Test Report issued under the responsibility of:

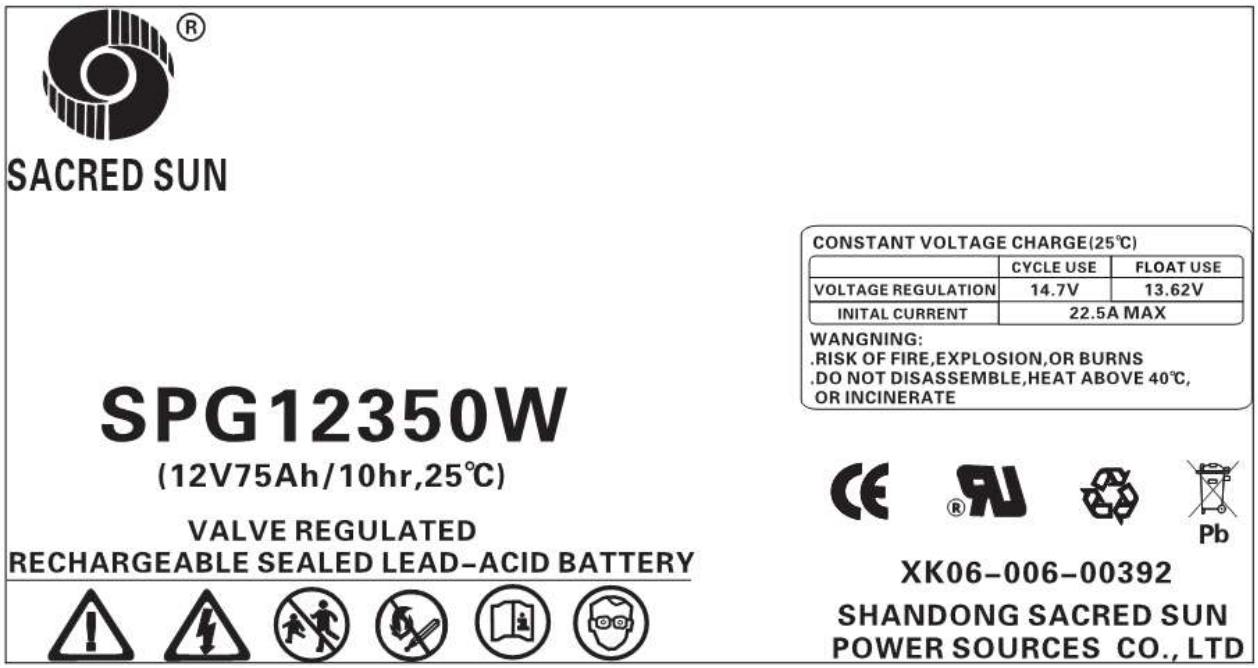
TEST REPORT
IEC 60896
Stationary lead-acid batteries —
Part 21: Valve regulated types — Methods of test
Part 22: Valve regulated types — Requirements

Report Reference No.....:	160502697SHA-001
Date of issue .....:	2016-05-26
Total number of pages	34
Testing Laboratory.....:	Intertek Testing Services Shanghai
Address .....:	Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China
Applicant's name.....:	Shandong Sacred Sun Power Sources Co., Ltd.
Address .....:	NO.1 Shengyang Road Qufu Shandong china
Test specification:	
Standard.....:	IEC 60896-21:2004, IEC 60896-22:2004
Test procedure .....:	Testing
Non-standard test method……..:	N/A
Test Report Form No.....:	TTRF_EN60896_A
Test Report Form(s) Originator .....:	Intertek ETL SEMKO shanghai
Master TRF .....:	Dated 2010-11

Test item description .....:	Valve regulated lead acid battery
Trade Mark.....:	Sacred sun
Manufacturer .....:	Shandong Sacred Sun Power Sources Co., Ltd.
Model/Type reference .....:	SPG12350W
Ratings .....:	12V 75Ah

Testing procedure and testing location:	
☒ **Testing Laboratory:**	Intertek Testing Services Shanghai
Testing location/ address.....:	Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China
☐ **Associated Laboratory:**	
Testing location/ address.....:	
Tested by (name + signature) .....:	
Approved by (+ signature).....:	
☒ Testing procedure: TMP	
Tested by (name + signature) .....:	Sleif Sui
Approved by (+ signature).....:	Will Wang
Testing location/ address.....:	Shandong Sacred Sun Power Sources Co., Ltd NO.1 Shengyang Road Qufu Shandong China
☐ Testing procedure: WMT	
Tested by (name + signature) .....:	
Witnessed by (+ signature).....:	
Approved by (+ signature).....:	
Testing location/ address.....:	
☐ Testing procedure: SMT	
Tested by (name + signature) .....:	
Approved by (+ signature).....:	
Supervised by (+ signature) .....:	
Testing location/ address.....:	
☐ Testing procedure: RMT	
Tested by (name + signature) .....:	
Approved by (+ signature).....:	
Supervised by (+ signature) .....:	
Testing location/ address.....:	

Marking:



Note: Other models have similar label except model name and ratings.

Test item particulars ..... :	Valve regulated lead acid battery
Possible test case verdicts:	
- test case does not apply to the test object ..... :	N/A
- test object does meet the requirement ..... :	P (Pass)
- test object does not meet the requirement ..... :	F (Fail)
Testing ..... :	
Date of receipt of test item ..... :	2014-09-04
Date (s) of performance of tests ..... :	2014-09-04 to 2016-05-25

General remarks:

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
"(see Enclosure #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

Throughout this report a point is used as the decimal separator.
All cells have similar construction and belong to same series. All 12V models incorporate cells of same series.
After evaluation, throughout this report SPG12350W is tested as typical models.

General product information:

The battery is valve regulated type stationary lead-acid battery for general use.

Model	I_{10} (A)	I_8 (A)	I_3 (A)	I_1 (A)	$I_{0.25}$ (A)	C10 (25℃ 1.80V)	C3 (25℃ 1.70V)
SPG12350W	7.5	9.0	18.7	41.3	144.4	75	56.25

Charging parameters were provided by manufacturer			
Model	float charge voltage	Fully charging method	
SPG12350W	13.50V(2.25V/cell)	Ufinal	14.1V (2.35V/cell)
		I limited	1.5*I_{10},
		Max. Time	24h

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict

4 FUNCTIONAL REQUIREMENTS

4.1 Overview

The following requirements are grouped into safe operation, performance and durability needs.

