AlphaCell™ SMU-M Series Batteries

Technical Manual

Effective: December 2010

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Power

Alpha Technologies

Power

AlphaCell™ SMU-M Series Batteries Technical Manual

745-680-B12-001 Rev. A

Effective Date: December, 2010

member of The Group™

NOTE:

Photographs contained in this manual are for illustrative purposes only. These photographs may not match your installation.

NOTE:

Operator is cautioned to review the drawings and illustrations contained in this manual before proceeding. If there are questions regarding the safe operation of this product, please contact Alpha Technologies or your nearest Alpha representative.

NOTE:

Alpha shall not be held liable for any damage or injury involving its enclosures, power supplies, generators, batteries, or other hardware if used or operated in any manner or subject to any condition not consistent with its intended purpose, or is installed or operated in an unapproved manner, or improperly maintained.

Contacting Alpha Technologies: *www.alpha.com*

OR

For general product information and customer service (7 AM to 5 PM, Pacific Time), call

1-800-863-3930,

For complete technical support, call

1-800-863-3364

7 AM to 5 PM, Pacific Time or 24/7 emergency support

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Safety Notes

Review the drawings and illustrations contained in this manual before proceeding. If there are any questions regarding the safe installation or operation of the system, contact Alpha Technologies or the nearest Alpha representative. Save this document for future reference.

To reduce the risk of injury or death, and to ensure the continued safe operation of this product, the following symbols have been placed throughout this manual. Where these symbols appear, use extra care and attention.

ATTENTION:

The use of ATTENTION is only for specific regulatory/code requirements that may affect the placement of equipment and installation procedures.

NOTE:

A NOTE gives readers additional information to help them complete a specific task or procedure.

CAUTION!

The use of CAUTION indicates safety information intended to PREVENT DAMAGE to material or equipment.

WARNING!

WARNING presents safety information to PREVENT INJURY OR DEATH to the technician or user.

Battery Safety Notes

WARNING!

Lead-acid batteries contain dangerous voltages, currents and corrosive material. Battery installation, maintenance, service and replacement must be performed only by authorized personnel.

Chemical Hazards

Any gelled or liquid leakage from a valve-regulated lead-acid (VRLA) battery contains dilute sulfuric acid, which is harmful to the skin and eyes. Emissions are electrolytic, and are electrically conductive and corrosive.

To avoid injury:

- Servicing and connection of batteries shall be performed by, or under the direct supervision of, personnel knowledgeable of batteries and the required safety precautions.
- Always wear eye protection, rubber gloves, and a protective vest when working near batteries. Remove all metallic objects from hands and neck.
- Batteries produce explosive gases. Keep all open flames and sparks away from batteries.
- Use tools with insulated handles, do not rest any tools on top of batteries.
- Lead-acid batteries contain or emit chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. Battery post terminals and related accessories contain lead and lead compounds. Wash hands after handling (California Proposition 65).
- Wear protective clothing (insulated gloves, eye protection, etc.) when installing, maintaining, servicing, or replacing batteries.
- If any battery emission contacts the skin, wash immediately and thoroughly with water. Follow your company's approved chemical exposure procedures.
- Neutralize any spilled battery emission with the special solution contained in an approved spill kit or with a solution of one pound bicarbonate of soda to one gallon of water. Report a chemical spill using your company's spill reporting structure and seek medical attention if necessary.
- Always replace batteries with those of an identical type and rating. Never install old or untested batteries.
- Do not charge batteries in a sealed container. Each individual battery should have at least 0.5 inches of space between it and all surrounding surfaces to allow for convection cooling.
- All battery compartments must have adequate ventilation to prevent accumulation of potentially dangerous gas. Ventilation should prevent trapped hydrogen gas pockets from exceeding a 1% concentration as per regulation 70E of the National Fire Protection Agency (NFPA).
- Prior to handling the batteries, touch a grounded metal object to dissipate any static charge that may have developed on your body.
- Never use uninsulated tools or other conductive materials when installing, maintaining, servicing, or replacing batteries.
- Use special caution when connecting or adjusting battery cabling. An improperly connected battery cable or an unconnected battery cable can make contact with an unintended surface that can result in arcing, fire, or possible explosion.
- A battery showing signs of cracking, leaking, or swelling should be replaced immediately by authorized personnel using a battery of identical type and rating.

Equipment Cautions

- Do not operate NiCd and lead-acid batteries in the same room. NiCd emissions will neutralize the lead-acid solution, rendering the battery useless.
- Overcharging the battery can result in a loss of capacity and excess release of gas.

Recycling and Disposal Instructions

Spent or damaged batteries are considered environmentally unsafe. Always recycle used batteries or dispose of the batteries in accordance with all federal, state and local regulations.

1.0 Introduction

The SMU-M series of Valve Regulated Lead Acid (VRLA) batteries is designed to meet the needs of many industrial and utility applications. The success of the AlphaCell SMU-M series is due to a product design purpose-built for the needs of critical backup requirements, and an industry-leading manufacturing technology which delivers product consistency. Safety, reliability, and long service life in standby applications are the result. Alpha offers a full line of racking solutions to accommodate the SMU-M series of batteries.

