Validation Statement

The below described claim of the applicant:

Clarios Germany GmbH und Co. KG

Am Leineufer 51
30419 Hannover, Germany

has been validated by TÜV NORD CERT GmbH, with detailed method described in the report.
The correctness of the claim is confirmed by this validation statement.

Claim:	**Under regular use*, VARTA ProMotive Absorbed Glass Mat (AGM) battery will decrease the amount of time that the vehicle engine needs to run on weekend-rest period* (or other similar long standing time), compared with conventional VARTA ProMotive Super Heavy Duty (SHD) battery. This decrement in idling time* will reduce fuel consumption at such application.**
Related Product(s):	Starter Battery
Model Type(s):	VARTA ProMotive AGM (210Ah), VARTA ProMotive SHD (225Ah)

This statement of validation is based on document review and evaluation of samples of the products. It does not imply conformity of the products with product related safety or quality standards (in terms of product certification). It does not imply an assessment of the production and it does not permit the use of a conformity mark or of a safety mark of TÜV NORD CERT GmbH. The holder of this document may use it in conjunction with the related report(s).

* Definition of “regular use”, “weekend-rest period” and “idling time” are defined in the report mentioned below.

The level of assurance for this statement is considered “reasonable”.

Validation / Verification Program:	V02-VA-01, Rev. 00 / 11.23
Registered No.:	V01-8003062082-001
Report No.:	8003062082.001
File No.:	8003062082

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Essen, 2023-12-06

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Validation Report
No. 8003062082.001

Applicant: **Clarios Germany GmbH und Co. KG**
Am Leineufer 51
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Order No.: 8003062082

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1. Setting of tasks

On 15.03.2023, the applicant, Clarios Germany GmbH und Co. KG (hereafter referred as “Clarios”), has made application to TÜV NORD CERT GmbH (hereafter referred as TÜV NORD), for a validation on a claim of comparison on performances of two different model types of starter batteries, for the application used in heavy commercial vehicles (hereafter referred as “truck”), at weekend-rest period (see Chapter 3 for definition), under regular use (also see Chapter 3 for definition).

The two model types of starter batteries are both products of Clarios:

VARTA ProMotive Absorbed Glass Mat (AGM) battery

VARTA ProMotive Super Heavy Duty (SHD) battery

According to TÜV NORD’s validation / verification program V02-VA-01, after evaluation of the submitted documents by Clarios at pre-engagement stage, TÜV NORD accepts the application and make detailed validation plan as per Chapter 6.

Throughout this report, a comma is as the decimal separator.

2. Claim by Clarios

Under regular use, VARTA ProMotive Absorbed Glass Mat (AGM) battery will decrease the amount of time that the vehicle engine needs to run on weekend-rest period (or other similar long standing time), compared with conventional VARTA ProMotive Super Heavy Duty (SHD) battery. This decrement in idling time will reduce fuel consumption at such application.

3. Terms in the claim

3.1 Regular use

Truck drivers in long haul logistics usually work and live inside their vehicle cabins for several weeks. Starter batteries, as part of the power supply system on the truck, not only provide cranking ability for the engine, but also provide electricity for all kinds of daily used appliances by drivers, such as air conditioner, refrigerator, lightings, etc. The term “regular use” here is referring that no special treatment or maintenance on the starter batteries in daily use. Please also pay attention to Chapter 9.2 for a generic remark.

3.2 Weekend-rest period

According to Directive 2006/22/EC of the European Parliament and of the Council, truck drivers are mandatory to take rest on weekends with long standing time. During the weekend-rest period, the truck will be subject to a long standing time while the energy in starter batteries will be consumed to support daily life of truck drivers.

3.3 Idling time

During the weekend-rest period (or other similar long standing time), when the starter batteries reach the cut-off voltage or protection voltage, the combust engine need to start running to charge the starter batteries. The term “idling time” here is referring that the combust engine is running while the truck is in stationary.

4. Basis for validation

EN 50342-1:2015 + A1:2018 + A2:2021 Lead-acid starter batteries - Part 1: General requirements and methods of test

Remark:

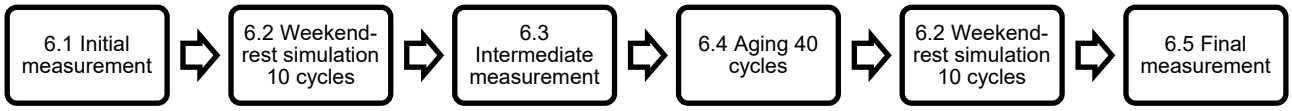
The test method(s) described in above standard(s) is(are) used as reference for the validation of the claim. It does not imply compliance of the product(s) with the standard(s).

5. Product information

	VARTA ProMotive AGM battery	VARTA ProMotive SHD battery
Nominal voltage [V]	12	12
Nominal capacity C_{20} [Ah]	210	225
Nominal cranking current I_{cc} [A]	1200	1200
Cut-off voltage [V]	11,5	11,5
Charging method	Constant voltage at 14,4V per battery	Constant voltage at 14,4V per battery

6. Validation plan

To validate the claim, a test plan to compare the performance of the two different model types 3 pcs of battery samples of each model type have been selected as representative test samples and conduct with following tests:



6.1 Initial measurement

6.1.1 Weight

6.1.1.1 Test method:

Measure the weight using electrical balance, prior to 6.1.4 and 6.1.5, to assess initial conditions after "production of battery".

6.1.1.2 Requirement:

Record the weight value.

6.1.2 Measurement of open circuit voltage (OVC) of battery (U_0)

6.1.2.1 Test method:

Measure the open circuit voltage using multi-meter, prior to 6.1.4 and 6.1.5, to assess initial conditions after "production of battery".

6.1.2.2 Requirement

Record the voltage value.

6.1.3 Measurement of internal resistance (R_i)

6.1.3.1 Test method:

Measure the internal resistance using multi-meter, prior to 6.1.4 and 6.1.5, to assess initial conditions after "production of battery".

6.1.3.2 Requirement

Record the resistance value.

6.1.4 Capacity check (C_{20})

6.1.4.1 Test method

Test according to Clause 6.1 Capacity check of EN 50342-1.

6.1.4.2 Requirement

Record the capacity value. For initial measurement, if the capacity C20 is less than 95% of nominal capacity, this test need to be repeated until this requirement is fulfilled.

6.1.5 Cranking performance test (HCD)

6.1.5.1 Test method

Test according to Stage 2 of Clause 6.2 Cranking performance test of EN 50342-1, with following modifications:

Temperature of the samples shall be 25±2°C.

6.1.5.2 Requirement

Record the voltage at 60s and 150s.

6.2 Weekend-rest simulation 10 cycles

6.2.1 Test method for each cycle (simulation for one week application)

6.2.1.1 Discharge the battery (DCH) at constant current 5A, until 11,5V

6.2.1.2 Charge the battery (CHA) at constant voltage 14,4V, with maximum current of 100A, for 1 hour

6.2.1.3 Repeat 6.2.1.1 and 6.2.1.2 until the total time reaches 48 hours.

6.2.1.4 Charge at constant voltage 14,4V with maximum current of 100A, for 12 hours

6.2.2 Repeat 10 cycles of 6.2.1.

Remark: see Chapter 9.2 for explanation of this designated test method.

6.3 Intermediate measurement

6.3.1 Capacity check (C_{20}) - Same as 6.1.4

6.3.2 Cranking performance test (HCD) - Same as 6.1.5

6.4 Aging 40 cycles

6.4.1 Test method

Test according to Clause 6.6 Endurance in cycling of EN 50342-1, with following modifications:
Temperature of the samples shall be 25±2°C. Total number of cycles is 40.

6.4.2 Requirement

Repeat 6.1.4 and 6.1.5

6.5 Final measurement

6.5.1 Capacity check (C_{20}) - Same as 6.1.4

6.5.2 Cranking performance test (HCD) - Same as 6.1.5

7. Validation execution

Tests according to validation plan is executed at in-house laboratory in Clarios, at following location:

Am Leineufer 51, D-30419 Hannover, Germany

On 28.06.2023, project engineer of TÜV NORD conducted an on-site visit to the laboratory, to confirm the validity of calibration of equipment used and to check the samples for testing.

The written procedure for calibration requirement is “Kalibrierschrift für Messgeräte / Kalibriernormal durch externe Kalibrierdienstleister” (German for “Calibration document for measuring devices / Calibration standard from external calibration service providers”), which is a controlled document with number PSHA-LOS-KV-PR05351-G, Rev. 02. This document described procedure and requirement to send the equipment to external calibration service providers for calibration, and after receiving the calibrated equipment, how to conduct internal calibration of other equipment using the calibrated ones.

The conclusion after reviewing the evidence for calibration of equipment during on-site visit is satisfied. Please refer to Annex 3 for calibration certificates / records.

The samples checked on-site are found in compliance with the requirement. Please refer to Annex 4 for photos of samples.