4.2 Safe operation characteristics

Test clause	Measures	Purpose
6.1	Gas emission	To determine the emitted gas volume
6.2	High current tolerance	To verify the adequacy of current conduction cross- sections
6.3	Short circuit current and d.c. internal resistance	To provide data for the sizing of fuses in the exterior circuit
6.4	Protection against internal ignition from external spark sources	To evaluate the adequacy of protective features
6.5	Protection against ground short propensity	To evaluate the adequacy of design features
6.6	Content and durability of required markings	To evaluate the quality of the markings and the content of the information
6.7	Material identification	To ensure the presence of material identification markings
6.8	Valve operation	To ensure the correct opening of safety valves
6.9	Flammability rating of materials	To verify the fire hazard class of battery materials
6.10	Intercell connector performance	To verify the maximum surface temperatures of the connectors during high rate discharges

4.3 Performance characteristics

Test Clause	Measures	Purpose
6.11	Discharge capacity	To verify the available capacities at selected discharge rates or discharge durations.
6.12	Charge retention during storage	To provide storage duration data
6.13	Float service with daily discharges	To determine cyclic performance under float charge conditions
6.14	Recharge behaviour	To determine the recovery of capacity or autonomy time after a power outage

4.4 Durability requirements

Test Clause	Measures	Purpose
6.15	Service life at an operating temperature of 40 °C	To determine the operational life at elevated temperatures
6.16	Impact of a stress temperature of 55 °C or 60 °C	To determine the influence of high stress temperatures on cell or monobloc battery life
6.17	Abusive over-discharge	To determine the expected behaviour when excessive capacity is discharged
6.18	Thermal runaway sensitivity	To determine the expected times to establish a condition of escalating current and temperature
6.19	Low temperature sensitivity	To determine the sensitivity toward damage induced by electrolyte freezing
6.20	Dimensional stability at elevated internal pressure and temperature	To determine the propensity of the cell or monobloc to be deformed by internal gas pressure and at elevated temperatures
6.21	Stability against mechanical abuse of units during installation	To determine the propensity of the cell or monobloc battery to fracture or leak when dropped.

4.5 Test result requirements

The test results required to verify the characteristics defined in 6.1 to 6.21

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict

5	**TEST SET-UP (IEC 60896-21:2004)**		P
5.1	Accuracy of measuring instruments		P
5.1.1	Voltage measurements		P
	The instruments used shall be of an accuracy class 0,5 or better where required. The resistance of the voltmeters shall be at least 10 000 Ω/V.		P
5.1.2	Current measurements		P
	The instruments used shall be of an accuracy class 0,5 or better where required.		P
5.1.3	Temperature measurement		P
	The instruments used shall have a resolution of 1 K. The absolute accuracy of the instruments shall be 1 K or better where required.		P
5.1.4	Time measurements		P
	The time measurements shall have of an accuracy of ±1 % or better where required.		P
5.1.5	Length measurements		P
	The instruments used shall have an accuracy of ±0,1 % or better where required.		P
5.1.6	Weight measurements		P
	The instruments used shall have an accuracy of ±1 % or better where required.		P
5.1.7	Gas volume measurements		P
	The instruments used shall have an accuracy of ±5 % or better where required.		P
5.1.8	Gas pressure measurements		P
	The instruments used shall have an accuracy of ±10 % or better where required.		P
5.2	Selection of test units		P
	The units to be used for type testing according to this part of IEC 60896 shall be selected in accordance with the procedures as standard specified		P
5.3	General test features and rules		P

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict
5.3.1	The test units shall not undergo any maintenance operations such as water or electrolyte additions or withdrawals during the entire duration of a test.		P
5.3.2	The test units shall be tested in the position specified by the manufacturer in the relevant technical documentation of the product range except for those cases in which a particular position is specified in the test clause. The position used in any given test shall be reported in the relevant test documentation.		P
5.3.3	The test units shall always be tested fully charged with the method and duration of charge being exclusively that specified by the manufacturer in the relevant technical documentation of the product range except for those cases in which a particular method or duration is specified in the test subclause. The charge methods and duration used in each test shall be reported in the relevant test documentation.		P
5.3.4	Whenever there is a significant change in a specified design feature, material, manufacturing process, relevant quality inspection and test procedures of the manufacturing location(s) of a product range, the relevant type test(s) shall be repeated to ensure that the affected product range continues to be in compliance with the defined Safe operation, Performance and Durability requirements for the intended application.		P
5.3.5	Each test and test set-up shall be documented with photographs that give a clear image of the test units and their identification numbers.		P
5.4	Number of test units		P

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict

5.4.1 — The number of units to be tested is summarized below — P

Test Clause	Measures	Number of test units
6.1	Gas emission	6 cells or 3 monobloc batteries
6.2	High current tolerance	3 cells or 3 monobloc batteries
6.3	Short circuit current and d.c. internal resistance	3 cells or 3 monobloc batteries
6.4	Protection against internal ignition from external spark sources	3 valve assemblies
6.5	Protection against ground short propensity	1 cell or 1 monobloc battery
6.6	Content and durability of required markings	3 samples
6.7	Material identification	1 cover or 1 case sample
6.8	Valve operations	3 cells or 3 monobloc batteries
6.9	Flammability rating of materials	1 sample per material
6.10	Intercell connector performance	6 cells or 6 monobloc batteries

P

Test Clause	Measures	Number of test units
6.11	Discharge capacity	5 x 6 cells or 5 x 6 monobloc batteries
6.12	Charge retention during storage	6 cells or 6 monobloc batteries
6.13	Float service with daily discharges	6 cells or 3 monobloc batteries
6.14	Recharge behaviour	3 cells or 3 monobloc batteries

P

Test Clause	Measures	Number of test units
6.15	Service life at an operating temperature of 40 °C	3 cells or 3 monobloc batteries
6.16	Impact of a stress temperature of 55 °C or 60 °C	3 cells or 3 monobloc batteries
6.17	Abusive over-discharge	4+3 cells or 4+3 monobloc batteries
6.18	Thermal runaway sensitivity	6 cells or 6 monobloc batteries
6.19	Low temperature sensitivity	3 cells or 3 monobloc batteries
6.20	Dimensional stability at elevated internal pressure and temperature	1 cell or 1 monobloc battery
6.21	Stability against mechanical abuse of units during installation	2 cells or 2 monobloc batteries

P

5.5	Suggested test sequence		P
	Multiple tests on the same units are allowed. However, the test sequence should be planned carefully to ensure that the execution of one test does not disturb or unduly influence the outcome of a subsequent test or cause hidden safety problems. In some cases, a test clause may proscribe a sequence of tests. Separate units may be used for each test unless otherwise specified. The manufacturer makes the final decision on the test sequence. The adopted test sequence shall be recorded in the relevant test documentation.		P
5.6	Customer test		N/A
5.6.1	The test units and test to be used for acceptance or commissioning tests shall be selected and defined by a joint agreement between the battery supplier and battery user.		N/A

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict
	For an acceptance or commissioning capacity test, a discharge at the 3 h rate to a final voltage of 1,70 Vpc or as agreed upon between battery supplier and battery user, shall be selected.		N/A
6	**TEST METHODS AND REQUIREMENTS AND CHARACTERISTICS**		P
6.1	Gas emission	Refer to table 6.1	State data
6.2	High current tolerance	Refer to table 6.2	P
6.3	Short-circuit current and d.c. internal resistance	Refer to table 6.3	State data
6.4	Protection against internal ignition from external spark sources	Refer to table 6.4	P
6.5	Protection against ground short propensity	Refer to table 6.5	P
6.6	Content and durability of required markings	Refer to table 6.6	P
6.7	Material identification	Refer to table 6.7	P
6.8	Valve operations	Refer to table 6.8	P
6.9	Flammability rating of materials	Refer to table 6.9	State data
6.10	Intercell connector performance	Refer to table 6.10	State data
6.11	Discharge capacity	Refer to table 6.11	P
6.12	Charge retention during storage	Refer to table 6.12	P
6.13	Float service with daily discharges	Refer to table 6.13	P
6.14	Recharge behaviour	Refer to table 6.14	P
6.15	Service life at an operating temperature of 40 °C	Not conducted according manufacturer's requirement	N/A
6.16	Impact of a stress temperature of 55 °C or 60 °C	Refer to table 6.16	P
6.17	Abusive over-discharge	Refer to table 6.17	P
6.18	Thermal runaway sensitivity	Refer to table 6.18	P
6.19	Low temperature sensitivity	Refer to table 6.19	P
6.20	Dimensional stability at elevated internal pressure and temperature	Refer to table 6.20	State data
6.21	Stability against mechanical abuse of units during installation	Refer to table 6.21	P
ANNEX A	**(NORMATIVE) USER STATEMENT OF REQUIREMENTS (IEC 60896-22)**		N/A
1)	Application description information		N/A
	Application summary		N/A
	Load (in A or W) and autonomy time profile(s)		N/A

