

AlphaCell™ SMU-HR

Valve Regulated Lead Acid Battery



Power



Technical Manual

AlphaCell SMU-HR Battery Series

Effective: March, 2008

Power

Alpha Technologies



AlphaCell SMU-HR

745-680-B2-002, Rev. B

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 **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.

Contact 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!

A 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-HR series of Valve Regulated Lead Acid (VRLA) batteries is designed to meet the needs of the wireless communications industry. The SMU-HR series of Valve Regulated Lead Acid (VRLA) batteries is specifically designed for UPS, power generation and switchgear applications. Safety, reliability, and long service life in standby applications are the result.

Alpha offers a full line of racking solutions to accommodate the SMU-HR series of batteries. Front-terminal SMU-HR batteries provide easy terminal access for installation and maintenance, eliminating the need to purchase expensive sliding mechanisms. The SMU-HR series includes nine models to make it easier to install and maintain the 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-HR 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.
- Designed with molded handles, SMU-HR batteries are very easy to maneuver. Smaller, more compact, and lighter than traditional batteries, SMU-HR batteries are supplied filled and charged so they can be immediately installed directly into cabinets or on easily assembled racks (also available from AlphaCell).
- With a minimum 10 year design life, the SMU-HR batteries are highly reliable and fully comply with established international standards. The SMU-HR range has been fully tested with respect to charge and discharge characteristics, cycle life, recombination efficiency, mechanical strength, vibration life, and flame retardancy.

1.0 Introduction, continued

1.2 General Specifications

Type	Normal Voltage (V)	Rated Capacity C20 (Ah)	Rated Power (W) (15min, 1.67V)	Dimensions (L x W x H) (in)	WT (lb)
SMU-HR-12-18	12	20	75	7.13 x 3.03 x 6.57	13.23
SMU-HR 12-33	12	33	140	7.76 x 5.20 x 7.36	33.49
SMU-HR 12-50	12	50	170	8.98 x 5.47 x 8.86	46.89
SMU-HR 12-55	12	54	200	8.98 x 5.47 x 8.86	46.89
SMU-HR 12-75	12	75	270	10.28 x 6.81 x 8.82	69.66
SMU-HR 12-90	12	90	310	12.01 x 6.61 x 8.35	80.38
SMU-HR 12-100	12	100	370	13.43 x 6.81 x 9.49	96.45
SMU-HR 12-134	12	134	475	13.58 x 6.77 x 10.94	120.56
SMU-HR 12-150	12	150	515	13.58 x 6.77 x 10.94	136.10

Table 1-1, SMU-HR Models and General Specifications

1.3 Operating Conditions

Because SMU-HR batteries are valve regulated and virtually sealed, and 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: -40°F to 131°F (-40°C to 55°C)
- Ideal ambient operating temperature: 68°F to 77°F (20°C to 25°C)
- 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 Table 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 (See Fig. 1-1).



NOTE:

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

1.4 Capacity, continued

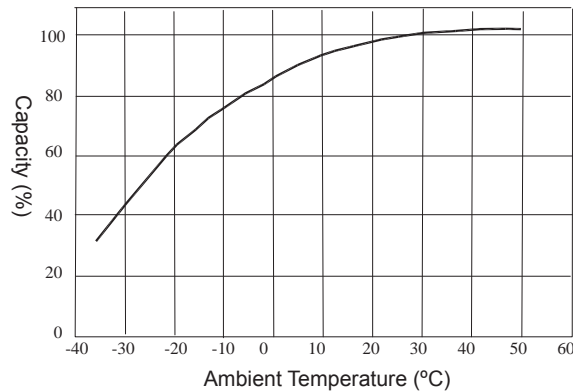


Fig. 1-1, Available Capacity vs. Ambient Temperature

1.5 Temperature and Battery Life

High temperature can harm the battery and reduce its lifespan. Battery life decreases by 50% every 10° rise in temperature above the standard operating temperature of 77°F (25°C)

To minimize battery damage:

- Use temperature compensated chargers.
- Never allow the battery's temperature to exceed +131°F (+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 (mΩ)	Short Circuit Current (A)
SMU-HR 12-18	14	907
SMU-HR 12-33	10	1239
SMU-HR 12-50	8.5	1498
SMU-HR 12-55	8.5	1498
SMU-HR 12-75	6.50	1959
SMU-HR 12-90	5.20	2442
SMU-HR 12-100	5.22	2247
SMU-HR 12-134	4.63	2744
SMU-HR 12-150	4.14	3072

Table 1-2, Internal Resistance and Short Circuit Current at 77°F (25°C)



CAUTION!