On the same day, a real-time monitoring system is deployed on sample # 5121_1, so TÜV NORD could supervise the whole testing period remotely.

7.1 Samples

Sample #	Model type	Serial number
5121_1	VARTA ProMotive AGM (210Ah)	0001 2 682272 2 13 230305 0157 N
5121_2		0001 2 682272 2 13 230305 0729 S
5121_3		0001 2 682272 2 13 230305 0726 S
5122_1	VARTA ProMotive SHD (225Ah)	614543 C4C339182 0908
5122_2		614543 C4C330242 0021
5122_3		614543 04C339182 0665

7.2 Initial measurement results and evaluation

Table 1 Test results for 6.1 Initial measurement							
Test date	05.07.2023 - 11.07.2023						
Test clause	Sample #						Remark
-	5121_1	5121_2	5121_3	5122_1	5122_2	5122_3	-
Weight [kg]	61,61	61,43	61,49	56,37	56,56	56,31	-
U_0 [V]	12,72	12,73	12,72	12,72	12,73	12,74	-
R_i [mΩ]	1,85	1,86	1,86	2,75	2,75	2,78	-
1st C_{20} [Ah]	179,97	181,58	181,99	200,54	179,56	206,08	-
- Percentage	86%	86%	87%	89%	80%	92%	-
- HCD (60s) [V]	10,84	10,85	10,84	10,13	10,08	10,16	-

- HCD (150s) [V]	10,64	10,65	10,64	9,73	9,61	9,79	-
2nd C_{20} [Ah]	218,46	221,41	221,09	233,76	210,50	238,15	-
- Percentage	104%	105%	105%	104%	94%	106%	-
- HCD (60s) [V]	10,82	10,83	10,83	10,29	10,25	10,31	-
- HCD (150s) [V]	10,64	10,65	10,64	9,95	9,86	9,98	-
3rd C_{20} [Ah]	-	-	-	-	213,35	-	-
- Percentage	-	-	-	-	95%	-	-
- HCD (60s) [V]	-	-	-	-	10,31	-	-
- HCD (150s) [V]	-	-	-	-	9,98	-	-

Evaluation of the test results:

The above test results showed that the samples are pre-conditioned and are in good condition to continue the weekend-rest simulation.

7.3 Weekend-rest simulation 10 cycles results (before aging) and evaluation

Table 2.1 Test results for 6.2 Weekend-rest simulation 1st cycle (before aging)									
Test date		19.07.2023 - 21.07.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	191,09	100,00	43,77	-	-	-	-	-	-
5121_2	188,52	100,00	43,77	-	-	-	-	-	-
5121_3	190,28	100,00	44,72	-	-	-	-	-	-
5122_1	239,96	-	-	-	-	-	-	-	-
5122_2	227,17	100,00	7,68	-	-	-	-	-	-
5122_3	239,87	-	-	-	-	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	-	-	-	-	-	-	-	-
5122_2	-	60	-	-	-	-	-	-	-
5122_3	-	-	-	-	-	-	-	-	-

Table 2.2 Test results for 6.2 Weekend-rest simulation 2nd cycle (before aging)									
Test date		21.07.2023 - 24.07.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	192,06	100,00	42,79	-	-	-	-	-	-
5121_2	190,24	100,00	44,78	-	-	-	-	-	-
5121_3	191,02	100,00	43,98	-	-	-	-	-	-
5122_1	207,32	99,88	27,65	-	-	-	-	-	-
5122_2	195,02	98,70	39,83	-	-	-	-	-	-
5122_3	210,35	99,99	24,52	-	-	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	-	-	-	-	-	-
5122_2	-	60	-	-	-	-	-	-	-
5122_3	-	60	-	-	-	-	-	-	-

Table 2.3 Test results for 6.2 Weekend-rest simulation 3rd cycle (before aging)									
Test date		24.07.2023 - 26.07.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	191,60	100,00	43,26	-	-	-	-	-	-
5121_2	189,54	100,00	45,32	-	-	-	-	-	-
5121_3	192,29	100,00	44,71	-	-	-	-	-	-
5122_1	166,26	92,51	68,57	-	-	-	-	-	-
5122_2	167,57	90,44	77,03	-	-	-	-	-	-
5122_3	170,45	93,19	64,30	-	-	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	-	-	-	-	-	-
5122_2	-	60	-	-	-	-	-	-	-
5122_3	-	60	-	-	-	-	-	-	-

Table 2.4 Test results for 6.2 Weekend-rest simulation 4th cycle (before aging)									
Test date		26.07.2023 - 29.07.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	191,31	100,00	43,51	-	-	-	-	-	-
5121_2	189,13	100,00	45,81	-	-	-	-	-	-
5121_3	189,75	100,00	45,25	-	-	-	-	-	-
5122_1	130,39	81,82	77,14	69,47	22,43	-	-	-	-
5122_2	124,83	77,88	73,29	66,28	31,73	-	-	-	-
5122_3	134,04	82,32	76,66	68,99	19,18	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	-	-	-	-
5122_2	-	60	-	60	-	-	-	-	-
5122_3	-	60	-	60	-	-	-	-	-

Table 2.5 Test results for 6.2 Weekend-rest simulation 5th cycle (before aging)									
Test date		29.07.2023 - 31.07.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	191,24	100,00	43,62	-	-	-	-	-	-
5121_2	188,99	100,00	45,94	-	-	-	-	-	-
5121_3	189,47	100,00	45,53	-	-	-	-	-	-
5122_1	113,50	73,51	70,36	63,23	46,10	-	-	-	-
5122_2	108,26	70,10	66,50	60,25	55,09	-	-	-	-
5122_3	114,44	72,66	68,87	62,02	46,56	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	-	-	-	-
5122_2	-	60	-	60	-	-	-	-	-
5122_3	-	60	-	60	-	-	-	-	-

Table 2.6 Test results for 6.2 Weekend-rest simulation 6th cycle (before aging)									
Test date		31.07.2023 - 03.08.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	191,10	100,00	43,75	-	-	-	-	-	-
5121_2	188,69	100,00	46,24	-	-	-	-	-	-
5121_3	189,10	100,00	45,90	-	-	-	-	-	-
5122_1	99,99	67,34	63,69	57,84	56,64	51,30	6,65	-	-
5122_2	94,34	62,49	59,14	53,85	50,44	48,08	20,93	-	-
5122_3	98,93	65,99	62,65	56,62	53,28	50,16	10,03	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Table 2.7 Test results for 6.2 Weekend-rest simulation 7th cycle (before aging)									
Test date		03.08.2023 - 05.08.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	191,00	100,00	43,85	-	-	-	-	-	-
5121_2	188,53	100,00	46,40	-	-	-	-	-	-
5121_3	188,86	100,00	46,14	-	-	-	-	-	-
5122_1	92,57	62,84	59,91	54,07	51,31	48,00	21,17	-	-
5122_2	86,86	59,03	56,39	51,15	48,29	45,72	33,31	-	-
5122_3	90,93	60,86	58,09	52,55	49,86	46,96	25,99	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Table 2.8 Test results for 6.2 Weekend-rest simulation 8th cycle (before aging)									
Test date		05.08.2023 - 08.08.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	190,88	100,00	43,97	-	-	-	-	-	-
5121_2	188,35	100,00	46,58	-	-	-	-	-	-
5121_3	188,60	100,00	46,40	-	-	-	-	-	-
5122_1	85,22	59,83	57,52	51,54	48,91	45,91	33,32	-	-
5122_2	78,81	55,84	53,02	48,25	46,01	43,54	42,04	40,17	-
5122_3	82,99	57,81	55,59	50,23	47,70	45,03	38,60	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	60	-
5122_3	-	60	-	60	-	60	-	-	-