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict
	Minimum and maximum system float voltage		N/A
	Maximum or boost charge system voltage available Y/N If yes what value?		N/A
	Minimum system discharge voltage or low voltage disconnect Y/N If yes what value?		N/A
	Expected minimum and maximum operating temperatures and their duration per year		N/A
	Any other relevant information or operational requirements such as duration and frequency of power outages, of diagnostic discharges and of energy cost saving actions		N/A
2)	Product specification information		N/A

	Product safe operation in service	Compliance information mandatory
6.1	Gas emission (at float voltage and at 2,40 Vpc)	Data requested
6.2	High current tolerance	Pass
6.3	Short circuit current and d.c. internal resistance	Data requested
6.4	Internal ignition from external spark sources	Pass
6.5	Protection against ground short propensity	Pass
6.6	Content and durability of required markings	Pass
6.7	Material identification	Pass
6.8	Valve operation	Pass
6.9	Flammability rating of materials	Data requested
6.10	Intercell connector performance	Data requested

N/A

	Product performance in service	Compliance information mandatory or on as-needed basis					
6.11	Discharge capacity	Data for	C_{10}	C_8	C_3	C	$C_{0.25}$
6.12	Charge retention during storage	Pass					
6.13	Float service with daily discharges	Value to be requested as function of service environment					
6.14	Recharge behaviour	Pass					

N/A

	Product durability in service	Compliance information mandatory or on as-needed basis
6.15	Service life at an operating temperature of 40 °C	Value to be requested as function of service environment
6.16	Impact of a stress temperature of 55 °C or 60 °C	Value to be requested as function of service environment
6.17	Abusive over-discharge	Value to be requested if service environment warrants
6.18	Thermal runaway sensitivity	Pass and show data
6.19	Low temperature sensitivity	Value to be requested if service environment warrants
6.20	Dimensional stability at elevated internal pressure and temperature	Show data
6.21	Stability against mechanical abuse of units during installation	Pass

IEC 60896-21:2004, IEC 60896-22:2004			
Clause	Requirement + Test	Result - Remark	Verdict

ANNEX B	**(NORMATIVE) SUPPLIER STATEMENT OF PRODUCT RANGE TEST RESULTS (IEC 60896-22)**		N/A
1)	General product type information		N/A
	Product manufacturer		N/A
	Manufacturing site of tested product		N/A
	Product name		N/A
	Product model range		N/A
	Product comprising the above model range		N/A
	Product tested		N/A
2)	Product test performance information		N/A

	Product safe operation in service	IEC 60896-21 test clause result	
6.1	Gas emission (at the float voltage and at 2,40 Vpc)		
6.2	High current tolerance		
6.3	Short circuit and d.c. internal resistance		
6.4	Internal ignition from external spark sources		
6.5	Protection against ground short propensity		
6.6	Content and durability of required markings		
6.7	Material identification	Case	Cover
6.8	Valve operation	Before	After
6.9	Flammability rating of materials	Case	Cover
6.10	Intercell connector performance		

N/A

	Product performance in service	IEC 60896-21 test clause result				
6.11	Discharge capacity	C_{10}	C_8	C_3	C	$C_{0.25}$
6.12	Charge retention during storage					
6.13	Float service with daily discharges	Cycles		C_{at}		C_{ah}
6.14	Recharge behaviour	24 h			168 h	

N/A

	Product durability in service	IEC 60896-21 test clause result	
6.15	Float service life at 40 °C	Days with C_3 rate test at 40 °C	
6.16	Impact of stress temperature of 55 °C or 60 °C	Days with C_3 rate test at 55 °C or 60 °C Days with $C_{0.25}$ rate test at 55 °C or 60 °C	
6.17	Abusive over-discharge		
6.18	Thermal runaway sensitivity		
6.19	Low temperature sensitivity		
6.20	Dimensional stability at elevated internal pressure and temperature		
6.21	Stability against mechanical abuse of units during installation		

N/A

Company name:
Company officer:
Address/phone/fax/e-mail:
Signature/date/place:
Document established as reply for RFI:

N/A

IEC 60896-21:2004, IEC 60896-22:2004

Table 6.1	Gas emission	Verdict:	State data
Test method:			

Each cell has an actual capacity Ca ≥ C3 and was fully charged.
Test A: The normalized gas emission Ge per cell at float charge voltage conditions at 25 °C:
1. Three batteries in a series string, for 72 h with float charge voltage 40.5V (13.5V / each battery);
2. After 72 h float charge, check whether the battery is leakage or not first. Continue float charging for 168 h and collect gas at the same time. Record Va value and convert to Vn at 25°C;
3. The corrected volume of gas Vn emitted at the reference temperature of 25 °C and the reference pressure of 101,3 kPa shall be calculated by the formula $V_n = \frac{V_a \times T_r}{T_a} \times \frac{P_a}{P_r}$
4. Four cycles, time for each cycle is 168 h;
5. Calculate normalized gas emission Ge.
   Ge = Vn / (n 168 Crt) in ml per cell, hour and Ah (rated C3), n=1

Test B: The normalized gas emission Ge per cell at 14.4V charge voltage conditions at 25 °C:
1. After test A, three batteries in a series string, for 24 h with charge voltage 43.2V (14.4V / each battery);
2. Then collect gas. Stop collecting when the time is up to 48 h or gas is up to 1000ml.
3. Record the cumulative total gas volume (Va in ml) collected over one period of 48 h or the time tc (in hours) to collect 1 000 ml.
4. The corrected volume of gas Vn emitted at the reference temperature of 25 °C and the reference pressure of 101,3 kPa shall be calculated by the formula $V_n = \frac{V_a \times T_r}{T_a} \times \frac{P_a}{P_r}$
5. The normalized gas emission Ge per cell at float charge voltage conditions (14.4V) shall be calculated for each of the four 168 h ± 0,1 h periods with the formula below:
   Ge = Vn / (n 48 Crt) in ml per cell, hour and Ah (rated C3), n=1

Test result:

Model：SPG12350W

Sample No:	168h cycle	Test A					Remark after 72h float charging
		Va (ml)	Vn (ml)	Ta (K)	Pa (kPa)	Ge (ml)	
1	1	848.0	848.6	297.5	101.2	0.017	No leakage
	2	777.0	776.2	298.0	101.2	0.016	
	3	381.0	381.3	297.5	101.2	0.008	
	4	110.0	110.3	297.0	101.2	0.002	
2	1	868.0	868.6	297.5	101.2	0.018	No leakage
	2	752.0	751.3	298.0	101.2	0.015	
	3	368.0	368.3	297.5	101.2	0.007	
	4	142.0	142.3	297.0	101.2	0.003	
3	1	903.0	903.6	297.5	101.2	0.018	No leakage
	2	765.0	764.2	298.0	101.2	0.016	
	3	383.0	383.3	297.5	101.2	0.008	
	4	112.0	112.1	297.5	101.2	0.002	

	Sample No:	Test B				Remark after 24h charging
		t_c (h) to 1000ml	Va (ml)	Vn (ml)	Ge (ml)	
	1	36.0	1333.3	1329.4	0.095	No leakage
	2	35.6	1349.8	1345.8	0.096	No leakage
	3	36.2	1326.0	1322.0	0.094	No leakage

Table 6.2	**High current tolerance**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_3 and was fully charged.

