 s		100	Key engine crank		
	44	CHA	58 s	14,4	$33{,}3 \cdot I_n$	Conventional charging		
	45	CAS				Case Ah_balance/C_n of:		
		DCH	30 s		$1{,}25 \cdot I_n$	> 0,01		
		CHA	30 s	14,4	$33{,}3 \cdot I_n$	< −0,01		
		PAU	30 s			[-0,01..0,01]		
	46	CHA	5 s	15,0	$33{,}3 \cdot I_n$	Regenerative charging	1/s	Record amount of charge ΔQ1..19
	47	DCH	9 s		$10 \cdot I_n$	Engine idle off		
	48	DCH	1 s		100	Engine restart		
	49	CAS				Case Ah_balance/C_n of:		
		DCH	20 s		$1{,}25 \cdot I_n$	> 0,01		
		CHA	20 s	14,4	$33{,}3 \cdot I_n$	< −0,01		
		PAU	20 s			[-0,01..0,01]		
	50	CHA	5 s	15,0	$33{,}3 \cdot I_n$	Regenerative charging	1/s	Record amount of charge ΔQ1..19
	51	CAS				Case Ah_balance/C_n of:		
		DCH	20 s		$5 \cdot I_n$	> 0		
		CHA	20 s	14,4	$33{,}3 \cdot I_n$	< −0,01		
		PAU	20 s			[-0,01..0]		
	52	RPT				Run steps 45 to 51 19 times		
	53	DCH	30 s		$2 \cdot I_n$			
	54	DCH	120 s		$1{,}05 \cdot I_n$			
	55	DCH	330 s		$0{,}4182 \cdot I_n$			
	56	PAU	3,33 h			Correct Ah_balance by −0,12 % of C_n	1/h	
	57	RPT				Run steps 42 to 56 3 times		
	58	RPT				Run steps 41 to 57 5 times		
	59	Disconnect the resistors						

The 90 s drive phases (steps 45-51) consist of these sub-phases each:

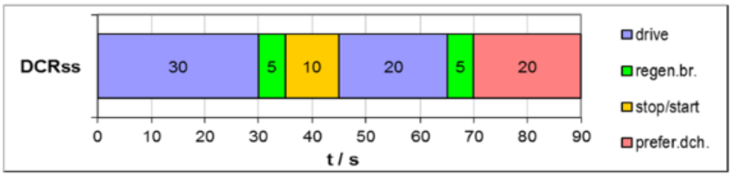


Figure 1 — Sub-phases of the DCRss part

7.3.11 The average regenerative charge current, I_r (data from steps 46 and 50) shall be calculated as the integral of amount of charge recharged in all (15V, 5 s) charge pulses, divided by the total charge time (19 phases with 2·5 s each = 190 s) and by the number of drive phases (15):

$$I_r[A] = \frac{\int_{regenerative\ charging} Idt}{15 \cdot 190\ s}$$

It is recommended that all three charge current integrals defined above are calculated automatically during test execution, utilizing the programming interface of the test bench. Calculation of average currents requires only division by pre-defined times and may hence be executed off-line more easily.

7.3.12 The normalized charge acceptance of the battery shall be calculated from the above results as:

$$I_{\mathrm{DCA}}\left[\frac{A}{Ah}\right] = 0{,}512 \cdot \frac{I_{\mathrm{c}}}{C_{\mathrm{n}}} + 0{,}223 \cdot \frac{I_{\mathrm{d}}}{C_{\mathrm{n}}} + 0{,}218 \cdot \frac{I_{\mathrm{r}}}{C_{\mathrm{n}}} - 0{,}181$$

7.4 Endurance in cycle test with 17,5 % depth of discharge (DoD)

7.4.1 Purpose:

The background of this test is to check the ability to deliver energy under high cyclic conditions in a partially discharged state of charge. Batteries used for start stop applications have a dramatically increased throughput of energy compared to the standard flooded batteries in EN 50342-1. It shall be tested if the battery is able to work in a car with these demands during the projected lifetime.

7.4.2 Procedure:

7.4.2.1 During the entire test procedure, the battery shall be placed into a water bath at 25 ± 2°C, according to 5.3.3.

7.4.2.2 The test shall be performed with a fully charged battery (according to 7.1) which has undergone the complete test sequences of lines 1 to 6 according to Table 6.

7.4.3 The cycling units shall be carried out according to the following scheme. Steps 10 to 16 of Table 14 represent one cycle test unit.