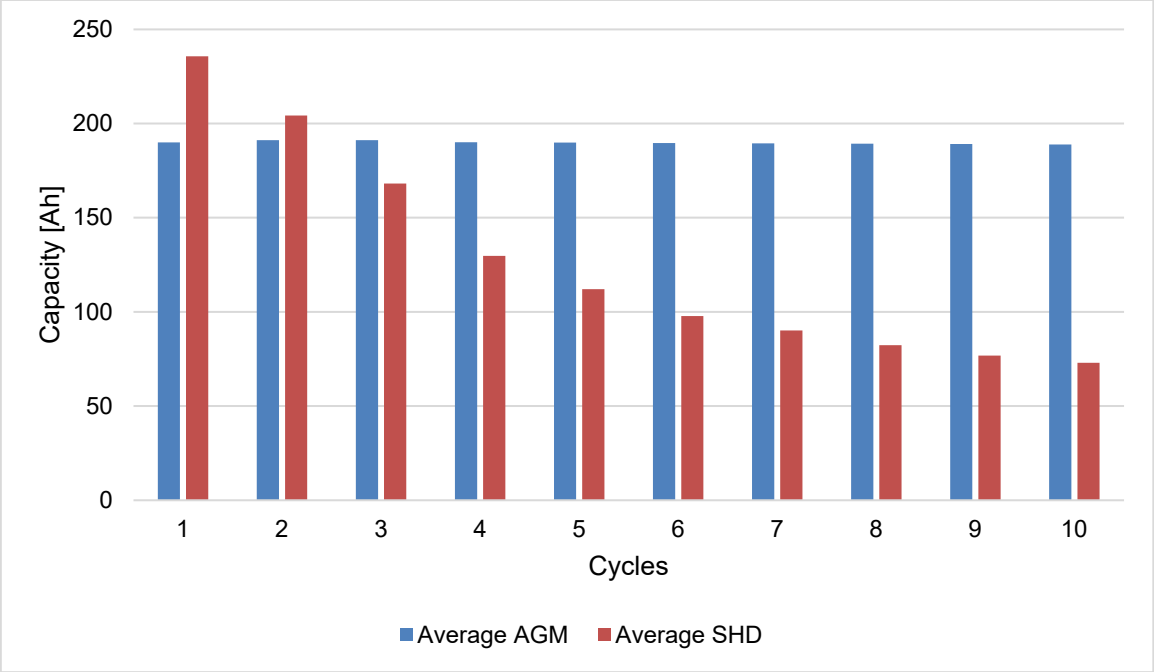
Table 2.9 Test results for 6.2 Weekend-rest simulation 9th cycle (before aging)									
Test date		08.08.2023 - 10.08.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	190,74	100,00	41,11	-	-	-	-	-	-
5121_2	188,17	100,00	46,77	-	-	-	-	-	-
5121_3	188,31	100,00	46,69	-	-	-	-	-	-
5122_1	78,75	56,93	54,31	48,82	46,67	43,87	42,33	33,99	-
5122_2	75,04	54,10	54,46	46,69	44,55	42,03	40,63	38,95	8,17
5122_3	76,65	55,03	54,45	47,44	45,53	43,06	41,73	39,96	3,53
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	35	-
5122_2	-	60	-	60	-	60	-	60	-
5122_3	-	60	-	60	-	60	-	60	-

Table 2.10 Test results for 6.2 Weekend-rest simulation 10th cycle (before aging)									
Test date		10.08.2023 - 13.08.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	190,60	100,00	44,25	-	-	-	-	-	-
5121_2	187,97	100,00	49,96	-	-	-	-	-	-
5121_3	188,01	100,00	46,99	-	-	-	-	-	-
5122_1	73,85	54,31	51,98	46,73	44,88	42,08	41,06	39,36	8,28
5122_2	71,09	52,86	50,57	45,64	43,68	41,22	40,24	38,70	14,27
5122_3	73,94	53,87	51,60	46,49	44,65	41,77	40,85	39,08	8,85
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	60	-
5122_2	-	60	-	60	-	60	-	60	-
5122_3	-	60	-	60	-	60	-	60	-

Evaluation of the results:

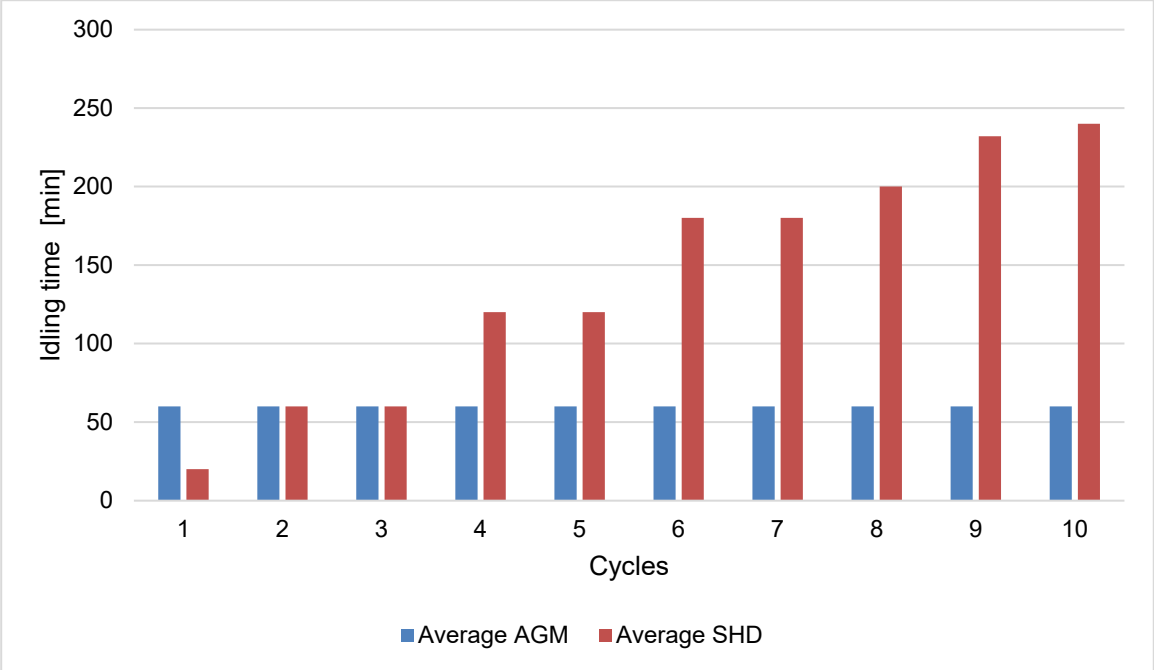
Below is the summary table of capacity, after each Weekend-rest simulation cycle:

Table 2.11 Summary of capacity for 6.2 Weekend-rest simulation 10 cycles (before aging)								
Cycles	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
1st cycle	191,09	188,52	190,28	189,96	239,96	227,17	239,87	235,67
2nd cycle	192,06	190,24	191,02	191,11	207,32	195,02	210,35	204,23
3rd cycle	191,60	189,54	192,29	191,14	166,26	167,57	170,45	168,09
4th cycle	191,31	189,13	189,75	190,06	130,39	124,83	134,04	129,75
5th cycle	191,24	188,99	189,47	189,90	113,50	108,26	114,44	112,07
6th cycle	191,10	188,69	189,10	189,63	99,99	94,34	98,93	97,75
7th cycle	191,00	188,53	188,86	189,46	92,57	86,86	90,93	90,12
8th cycle	190,88	188,35	188,60	189,28	85,22	78,81	82,99	82,34
9th cycle	190,74	188,17	188,31	189,07	78,75	75,04	76,65	76,81
10th cycle	190,60	187,97	188,01	188,86	73,85	71,09	73,94	72,96



Below is the summary table of idling time, after each Weekend-rest simulation cycle:

Table 2.12 Summary of idling time for 6.2 Weekend-rest simulation 10 cycles (before aging)								
Cycles	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]
1st cycle	60	60	60	60	0	60	0	20
2nd cycle	60	60	60	60	60	60	60	60
3rd cycle	60	60	60	60	60	60	60	60
4th cycle	60	60	60	60	120	120	120	120
5th cycle	60	60	60	60	120	120	120	120
6th cycle	60	60	60	60	180	180	180	180
7th cycle	60	60	60	60	180	180	180	180
8th cycle	60	60	60	60	180	240	180	200
9th cycle	60	60	60	60	215	240	240	232
10th cycle	60	60	60	60	240	240	240	240
Average	60	60	60	60	136	150	138	141



It can be concluded that average idling time of AGM batteries in weekend-rest simulation 10 cycles (before aging) is 60 minutes, while it is 141 minutes of SHD batteries.

7.4 Intermediate measurement results and evaluation

Table 3.1 Test results for 6.3 Intermediate measurement							
Test date	14.08.2023 - 15.08.2023						
Test clause	Sample #						Remark
-	5121_1	5121_2	5121_3	5122_1	5122_2	5122_3	-
1st C20 [Ah]	225,18	226,46	225,76	194,76	191,80	203,04	-
- Percentage	107%	108%	108%	87%	85%	90%	-
- HCD (60s) [V]	10,84	10,82	10,82	10,02	9,99	10,08	-
- HCD (150s) [V]	10,65	10,57	10,59	9,50	9,45	9,60	-

Evaluation of test results:

Below is the summary table of capacity, after the current test sequence:

Table 3.2 Summary of capacity of test sequence								
Test sequence	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
6.1 Initial measurement	218,46	221,41	221,09	220,32	233,76	213,35	238,15	228,42
After 6.2 Weekend-rest simulation 10 cycles (before aging)	190,60	187,97	188,01	188,86	73,85	71,09	73,94	72,96
6.3 Intermediate measurement	225,18	226,46	225,76	225,80	194,76	191,80	203,04	196,53

Please refer to Chapter 9.3 for analysis on the recovery behavior of capacity.