1. The test units shall be discharged for 30 s with a current equal to 3 times the 5 min rate current (to U_{final} 1,80 V_{pc} at 20 °C or 25 °C) or with a current equal to the maximum allowable discharge current, both as specified by the manufacturer in the relevant technical documentation of the product range.
2. After the completion of the specified discharge duration, the test units shall stand for 5 min in open circuit and their voltage measured and reported.

Test result:				
Sample NO.	4#	5#	6#	Requirements
SPG12350W Discharge current =(580) A (U_{final}=1.80Vpc)				
The battery status after large current	No terminal melting; No stripe melting; Exterior appearance normal;	No terminal melting; No stripe melting; Exterior appearance normal;	No terminal melting; No stripe melting; Exterior appearance normal;	Show evidence of no incipient melting or of no loss of electrical continuity after 30 s of high current flow
Voltage after open circuit for 5min (V)	12.88	12.89	12.89	Voltage of unit >2,0 Vpc

Table 6.3	**Short-circuit current and d.c. internal resistance**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_3 and was fully charged.

1. The short circuit current shall be defined by determining two data pairs in the following way:

a) First data pair (Ua, Ia) After 20 s of discharge at the current Ia = 4 x I_{10}, the voltage and current shall be recorded to give the first data pair. The current shall be interrupted after 25 s maximum and, without recharge and after an open circuit stand of 5 min, the second data pair shall be determined.

b) Second data pairs (Ub, Ib) After 5 s of discharge at the current Ib = 20 × I_{10}, the voltage and current shall be recorded to give the second data pair.

2. Short circuit current $I_{sc} = [(U_a \times I_b) - (U_b \times I_a)] / (U_a - U_b)$ in amperes

Internal resistance $R_i = (U_a - U_b) / (I_b - I_a)$ in ohms

Test result:

Model name:	Sample No:	Ia (A)	Ua (V)	Ib (A)	Ub (V)	Short circuit current Isc (A)	Internal resistance Ri (Ω)	Remark
SPG12350W	19#	30	12.360	150	11.788	2623.01	0.0048	Actual capacity Ca > C3
	20#	30	12.365	150	11.786	2592.69	0.0048	
	21#	30	12.359	150	11.789	2631.89	0.0048	

Table 6.4	**Protection against internal ignition from external spark sources**		**Verdict:**	**Pass**
Test method:				
1. The test shall be carried out at an ambient temperature between 15 °C and 30 °C. 2. Fill the test fixture with water to a level 3 mm below the underside of the top. Place the hold-down frame over a 0,025 mm thickness of polyethylene film cut as shown in figure 1. Place the frame, with the film in place, over the four studs so that the film covers the open area between the fixture and the frame. Tighten the frame down finger tight with wing nuts to ensure a gas-tight seal around the gasket. Fit the vent system to be tested into the fixture. 3. The whole system shall be checked for gas leakage at any place other than the vent opening, for example with a soap solution whilst charging the gas source battery. 4. Within 1 h of charging the gas source battery commence the gassing test or otherwise commence the spark test. 5. The valve assembly is deemed to have passed the test when no explosion or rapid combustion event occurred within the test fixture.				
Requirements	No evidence of rapid combustion or explosion beyond valve/barrier assemblies			
Test result:				
Sample NO.	1#	2#	3#	Remark
The gas generated by $0.2I_{10}$ current				
Spark1st	No fire; No explode; No other issues	No fire; No explode; No other issues	No fire; No explode; No other issues	
Spark2st	No fire; No explode; No other issues	No fire; No explode; No other issues	No fire; No explode; No other issues	

Table 6.5	**Protection against ground short propensity**		**Verdict:**	**Pass**
Test method:				
Each battery has an actual capacity Ca ≥ 0,95C_3 and was fully charged. 1. The case to cover seal line of the unit shall be placed in contact with a metallic surface. 2. The unit shall be placed horizontally and sequentially on all four possible faces according to the time schedule in 5 and 6, and float charged, with Uflo as specified by the manufacturer, at a room temperature between 20 °C and 25 °C. 3. The units shall be connected, to a circuit which applies a d.c. voltage of at least 500 V ± 5 V between one terminal and the metallic surface (aluminium foil strip) in contact with the seal line. 4. The negative terminal of the d.c. voltage source shall be connected to the terminal of the unit(s) and the positive terminal to the aluminium foil strip. 5. The unit shall be placed horizontally first on face 1 for 30 days or until either electrolyte leakage or significant ground short current flow (few mA of current) is detected. 6. After 30 days of test, the unit shall be placed horizontally for 7 days on face 2, followed by 7 days on face 3 followed by 7 days on face 4 or until either electrolyte leakage or significant ground short current flow is detected. 7. The presence or absence of ground short/leakage phenomena shall be reported.				
Requirements	No evidence of ground short and leakage phenomena			
Test result:				
Sample NO.	electrolyte leakage?	ground short?	Leakage current measured?	Remark
4#	No	No	No	

Table 6.6	**Content and durability of required markings**	**Verdict:**	**Pass**
Test method:			

The test shall be carried out on three of the required markings.

Test with water and aliphatic solvent.

1. 1# label is rubbed for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit, dried in air and then inspected visually.

Test with neutralizing solutions

2. 2# label is rubbed for 15 s with a piece of cloth soaked with a saturated solution of sodium carbonate (Na_2CO_3) or bicarbonate ($NaHCO_3$) in water, dried in air and then inspected visually.

Test with electrolyte

3. 3# label is rubbed for 15 s with a piece of cloth soaked with a solution of 40 % in weight of H_2SO_4 in water, washed with water, dried in air and then inspected visually.

Requirements	Information shall remain readable after exposure to chemicals and remain in place	
Test result:		
Sample NO.	Phenomena observed	Remark
1#	No obvious change, the label is still visible clearly.	
2#	No obvious change, the label is still visible clearly.	
3#	No obvious change, the label is still visible clearly.	