1.1 Features

- Require no additional water throughout their life cycle, reducing maintenance costs.
- Specifically designed to meet the requirements of modern electronic equipment.
- Compatible with commonly available recharging systems.
- Compact construction and excellent performance at high rates of discharge provide big savings in volume and weight compared to conventional vented batteries.
- SMU-M batteries offer substantial savings in installation and maintenance costs compared to conventional vented batteries. No specifically designed rooms are required and only minimal maintenance is needed during the life of the battery.
- Smaller, more compact, and lighter than traditional batteries, SMU-M batteries are supplied filled and charged so that they can be immediately installed directly into cabinets or on easily assembled racks (also available from Alpha Industrial Power).
- Modular unit structure allows for minimal footprint.
- With a minimum 20 year design life, the SMU-M batteries are highly reliable and fully comply with established international standards. The SMU-M range has been fully tested with respect to charge and discharge characteristics, cycle life, recombination efficiency, mechanical strength, vibration life, and flame retardency.

1.2 Typical Electrical and Mechanical Specifications

Type	Normal Voltage (V)	Rated Capacity C10 (Ah)	Rated Power (15min, 1.80V, W)	Dimensions (L x W x H) (in)	WT (lb)
SMU-M 2-200	2	200	403	3.7 x 7.3 x 14.7	31.5
SMU-M 2-260	2	260	524	4.3 x 7.3 x 14.7	37.5
SMU-M 2-300	2	300	604	4.8 x 7.3 x 14.7	41.9
SMU-M 2-400	2	400	806	6.5 x 7.3 x 14.7	57.3
SMU-M 2-500	2	500	1007	7.7 x 7.3 x 14.7	68.3
SMU-M 2-600	2	600	1209	8.8 x 7.3 x 14.7	81.6
SMU-M 2-800	2	800	1410	6.1 x 9.1 x 22.3	115
SMU-M 2-800A	2	800	1413	11.0 x 7.3 x 14.7	104
SMU-M 2-1000	2	1000	1762	7.3 x 9.1 x 22.3	137
SMU-M 2-1000A	2	1000	1762	13.4 x 15.4 x 14.7	128
SMU-M 2-1200	2	1200	2136	8.9 x 15.4 x 14.7	128
SMU-M 2-1250	2	1250	2157	8.9 x 9.1 x 22.3	174
SMU-M 2-1500	2	1500	2643	10.5 x 9.1 x 22.3	203
SMU-M 2-2000	2	2000	3524	13.7 x 9.2 x 22.3	267
SMU-M 2-3000	2	3000	5287	19.5 x 14.3 x 14.7	386

Table 1-1, General Electrical and Mechanical Specifications by Model
(Specifications subject to change without notice)

Torque Specification

Torque specifications are 8.0Nm (70.8 Lb-in). Torque all terminal connections to the specified value. Improper torquing can result in loose connections or damaged terminals.

1.3 Operating Conditions

Because SMU-M batteries, which are valve regulated and virtually sealed, do not give off perceptible amounts of gas under normal operating conditions, they can be installed in the same environment where people live and work.

- Acceptable ambient operating temperature: -40ºF to 131ºF (-40ºC to 55ºC)
- Ideal ambient operating temperature: 68ºF to 77ºF (20ºC to 25ºC)
- Ambient humidity: ≤ 95%
- Operating room or area: ventilated and not fully sealed

1.4 Capacity

Battery capacity is rated in Ampere hours (Ah) and is the quantity of electricity that can be supplied during discharge (See Fig. 1-1).

The actual capacity is related to the utilization ratio of the active positive and negative materials within the battery. The utilization ratio is influenced by the depth of discharge, the structure of the battery, and the manufacturing technology. During normal usage, the factors that influence the actual capacity are discharge rate, depth of discharge, end voltage, and temperature.

- The higher the discharge rate, the lower the available capacity.
- As batteries get colder, the available capacity is reduced. This is related to the kinetics of the electrochemical reactions and the resistivity of the electrolyte.

NOTE:

Although the battery can be operated at temperatures below 5ºF (-15ºC), the capacity and ability to discharge will be dramatically decreased. Similarly, temperatures approaching 122ºF (50ºC) will increase water loss and corrosion of the plates, resulting in a shorter battery life.

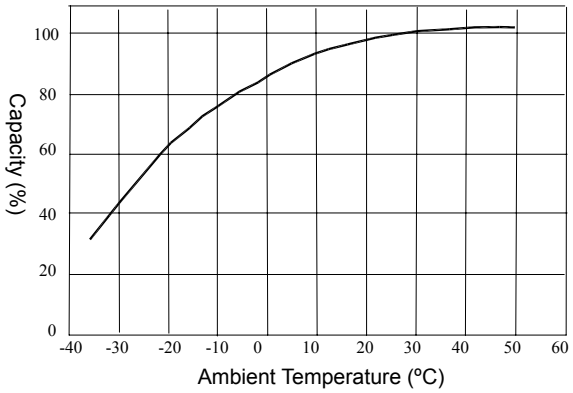

Fig. 1-1, Available Capacity vs. Ambient Temperature

1.5 Temperature and Battery Life

High temperatures can harm the battery and reduce its lifespan. Battery life decreases by 50% per 15ºF (~ 9ºC) above the standard operating temperature of 77ºF (25ºC).

To minimize battery damage:

- Use temperature compensated chargers.
- Never allow the battery's temperature to exceed +131ºF (+55°C).
- Make sure operating area is properly ventilated so heat cannot accumulate.
- Provide at least 0.39" (10mm) of space between batteries to enhance convective cooling.
- Visit sites annually to check for shorted cells, improperly set voltages, filter cleaning on ventilation systems, etc.