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

2.0 Charging Procedures



NOTE:

Take measurements before and after charging and during discharge to help track changes and problems. Use a form (see examples in Section 6.0), to record the results. Wait two hours after charging before taking final measurements, in order to allow the electrolyte to cool sufficiently.



CAUTION!

If the heat generated as a result of charging exceeds the rate at which heat can be transferred out of the battery thermal runaway can occur and excessive overheating will result.



NOTE:

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

2.1 General Charge

The limited current and constant voltage recharge method, also known as the modified constant potential method, satisfies the need to have the battery quickly recharged while ensuring maximum battery life. Figure 2-1 shows the relationship between current, voltage, and charge for the SMU-HR 12-100.

When to Charge

- After installing or discharging the battery
- If the battery has been stored for more than three months and the open circuit voltage is lower than 12.6V/block

General Charge Procedure

1. Charge the batteries with a constant current no greater than $0.2C_{20}$ A until an average voltage of 14.4V/block at 77°F (25°C) is reached
2. Continue charging, reducing the current to maintain a constant voltage of 14.4V/block

Fast Charge Procedure

1. Charge the batteries with a constant current no greater than $0.2C_{30}$ A until an average voltage of 14.4V/block at 77°F (25°C) is reached
2. Continue charging, reducing the current to maintain a constant voltage of 14.4V/block

The batteries will be fully charged in 18-24 hours when the voltage is a constant 14.4V/block and the charge current has not needed adjustment for three continuous hours.

2.0 Charging Procedures, *continued*

2.1 General Charge, *continued*

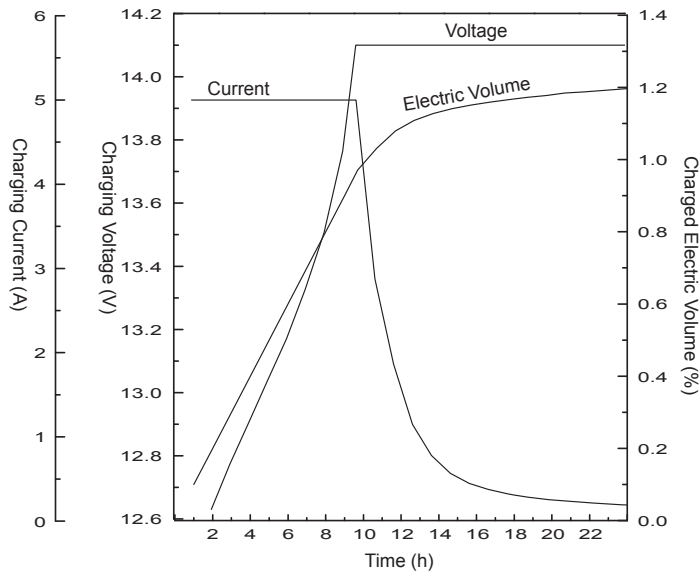


Fig. 2-1, Charge Characteristics Curve
(SMU-HR 12-100 with initial $0.1C_{20}$ A current and limit voltage 14.4V/Cell)

2.2 Floating Charge

A float charge keeps the battery in a fully charged state with a small but constant current to automatically cover capacity loss resultant from self discharge and other discharges.

At 25°C, the proper floating voltage for the HR series is 13.68V/block. The temperature compensate coefficient is -32.4mV/°F/block (-18mV/°C/block).

Ambient Temperature °F (°C)	Floating Voltage (Vpc)
32 (0)	13.73
41 (5)	13.72
50 (10)	13.71
58 (15)	13.70
68 (20)	13.69
77 (25)	13.68
86 (30)	13.67
95 (35)	13.66
104 (40)	13.65

Table 2-1, Floating Voltage at Different Temperatures



CAUTION!