Table 6.7	**Material identification**	**Verdict:**	**Pass**
Test method:			
Battery cover or case. 1. The specified information for material identification shall be selected from the list of abbreviation published in ISO 1043-1. 2. The cover and case shall be visually inspected for a marking showing an ISO 1043-1 defined abbreviation of the name of the polymer(s) forming the bulk of the case and/or cover. 3. The stability of the marking shall be tested, if needed, with the test outlined in 6.6.			
Requirements	ISO symbol present on the outside of the cover or/and case Symbol shall remain readable after exposure to chemicals and remain in place		
Test result:			
Sample NO.	Abbreviation of the name of the polymer(s)		Remark
Battery cover(8#,9#)	FF FR		
Battery case(8#,9#)	FF FR		

Table 6.8	**Valve operation**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ 0,95C_3 and was fully charged.

1. The units are fully charged and at a temperature between 25 °C.
2. The units are overcharged with a constant voltage between 2.60 V_{pc} to 2.70 V_{pc} for at least 1 h.
3. A gas collection cover shall be placed sequentially onto each valve opening in such a way that all gas released from that valve is captured.
4. If the valve openings are hidden by, or integrated in a gas collection cover or manifold, gas flowing from the outlet of this cover or manifold shall be collected.
5. A tubing shall carry the gas from this collection cover to the bubble detection device such as for example an U-shaped glass tubing of about 15 mm diameter and with the bottom of the U filled with water.
6. The opening of each valve, at a test temperature of 25 °C shall be verified visually by detecting the released gas bubbling through the liquid at the bottom of the U shaped glass tubing.

Requirements	Gas release detected before and after stress temperature impact test		
Test result:			
Model name:	Sample No:	Gas release detected:	Remark
SPG12350W	7#	Emitted gas observed	
	8#	Emitted gas observed	
	9#	Emitted gas observed	

Table 6.9	**Requirement for definition of the flammability rating of the materials**	**Verdict:**	**Pass**

Test method:

1. The test shall be carried out with appropriately sized samples of the material used for the manufacture of the cell or monobloc battery case and, if different, also of the cell or monobloc battery cover.
2. The test shall be carried out by an appropriate test laboratory
3. The test method used shall be in accordance with IEC 60707 and IEC 60695-11-10 or equivalent test methods for all of the above.
4. The test result and the resulting flammability classification of the material shall appear on a dated and signed test certificate.

Test result:

Precondition temperature	Sample No:	t1 (s)	t2 (s)	t3 (s)	t2+t3 (s)	cotton ignited	Flammability rate level
25°C	A	1.9	1.3	0	1.3	yes	V-0
	B	1.6	1.2	0	1.2	yes	V-0
	C	1.8	1.3	0	1.3	yes	V-0
	D	1.8	1.2	0	1.2	yes	V-0
	E	1.8	1.3	0	1.3	yes	V-0
70°C	A	2	1.3	0	1.3	yes	V-0
	B	1.8	1.3	0	1.3	yes	V-0
	C	1.8	1.3	0	1.3	yes	V-0
	D	1.7	1.3	0	1.3	yes	V-0
	E	1.7	1.2	0	1.2	yes	V-0

Table 6.10	**Requirement for performance of the intercell connector**	**Verdict:**	**Pass**

Test method:

1. The test shall be carried out with the cells and monobloc batteries destined for the test of 6.11 (discharge capacity at the $C_{0.25}$ or 0,25 h rate with a current $I_{0.25}$ to U_{final} =1,60 V_{pc}) or alternatively with the highest discharge current for a particular unit and intercell connector size as specified/allowed by the manufacturer in the relevant technical documentation of the product range The temperature of the units at the start of the test shall be between 20 °C and 25 °C.
2. The shape, size and construction details and the maximum temperature reached of the intercell connectors during this discharge test shall be reported.

Test result:

	Sample No.	26#	27#	28#	29#	30#	Remark
SPG12350W	Initial temp. of samples (°C)	25.2	25.6	24.8	25.1	25.0	Discharge current: 162A; Discharge till 1.60Vpc;
	Highest temp. (°C)	43.5	43.3	43.7	44.2	43.8	
	Dimension of Connector	Length: 80mm; cross area: 60mm2;					

Table 6.11	**Discharge capacity**	**Verdict:**	**Pass**
Test method:			

Capacity $C_{0.25}$ (0,25 h rate)

1. The discharge shall be started within 1 h to 24 h after fully charged.
2. Discharged with a constant current $I_{0.25}$ to U_{final} = 1.60 Vpc.
3. Recorded discharge time and calculated capacity.
4. Corrected the capacity to temperature of 25 °C. θ is the initial temperature,

$$C_{a25\,°C} = C\,/[1+\lambda\,(\theta - 25)] \quad \text{in Ah}, \ (\lambda = 0{,}01)$$

Capacity C (1 h rate)

1. The discharge shall be started within 1 h to 24 h after fully charged.
2. Discharged with a constant current I_1 to U_{final} = 1.60 Vpc.
3. Recorded discharge time and calculated capacity.
4. Corrected the capacity to temperature of 25 °C. θ is the initial temperature,

$$C_{a25\,°C} = C\,/[1+\lambda\,(\theta - 25)] \quad \text{in Ah}, \ (\lambda = 0{,}01)$$

Capacity C_3 (3 h rate)

1. The discharge shall be started within 1 h to 24 h after fully charged.
2. Discharged with a constant current I_3 to U_{final} = 1.70 Vpc .
3. Recorded discharge time and calculated capacity.
4. Corrected the capacity to temperature of 25 °C. θ is the initial temperature,

$$C_{a25\,°C} = C\,/[1+\lambda\,(\theta - 25)] \quad \text{in Ah}, \ (\lambda = 0{,}006)$$

Capacity C_8 (8 h rate)

1. The discharge shall be started within 1 h to 24 h after fully charged.
2. Discharged with a constant current I_8 to U_{final} = 1.75 Vpc .
3. Recorded discharge time and calculated capacity.
4. Corrected the capacity to temperature of 25 °C. θ is the initial temperature,

$$C_{a25\,°C} = C\,/[1+\lambda\,(\theta - 25)] \quad \text{in Ah}, \ (\lambda = 0{,}006)$$

Capacity C_{10} (10 h rate)

1. The discharge shall be started within 1 h to 24 h after fully charged.
2. Discharged with a constant current I_{10} to U_{final} = 1.80 Vpc.
3. Recorded discharge time and calculated capacity.
4. Corrected the capacity to temperature of 25 °C. θ is the initial temperature,

$$C_{a25\,°C} = C\,/[1+\lambda\,(\theta - 25)] \quad \text{in Ah}, \ (\lambda = 0{,}006)$$

Test result:

Model name:	Sample No:	Capacity C_{10} (Ah)	Capacity C_8 (Ah)	Capacity C_3 (Ah)	Capacity C_1 (Ah)	Capacity $C_{0.25}$ (Ah)	Remark
SPG12350W	1#	81.2	76.1	61.3	44.5	38.2	I_{10}= 7.5A C_{10}= 75Ah I_8= 9A C_8= 72Ah I_3= 18.7A C_3= 56.1Ah I_1= 41.3A C_1= 41.3Ah $I_{0.25}$=144.4A $C_{0.25}$=36.1Ah
	2#	81.2	76.2	61.3	44.4	38.5	
	3#	80.6	76.1	61.1	44.3	38.5	
	5#	81.0	76.1	61.3	44.5	38.5	
	4#	80.9	76.1	61.2	44.5	38.5	
	6#	81.0	76.4	61.4	44.6	38.5	

Charging parameters were provided by manufacturer			
Model	float charge voltage	Fully charging method	
SPG12350W	13.5V (2.25V/cell)	Ufinal	14.1V (2.35V/cell)
		I limited	1.5*I_{10},
		Max. Time	24h

Table 6.12	**Charge retention during storage**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_3 and was fully charged.