Table 14 — Endurance 17,5 % DoD – Cycling units

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
Cycling unit	10	DCH	2,5 h	> 10,0	$4 \cdot I_n$	Pre-discharge	25		U(EOS)
	11	CHA	2 400 s	14,4	$7 \cdot I_n$	Constant voltage Charge	25		
	12	DCH	1 800 s	> 10,0	$7 \cdot I_n$	Discharge	25		U(EOS)
	13	RPT				Run steps 11 and 12 85 times – stop if U ≤ 10V	25		
	14	CHA	18 h	U_c	$2 \cdot I_n$	Equalization charge	25		Q_{CHA}
	15	DCH		> 10,5		C_e capacity	25		C_e
	16	CHA	24 h	U_c	$5 \cdot I_n$	Recharge according to EN 50342–1:2015, 5.2	25		Q_{CHA}

7.4.4 The cycling unit 7.4.3 shall be repeated until one of the failure criteria is reached: If the voltage criteria in steps 10 or 12 are undercut, the cycling test is terminated.

7.4.5 The battery shall be recharged according to 7.1.

7.5 Endurance in cycle test with 50 % depth of discharge (DoD) at 40 °C and preceded deep discharge

7.5.1 Purpose:

Background of this test is to check if the battery can withstand a deep discharge without losing its cycling capability. Batteries for micro-cycle applications can have a low acid / active mass ratio. So during deep discharge and subsequent charge there is a risk that the battery is damaged by micro shorts if not designed for this application. In vehicles designed for micro-cycle applications, during engine-off phases the battery alone shall supply the electrical power consumption. A deep discharge is possible, but it shall be ensured that the battery withstands this without damage. The test also checks for the battery's ability to withstand deep cycling (positive active mass degradation).

7.5.2 Procedure:

The complete test consists of these nine steps (also listed in test sequence Table 6):

a) Initial recharge prior to test (7.1);

b) C_e capacity test without subsequent recharge (EN 50342-1:2015, 6.1);

c) Deep discharge at 25 °C and recharge 24h (7.5.3);

d) Rest time of 1 to 4 days (7.5.4);

e) C_e capacity test (EN 50342-1:2015, 6.1);

f) Cranking performance test at −18 °C (EN 50342-1:2015, 6.2);

g) Cycling part in a water bath at 40 °C (7.5.5);

h) High current discharge test at low temperature, but without preceding recharge (EN 50342-1:2015, 6.3);

i) C_e capacity test (EN 50342-1:2015, 6.1).

7.5.3 Deep discharge part:

Directly after the C_e testing (line 2 of Table 6), with a delay of maximum 48 h and without any recharge, the following procedure shall be started:

Table 15 — Endurance 50 % DoD – Deep discharge part

Structure	*N°*	*Step*	*t*	*U [V]*	*I [A]*	*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
Deep discharge part	10					Connect a light bulb 12V / 10 W (R10W)	25		
	11	PAU	168 h ± 4 h			Deep discharge with light bulb connected	25		
	12					Disconnect the light bulb	25		
	13	CHA	24 h	16,0 14,8	$5 \cdot I_n$	Recharge voltage for flooded / VRLA	25	6/min for the first 10 min	f = I(t)
NOTE For N°10, "R10W" according to ECE 37.									

Step 13: Maximum 24 h after disconnection of the light bulb, the battery shall be recharged for 24 h.

7.5.4 Rest time:

The battery shall be left at OCV at room temperature for a time period of minimum 1 to maximum 4 d (water bath or air). This allows for OCV stabilization.

7.5.5 Cycling part:

This part of the test shall be carried out on fully charged batteries in accordance with 7.1.

Throughout the whole cycle test period the battery shall be placed in a water bath at a temperature of 40° C ± 2 °C according to 5.3.3.

The battery shall be connected to a test device where it undergoes a series of cycles (Table 16).

Step 20: If the discharge voltage drops below 10,0 V, the cycling test part shall be terminated.

Step 21: Stop the charging phase before the time limit if the charging ratio CR reaches 1,08.

$$CR = \frac{2 \cdot C_{\text{rch}}}{C_{\text{n}}}$$

Step 22: If the ratio CR < 1,08, continue recharging the battery with a constant current of $I = 1{,}0\ I_n$ until the ratio CR reaches 1,08 or until the maximum duration of 1 h for this step is reached.