If the floating voltage is higher than indicated in Table 2-1, then the floating current is also higher than ideal and will accelerate corrosion of the grid and shorten the life of the battery. If the floating voltage is lower, the battery will not be kept in fully charged state, which will crystallize the PbSO₄, decrease the capacity, and also shorten the life of the battery.

2.0 Charging Procedures, *continued*

2.3 Discharge

The end voltage is the lowest voltage the battery can be discharged to without causing damage. Usually, the 20 hour rate (C_{20}) end voltage of an SMU-HR battery is 10.5V/block. Although the battery can be discharged below this voltage, doing so will not discharge any more capacity and can affect its lifespan. It may be impossible to recharge a battery after several over-discharges. After a discharge, recharge the batteries as soon as possible to maximize battery life. See Section 5.0 for discharge specifications.

Discharge Current (A)	Discharge End Voltage (Vpc)
$I < 0.2C$	10.5
$0.2C \leq I < 0.5C$	10.2
$0.5C \leq I < 1.0C$	9.30
$I \geq 1.0C$	7.80

Table 2-2, Discharge End-Voltage

3.0 Storage

All lead acid batteries experience self-discharge while in open circuit storage. This causes circuit voltage and capacity to decrease (see Fig. 4-1).

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 32°F–95°F (0°C–35°C).
- 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).

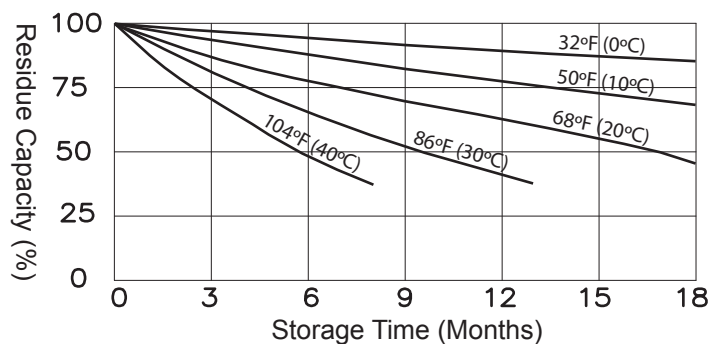


Fig. 3-1, Capacity vs. Storage Time

4.0 Maintenance

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

4.1 Recommended Maintenance Tasks

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.

4.0 Maintenance, *continued*

4.2 VRLA Battery Maintenance Record

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

No.	Voltage (V)	No.	Voltage (V)
1		13	
2		14	
3		15	
4		16	
5		17	
6		18	
7		19	
8		20	
9		21	
10		22	
11		23	
12		24	
Visual check:			

5.0 Discharge Specifications

5.1 Discharge Data with Constant Current (A, 77°F (25°C))

SMU-HR 12-18

End voltage	5 Min	10 Min	15 Min	30 Min	1h	3h	5h	10h	20h
1.60V	88.6	55.1	41.6	25.4	14.2	6.24	3.81	2.08	1.12
1.67V	83.2	52.3	40.0	24.3	14.0	6.00	3.73	2.06	1.08
1.70V	76.2	50.4	39.1	22.1	13.6	5.6	3.65	2.05	1.07
1.75V	74.7	48.8	37.8	21.0	13.0	5.41	3.57	2.04	1.04
1.80V	66.9	46.6	34.3	19.4	12.1	5.20	3.36	2.00	1.01
1.85V	59.0	44.4	30.9	17.9	11.3	5.01	3.15	1.97	0.99

SMU-HR 12-33

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	106	73.2	59.4	50	38	31	28.5	27	23.4	16.8	14	9.4	6	3.40
1.60V	106	73.2	58	49	37.5	30.8	28.5	27	23.3	16.8	14	9.30	6.00	3.40
1.63V	105	73	57	48	37	30.6	28.4	27	23.2	16.7	13.9	9.30	5.90	3.30
1.65V	105	73	55	48	36.5	30.4	28.2	26.4	23.2	16.7	13.9	9.29	5.90	3.30
1.67V	104	72.8	55	47	36	30.4	28	26.4	23.1	16.5	13.8	9.26	5.9	3.2
1.70V	104	72.8	54	47	36	30.4	28	26.3	23.1	16.5	13.7	9.24	5.8	3.2
1.75V	103	72.6	53.3	47	36	29.7	28	26.2	23.1	16.4	13.6	9.2	5.8	3.2
1.80V	98	70	52.8	46.2	35.2	29.4	27.6	25.8	22.5	16.2	13.3	9.2	5.8	3.1
1.85V	92	66	51	44	34	28.2	27.3	25.5	21.5	15.9	12.9	8.8	5.7	3.1