1. The units shall be stored at an ambient temperature of 25 °C ± 5 K and fully disconnected from any external circuit.
2. After 180 days of storage the units shall be discharged without any prior recharge so that their actual capacity after storage Cast (3 h – U_{final} 1,70 V_{pc} at the selected reference temperature) can be determined.
3. The charge retention factor Crf shall be expressed as percentage, and is equal to

$$C_{rf} = (C_{ast} \times 100) / C_a \quad (\%)$$

4. The six individual values of Crf shall be reported

Requirements	Crf ≥70 %						
Test result:							
Sample No.		1#	2#	3#	4#	5#	6#
SPG12350W	Ca	60.5	60.5	60.6	60.5	60.4	60.5
	Cast	53.7	54.0	53.7	54.2	53.8	53.4
	Crf	88.7%	89.2%	88.5%	89.6%	89.1%	88.3%

Table 6.13	**Float service with daily discharges**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ 0,95C_3 and was fully charged.

1. A discharge for 2 h with a current of I = 2,0 I_{10} maintained constant within ±1 % where I_{10} = [C_{10}] / [10] in A and followed immediately by
2. A charge for 22 h with a current limited to I = 2,0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for either 20 °C or 25 °C.
3. The cells and monobloc batteries shall be operated at a temperature between 18 °C and 27 °C and the discharge–charge cycle routine a) and b) continued until, during a discharge of step a), a voltage of U_{final} 1,80 Vpc × n cells per string is reached in a time shorter than 2 h.
4. The unit or string voltages and number of cycles achieved with the discharge–charge cycle routine a) and b) shall be recorded.
5. The units having reached the conditions outlined in c) shall then be subjected for 168 h ± 0,1 h to a charge with a current limited to I = 2,0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for either 20 °C or 25 °C.
6. At the end of the 168 h ± 0,1 h of charge, the units shall be subjected to a capacity test with a constant current of I = I_3 to U_{final} 1,70 Vpc and the capacity C_{af} corrected to 20 °C or 25 °C and recorded. This value C_{af} represents the residual capacity available when units, after numerous cycles, are then subjected to a prolonged period of charge with a charge voltage equivalent to the float voltage.
7. At the conclusion of the capacity test outlined in f), the units shall be fully charged and then subjected to an equalization or boost charge according to the manufacturer's specifications. At the conclusion of this equalization or boost charge treatment the units shall be subjected to a capacity test with a constant current of I = I_3 to U_{final} 1,70 Vpc and the capacity C_{ab} corrected to 20 °C or 25 °C and recorded. This value C_{ab} represents the residual capacity available when the units, after numerous cycles and a prolonged charge with float voltage settings, are subjected to a manufacturer specific equalization or boost charge treatment.
8. The test sequence 1) to 7) shall be repeated until, in the steps 6) and 7), the test units show a capacity C_{af} and Cab lower than 80 % of Crt (3 h rate to Ufinal 1,70 Vpc at the selected reference temperature).

Test result: For SPG12350W

Sample No.	Sequence 1) to 7) No.1			Sequence 1) to 7) No.2			Sequence 1) to 7) No.3		
	Value a) Number of 2 h cycles	Value b) Caf	Value c) Cab	Value a) Number of 2 h cycles	Value b) Caf	Value c) Cab	Value a) Number of 2 h cycles	Value b) Caf	Value c) Cab
1#	164	94.8%	95.9%	81	84.8%	91.3%	25	81.6%	87.4%
2#	164	94.8%	95.8%	81	84.7%	91.5%	25	81.5%	87.5%
3#	164	95.2%	96.9%	81	84.7%	91.6%	25	81.6%	87.5%

Sample No	Number of sequences 1) to 7)	Total number of cycles achieved
1#	3	270
2#	3	270
3#	3	270

Note 1: The batteries are discharged for step 1 and step 2. The end voltage of final 2 h cycle discharging is 12.054V (1#), 12.059V (2#) and 12.063V (3#), more than end condition 10.8V.
Note 2: Verdict is based on current test results.

Table 6.14	**Recharge behaviour**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_{10} and was fully charged.

1. Three monobloc batteries in a single string.
2. The string shall be discharged, with unit temperature 25 °C, and a constant current of I = I_{10} to a string voltage U_{final} n × 1.80 V_{pc}. This capacity Ca value shall be corrected to 25 °C.
3. After the discharge and a 1 h stand in the discharged state, the units shall be recharged, with unit temperature of 25 °C, with a current limited to I = 2.0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for 25 °C.
4. After 24 h of charge the units shall be immediately discharged again with a current of I_{10} to a string voltage U_{final} n × 1.80 V_{pc}. This capacity value C_{a24} shall be corrected to 25 °C.
5. The capacity found after 24 h of charge C_{a24} shall be expressed as percentage of the initial actual capacity (recharge behaviour factor R_{bf}) as follows:
   $R_{bf24h} = (C_{a24} \times 100) / C_a$ %
6. The units shall be fully recharged and then again discharged, with unit temperature of 25 °C and a constant current of I = I_{10} to a string voltage of n × 1.80 V_{pc}. This capacity Ca value shall be corrected to 25 °C.
7. After the discharge and a 1 h stand in the discharged state, the units shall be recharged with a current limited to I = 2.0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for 25 °C.
8. After 168 h of charge the units shall be discharged again with a current of I_{10} to a string voltage of U_{final} n × 1.80 V_{pc}. This capacity value C_{a168} shall be corrected to 25 °C.
9. The capacity found after 168 h C_{a168} shall be expressed as percentage of the initial actual capacity charge (recharge behaviour factor R_{bf}) as follows:
   $R_{bf168\ h} = (C_{a168} \times 100) / C_a$ %

Requirements	Rbf24h≥90%, Rbf168h≥98% to individual tested units
Test result:	

Model name:	Sample No:	C_{a24} (Ah)	C_a (Ah)	R_{bf24h} (%)	C_{a168} (Ah)	C_a (Ah)	R_{bf168h} (%)
SPG12350W	1#	80.8	80.9	99.91%	81.1	80.9	100.19%
	2#						
	3#						
Note							

Charging parameters were provided by manufacturer			
Model	float charge voltage	Fully charging method	
SPG12350W	13.5V (2.25V/cell)	Ufinal	14.1V (2.35V/cell)
		I limited	1.5*I_{10},
		Max. Time	24h

Table 6.15	**Service life at an operating temperature of 40 °C**	**Verdict:**	**Pass and stop testing**
Test method:			

Each battery has an actual capacity Ca ≥ 0,95C_3 and was fully charged.