1.6 Internal Resistance and Short-circuit Current

The internal resistance of the battery is affected by temperature and charge state. The internal resistance is lowest when the battery is fully charged.

Type	Internal Resistance (m Ω)	Short Circuit Current (A)
SMU-M 2-200	0.66	3084
SMU-M 2-260	0.54	3400
SMU-M 2-300	0.47	3960
SMU-M 2-400	0.35	5089
SMU-M 2-500	0.33	6009
SMU-M 2-600	0.28	7178
SMU-M 2-800	0.21	9061
SMU-M 2-800A	0.20	9296
SMU-M 2-1000	0.18	10696
SMU-M 2-1000A	0.17	12880
SMU-M 2-1200	0.17	12068
SMU-M 2-1250	0.17	12570
SMU-M 2-1500	0.14	14068
SMU-M 2-2000	0.11	17217
SMU-M 2-3000	0.10	31879

Table 1-2, Internal Resistance and Short Circuit Current at 77ºF (25ºC)
(Specifications subject to change without notice)

CAUTION!

A short circuit current will decrease the voltage of the battery to 0V, and damage the internal components.

2.0 Charging Procedures

NOTE:

Refer to your particular charger's manual for specific instructions regarding charger setup and operation.

During operation, verify batteries are:

- Float-charged in order to maintain a fully charged condition during the standby period.
- Completely recharged after a discharge. Recharge as soon as possible to ensure maximum protection against subsequent power outages. Early recharge also ensures maximum battery life.

While recharging procedures vary depending on the recharge time and battery life, generally charging is performed as follows:

- At a voltage equal to the float voltage and a low current (long recharge time);
- At a voltage not higher than 2.4Vpc and a high current (faster recharge).

The IU recharge method, also known as modified constant potential, has been used for many years and in a variety of applications. It satisfies the need to have the battery quickly recharged while ensuring maximum battery life.

1. Recharge at a constant current rate until the voltage reaches a pre-set value.
2. Maintain the pre-set voltage and decrease the current until a minimum defined value is reached.
3. Complete the recharge at a final constant voltage value equal to or less than that defined for float charge and decrease the current to the value used in float.

2.1 Float Charge

2.27V at 68ºF (20ºC) is the recommended voltage for float charge. This voltage ensures the maximum life of SMU-M batteries. These batteries can operate over a temperature range of -4ºF (-20ºC) to +140ºF (+60ºC). Performance and life are greatly reduced outside of this temperature range.

Temperature ºF (ºC)	Floating Voltage (Vpc)
-4 (-20)	2.37
32 (0)	2.32
68 (20)	2.27
77 (25)	2.26
140 (60)	2.17

Table 2-1, Float Voltage at Different Temperatures

The equation to determine float voltage at a given temperature is:

$V = 2.32 – 0.0025 * T$

Where: V = Float Voltage and T = Temperature

or

-2.5 mV per 1.8ºF (1ºC) temperature fluctuation outside of 68ºF (20ºC)

The minimum and maximum recommended voltages are 0.010V on either side of the determined voltage at a given temperature. Batteries floated at voltages above the range will have an increased risk of dry out, grid corrosion and thermal runaway. Batteries floated below the range will not receive enough charge, and will be subject to sulfation.

2.1 Float Charge, continued

Float Current

The normal float current observed in fully charged SMU-M batteries at 2.27Vpc at a temperature of 68ºF (20ºC) is approximately 30mA per 100Ah. Because of the nature of recombination phenomena, the float current observed in SMU-M batteries is normally higher than that of vented batteries and is not an indication of the state of charge of the batteries.

Thermal Runaway

Float current is primarily a function of voltage and temperature. As either voltage or temperature increases, the float current also increases exponentially. Much of the float current is going into the recombination reaction, which is exothermic. If the heat generated by recombination exceeds the rate at which heat can be transferred out of the battery (based on conduction, convection, and black body radiation), thermal runaway can occur. The battery will continue to take very large amounts of current from the rectifier and excessive gassing and overheating will result.

WARNING!

In the most severe cases of thermal runaway, equipment can be damaged by sulfuric acid mist that escapes the battery, hydrogen can build up to dangerous levels, and battery cases can rupture because of weakening and melting of the plastic. Ruptured cases can lead to ground faults.

To minimize the risk of thermal runaway:

1. Use temperature compensated chargers
2. Never allow the batteries to exceed 131ºF (55ºC)
3. Make sure cabinets are properly ventilated
4. Provide spacing between batteries to enhance convective cooling
5. Visit sites annually to check for shorted cells, improperly set voltages, filter cleaning on ventilation systems, etc.

2.2 Recharge Following Discharge

Recommended Charge

The recommended recharge method to maximize battery life is to charge with a constant voltage equal to the float charge voltage (2.27Vpc at 68ºF (20ºC)) (see Table 2-1) and a maximum charge current of 0.25 C_8 amperes.

Fast Charge

If it is necessary to reduce the recharge time, charge with a maximum voltage of 2.4Vpc at 68ºF (20ºC) and a maximum current of 0.25 C_8 (use the temperature adjustment formula in section 3.1 for voltage adjustment). This recharge should be used no more than once per month to maximize the service life of the battery.

WARNING!

Avoid situations where excess current is available to recharge the battery. This can occur when the DC load is low relative to the charger or maximum rectifier output, and the battery is fully discharged. If too much current enters the battery, the battery can heat up excessively, be permanently damaged, or may cause an explosion.