Table 3.3 Summary of cranking performance of test sequence								
Test sequence	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]
HCD (60s)								
6.1 Initial measurement	10,82	10,83	10,83	10,83	10,29	10,31	10,31	10,30
6.3 Intermediate measurement after 6.2 Weekend-rest simulation 10 cycles (before aging)	10,84	10,82	10,82	10,83	10,02	9,99	10,08	10,03
HCD (150s)								
6.1 Initial measurement	10,64	10,65	10,64	10,64	9,95	9,98	9,98	9,97
6.3 Intermediate measurement after 6.2 Weekend-rest simulation 10 cycles (before aging)	10,65	10,57	10,59	10,60	9,50	9,45	9,60	9,52

Cranking performance shows all samples are still able to provide cranking.

7.5 Aging results and evaluation

Table 4.1 Test results after 6.4 Aging 40 cycles							
Test date	29.08.2023 - 03.09.2023						
Test clause	Sample #						Remark
-	5121_1	5121_2	5121_3	5122_1	5122_2	5122_3	-
1st C20 [Ah]	226,64	232,11	232,33	211,98	194,20	216,46	-
- Percentage	108%	111%	111%	94%	86%	96%	-
- HCD (60s) [V]	10,95	10,99	11,00	10,52	10,48	10,53	-
- HCD (150s) [V]	10,65	10,80	10,79	10,12	10,08	10,17	-
Remark: Aging 40 cycles were performed during 18.08.2023 - 29.08.2023							

Evaluation of test results:

Below is the summary table of capacity, after the current test sequence:

Table 4.2 Summary of capacity of test sequence								
Test sequence	Sample # of AGM batteries				Sample # of SHD batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
6.1 Initial measurement	218,46	221,41	221,09	220,32	233,76	213,35	238,15	228,42
After 6.2 Weekend-rest simulation 10 cycles (before aging)	190,60	187,97	188,01	188,86	73,85	71,09	73,94	72,96
6.3 Intermediate measurement	225,18	226,46	225,76	225,80	194,76	191,80	203,04	196,53
After 6.4 aging 40 cycles	226,64	232,11	232,33	230,36	211,98	194,20	216,46	207,55

Please refer to Chapter 9.3 for analysis on the recovery behavior of capacity.

Table 4.3 Summary of cranking performance of test sequence								
Test sequence	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]
HCD (60s)								
6.1 Initial measurement	10,82	10,83	10,83	10,83	10,29	10,31	10,31	10,30
6.3 Intermediate measurement after 6.2 Weekend-rest simulation 10 cycles (before aging)	10,84	10,82	10,82	10,83	10,02	9,99	10,08	10,03
After 6.4 aging 40 cycles	10,95	10,99	11,00	10,98	10,52	10,48	10,53	10,51
HCD (150s)								
6.1 Initial measurement	10,64	10,65	10,64	10,64	9,95	9,98	9,98	9,97
6.3 Intermediate measurement after 6.2 Weekend-rest simulation 10 cycles (before aging)	10,65	10,57	10,59	10,60	9,50	9,45	9,60	9,52
After 6.4 aging 40 cycles	10,65	10,80	10,79	10,75	10,12	10,08	10,17	10,12

Cranking performance shows all samples are still able to provide cranking.

7.6 Weekend-rest simulation 10 cycles results (after aging) and evaluation

Table 5.1 Test results for 6.2 Weekend-rest simulation 1st cycle (after aging)									
Test date		03.09.2023 - 05.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	199,99	100,00	34,95	-	-	-	-	-	-
5121_2	199,16	100,00	35,77	-	-	-	-	-	-
5121_3	200,21	100,00	34,78	-	-	-	-	-	-
5122_1	211,41	95,64	23,55	-	-	-	-	-	-
5122_2	205,66	95,08	29,19	-	-	-	-	-	-
5122_3	212,29	95,43	22,58	-	-	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	-	-	-	-	-	-
5122_2	-	60	-	-	-	-	-	-	-
5122_3	-	60	-	-	-	-	-	-	-

Table 5.2 Test results for 6.2 Weekend-rest simulation 2nd cycle (after aging)									
Test date		05.09.2023 - 08.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	200,20	100,00	34,65	-	-	-	-	-	-
5121_2	199,05	100,00	35,48	-	-	-	-	-	-
5121_3	200,20	100,00	34,80	-	-	-	-	-	-
5122_1	159,42	85,41	75,54	-	-	-	-	-	-
5122_2	155,78	84,34	76,84	43,58	-	-	-	-	-
5122_3	158,90	84,96	75,97	-	-	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	-	-	-	-	-	-
5122_2	-	60	-	27	-	-	-	-	-
5122_3	-	60	-	-	-	-	-	-	-

Table 5.3 Test results for 6.2 Weekend-rest simulation 3rd cycle (after aging)									
Test date		08.09.2023 - 10.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	200,08	100,00	34,77	-	-	-	-	-	-
5121_2	199,17	100,00	35,76	-	-	-	-	-	-
5121_3	200,21	100,00	34,78	-	-	-	-	-	-
5122_1	121,80	75,24	70,86	65,01	37,31	-	-	-	-
5122_2	118,05	73,88	68,75	65,53	43,05	-	-	-	-
5122_3	122,37	76,59	72,00	65,62	35,50	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	-	-	-	-
5122_2	-	60	-	60	-	-	-	-	-
5122_3	-	60	-	60	-	-	-	-	-

Table 2.4 Test results for 6.2 Weekend-rest simulation 4th cycle (after aging)									
Test date		10.09.2023 - 13.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	200,03	100,00	34,82	-	-	-	-	-	-
5121_2	198,78	100,00	36,15	-	-	-	-	-	-
5121_3	199,46	100,00	35,54	-	-	-	-	-	-
5122_1	103,23	68,66	66,55	61,26	56,89	46,28	-	-	-
5122_2	102,51	69,16	66,09	61,20	56,88	51,88	-	-	-
5122_3	107,01	71,47	68,69	63,36	54,18	-	-	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	40	-	-	-
5122_2	-	60	-	60	-	52	-	-	-
5122_3	-	60	-	60	-	-	-	-	-

Table 5.5 Test results for 6.2 Weekend-rest simulation 5th cycle (after aging)									
Test date		13.09.2023 - 15.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	199,13	100,00	35,72	-	-	-	-	-	-
5121_2	197,95	100,00	36,98	-	-	-	-	-	-
5121_3	198,49	100,00	36,51	-	-	-	-	-	-
5122_1	94,31	65,22	62,80	57,83	54,40	52,31	13,46	-	-
5122_2	95,27	65,89	62,68	58,06	54,38	52,29	12,52	-	-
5122_3	95,61	66,44	63,80	58,80	55,35	53,35	10,12	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Table 5.6 Test results for 6.2 Weekend-rest simulation 6th cycle (after aging)									
Test date		15.09.2023 - 18.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	198,85	100,00	36,00	-	-	-	-	-	-
5121_2	197,60	100,00	37,33	-	-	-	-	-	-
5121_3	198,10	100,00	36,90	-	-	-	-	-	-
5122_1	90,16	63,36	60,84	55,90	53,05	50,63	20,91	-	-
5122_2	91,44	64,63	61,36	56,78	53,69	51,44	18,36	-	-
5122_3	91,91	65,04	62,29	57,80	54,59	52,57	16,08	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Table 5.7 Test results for 6.2 Weekend-rest simulation 7th cycle (after aging)									
Test date		18.09.2023 - 20.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	198,29	100,00	36,56	-	-	-	-	-	-
5121_2	196,94	100,00	37,99	-	-	-	-	-	-
5121_3	197,44	100,00	37,56	-	-	-	-	-	-
5122_1	86,35	62,11	59,74	54,83	52,19	49,96	26,69	-	-
5122_2	89,06	64,23	60,95	56,49	53,45	51,38	21,39	-	-
5122_3	89,02	64,81	61,66	57,18	54,01	51,18	20,19	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Table 5.8 Test results for 6.2 Weekend-rest simulation 8th cycle (after aging)									
Test date		20.09.2023 - 23.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	197,84	100,00	37,01	-	-	-	-	-	-
5121_2	196,39	100,00	38,54	-	-	-	-	-	-
5121_3	196,88	100,00	38,12	-	-	-	-	-	-
5122_1	83,39	61,43	59,24	54,55	52,25	50,12	30,09	-	-
5122_2	86,69	63,72	60,43	56,15	53,38	51,43	24,36	-	-
5122_3	86,62	63,36	60,51	56,39	53,30	51,60	25,44	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