Table 16 — Endurance 50 % DoD – Cycling part

Structure	*N° Step*		*t*	*U [V]*	*I [A]*	*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
50 % DoD cycling part	20	DCH	2 h	≥ 10	$5 \cdot I_n$	Discharge 50 % DoD	40		U_{DCH}
	21	CHA	≤ 5 h	15,6[a] 14,4[b]	$5 \cdot I_n$	Charge 15,6V[a] for flooded Charge 14,4V[b] for VRLA Abort this step if CR ≥ 1,08	40		Recharged capacity C_{rch}
	22	CHA	≤ 1 h	18,0	$1 \cdot I_n$	Abort this step if CR ≥ 1,08	40		Recharge with I = const.
	23	RPT				Run steps 20 to 22 up to 360 times	40		

[a] The charging voltage for flooded batteries shall be 15.6V if not specified differently by the battery manufacturer.

[b] The charging voltage for VRLA batteries shall be 14.4V if not specified differently by the battery manufacturer.

7.5.6 The subsequent high current discharge test at low temperature according to line 15 of Table 6 shall be performed without any preceding recharge of the battery. Last test step is a final C_e capacity check.

8 Requirements and battery performance levels

8.1 General

The overall performance of a battery according to this standard is determined from two sections:

- Tests to be passed (8.2);
- Tests determining cycle life performance level (8.3).

The final classification M1, M2 or M3 shall be used for battery marking according to Annex B of this document. The use of the “Start-Stop” symbol according to Annex B is optional.

In addition, the battery shall be marked with the necessary information defined in EN 50342-1.

8.2 Tests to be passed (no performance differentiation)

According to Table 6, these tests shall be passed, otherwise the tested batteries will not get any performance level classification according to this standard:

Table 17 — Requirements of tests to be passed

Section	*Test*	*Requirements*	
EN 50342–1:2015, 6.1	Capacity check C_e	The test shall be passed according to EN 50342–1:2015 with limits defined there	
EN 50342–1:2015, 6.2	Cranking performance	The test shall be passed according to EN 50342–1:2015 with limits defined there	
EN 50342–6, 7.3	DCA test	DCA shall be at least 0,1 A/Ah	
EN 50342–6, 7.5	50 % DoD cycle test with preceded deep discharge	Charge phase after deep discharge	Recharge after 7 days of deep discharge (I_{max} = 5 · I_n): Current after 1 min > 2 · I_n Current after 2 min > 3 · I_n Current after 10 min = 5 · I_n C_e after deep discharge phase shall be ≥ 80 % of C_n Cranking performance test at −18°C: U_{10} ≥ 7,5 V
		After 50 % DoD cycling test	High current discharge test at −18°C: U_{30} ≥ 7,2 V C_e after end of test shall be ≥ 50 % of C_n
EN 50342–1:2015, 6.9	Water consumption	Test shall be passed according to EN 50342–1:2015, 6.9, with requirement level W3 or higher	
EN 50342–1:2015, 6.5	Charge retention	Test shall be passed according to EN 50342–1:2015, 6.5, with requirement level C2.	
EN 50342–1:2015, 6.10	Vibration resistance	Test shall be passed according to EN 50342–1:2015, 6.10, with requirement level V1 or higher	
EN 50342–1:2015, 6.4	Charge acceptance	Test shall be passed according to EN 50342–1:2015, 6.4	
EN 50342–1:2015, 6.11	Electrolyte retention	Test shall be passed according to EN 50342–1:2015, 6.11	

8.3 Tests determining the micro-cycle performance level

Table 18 — Requirements of tests determining the micro-cycle performance level M1…M3

Section	*Test*	*Level M1*	*Level M2*	*Level M3*
EN 50342–6:2015, 7.2	MHT Micro-hybrid test	Normalized mean R_{dyn} increase ≤ 1,5 after 8000 cycles $U(EOS)_{300A}$ ≥ 9,5 V C_e ≥ 50 % of C_n after 8000 cycles		
EN 50342–6:2015, 7.4	17,5 % DoD cycle test	≥ 9 units	≥ 15 units	≥ 18 units
EN 50342–6:2015, 7.5	50 % DoD cycle test	≥ 150 cycles	≥ 240 cycles	≥ 360 cycles

To be classified as level 3, the batteries shall fulfil the level 3 requirements of all three tests listed above. Otherwise the classification is level 2 or level 1 only, depending on the worst result in one of the tests. The same is valid for the level 2 classification, respectively.