2.2 Recharge Following Discharge, continued

Using a current limit of 0.1 -C_{10}, it takes approximately 9 hours to restore 80% of the discharge, and 11 hours to restore 90%. This can be compared to a current limit of 0.25 C_{10}, whereby 80% is returned in approximately 4 hours, and 90% within 5 hours.

NOTE:

While less charger (rectifier) amps means a longer recharge time, too many charger (rectifier) amps can damage the battery.

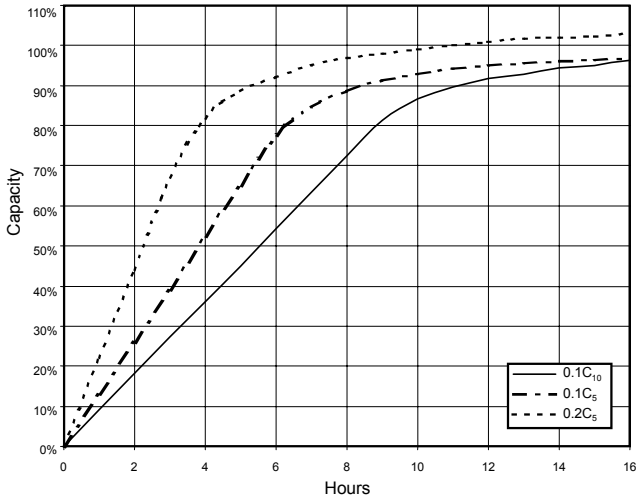

Fig. 2-1, Recharge Time and Capacity Restored as a Function of Current Limit

3.0 Storage

Open circuit

When a battery is stored in an open circuit, two major things occur:

1. Sulfate leaves the electrolyte and reacts with the plates, causing a reduction in the charge state of the battery.
2. Grid corrosion accelerates, especially when the open circuit voltage of the battery is allowed to go below 2.05Vpc.

The state of charge of lead acid batteries slowly decreases in an open circuit due to self-discharge. In SMU-M batteries, the rate of self-discharge is about 2–3% per month at 77ºF (25ºC). During prolonged storage it is necessary to boost-charge the battery at least every 6 months to maintain a fully charged condition of the battery (see Section 2.2). Excessive open circuit storage of any lead acid battery without recharge will result in a permanent loss of capacity. When stored at higher temperatures, the boost interval should be more frequent. Keep the open circuit voltage (measured in a fully rested state of at least 16 hours) at or above 2.05Vpc to minimize the amount of irreversible grid corrosion.

Storage Temperature ºF (ºC)	Boost Interval
77 (25)	6 Months
95 (35)	3 Months
113 (45)	1 Month

Table 3-1 Boost Charge Intervals

3.0 Storage, continued

All lead acid batteries experience self-discharge while in open circuit storage. This causes circuit voltage and capacity to decrease (see Fig. 3-1).

During storage please note:

- The self-discharge rate is related to ambient temperature. The lower the temperature, the less the discharge. Batteries should be stored in a clean, ventilated, and dry location with an ambient temperature of 32ºF to 95ºF (0ºC to 35ºC).
- It is important to track open circuit voltage which is related to the density of the electrolyte. If the open circuit voltage is lower than 12.6V/block, or the batteries have been stored for three months, the batteries should be charged to avoid damage caused by self-discharge.
- All batteries should be fully charged before storage. Record the storage date and next supplemental charge date in a maintenance record (See Fig. 4-2).

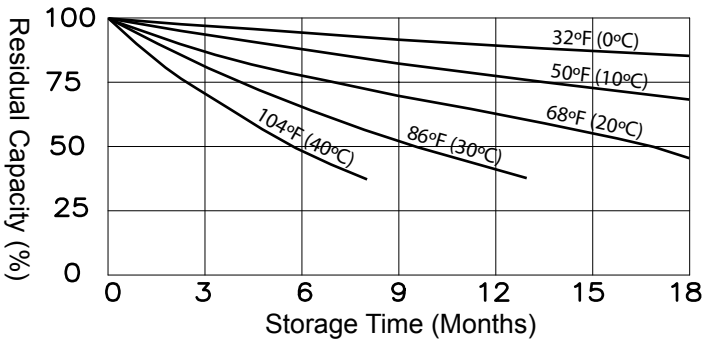

Fig. 3-1, Capacity vs. Storage Time

4.0 Maintenance

4.1 Recommended Maintenance Tasks

In order to prolong battery life, perform regular maintenance and inspections.

Monthly Maintenance

- Keep the batteries and battery room clean.
- Measure and record the ambient temperature of the battery-room.
- Check for damage and overheating evidence on the terminal, container, and lid.
- Measure and record the total voltage and floating current of the battery system.

Quarterly Maintenance

Measure and record the floating voltage of every on-line battery. If the voltage of more than two cells is less than 13.0V after temperature adjustment, discharge the battery and then recharge at the float rate. If the problem still exists, conduct yearly or three-year maintenance procedures. If the problem persists, please contact Alpha Technologies.

Yearly Maintenance

- Check for loose connections.
- Conduct a discharge test to check the exact load, discharging 30-40% of the rated capacity.

Three-Year Maintenance

After three years of operation, conduct an 80% capacity test annually.