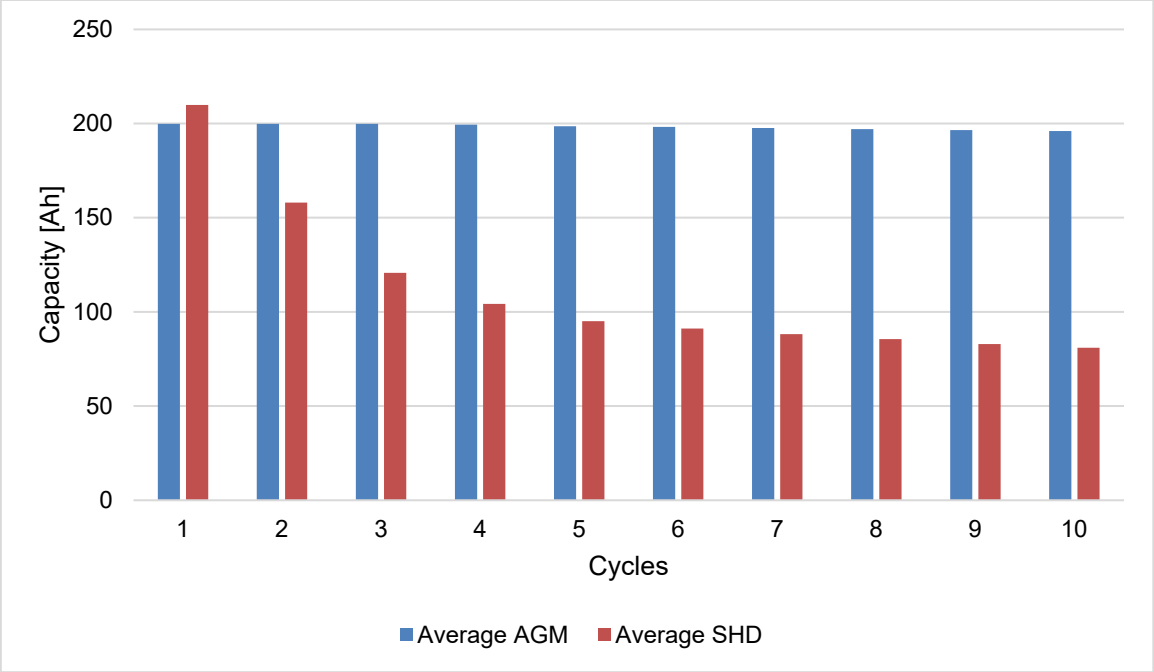
Table 5.9 Test results for 6.2 Weekend-rest simulation 9th cycle (after aging)									
Test date		23.09.2023 - 25.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	197,40	100,00	37,45	-	-	-	-	-	-
5121_2	195,79	100,00	39,15	-	-	-	-	-	-
5121_3	196,33	100,00	38,67	-	-	-	-	-	-
5122_1	81,77	61,42	59,04	54,41	52,25	50,18	31,90	-	-
5122_2	84,61	63,25	60,37	56,01	53,14	51,31	26,74	-	-
5122_3	82,26	62,43	59,95	55,66	52,76	51,06	29,91	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Table 5.10 Test results for 6.2 Weekend-rest simulation 10th cycle (after aging)									
Test date		25.09.2023 - 28.09.2023							
Step	1st DCH	1st CHA	2nd DCH	2nd CHA	3rd DCH	3rd CHA	4th DCH	4th CHA	5th DCH
Sample #	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
5121_1	196,94	100,00	37,91	-	-	-	-	-	-
5121_2	195,17	100,00	39,75	-	-	-	-	-	-
5121_3	195,77	100,00	39,23	-	-	-	-	-	-
5122_1	80,53	61,30	58,85	54,33	52,29	50,29	33,29	-	-
5122_2	82,84	62,73	59,79	55,56	52,98	51,11	29,25	-	-
5122_3	79,38	61,27	59,09	54,91	52,20	50,54	34,21	-	-
Sample #	-	Idling [min]	-	Idling [min]	-	Idling [min]	-	Idling [min]	-
5121_1	-	60	-	-	-	-	-	-	-
5121_2	-	60	-	-	-	-	-	-	-
5121_3	-	60	-	-	-	-	-	-	-
5122_1	-	60	-	60	-	60	-	-	-
5122_2	-	60	-	60	-	60	-	-	-
5122_3	-	60	-	60	-	60	-	-	-

Evaluation on test results:

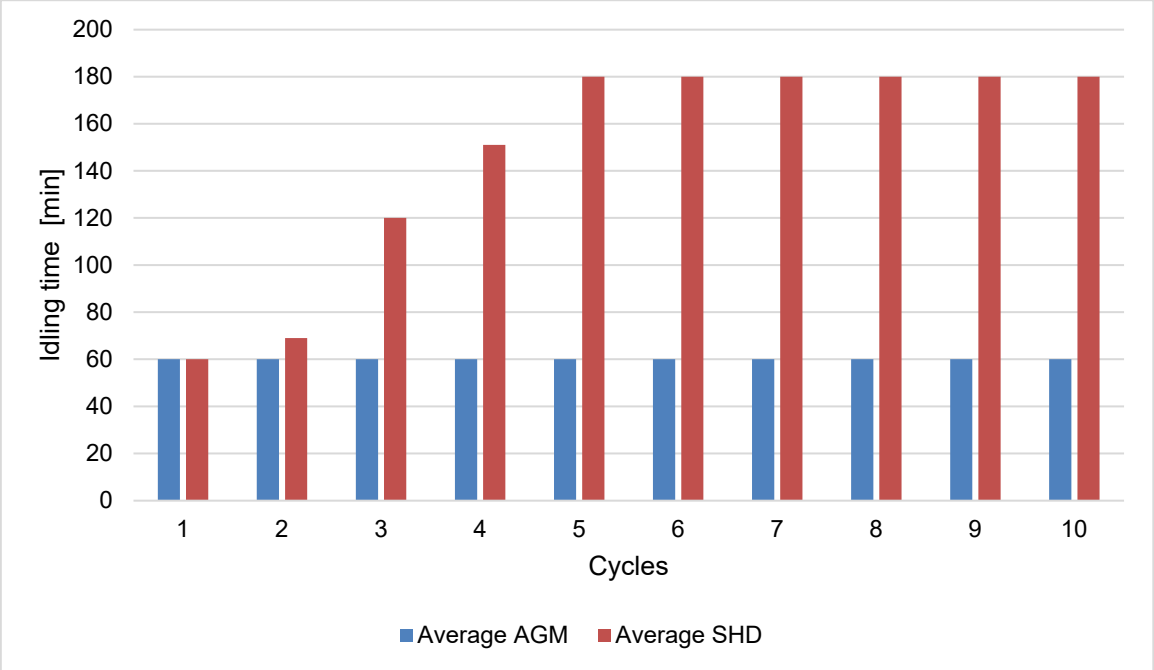
Below is the summary table of capacity, after each Weekend-rest simulation cycle:

Table 5.11 Summary of capacity for 6.2 Weekend-rest simulation 10 cycles (after aging)								
Cycles	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
1st cycle	199,99	199,16	200,21	199,79	211,41	205,66	212,29	209,79
2nd cycle	200,20	199,05	200,20	199,82	159,42	155,78	158,90	158,03
3rd cycle	200,08	199,17	200,21	199,82	121,80	118,05	122,37	120,74
4th cycle	200,03	198,78	199,46	199,42	103,23	102,51	107,01	104,25
5th cycle	199,13	197,95	198,49	198,52	94,31	95,27	95,61	95,06
6th cycle	198,85	197,60	198,10	198,18	90,16	91,44	91,91	91,17
7th cycle	198,29	196,94	197,44	197,56	86,35	89,06	89,02	88,14
8th cycle	197,84	196,39	196,88	197,04	83,39	86,69	86,62	85,57
9th cycle	197,40	195,79	196,33	196,51	81,77	84,61	82,26	82,88
10th cycle	196,94	195,17	195,77	195,96	80,53	82,84	79,38	80,92



Below is the summary table of idling time, after each Weekend-rest simulation cycle:

Table 5.12 Summary of idling time for 6.2 Weekend-rest simulation 10 cycles (after aging)								
Cycles	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]
1st cycle	60	60	60	60	60	60	60	60
2nd cycle	60	60	60	60	60	87	60	69
3rd cycle	60	60	60	60	120	120	120	120
4th cycle	60	60	60	60	160	172	120	151
5th cycle	60	60	60	60	180	180	180	180
6th cycle	60	60	60	60	180	180	180	180
7th cycle	60	60	60	60	180	180	180	180
8th cycle	60	60	60	60	180	180	180	180
9th cycle	60	60	60	60	180	180	180	180
10th cycle	60	60	60	60	180	180	180	180
Average	60	60	60	60	148	152	144	148



It can be concluded that average idling time of AGM batteries in weekend-rest simulation 10 cycles (after aging) is 60 minutes, while it is 148 minutes of SHD batteries.