SMU-HR 12-50

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	137	94.3	90.0	75.8	57.6	47.0	43.2	40.9	35.5	25.5	21.2	14.2	9.09	4.95
1.60V	137	94.3	87.9	74.2	56.8	46.7	43.2	40.9	35.3	25.5	21.2	14.1	9.09	4.95
1.63V	135	94.0	86.4	72.7	56.1	46.4	43.0	40.9	35.2	25.3	21.1	14.1	8.94	4.80
1.65V	135	94.0	83.3	72.7	55.3	46.1	42.7	40.0	35.2	25.3	21.1	14.1	8.94	4.80
1.67V	134	93.8	83.3	71.2	54.5	46.1	42.4	40.0	35.0	25.0	20.9	14.0	8.94	4.65
1.70V	134	93.8	81.8	71.2	54.5	46.1	42.4	39.8	35.0	25.0	20.8	14.0	8.79	4.65
1.75V	133	93.5	80.8	71.2	54.5	45.0	42.4	39.7	35.0	24.8	20.6	13.9	8.79	4.65
1.80V	126	90.2	80.0	70.0	53.3	44.5	41.8	39.1	34.1	24.5	20.2	13.9	8.79	4.51
1.85V	118	85.0	77.3	66.7	51.5	42.7	41.4	38.6	32.6	24.1	19.5	13.3	8.64	4.32

5.0 Discharge Specifications, *continued*

5.1 Discharge Data with Constant Current (A, 77°F (25°C)), *continued*

SMU-HR 12-55

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	177	122	99.0	83.3	63.3	51.7	47.5	45.0	39.0	28.0	23.3	15.7	10.0	5.44
1.60V	177	122	96.7	81.7	62.5	51.3	47.5	45.0	38.8	28.0	23.3	15.5	10.0	5.44
1.63V	175	122	95.0	80.0	61.7	51.0	47.3	45.0	38.7	27.8	23.2	15.5	9.83	5.28
1.65V	175	122	91.7	80.0	60.8	50.7	47.0	44.0	38.7	27.8	23.2	15.5	9.8	5.28
1.67V	173	121	91.7	78.3	60.0	50.7	46.7	44.0	38.5	27.5	23.0	15.4	9.8	5.12
1.70V	173	121	90.0	78.3	60.0	50.7	46.7	43.8	38.5	27.5	22.8	15.4	9.7	5.12
1.75V	172	121	88.8	78.3	60.0	49.5	46.7	43.7	38.5	27.3	22.7	15.3	9.7	5.12
1.80V	163	117	88.0	77.0	58.7	49.0	46.0	43.0	37.5	27.0	22.2	15.3	9.7	4.96
1.85V	153	110	85.0	73.3	56.7	47.0	45.5	42.5	35.8	26.5	21.5	14.7	9.5	4.75

SMU-HR 12-75

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	196	137	105	99.0	78.0	62.0	57.5	54.0	49.5	37.8	34.0	23.3	14.8	7.60
1.60V	196	136	105	99.0	77.0	62.0	57.5	54.0	49.5	37.5	34.0	23.3	14.8	7.50
1.63V	195	136	105	99.0	77.0	61.0	57.5	53.5	49.5	37.5	33.9	23.3	14.8	7.50
1.65V	194	136	105	99.0	77.0	61.0	57.0	53.5	49.2	37.5	33.8	23.2	14.7	7.50
1.67V	192	135	103	98.0	76.0	61.0	57.0	53.5	49.2	37.5	33.7	23.1	14.7	7.40
1.70V	192	135	103	98.0	76.0	61.0	57.0	53.5	49.2	37.4	33.4	23.0	14.6	7.40
1.75V	190	135	103	97.0	76.0	61.0	57.0	53.5	49.0	37.4	32.8	23.0	14.4	7.30
1.80V	188	135	103	94.0	75.0	60.0	56.0	52.5	47.0	37.0	31.8	22.5	14.0	7.20
1.85V	175	123	99	90.0	67.5	57.0	55.0	51.5	45.8	36.5	31.0	20.7	14.0	7.10