Type:	Place:
Test Status:	Qty:
Total Voltage (V):	Room Temperature:
Current (A):	

No.	Voltage (V)	No.	Voltage (V)
1		31	
2		32	
3		33	
4		34	
5		35	
6		36	
7		37	
8		38	
9		39	
10		40	
11		41	
12		42	
13		43	
14		44	
15		45	
16		46	
17		47	
18		48	
19		49	
20		50	
21		51	
22		52	
23		53	
24		54	
25		55	
26		56	
27		57	
28		58	
29		59	
30		60	
Visual check:			

Fig. 4-1, VRLA Battery Regular Maintenance Record

5.0 Discharge Specifications

5.1 Discharge Data with Constant Current

Amperage values for each battery model as a function of time and voltage @ 77°F/25°C.
(Specifications subject to change without notice)

SMU-M 2-200												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	333	279	207	131	77.0	56.5	38.3	33.1	26.4	21.9	18.5	9.75
1.65V	308	260	198	124	75.2	55.1	37.4	32.6	26.0	21.7	18.3	9.69
1.70V	288	244	182	118	72.5	53.5	37.1	32.2	25.5	21.3	18.1	9.63
1.75V	274	231	169	113	69.9	51.9	36.0	31.7	25.2	21.0	17.8	9.51
1.80V	264	218	158	106	66.9	50.3	35.2	30.9	24.8	20.6	17.4	9.33
1.85V	234	193	141	95.4	60.4	47.7	34.0	29.9	24.0	20.0	17.0	9.05
1.90V	201	163	121	84.7	56.6	44.7	32.7	28.8	23.1	19.3	16.5	8.83

SMU-M 2-260												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	433	363	269	170	100	73.5	49.8	43.0	34.3	28.5	24.0	12.7
1.65V	400	338	257	161	97.8	71.7	48.6	42.4	33.8	28.2	23.8	12.6
1.70V	374	317	237	154	94.2	69.6	48.2	41.9	33.2	27.7	23.5	12.5
1.75V	357	300	220	147	90.9	67.4	46.8	41.2	32.8	27.3	23.2	12.4
1.80V	343	283	206	137	87.0	65.4	45.8	40.2	32.2	26.7	22.6	12.1
1.85V	304	251	184	124	78.5	62.0	44.2	38.9	31.2	26.0	22.1	11.8
1.90V	261	212	158	110	73.6	58.2	42.6	37.4	30.1	25.1	21.5	11.5

SMU-M 2-300												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	500	419	310	196	116	84.8	57.5	49.6	39.6	32.8	27.7	14.6
1.65V	462	390	297	186	113	82.7	56.1	48.9	39.0	32.5	27.4	14.5
1.70V	432	366	273	178	109	80.3	55.6	48.3	38.3	32.0	27.1	14.4
1.75V	411	347	254	169	105	77.8	54.1	47.5	37.8	31.5	26.7	14.3
1.80V	396	327	238	159	100	75.4	52.8	46.3	37.1	30.8	26.1	14.0
1.85V	350	290	212	143	90.6	71.6	51.0	44.8	36.1	30.0	25.5	13.6
1.90V	301	245	182	127	84.9	67.1	49.1	43.2	34.7	29.0	24.8	13.2

SMU-M 2-400												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	667	558	413	261	154	113	76.7	66.1	52.7	43.8	37.0	19.5
1.65V	616	520	396	248	150	110	74.8	65.3	52.0	43.3	36.6	19.4
1.70V	576	488	364	237	145	107	74.1	64.4	51.1	42.7	36.2	19.3
1.75V	549	462	339	226	140	104	72.1	63.4	50.5	42.1	35.6	19.0
1.80V	528	436	317	211	134	101	70.4	61.8	49.5	41.1	34.8	18.7
1.85V	467	386	282	191	121	95.4	68.0	59.8	48.1	40.0	34.0	18.1
1.90V	402	327	242	169	113	89.5	65.5	57.6	46.3	38.6	33.0	17.7

5.1 Discharge Data with Constant Current, continued

Amperage values for each battery model as a function of time and voltage @ 77°F/25°C.

SMU-M 2-500												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	833	698	517	327	193	141	95.8	82.7	65.9	54.7	46.2	24.4
1.65V	770	651	495	310	188	138	93.5	81.6	65.0	54.2	45.7	24.2
1.70V	720	610	455	296	181	134	92.7	80.5	63.9	53.4	45.2	24.1
1.75V	686	578	423	282	175	130	90.1	79.2	63.1	52.6	44.6	23.8
1.80V	660	545	396	264	167	126	88.0	77.2	61.9	51.4	43.5	23.3
1.85V	584	483	353	239	151	119	85.0	74.7	60.1	50.0	42.5	22.6
1.90V	502	408	303	212	142	112	81.9	72.0	57.8	48.3	41.3	22.1

SMU-M 2-600												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1000	837	620	392	231	170	115	99.2	79.1	65.7	55.5	29.3
1.65V	924	781	594	372	226	165	112	97.9	78.1	65.0	54.9	29.1
1.70V	864	732	546	355	217	161	111	96.6	76.6	64.0	54.3	28.9
1.75V	823	693	508	339	210	156	108	95.0	75.7	63.1	53.5	28.5
1.80V	791	653	475	317	201	151	106	92.7	74.3	61.7	52.2	28.0
1.85V	701	579	424	286	181	143	102	89.7	72.1	60.0	51.0	27.1
1.90V	603	490	364	254	170	134	98.2	86.4	69.4	58.0	49.5	26.5