7.7 Final measurement results and evaluation

Table 6.1 Test results for 6.5 Final measurement							
Test date	04.10.2023 - 12.10.2023						
Test clause	Sample #						Remark
-	5121_1	5121_2	5121_3	5122_1	5122_2	5122_3	-
1st C_{20} [Ah]	225,32	224,39	181,99	172,86	161,68	147,48	-
- Percentage	107%	107%	87%	77%	72%	66%	-
- HCD (60s) [V]	10,85	10,87	10,85	10,32	10,31	10,29	-
- HCD (150s) [V]	10,69	10,71	10,69	9,96	9,95	9,92	-

Evaluation of test results:

Table 6.2 Summary of capacity of test sequence								
Test sequence	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]	Capacity [Ah]
6.1 Initial measurement	218,46	221,41	221,09	220,32	233,76	213,35	238,15	228,42
After 6.2 Weekend-rest simulation 10 cycles (before aging)	190,60	187,97	188,01	188,86	73,85	71,09	73,94	72,96
6.3 Intermediate measurement	225,18	226,46	225,76	225,80	194,76	191,80	203,04	196,53
After 6.4 aging 40 cycles	226,64	232,11	232,33	230,36	211,98	194,20	216,46	207,55
After 6.2 Weekend-rest simulation 10 cycles (after aging)	196,94	195,17	195,77	195,96	80,53	82,84	79,38	80,92
6.5 Final measurement	225,32	224,39	229,56	226,42	172,86	161,68	147,48	160,67

Please refer to Chapter 9.3 for analysis on the recovery behavior of capacity.

Table 6.3 Summary of cranking performance of test sequence								
Test sequence	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]	Voltage [V]
HCD (60s)								
6.1 Initial measurement	10,82	10,83	10,83	10,83	10,29	10,31	10,31	10,30
6.3 Intermediate measurement after 6.2 Weekend-rest simulation 10 cycles (before aging)	10,84	10,82	10,82	10,83	10,02	9,99	10,08	10,03
After 6.4 aging 40 cycles	10,95	10,99	11,00	10,98	10,52	10,48	10,53	10,51
6.5 Final measurement after 6.2 Weekend-rest simulation 10 cycles (after aging)	10,85	10,87	10,85	10,86	10,32	10,31	10,29	10,31
HCD (150s)								
6.1 Initial measurement	10,64	10,65	10,64	10,64	9,95	9,98	9,98	9,97
6.3 Intermediate measurement after 6.2 Weekend-rest simulation 10 cycles (before aging)	10,65	10,57	10,59	10,60	9,50	9,45	9,60	9,52
After 6.4 aging 40 cycles	10,65	10,80	10,79	10,75	10,12	10,08	10,17	10,12
6.5 Final measurement after 6.2 Weekend-rest simulation 10 cycles (after aging)	10,69	10,71	10,69	10,70	9,96	9,95	9,92	9,94

Cranking performance shows all samples are still able to provide cranking.

8. Validation conclusion

Table 7 Comparison of idling time (extraction of Table 2.11 and Table 5.11)								
Test sequence	Sample # of AGM batteries				Sample # of SHD Batteries			
	5121_1	5121_2	5121_3	Average	5122_4	5122_5	5122_6	Average
	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]	Idling [min]
Average in 6.2 Weekend-rest simulation 10 cycles (before aging)	60	60	60	60	136	150	138	141
Average in 6.2 Weekend-rest simulation 10 cycles (after aging)	60	60	60	60	148	152	144	148

Based on above summary, it is concluded that the claim is valid.

9. Other remarks

9.1 Consideration of risk for the validation

The validation plan is based on best understanding of the application. The risk of this validation is considered “Reasonable”.

9.2 Consideration of “weekend-rest simulation”

For Chapter 6.2 “weekend-rest simulation”, the consideration of this test is:

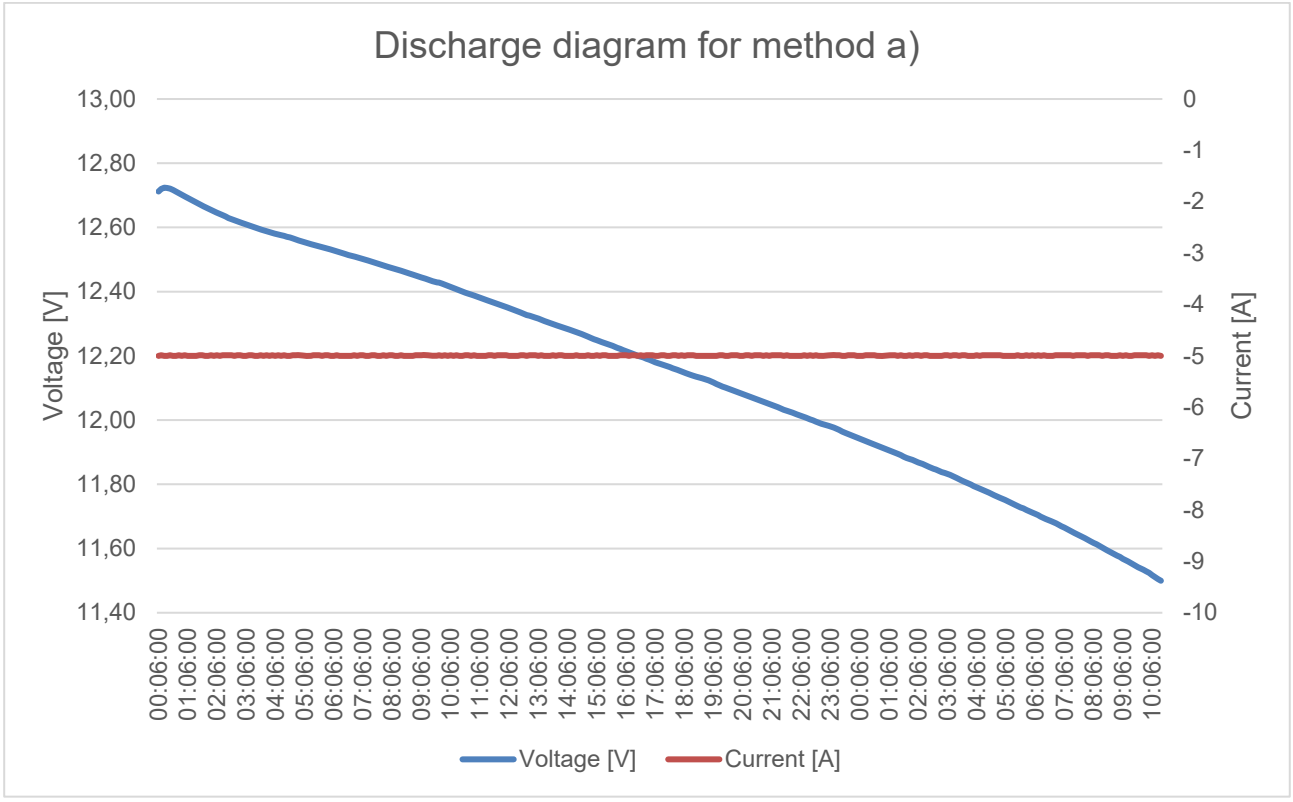
9.2.1 Use step 6.2.1.1 to simulate start of weekend, when the batteries are full and start to discharge until cut-off voltage. In reality, the discharge current will never be a constant value. Depending on how many appliances are used at the same time, the discharge current always various. However, if the test is also designed with variable discharge current, the programming would be very difficult. To compare the differences between using a constant discharge current and using a variable discharge current, a pre-test is conducted with two fully-charged batteries, following settings:

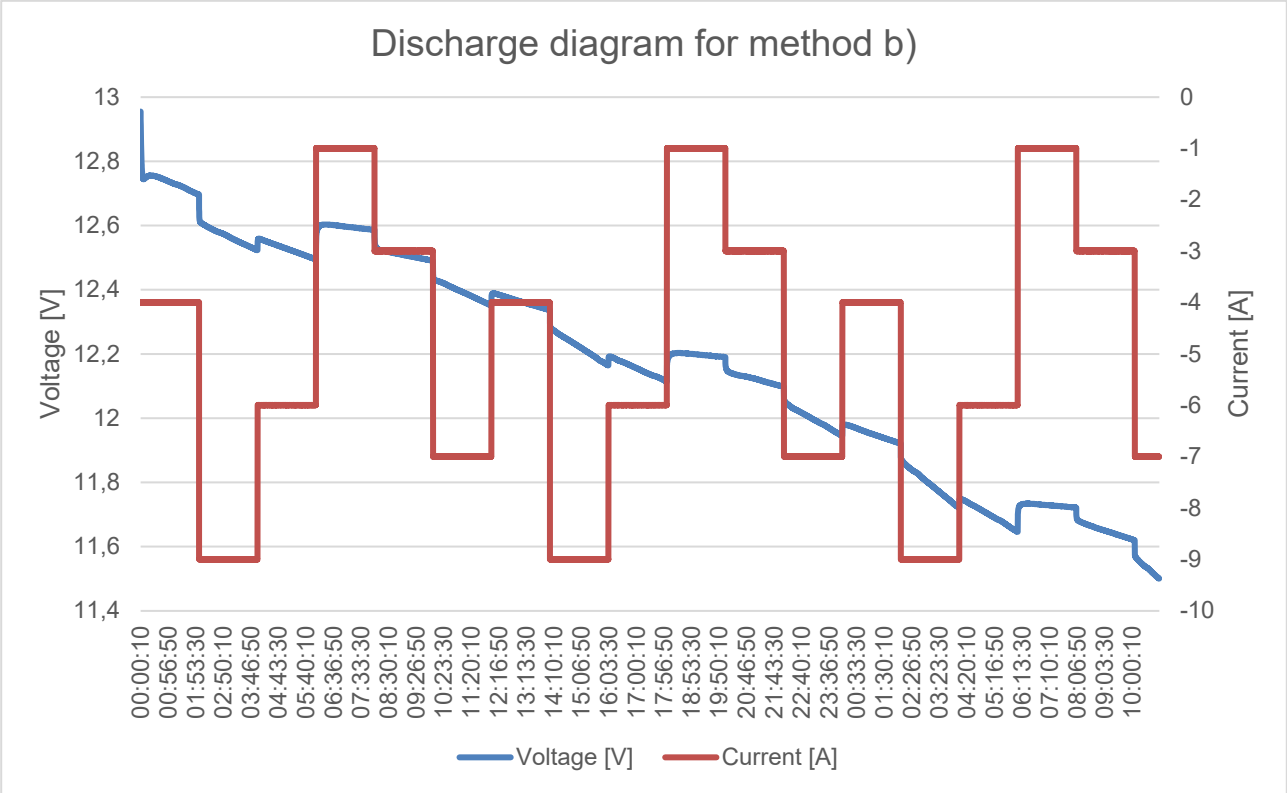
a) Constant discharge at 5A, until cut-off voltage 11,5V.

b) Discharge with following setup for each cycle, and repeat the cycle until cut-off voltage 11,5V:

2 hours at 4A, 2 hours at 9A, 2 hours at 6A, 2 hours at 1A, 2 hours at 3A, 2 hours at 7A (i.e. average at 5A)

The result of the pre-test is listed below:





Measured discharged capacity of method a): 171,68Ah

Measured discharged capacity of method b): 171,72Ah

From the result, it can be concluded that the differences between using a constant discharge current and using a variable discharge current is comparable. Therefore, in step 6.2.1.1, a constant discharge current is used.

9.2.2 Use step 6.2.1.2 to simulate when the cut-off voltage is reached, the truck drivers then must start the engine to charge the batteries. For fuel consumption consideration, this charging is usually 1 hours.

9.2.3 Use Step 6.2.1.3 to repeat Step 6.2.1.1 and Step 6.2.1.2 up to 48 hours, i.e. end of the weekend-rest.

9.2.4 Use Step 6.2.1.4 to simulate the workdays where the batteries are again fully charged. For simulation purpose, 12 hours of charging time is enough to fully charge the batteries.

9.3 Additional remark of “maintenance”

By analysis on table 6.2 in Chapter 7.7, it is found that, after weekend-rest 10 simulations cycles, in average, capacity of AGM battery samples are still about 86% of initial capacity, while SHD battery samples are only about 32% of the initial capacity.

However, when these samples received an intermediate measurement, where a proper charging - discharging cycle is conducted, in average, the capacity of AGM battery samples recovered to 102% of initial capacity, and SHD battery samples also recovered to 86% of initial capacity.

During the aging 40 cycles, since the charging voltage is higher than intermediate measurement, to some degree, this helps to further recover the capacity of the samples. In average, the capacity of AGM battery samples reached 105% of initial capacity, and SHD battery samples reached 91% of initial capacity.

It is therefore noticed that if this “in-depth” charging - discharging cycle, also commonly known as “maintenance” of batteries, could be applied regularly, especially for SHD batteries, the performance of SHD batteries can be improved.

Annex 1: Product datasheet

VARTA®

VARTA ProMotive AGM

Vehicle Key Benefits

Made in Germany

Patented PowerFrame® grid for reliable starting power, fast recharge and corrosion resistance.

Meets all original criteria of the commercial vehicle manufacturer

For advanced hoteling functions with parking cooler / heater

For more information visit varta-automotive.com

ORDER INFORMATION	
European Type No. (ETN):	710901120
Article Number:	710901120E652
Short Code:	A1
Barcode:	4016987152980
UK Code:	625AGM
Packaging Unit:	1
Quantity per Pallet:	12

TECHNICAL INFORMATION			
Voltage [V]:	12	**Base Hold-down:**	B00
Battery Capacity [Ah]:	210	**Layout:**	3
CCA, EN [A]:	1200	**Terminal Types:**	1
Length [mm]:	518	**Case Size:**	C
Width [mm]:	276	**Weight filled (kg):**	61
Height [mm]:	242		

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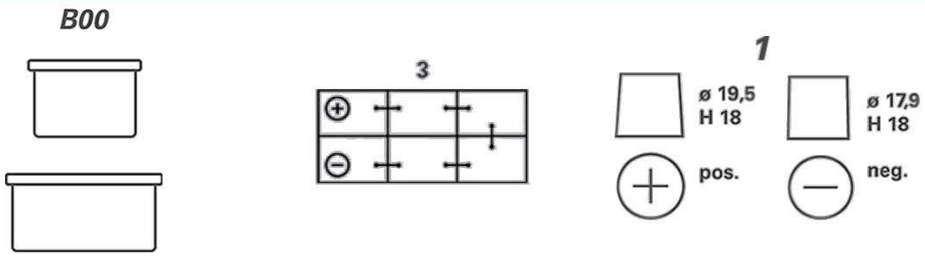
DRAWINGS



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VARTA

VARTA ProMotive SHD

Vehicle Key Benefits

- Engineered in Germany
- Patented PowerFrame® grid for reliable starting power, fast recharge and corrosion resistance.
- Meets all original criteria of the commercial vehicle manufacturer

For more information visit varta-automotive.com

ORDER INFORMATION	
European Type No. (ETN):	725103115
Article Number:	725103115A722
Short Code:	N9
Barcode:	4016987128831
UK Code:	625SHD
Packaging Unit:	1
Quantity per Pallet:	12

TECHNICAL INFORMATION			
Voltage [V]:	12	**Base Hold-down:**	B00
Battery Capacity [Ah]:	225	**Layout:**	3
CCA, EN [A]:	1150	**Terminal Types:**	1
Length [mm]:	518	**Case Size:**	C
Width [mm]:	276	**Weight filled (kg):**	57,5
Height [mm]:	242		

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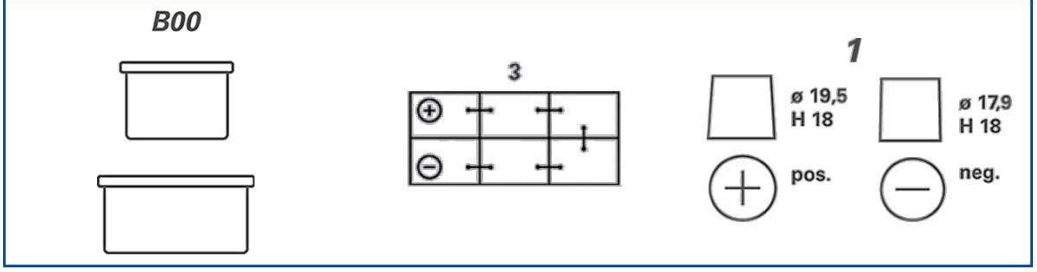
DRAWINGS



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Annex 2: List of measurement equipment

External calibration

No.	Equipment	Identification	Calibrated on
1	Temperature sensor / Testo 950	ELK100.00	29.06.2023
2	Multi-function calibrator / Fluke 5520A	ELP198.02	26.10.2022

Internal verification

No.	Equipment	Identification	Verified on
1	Multimeter / Fluke 45	LB100	14.12.2022
2	Multimeter / Solartron 7055	LB135	14.12.2022
3	Multimeter / Keysight U1271A D	ELB110.08	21.04.2023
4	Cranking test, discharge bench / Digatron BTS600 HEW 1500	ELB510.03	28.10.2022
5	Shunt	LP9	30.06.2023
6	Temperature sensor	ELB 100.02	05.09.2022
7	Charge / discharge bench / Digatron BTS 600 ME	ELB563.01	17.04.2023
8	Charge / discharge bench / Digatron BTS 600 ME	ELB563.02	05.12.2022
9	Charge / discharge bench / Digatron BTS 600 ME	ELB563.03	06.10.2022
10	Charge / discharge bench / Digatron BTS 600 ME	ELB563.13	02.12.2022
11	Charge / discharge bench / Digatron BTS 600 ME	ELB563.14	01.06.2023
12	Charge / discharge bench / Digatron BTS 600 ME	ELB563.15	18.10.2022
13	Temperature sensor / BTS 600	ELB202.041	24.08.2022
14	Temperature sensor / BTS 600	ELB202.041-2	24.08.2022
15	Temperature sensor / BTS 600	ELB202.041-3	24.08.2022
16	Temperature sensor / BTS 600	ELB202.045	24.08.2022
17	Temperature sensor / BTS 600	ELB202.045-2	24.08.2022
18	Temperature sensor / BTS 600	ELB202.045-3	24.08.2022