SMU-HR 12-90

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	291	200	155	129	95.0	76.0	73.0	57.0	54.5	38.2	34.5	24.0	15.0	8.00
1.60V	288	197	152	126	93	75.9	72.5	56.5	54.3	38	34.5	24	15	8
1.63V	280	195	150	124	93	75.4	72.3	56.5	54.3	38	34	24	15	8
1.65V	280	194	150	124	93	75.4	72.3	56.5	54.3	38	34	23.5	15	8
1.67V	276	192	150	124	93	75	72.3	56.5	54.3	38	34	23.5	15	8
1.70V	268	170	144	115	90	73	72.1	56.5	54.3	38	34	23.5	15	8
1.75V	252	168	144	115	90	73	72.1	56.5	54.3	38	33	23.5	15	8
1.80V	222	162	132	106.5	85	72	68	56.1	51	38	32	23	15	8
1.85V	184	146	120	102.6	77	65.1	62.3	53.6	47.7	38	32	22	15	8

5.0 Discharge Specifications, *continued*

5.1 Discharge Data with Constant Current (A, 77°F (25°C)), *continued*

SMU-HR 12-100

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	342	220	180	149	115	97.0	89.0	85.0	76.0	54.5	43.7	30.1	19.2	10.1
1.60V	320	218	180	148	114	96.0	89.0	84.5	75.0	54.5	43.6	30.0	19.1	10.0
1.63V	312	217	177	148	114	96.0	88.7	84.0	75.0	54.5	43.4	29.9	19.0	10.0
1.65V	295	217	175	147	113	95.0	88.5	83.5	74.0	54.0	43.3	29.8	18.9	9.9
1.67V	290	215	173	147	113	94.0	88.3	83.5	74.0	54.0	43.1	29.7	18.9	9.9
1.70V	280	213	172	145	113	94.0	88.0	83.0	73.0	53.5	42.8	29.5	18.7	9.8
1.75V	280	213	172	145	113	94.0	88.0	83.0	73.0	53.5	42.8	29.5	18.7	9.8
1.80V	250	208	168	140	110	90.0	86.0	80.0	70.0	52.0	41.1	28.5	18.3	9.7
1.85V	228	200	164	131	103	88.0	82.8	78.0	68.0	50.0	40.0	27.9	18.0	9.7

SMU-HR 12-134

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	420	295	237	177	147	121	112	103	79.5	60.3	47.8	33.9	23.0	12.8
1.60V	420	278	235	174	146	118	109	101	79.1	59.9	47.3	33.5	22.8	12.7
1.63V	420	273	232	174	145	118	109	101	79.1	59.8	47.3	33.5	22.8	12.7
1.65V	402	271	232	174	146	118	109	100	79	59	47.3	33.5	22	12.5
1.67V	350	265	230	174	145	117	108	100	79	59	47	33.5	22	12.5
1.70V	335	260	233	171	145	117	108	99	79	59	46	33.5	22	12.5
1.75V	321	242	216	168	142	116	107	93.8	78.9	58.1	45.1	32.4	20.9	12.5
1.80V	289	227	209	174	138	114	104	83.6	75.9	56.8	44	31.5	20.5	12.5
1.85V	272	217	202	157	123	105	86.6	81.3	71.5	59.49	41.8	30.3	19.7	12

SMU-HR 12-150

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	470	330	265	198	165	135	125	115	89.0	67.5	53.5	37.9	25.8	13.8
1.60V	470	311	263	195	163	132	122	113	88.5	67.0	53.0	37.5	25.5	13.4
1.63V	470	306	260	195	163	132	122	113	88.5	67	53	37.5	25.5	13.4
1.65V	450	303	260	195	163	132	122	113	88.5	67	53	37.5	25.5	13.4
1.67V	392	297	258	195	163	132	122	113	88.5	67	53	37.5	25.5	13.4
1.70V	375	292	250	192	163	132	122	113	88.5	67	53	37.5	25.5	13.4
1.75V	360	271	242	188	160	130	120	105	88.3	65	50.5	36.3	23.4	13.4
1.80V	324	255	234	194.7	155	127.5	117	93.6	85	63	49.3	35.3	23	13.4
1.85V	305	243	226	176	138	118	97	91	80	66.6	46.8	33.9	22.1	12.6