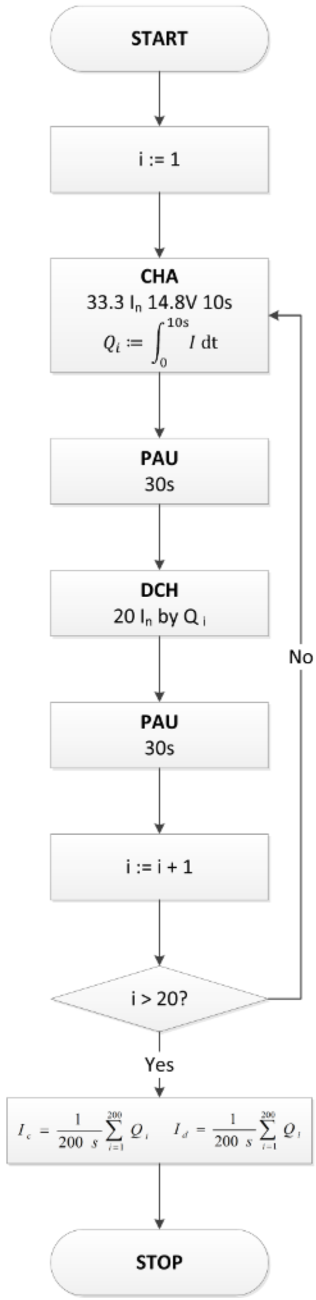
All batteries with one of these classifications are suitable for Start-Stop applications and shall be marked with a label containing the final classification according to Annex B of this document.

Annex A
(normative)