SMU-M 2-800												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1158	975	792	522	321	235	154	133	104	86.0	73.1	39.9
1.65V	1086	917	722	493	312	229	152	131	103	85.5	72.6	39.3
1.70V	1021	868	661	468	301	219	148	128	101	84.2	72.0	39.1
1.75V	963	817	609	442	290	214	146	126	100	83.5	71.7	38.8
1.80V	910	762	570	420	281	209	142	124	98.2	82.4	70.9	38.0
1.85V	781	648	501	371	253	192	133	117	94.2	79.0	67.7	36.9
1.90V	640	512	417	307	212	171	121	106	85.4	72.0	62.5	34.4

SMU-M 2-800A												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1161	977	794	523	321	236	154	133	104	86.2	73.3	40.0
1.65V	1088	919	724	494	312	230	152	131	103	85.7	72.7	39.4
1.70V	1023	870	662	469	302	219	149	128	102	84.4	72.2	39.1
1.75V	965	819	610	443	290	214	146	126	100	83.6	71.8	38.9
1.80V	912	764	571	421	282	210	143	124	98.4	82.5	71.0	38.1
1.85V	783	650	502	371	254	192	134	117	94.4	79.2	67.9	36.9
1.90V	641	513	417	307	212	172	121	106	85.6	72.1	62.6	34.5

5.1 Discharge Data with Constant Current, continued

Amperage values for each battery model as a function of time and voltage @ 77°F/25°C.

SMU-M 2-1000												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1448	1218	990	652	401	294	192	166	130	108	91.4	49.8
1.65V	1358	1147	903	616	390	286	190	164	129	107	90.8	49.1
1.70V	1276	1085	826	585	376	274	185	160	127	105	90.0	48.9
1.75V	1204	1021	761	552	362	267	182	158	125	104	89.6	48.5
1.80V	1137	953	713	525	351	261	178	154	123	103	88.6	47.4
1.85V	976	810	627	463	317	240	167	146	118	98.8	84.6	46.1
1.90V	800	640	521	383	265	214	151	132	107	90.0	78.1	43.0

SMU-M 2-1000A												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1451	1221	992	654	402	295	193	166	130	108	91.6	49.9
1.65V	1360	1149	905	617	390	287	191	164	129	107	90.9	49.2
1.70V	1279	1087	827	586	377	274	186	160	127	105	90.2	49.0
1.75V	1206	1023	763	554	363	268	183	158	125	105	89.8	48.6
1.80V	1140	954	714	526	352	262	178	155	123	103	88.8	47.5
1.85V	978	812	628	464	317	240	167	146	118	99.0	84.8	46.2
1.90V	801	641	522	384	265	215	151	133	107	90.2	78.3	43.1

SMU-M 2-1200												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1737	1462	1188	783	481	353	231	199	156	129	110	59.8
1.65V	1629	1376	1083	739	467	344	228	197	154	128	109	58.9
1.70V	1531	1302	991	702	451	328	222	192	152	126	108	58.7
1.75V	1444	1226	914	663	435	321	219	189	150	125	108	58.2
1.80V	1365	1143	855	630	422	314	214	185	147	124	106	56.9
1.85V	1172	972	752	556	380	288	200	175	141	119	102	55.3
1.90V	960	768	625	460	318	257	181	159	128	108	93.8	51.6

SMU-M 2-1250												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1757	1479	1202	792	487	357	234	201	158	130	111	60.5
1.65V	1648	1392	1096	747	473	348	231	199	156	130	110	59.6
1.70V	1549	1317	1002	710	457	332	225	194	154	128	109	59.4
1.75V	1461	1240	924	670	440	324	221	191	152	127	109	58.8
1.80V	1380	1156	865	637	427	317	216	187	149	125	108	57.6
1.85V	1185	983	761	562	385	291	202	177	143	120	103	55.9
1.90V	971	776	632	465	321	260	183	161	130	109	94.8	52.2

5.1 Discharge Data with Constant Current, continued

Amperage values for each battery model as a function of time and voltage @ 77°F/25°C.

SMU-M 2-1500												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	2172	1827	1485	979	601	442	289	249	195	161	137	74.7
1.65V	2037	1720	1354	924	584	430	285	246	193	160	136	73.7
1.70V	1914	1628	1238	878	564	410	278	240	190	158	135	73.4
1.75V	1806	1532	1142	829	544	401	273	236	188	157	134	72.7
1.80V	1706	1429	1069	787	527	392	267	232	184	154	133	71.2
1.85V	1464	1215	940	695	475	360	250	219	177	148	127	69.1
1.90V	1199	960	781	575	397	321	227	199	160	135	117	64.5

SMU-M 2-2000												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	2896	2437	1980	1305	802	589	385	332	260	215	183	99.7
1.65V	2715	2293	1806	1232	779	573	380	328	257	214	182	98.2
1.70V	2552	2170	1651	1170	752	547	371	320	254	210	180	97.8
1.75V	2407	2043	1523	1105	725	535	364	315	250	209	179	96.9
1.80V	2274	1905	1426	1049	703	523	356	309	246	206	177	94.9
1.85V	1953	1620	1253	927	634	479	334	292	236	198	169	92.2
1.90V	1599	1279	1041	766	530	428	302	265	214	180	156	86.0

SMU-M 2-3000												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	4352	3662	2976	1961	1205	885	579	499	390	323	275	150
1.65V	4081	3447	2714	1851	1171	861	571	493	387	321	273	148
1.70V	3836	3262	2482	1759	1131	822	557	481	381	316	271	147
1.75V	3618	3070	2289	1661	1089	804	548	474	376	314	269	146
1.80V	3419	2863	2143	1577	1057	786	535	464	369	310	266	143
1.85V	2935	2435	1884	1393	952	721	501	439	354	297	254	139
1.90V	2404	1923	1565	1152	796	644	454	398	321	271	235	129