5.0 Discharge Specifications, *continued*

5.2 Discharge Data with Constant Power (Watts/Cell, 77°F (25°C))

SMU-HR 12-18

End voltage	5 Min	10 Min	15 Min	30 Min	1h	3h	5h	10h	20h
1.60V	155.5	99.6	75.9	45.7	25.7	11.1	6.44	4.27	2.24
1.67V	150.1	97.1	75.0	44.7	25.5	10.7	6.42	4.24	2.16
1.70V	141.3	96.1	74.4	41.9	25.0	10.2	6.33	4.21	2.13
1.75V	142.2	95.8	73.7	40.7	24.6	10.0	6.28	4.16	2.08
1.80V	130.1	64.4	68.4	38.8	23.2	9.71	6.08	4.11	2.06
1.85V	118.0	89.5	62.0	36.3	21.8	9.41	5.89	4.05	2.03

SMU-HR 12-33

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	292	189	145	104	76.2	63	58.8	55.7	46.2	34.2	28.0	20.0	12.9	7.17
1.60V	289	186	143	104	75.8	63.0	58.7	55.5	45.8	34	27.9	19.8	12.9	7.10
1.63V	287	185	142	104	75.7	62.9	58.7	55.4	45.7	33.7	27.9	19.8	12.8	7.07
1.65V	285	184	141	104	75.4	62.9	58.6	55.3	45.7	33.6	27.8	19.8	12.8	7.07
1.67V	280	183	140	103	75.0	62.7	58.5	55.2	45.6	33.5	27.7	19.8	12.73	7.00
1.70V	270	182	139	101	75.0	62.5	58.3	55.0	45.5	33.4	27.7	19.7	12.7	6.92
1.75V	265	177	137	101	74.7	62.2	57.8	54.5	45.3	33.2	27.5	19.7	12.5	6.87
1.80V	259	173	135	99	73.7	61.2	57.0	54.0	44.9	33	27.3	19.5	12.3	6.83
1.85V	252	168	120	92	72.5	59.3	56.0	52.7	44.3	32.5	26.3	19.2	12.0	6.67

SMU-HR 12-50

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	301	219	177	143	109	88	83.0	76.8	67.9	49.2	40.3	28.8	18.6	10.3
1.60V	298	215	175	142	108	88.0	82.7	76.6	67.4	48.9	40.2	28.5	18.5	10.2
1.63V	296	214	174	142	108	87.8	82.8	76.5	67.1	48.5	40.2	28.5	18.5	10.2
1.65V	294	213	173	142	107	87.8	82.6	76.3	67.1	48.4	40.1	28.5	18.4	10.2
1.67V	288	212	171	141	107	87.5	82.5	76.1	67.0	48.2	39.9	28.4	18.3	10.1
1.70V	278	211	170	139	107	87.3	82.3	75.9	66.9	48.1	39.8	28.4	18.2	9.96
1.75V	273	205	168	138	106	86.8	81.5	75.2	66.6	47.7	39.6	28.3	18.0	9.89
1.80V	267	200	165	136	105	85.4	80.4	74.5	66.0	47.5	39.3	28.1	17.8	9.84
1.85V	260	194	147	126	103	82.8	79.0	72.7	65.2	46.8	37.9	27.6	17.3	9.60

5.0 Discharge Specifications, *continued*

5.2 Discharge Data with Constant Power (Watts/Cell, 77°F (25°C)), *continued*

SMU-HR12-55														
End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	389	261	205	165	126	102	92.2	85.4	74.6	54.1	44.3	31.7	20.4	11.3
1.60V	385	257	203	165	125	102	91.9	85.1	74.1	53.8	44.2	31.4	20.3	11.2
1.63V	383	256	201	165	125	102	92.0	84.9	73.8	53.3	44.2	31.4	20.3	11.2
1.65V	380	255	200	164	124	102	91.8	84.8	73.8	53.2	44.1	31.3	20.3	11.2
1.67V	373	253	198	163	124	101	91.7	84.6	73.7	53.0	43.9	31.3	20.2	11.1
1.70V	360	252	197	160	124	101	91.4	84.3	73.6	52.9	43.8	31.2	20.1	11.0
1.75V	353	245	194	160	123	101	90.6	83.6	73.3	52.5	43.5	31.1	19.8	10.9
1.80V	345	239	191	157	122	98.9	89.3	82.8	72.6	52.3	43.3	30.9	19.5	10.8
1.85V	327	224	152	141	114	91.1	82.5	73.6	68.2	49.3	40.1	28.5	17.7	10.4