Flow charts of DCA test procedure, 7.3

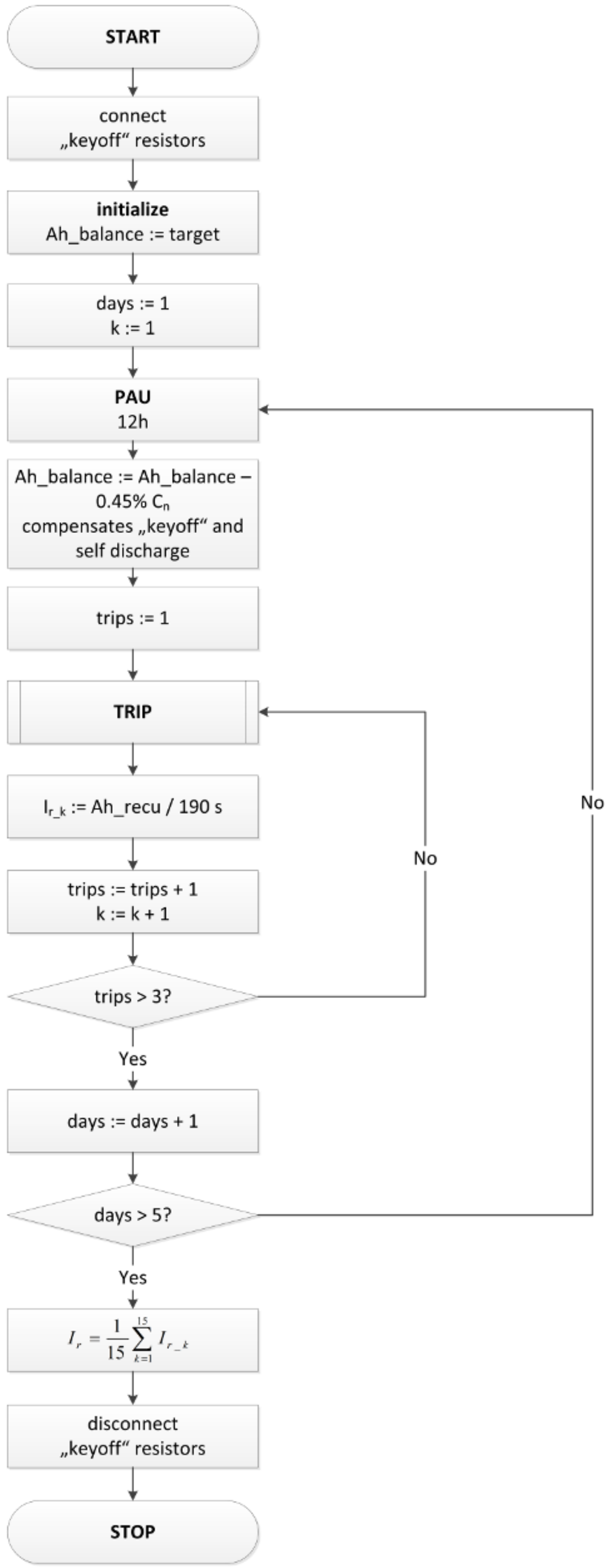
DCA_{PP} = DCA Pulse Profile

≈ 30 min