Annex 3: Photos of test samples


VARTA
ProMotive AGM
MAINTENANCE FREE
A1
12V 210Ah 1200A (EN)
710 901 120 E65 2


0001 2 682272 2
13 230305 0157 N

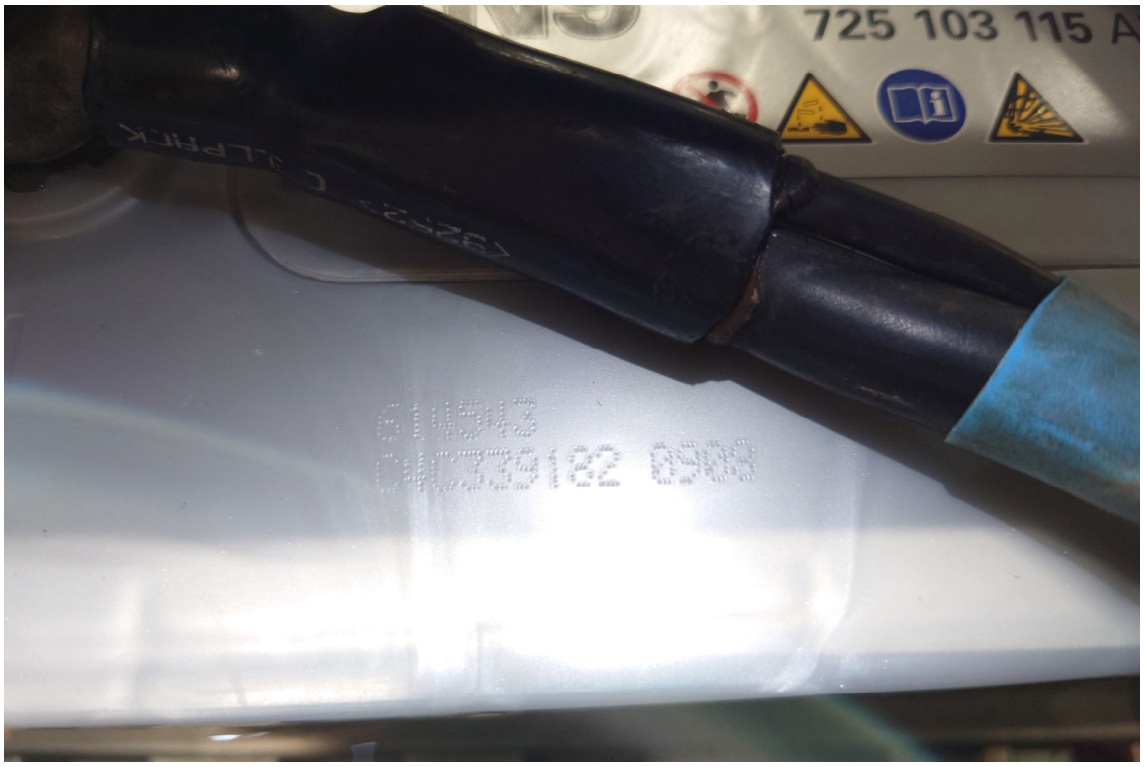

0001 2 682272 2
13 230305 0729 S

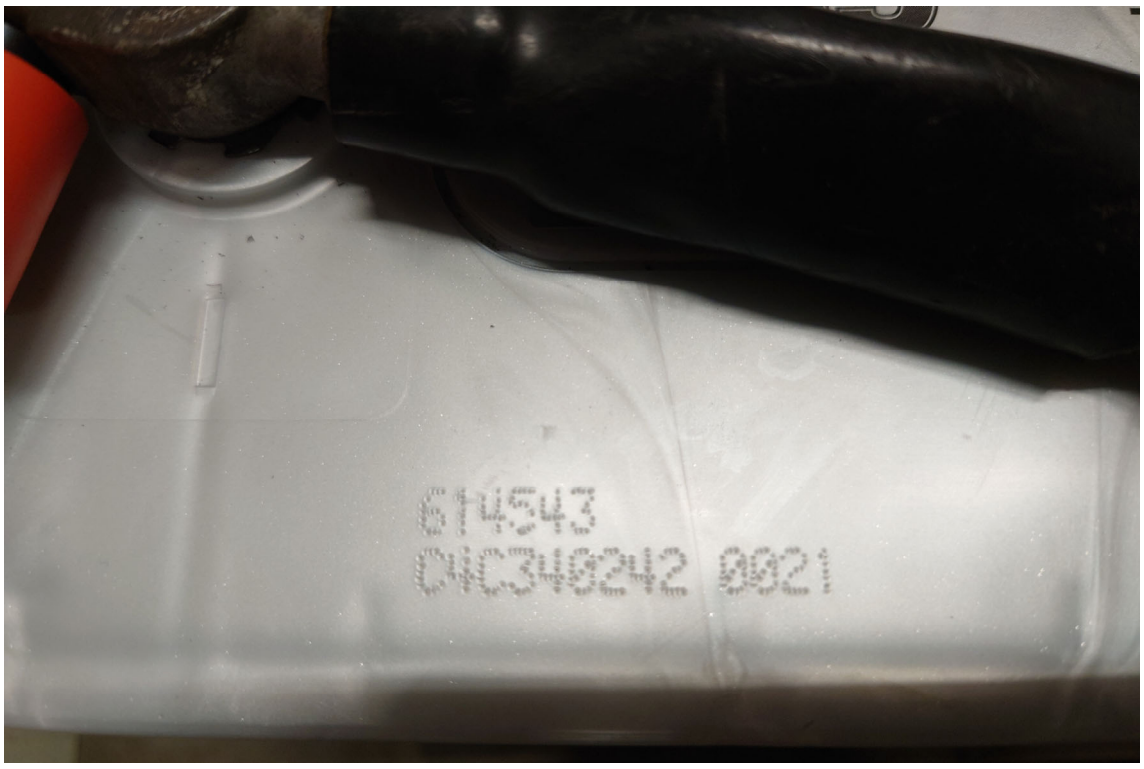

0001 2 682272 2
13 230305 0726 S


VARTA
ProMotive AGM
VARTA
ProMotive
SUPER-HEAVY DUTY
12V 225Ah 1150A
N9
VARTA
ProMotive
SUPER-HEAVY DUTY
N9


VARTA®
POWER FRAME
ProMotive
SUPER-HEAVY DUTY
N9
12V 225Ah 1150A (EN)
725 103 115 A72 2
CLARIOS


ProMotive AGM
VARTA
ProMotive
SUPER HEAVY DUTY
MAINTENANCE FREE
N9
12V 225Ah 1150A (EN)
725 103 115 A72 2
VARTA
ProMotive
SUPER HEAVY DUTY


725 103 115 A


614543
DIC340242 0021

Annex 4: Financial calculation (informative)

Based on table 5.12 of Chapter 7.6, following modeling is informative calculation to see the differences of the two battery types:

Table 8 Financial calculation (informative)				
-	**Type**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Weekends on parking lot	-	Once a month	Every 2 weeks	Every week
Weekends per year	-	12	24[1]	50[1]
Total idling time (1st year)[1]	SHD	1892 mins	4772 mins	11012 mins
	AGM	720 mins	1440 mins	3000 mins
Fuel consumption (1st year)[2]	SHD	94,6 Liters	238,6 Liters	550,6 Liters
	AGM	36 Liters (-62%)	72 Liters (-70%)	150 Liters (-73%)
CO_2 equivalents (CO_2e) for diesel consumption (1st year)[3]	SHD	246,0 kg	620,4 kg	1431,6 kg
	AGM	93,6 kg	187,2 kg	390 kg
Potential savings per vehicle[4]	SHD	170,3 euros	429,5 euros	991,1 euros
	AGM	64,8 euros (-105,5 euros)	129,6 euros (-299,9 euros)	270 euros (-721,1 euros)

Remarks:

1. Since the weekend-rest simulation is only tested for 10 cycles (i.e. 10 weekends), idling time since 11th week is considered same as the 10th week. (60mins for AGM batteries, 240 mins for SHD batteries). Idling time in real may differs.

2. Considered as 3 Liter per hour for average truck engine consumption when idling.

3. Considered 2,6 kg CO_2e per liter of diesel. The actual CO_2e emissions of diesel fuel can vary depending on a number of factors, including the quality of the fuel, the type of engine, and the driving conditions. TÜV NORD has not reviewed the manufacturing of Clarios' batteries. These numbers do not indicate overall CO_2e savings.

4. Considered 1,80 euros per liter of diesel. (as of 10.11.2023).

---------- End of validation report ----------