1. The units shall be float charged at 40 °C with the manufacturer's recommended float voltage for 25 °C.
2. Every 118 days ± 3 days the units shall, after cooling down to room temperature under float charge voltage setting, be subjected within 24 h ± 12 h to a determination of their individual actual capacity C_a (C_3).
3. No charge with voltages beyond the float charge voltage is admissible before or after such a capacity determination. After capacity determination, the units are returned to float charge in the hot air enclosure as in 6.15.6 for another 118 days at 40 °C. The test of a unit is terminated when the individual actual capacity of that unit is less than 0,8 C_{rt}. The remaining units continue to be tested until the actual capacity of each unit is less than 0,8 C_{rt}.
4. The individual capacity values C_a shall be plotted in a graph as function of days elapsed at 40 °C ± 2 K.
5. For each of the three cells or monobloc batteries, the intersection of the regression line, connecting the individual C_a data points, with a horizontal line representing a capacity level of 0,8 C_{rt} (C_3) shall be determined in terms of elapsed days at 40 °C and reported as the three individual values of days elapsed.

Test result:

Model name:	Sample No:	Ca after each 118 days cycle	Number for 118 days cycles
SPG12350W	1#	58.0 > 45(2^{nd} cycle)	2
	2#	58.5 > 45 (2^{nd} cycle)	2
	3#	58.5 > 45 (2^{nd} cycle)	2

Note 1: 0.8C_3= 0.8*56.1 Ah=45Ah (SPG12350W)
Note 2: Verdict is based on current test results. One 118 days cycle conducted.

Table 6.16	**Impact of a stress temperature of 55 °C or 60 °C**	**Verdict:**	**Pass and stop testing**
Test method:			

Each battery has an actual capacity Ca ≥ 0,95C_3 and was fully charged.

1. The units shall be float charged at 55 °C or 60 °C with the manufacturer's recommended float voltage for 25 °C.
2. When tested at 55 °C, the units shall be cooled down, every 42 days ± 3 days, to room temperature under float charge setting and subjected, within 24h ± 12h, to a determination of their individual actual capacity Ca (at the 3 h rate to Ufinal 1,70 Vpc and/or at the 0,25 h rate to Ufinal 1,60 Vpc at the selected reference temperature).
   When tested at 60 °C, the units shall be cooled down, every 30 days ± 3 days, to room temperature under float charge and subjected, within 24 h ± 12 h, to a determination of their individual actual capacity Ca (at the 3 h rate to Ufinal 1,70 Vpc and/or at the 0,25 h rate to Ufinal 1,60 Vpc at the selected reference temperature).
3. After capacity determinations, the units are returned to float charge in the hot air enclosure as in 6.16.6 for another 42 days at 55 °C (or 30 days at 60 °C). The test is terminated for a unit when the individual actual capacity of that unit is less than 0,8Crt. At the 3 h and/or the 0,25 h rate The remaining units continue to be tested until the actual capacity of each unit is less than 0,8Crt.

Requirement and service environment

Requirement and service environment	Days at elevated temperature, on float charge, of the units to a residual capacity of 0,8 Crt			
	at 55 °C Ca after each 42 days cycle		at 60 °C Ca after each 30 days cycle	
	3 h rate discharge test	0,25 h rate discharge test	3 h rate discharge test	0,25 h rate discharge test
Brief duration exposure time	≥150 days	≥75 days	≥105 days	≥55 days
Medium duration exposure time	≥250 days	≥175 days	≥175 days	≥90 days
Long duration exposure time	≥350 days	≥175 days	≥250 days	≥125 days
Medium duration exposure time	≥500 days	≥250 days	≥350 days	≥175 days
NOTE The requirement applies not to the average but to each of the individual tested units.				

Test result:

Model name:	Sample No:	Ca after each 42 days cycle (55 °C impact)	Number for 42 days cycles
SPG12350W	1#		
	2#		
	3#		
Model name:	**Sample No:**	**Ca after each 30 days cycle (60 °C impact)**	**Number for 30 days cycles**
SPG12350W	1#	60.2 > 45 (1st cycle); 45.7 >45 (10th cycle)	10
	2#	60.3 > 45 (1st cycle); 46.1 > 45 (10th cycle)	10
	3#	60.3 > 45 (1st cycle); 46.2 > 45 (10th cycle)	10

Note 1: passed current cycle and more cycles on running.
Note 2: SPG12350W tested according 3 h discharging rate (C_3=56.1Ah), 80%Crt(45 Ah)limits of above capacity considered as end condition;
Note 3: Verdict is based on current test results.

Table 6.17	**Abusive over-discharge**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_3 and was fully charged.

One of the 4 units shall be discharged, at a unit temperature of 18 °C to 27 °C, with a current of I10 for 3 h and then connected to the remaining 3 fully charged units in series and with the intercell connectors giving, between each units, an air gap of 10 mm or as specified in the appropriate technical documentation of the product range.

unbalanced string over-discharge test (four fully charged batteries string)

1. This four unit string shall then be discharged, with all unit temperatures between 18 °C to 27 °C, with a current I = I_{10} (U_{final} 1,80 V_{pc}) until the voltage of the three, initially fully charged units reach a total voltage of U_{final} of 3 × n × 1,70 V_{pc} where n is the number of cells in this substring.
2. After the discharge and a 24 h ± 0,1 h stand in the discharged state, the four unit string shall be recharged in series for 168 h ± 0,1 h with a current limited to I = 2,0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for either 20 °C or 25 °C.
3. At the end of the 168 h ± 0,1 h of charge, the units shall be subjected, as a four unit string, to a capacity test with a constant current of I = I_3 to a U_{final} of 4 × n × 1,70 V_{pc} and the capacity Ca corrected to 20 °C or 25 °C.
4. The capacity Ca of the string shall be referenced to the rated capacity Crt (3 h – U_{final} 1,70 Vpc at the selected reference temperature) as shown below and gives the unbalanced over-discharge C_{aod} capacity ratio. This value shall be reported.

   C_{aod} = Ca / Crt

cyclic over-discharge test (three fully charged batteries string)

1. The units shall be discharged individually or as a string, with all unit temperatures between 18 °C to 27 °C and with a constant current of I = I_{10} to a voltage U_{final} of n × 1,25 V_{pc} where n is the number of cells per unit or string.
2. After the discharge and a 1 h ± 0,1 h stand in the discharged state, the units shall be recharged for 168 h ± 0,1 h with a current limited to I = 2,0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for either 20 °C or 25 °C.
3. The sequence outlined above shall be repeated 5 times.
4. At the end of the fifth 168 h ± 0,1 h of charge, the units or the string shall be
5. subjected to a capacity test with a constant current of I = I_3 to U_{final} of n × 1,70 V_{pc} and the capacity Ca corrected to 20 °C or 25 °C.
6. The capacity Ca of each unit or of the string shall be referenced to the rated capacity Crt (3 h – U_{final} 1,70 Vpc at the selected reference temperature) as shown below and gives the cyclic over-discharge C_{aoc} capacity ratio. This value(s) shall be reported

   C_{aoc} = Ca / Crt

Test result:

Model name:	Sample No:	Ca (Ah)	Crt (Ah)	C_{aod} (%)
SPG12350W	four fully charged batteries string (16#/17#/18#/19#)	59.2	56.1	107%
	Sample No:			C_{aoc}
	three fully charged batteries string (10#/11#/12#)	70.8/70.4/70.3	67.5	1.05/1.04/1.04

Table 6.18	**Thermal runaway sensitivity**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_3 and was fully charged.