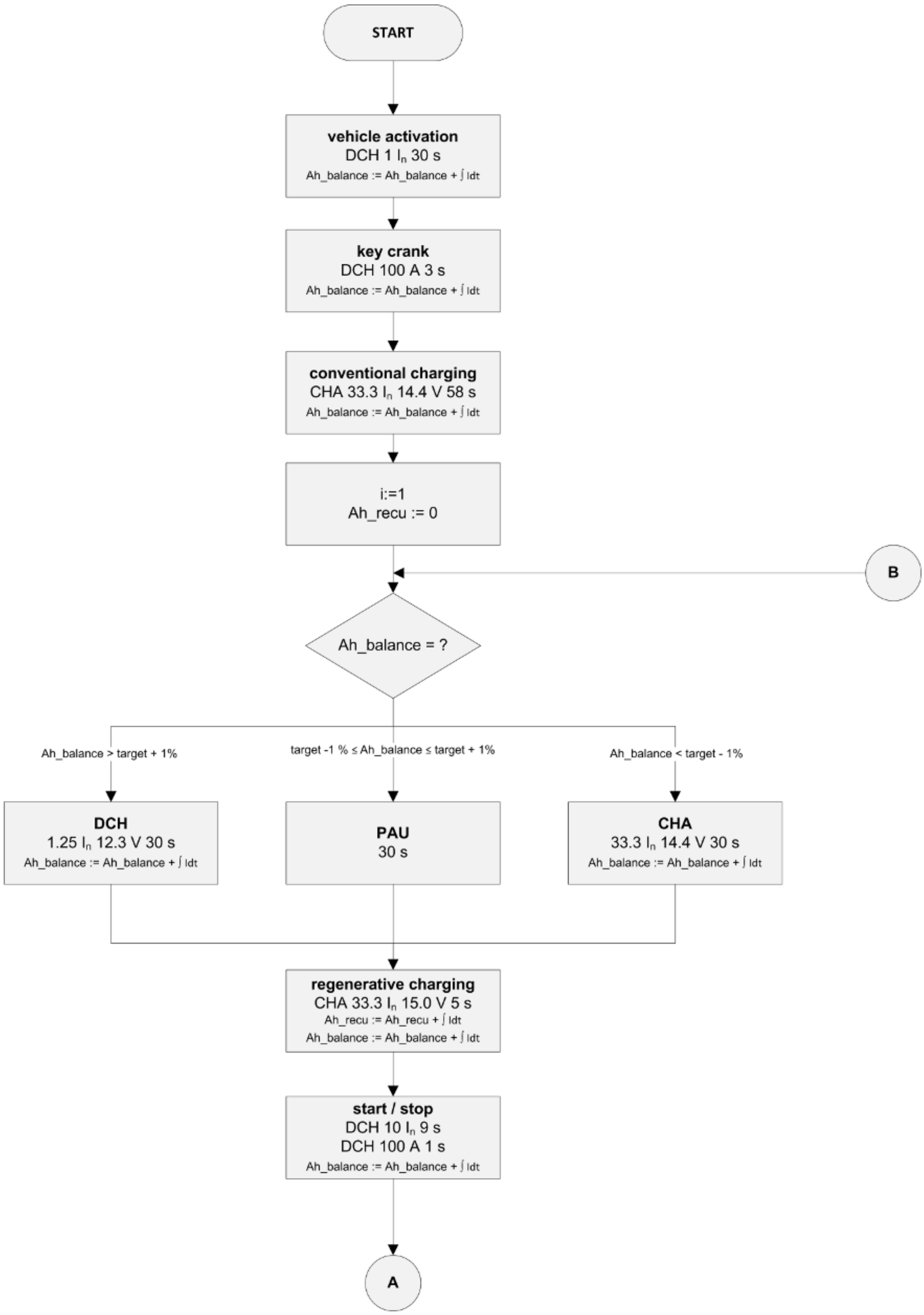


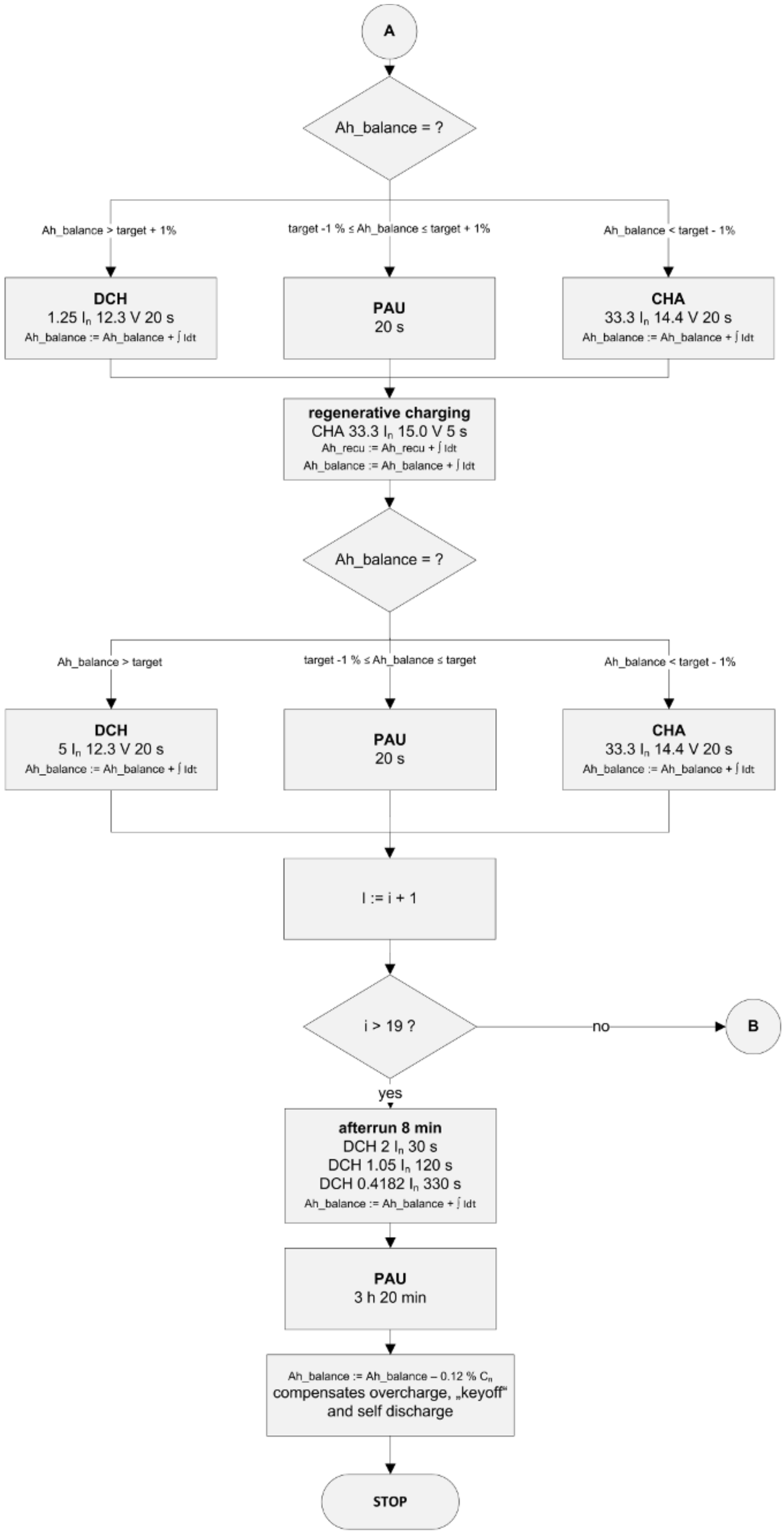
DCR_{SS} = DCA Real world simulation with stop/start