5.2 Discharge Data with Constant Power

Wattage values for each battery model as a function of time and voltage with constant Watts per cell @ 77°F/25°C. *(Specifications subject to change without notice)*

SMU-M 2-200												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	567	475	378	269	174	129	85.0	72.6	56.7	46.3	39.6	21.2
1.65V	539	455	357	249	159	121	82.0	70.3	54.6	45.2	38.6	20.7
1.70V	518	439	348	237	155	116	80.2	68.9	53.5	43.9	37.6	20.1
1.75V	502	423	337	228	149	112	78.2	67.3	51.5	43.2	37.0	19.8
1.80V	488	403	325	222	147	108	76.0	65.3	50.2	42.6	36.1	19.5
1.85V	444	367	289	202	135	102	72.5	61.9	48.5	40.9	35.0	18.8
1.90V	392	318	244	174	117	95.0	67.7	57.8	45.4	38.0	32.8	18.0

SMU-M 2-260												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	737	617	491	350	226	167	111	94.4	73.8	60.2	51.5	27.6
1.65V	701	592	465	323	207	157	107	91.4	71.0	58.8	50.2	26.9
1.70V	674	571	453	308	201	151	104	89.6	69.5	57.1	48.9	26.2
1.75V	653	550	438	296	194	146	102	87.5	66.9	56.2	48.0	25.8
1.80V	634	524	422	289	190	141	98.8	84.9	65.2	55.3	47.0	25.4
1.85V	577	477	375	263	175	133	94.2	80.4	63.1	53.2	45.5	24.4
1.90V	509	414	317	227	152	124	88.0	75.2	59.0	49.3	42.7	23.4

SMU-M 2-300												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	850	712	567	404	261	193	128	109	85.1	69.5	59.4	31.9
1.65V	808	683	536	373	239	181	123	105	82.0	67.8	57.9	31.1
1.70V	777	659	523	355	232	175	120	103	80.2	65.8	56.4	30.2
1.75V	753	634	505	342	224	168	117	101	77.2	64.8	55.4	29.7
1.80V	732	604	487	334	220	162	114	98.0	75.2	63.9	54.2	29.3
1.85V	666	550	433	303	202	154	109	92.8	72.8	61.4	52.5	28.1
1.90V	588	478	365	261	175	143	102	86.7	68.1	56.9	49.3	27.0

SMU-M 2-400												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1133	949	756	539	347	257	170	145	113	92.7	79.2	42.5
1.65V	1078	911	715	498	319	242	164	141	109	90.4	77.2	41.5
1.70V	1036	878	697	474	310	233	160	138	107	87.8	75.2	40.2
1.75V	1004	845	673	455	299	224	156	135	103	86.5	73.9	39.6
1.80V	976	806	649	445	293	216	152	131	100	85.1	72.3	39.0
1.85V	888	734	578	405	269	205	145	124	97.0	81.8	70.0	37.5
1.90V	783	637	487	348	234	190	135	116	90.8	75.9	65.7	36.0

5.2 Discharge Data with Constant Power, *continued*

Wattage values for each battery model as a function of time and voltage with constant Watts per cell @ 77°F/25°C

SMU-M 2-500												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1417	1186	945	673	434	322	213	182	142	116	99.0	53.1
1.65V	1347	1139	893	622	398	302	205	176	137	113	96.5	51.8
1.70V	1295	1098	871	592	387	291	200	172	134	110	94.1	50.3
1.75V	1255	1057	842	569	373	281	196	168	129	108	92.4	49.5
1.80V	1220	1007	812	556	366	271	190	163	125	106	90.3	48.8
1.85V	1110	917	722	506	337	256	181	155	121	102	87.5	46.9
1.90V	979	796	609	436	292	238	169	145	113	94.9	82.1	45.0

SMU-M 2-600												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1700	1424	1134	808	521	386	255	218	170	139	119	63.7
1.65V	1617	1366	1072	746	478	362	246	211	164	136	116	62.2
1.70V	1554	1318	1045	711	464	349	241	207	160	132	113	60.3
1.75V	1506	1268	1010	683	448	337	235	202	154	130	111	59.4
1.80V	1464	1209	974	667	440	325	228	196	150	128	108	58.5
1.85V	1332	1101	866	607	404	307	217	186	146	123	105	56.3
1.90V	1175	955	731	523	350	285	203	173	136	114	98.5	54.0

SMU-M 2-800												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1969	1657	1369	999	635	471	321	282	230	190	160	85.5
1.65V	1901	1605	1316	967	609	459	313	276	225	185	156	83.4
1.70V	1837	1563	1273	931	585	450	307	269	221	184	155	82.7
1.75V	1762	1495	1197	878	559	441	301	261	216	182	153	82.0
1.80V	1683	1410	1119	808	539	428	293	256	211	179	151	80.5
1.85V	1484	1232	966	692	499	404	277	242	199	169	143	76.3
1.90V	1247	998	790	587	450	368	259	228	187	160	134	71.8