1. The units shall be assembled with the intercell connectors.
2. The ambient temperature shall be between 20 °C to 25 °C during the test and any natural airflow across the units shall be slower than 0,5 m.s–1.
3. Temperature probes, with a resolution of 1 K and allowing a continuous registration of the temperature (interval between temperature measurements ⩽0,25 h), shall be installed as Figures 7 and 8
4. The string shall be charged with a source of d.c. current and with a voltage as specified below. The current flowing through the string shall be monitored with an appropriate resolution and at an interval, between measurements, of ⩽0,25 h.
5. The constant charge voltage, measured at the terminals of the string, shall be set to n × 2,45 V_{pc} ± 0,01 Vpc throughout the test, where n is the number of cells in the string.
6. The elapsed time of charge to a unit temperature of 60 °C ± 1 K, measured with the probe a) at the surface or the temperature reached after 168 h continuous charge, shall be recorded and the test stopped whichever comes first.
7. The string shall then be cooled down to room temperature in open circuit condition
8. The previously utilized string shall be charged with a source of d.c. current and with a voltage as specified below. The current flowing through the string shall be monitored with an appropriate resolution at an interval between measurements of ⩽0,25 h.
9. The constant charge voltage, measured at the terminals of the string, shall be set to n × 2,60 V_{pc} ± 0,01 V_{pc} throughout the test, where n is the number of cells in the string.
10. The elapsed time of charge to a temperature of unit 60 °C ± 1 K, measured with the probe a) at the surface or the temperature reached after 168 h continuous charge, shall be recorded and the test stopped whichever comes first.

Requirements	Achieve at least 1 week below 60 °C at 2,45 Vpc and at least 24 h below 60 °C at 2,60 Vpc Show ultimate time to 60 °C or ultimate temperature after 168 h at 2,45 Vpc and 2,60 Vpc.
Test result:	

Model name:	Sample No:	Duration of charge until a unit temperature of 60 °C ± 1 K (probe a) is reached or the effective temperature (probe a) after 168 h of charge with 2,45 Vpc	Duration of charge until a unit temperature of 60 °C ± 1 K (probe a) is reached or the effective temperature (probe a) after 168 h of charge with 2,60 Vpc
SPG12350W	Six batteries string (26#~31#)	25.3℃	30.4℃

Table 6.19	**Low temperature sensitivity**	**Verdict:**	**Pass**
Test method:			

Each battery has an actual capacity Ca ≥ C_3 and was fully charged.

1. The units shall be individually discharged with a current of I = I_{10} to an U_{final} of n × 1,80 V_{pc} at a unit temperature between 18 °C and 27 °C.
2. The discharged units shall then be placed in a test chamber with a forced flow of air having a temperature of –18 °C ± 2 K.
3. After 72 h ± 1 h of residence in the test chamber the units shall be withdrawn from the test chamber and, after 24 h ± 1 h of stand at open circuit, charged in a room with an ambient temperature between +18 to +27 °C for 168 h ± 0.1 h with a current limited to I =2.0 I_{10} and a voltage limited to the float voltage specified by the manufacturer for either 20 °C or 25 °C.
4. The units shall then be individually discharged with a current of I =I_3 to an U_{final} of n × 1.70 V_{pc} and the actual capacity C_a corrected to 20 °C or 25 °C shall be recorded.
5. The capacity C_a of each unit shall be referenced to the rated capacity C_{rt}. (3 h – U_{final} 1.70 Vpc at the selected reference temperature) as shown below and gives the C_{als} capacity ratio.

$$C_{als} = C_a / C_{rt}$$

6. These units shall be individually discharged in this second test, before low temperature exposure, with a current of I = I_3 to an U_{final} of n × 1.70 V_{pc} at a unit temperature between 18 °C and 27 °C.

Requirements	Cals >0,95 and no mechanical damages and report eventual freezing induced damages
Test result:	

Sample No.		20#	21#	22#	Remark
SPG12350W	Ca (Ah)	58.9	58.8	59.0	Ca>Crt
	Ca 25°C (Ah)	59.2	59.1	59.4	Ca>Crt
Cals (%)		105.6%	105.4%	105.8%	>95%
Battery status		No rupture; No bulge			

Table 6.20	**Dimensional stability at elevated internal pressures and temperatures**	**Verdict:**	**Pass**

Test method:

1. The test unit, inclusive eventual standard structural stabilizing features, shall be adapted with a pressure regulator to maintain a pressure in all interior cavities of the test unit equal to the maximum valve opening pressure present in units and as specified by the manufacturer. This value shall be measured and reported. This specified pressure shall be maintained throughout the test.
2. The maximum outside dimension (width and length) of the cell case shall be measured before pressurization and recorded.
3. The pressurized unit shall be placed into a chamber with recirculating air at a temperature of 50 °C ± 2 K.
4. After 24 h ± 0,1 h of residence in the test chamber and under pressure, the maximum outside dimension (width and length) of the cell case shall be measured and recorded at a temperature as close as possible to 50 °C ± 2 K.
5. The increase in the cell case dimensions after 24 h ± 0,1 h at 50 °C ± 2 K shall be reported both as percentage deviation from the value before the test and as measured change in mm.

Test result:

Sample No.		Inner gas pressure/kPa	Temperature in Chamber/°C	Remark
1#	Gas pressure shall be same with maximum valve open pressure provided by manufacturer. Stay in high temperature chamber for 24h±0.1h, record.	16-19kPa	50.0	Keep pressure during staying in high temperature chamber, record every 4hours.
2#		16-19kPa	50.0	
3#		16-19kPa	50.0	
		Max Length	Max Width	
SPG12350W	Battery dimension before pressuring /mm	267	171	Measure before pressuring
	Battery dimension after pressuring for 24h /mm	267	171	Measure under 50°C ±2°C condition
	Dimension change value/mm	0	0	
	Dimension change rate/ %	0	0	

Table 6.21	**Stability against mechanical abuse of units during installation**	**Verdict:**	**Pass**
Test method:			

1. The units shall be dropped according to the height prescriptions of IEC 60068-2-32 and amendment. Two "Free Fall", for resistance against leakages caused by two drops each onto a smooth, level concrete floor from drop heights as specified below:
   a) Fall from 100 mm for units weighing up to 50 kg
   b) Fall from 50 mm for units weighing between 50 kg and 100 kg
2. The drop test conditions shall assure, with test arrangements as shown in Figures 9, 10 and 11 below, reproducible impact points for the shortest edge drop impact and the corner impact. The two impacts, per impact type, shall be on the same corner and on the same shortest edge.
3. For the corner and edge drops, the unit shall be oriented in such a fashion that a straight line drawn through the struck corner/edge and the unit geometric centre is approximately perpendicular to the impact surface.
4. Each of the units shall be inspected, after the two consecutive drops, for gas and liquid leaks with adequate and sensitive means such as a high voltage (2 kV to 5 kV) dielectric breakdown test, helium leak detectors, hydrogen detectors, pH indicator paper and the like and the findings documented and reported.

Requirements	No leakage detectable after two times two drops
Test result:	
Sample No.	

5#	Shortest edge drops	Whether there is container broken or leakage trend	First time	No broken or leakage trend	Free drop from 100mm height
6#			Second time	No broken or leakage trend	
5#	Corner drops		First time	No broken or leakage trend	
6#			Second time	No broken or leakage trend	

Photos:

SPG12350W