5 x 24 h



Trip


START
vehicle activation
DCH 1 In 30 s
Ah_balance := Ah_balance + ∫ Idt
key crank
DCH 100 A 3 s
Ah_balance := Ah_balance + ∫ Idt
conventional charging
CHA 33.3 In 14.4 V 58 s
Ah_balance := Ah_balance + ∫ Idt
i:=1
Ah_recu := 0
B
Ah_balance = ?
Ah_balance > target + 1%
target -1 % ≤ Ah_balance ≤ target + 1%
Ah_balance < target - 1%
DCH
1.25 In 12.3 V 30 s
Ah_balance := Ah_balance + ∫ Idt
PAU
30 s
CHA
33.3 In 14.4 V 30 s
Ah_balance := Ah_balance + ∫ Idt
regenerative charging
CHA 33.3 In 15.0 V 5 s
Ah_recu := Ah_recu + ∫ Idt
Ah_balance := Ah_balance + ∫ Idt
start / stop
DCH 10 In 9 s
DCH 100 A 1 s
Ah_balance := Ah_balance + ∫ Idt
A


A
Ah_balance = ?
Ah_balance > target + 1%
target -1 % ≤ Ah_balance ≤ target + 1%
Ah_balance < target - 1%
DCH
1.25 I_n 12.3 V 20 s
Ah_balance := Ah_balance + ∫ Idt
PAU
20 s
CHA
33.3 I_n 14.4 V 20 s
Ah_balance := Ah_balance + ∫ Idt
regenerative charging
CHA 33.3 I_n 15.0 V 5 s
Ah_recu := Ah_recu + ∫ Idt
Ah_balance := Ah_balance + ∫ Idt
Ah_balance = ?
Ah_balance > target
target -1 % ≤ Ah_balance ≤ target
Ah_balance < target - 1%
DCH
5 I_n 12.3 V 20 s
Ah_balance := Ah_balance + ∫ Idt
PAU
20 s
CHA
33.3 I_n 14.4 V 20 s
Ah_balance := Ah_balance + ∫ Idt
I := i + 1
i > 19 ?
no
B
yes
afterrun 8 min
DCH 2 I_n 30 s
DCH 1.05 I_n 120 s
DCH 0.4182 I_n 330 s
Ah_balance := Ah_balance + ∫ Idt
PAU
3 h 20 min
Ah_balance := Ah_balance – 0.12 % C_n
compensates overcharge, „keyoff"
and self discharge
STOP

Annex B
(normative)

Marking / Labelling of Batteries

Batteries for micro-cycle applications are individually designed or selected for individual car types. So it is important that any kind of end user (from OE garage to the customer in a supermarket) is able to select the adequate battery for the car. Besides of the definitions given in EN 50342-1:2015 and additional geometrical features, this standard is testing batteries to their suitability for micro-cycle applications. For each battery, a unique information set for spare part exchange shall be documented. It should be possible for any producer or distributor of batteries to mark those which are electrically in accordance with the requirements of this standard with the name of this standard and the corresponding performance level M1 to M3. A unique label is the best way to avoid misunderstandings of the end user.

In addition to the mandatory marking defined in EN 50342-1:2015 (related to 4.1 and Annexes A and C, first line of the example given here), the battery shall be marked with a code according to the performance rating (second line of the example given):

VRLA 12V 70Ah 760A
EN 50342–6:W5-C2-V2-M3

The code is compiled according to these definitions:

W – Water consumption level	Level W3, W4 or W5, according to EN 50342–1:2015, 6.9
C – Charge retention performance level	C2 level is necessary for all batteries covered by this standard, according to EN 50342–1:2015, 6.5
V – Vibration resistance performance level	Level V1, V2, V3 or V4, according to EN 50342–1:2015, 6.10
M – Micro-cycle performance level	M1, M2 or M3 according to 8.3

This optional “Start-Stop” logo may be added to complete the information:

Figure B.1 — Optional Start-Stop logo

Bibliography

[1] EN 50342-2, *Lead-acid starter batteries — Part 2: Dimensions of batteries and marking of terminals*

[2] EN 50342-4, *Lead-acid starter batteries — Part 4: Dimensions of batteries for heavy vehicles*

[3] IEC 60050-482, *International Electrotechnical Vocabulary, Part 482: Primary and secondary cells and batteries*

[4] UN/ECE Regulation ECE37, *Agreement Concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions, Regulation No. 37: Uniform provisions concerning the approval of filament lamps for use in approved lamp units of power-driven vehicles and of their trailers*

[5] Directive 2006/66/EC *of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC*

[6] Directive 2008/12/EC *of the European Parliament and of the Council of 11 March 2008 amending Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators, as regards the implementing powers conferred on the Commission*

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™