SMU-M 2-800A												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	1969	1657	1369	999	635	471	321	282	230	190	160	85.5
1.65V	1901	1605	1316	967	609	459	313	276	225	185	156	83.4
1.70V	1837	1563	1273	931	585	450	307	269	221	184	155	82.7
1.75V	1762	1495	1197	878	559	441	301	261	216	182	153	82.0
1.80V	1683	1410	1119	808	539	428	293	256	211	179	151	80.5
1.85V	1484	1232	966	692	499	404	277	242	199	169	143	76.3
1.90V	1247	998	790	587	450	368	259	228	187	160	134	71.8

5.2 Discharge Data with Constant Power, *continued*

Wattage values for each battery model as a function of time and voltage with constant Watts per cell @ 77°F/25°C

SMU-M 2-1000												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	2461	2071	1712	1248	794	589	401	352	287	238	200	107
1.65V	2376	2007	1645	1209	761	574	391	345	281	232	195	104
1.70V	2297	1953	1591	1163	731	562	383	337	276	230	193	103
1.75V	2203	1869	1496	1097	699	551	376	327	270	228	192	102
1.80V	2104	1762	1398	1010	673	535	366	320	264	224	188	101
1.85V	1855	1539	1208	865	624	505	347	302	249	212	178	95.3
1.90V	1559	1247	988	734	562	460	324	285	234	199	168	89.7

SMU-M 2-1000A												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	2461	2071	1712	1248	794	589	401	352	287	238	200	107
1.65V	2376	2007	1645	1209	761	574	391	345	281	232	195	104
1.70V	2297	1953	1591	1163	731	562	383	337	276	230	193	103
1.75V	2203	1869	1496	1097	699	551	376	327	270	228	192	102
1.80V	2104	1762	1398	1010	673	535	366	320	264	224	188	101
1.85V	1855	1539	1208	865	624	505	347	302	249	212	178	95.3
1.90V	1559	1247	988	734	562	460	324	285	234	199	168	89.7

SMU-M 2-1200												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	2984	2510	2075	1513	962	714	486	427	348	288	240	127
1.65V	2880	2432	1994	1466	923	696	474	418	340	281	234	124
1.70V	2784	2368	1929	1410	886	682	464	408	335	278	232	122
1.75V	2670	2266	1814	1330	847	668	456	396	328	276	230	121
1.80V	2550	2136	1695	1224	816	648	444	388	320	271	226	119
1.85V	2249	1866	1464	1049	756	612	420	366	302	257	214	114
1.90V	1890	1512	1197	889	682	558	392	346	283	242	201	107

SMU-M 2-1250												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	3013	2535	2095	1528	972	721	491	431	351	291	242	128
1.65V	2909	2456	2014	1480	932	703	479	422	344	284	236	125
1.70V	2812	2391	1948	1424	895	688	469	412	338	281	234	123
1.75V	2696	2288	1831	1343	856	675	461	400	331	279	232	122
1.80V	2575	2157	1712	1236	824	654	448	391	324	274	228	120
1.85V	2271	1884	1478	1059	763	618	424	370	305	259	216	115
1.90V	1909	1527	1209	898	688	564	396	349	286	244	203	108

5.2 Discharge Data with Constant Power, *continued*

Wattage values for each battery model as a function of time and voltage with constant Watts per cell @ 77°F/25°C

SMU-M 2-1500												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	3692	3107	2568	1873	1191	884	601	529	431	356	300	160
1.65V	3564	3010	2468	1814	1142	861	587	517	421	347	292	156
1.70V	3445	2930	2387	1745	1096	843	575	505	414	345	290	155
1.75V	3304	2804	2244	1645	1048	827	564	490	405	342	287	154
1.80V	3156	2643	2098	1515	1010	802	549	480	396	336	282	151
1.85V	2783	2309	1812	1298	936	757	520	453	374	318	267	143
1.90V	2339	1871	1481	1100	843	691	486	428	350	299	252	135

SMU-M 2-2000												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	4923	4142	3423	2497	1588	1178	802	705	574	475	400	214
1.65V	4752	4013	3291	2418	1522	1148	782	689	561	463	390	208
1.70V	4594	3907	3183	2327	1462	1125	766	673	552	459	387	207
1.75V	4406	3738	2992	2194	1398	1103	752	653	541	455	383	205
1.80V	4208	3524	2797	2020	1346	1069	733	640	529	447	377	201
1.85V	3710	3079	2416	1731	1247	1010	693	604	499	424	357	191
1.90V	3119	2495	1975	1467	1125	921	647	570	467	399	336	179

SMU-M 2-3000												
End Voltage	5Min	15Min	30Min	1Hr	2Hr	3Hr	5Hr	6Hr	8Hr	10Hr	12Hr	24hr
1.60V	7385	6214	5136	3746	2382	1767	1203	1057	861	713	600	321
1.65V	7129	6021	4937	3627	2283	1723	1173	1034	842	695	585	313
1.70V	6891	5860	4775	3490	2193	1687	1150	1010	829	689	580	310
1.75V	6609	5608	4489	3291	2097	1654	1129	980	811	683	575	307
1.80V	6312	5287	4196	3030	2020	1604	1099	959	793	671	565	302
1.85V	5566	4619	3624	2596	1871	1515	1040	906	748	636	535	286
1.90V	4678	3743	2963	2201	1687	1381	971	855	701	598	504	269

6.0 Forms

6.1 Discharge Recording Form

Model of Battery		Date	
Battery Bank No.		Room Temperature	
Charging Current		Total battery Voltage	
Remarks			

Cell #	Inital Voltage	Cell Voltage at Time Period End							
		15min	30min	1hr	2hr	3hr	4hr	4:30hr	5 hr

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