SMU-HR 12-75														
End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	544	370	287	233	182	133	126	116	108	80.8	61.7	50.0	33.7	16.2
1.60V	537	368	284	233	181	132	125	115	108	80.3	61.3	49.7	33.3	16.2
1.63V	530	364	282	232	179	131	123	113	106	79.5	60.3	49.2	32.8	16.1
1.65V	524	361	279	231	179	130	123	113	106	78.8	60.0	48.8	32.5	16.1
1.67V	512	359	270	230	178	129	123	113	106	78.3	59.5	46.3	32.0	16.0
1.70V	500	350	268	228	177	128	122	112	105	77.5	58.8	45.7	31.3	15.8
1.75V	484	342	265	223	172	127	120	110	103	76.2	58.0	45.0	30.8	15.8
1.80V	470	330	263	222	162	125	118	108	103	75.0	56.0	43.3	30.0	15.7
1.85V	420	300	258	210	158	123	117	107	102	73.3	55.0	42.5	28.7	15.0

SMU-HR 12-90														
End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	641	436	338	279	206	168	153	141	122	94	71	53.5	39	20
1.60V	633	434	336	277	205	167	152	140	121	93	70.5	53	38.6	19.5
1.63V	619	430	334	275	205	166	151	139	120	93	70	52.5	38.4	19.2
1.65V	616	427	332	274	205	166	151	139	120	93	70	52.5	38.4	19.2
1.67V	608	423	330	273	205	165	151	139	120	93	70	52.5	38.4	19.2
1.70V	591	415	325	270	203	164	150	138	120	93	70	52.5	38.4	19.2
1.75V	555	397	314	262	199	161	147	136	118	92	69.6	52	38	19
1.80V	535	375	299	252	184	142	134	123	116	90	67.2	51.5	36	18.8
1.85V	504	355	283	244	168	130	125	117	113	88	66	50.5	34	18

5.0 Discharge Specifications, *continued*

5.2 Discharge Data with Constant Power (Watts/Cell, 77°F (25°C)), *continued*

SMU-HR 12-100

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	751	525	417	357	256	203	186	175	156	114	78.3	58.3	43.5	23.7
1.60V	740	518	405	346	254	201	184	173	154	113	78.2	58.0	43.3	23.7
1.63V	735	544	403	346	254	201	184	173	153	113	78.0	58.0	43.3	23.5
1.65V	723	510	400	345	254	201	184	173	153	113	78.0	57.8	43.2	23.5
1.67V	714	505	397	345	253	201	183	172	153	112	77.8	57.7	43.2	23.3
1.70V	700	496	390	345	253	200	183	172	152	112	77.7	57.7	43.2	23.2
1.75V	622	475	378	338	245	197	183	172	152	111	77.5	57.5	43.0	23.2
1.80V	594	462	369	329	240	196	180	170	150	109	77.2	57.2	42.7	23.0
1.85V	560	441	358	303	230	187	175	166	146	108	75.3	56.3	41.5	22.7

SMU-HR 12-134

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	756	549	489	364	304	249	231	212	181	135	90.4	68.3	44.3	24.4
1.60V	746	544	484	359.7	299.8	244.4	226	207.5	180	134	89.5	67.8	43.8	24
1.63V	741	535	479	359.7	299.8	244.4	226	207.5	180	134	89.5	67.8	43.8	24
1.65V	729	530	479	359.7	299.8	244.4	226	207.5	180	134	89.5	67.8	43.8	24
1.67V	719	521	475	359.7	299.8	244.4	226	207.5	180	134	89.5	67.8	43.8	24
1.70V	705	511	438	355.1	299.8	244.4	226	207.5	180	134	89.5	67.8	43.8	24
1.75V	666	479	424	345.9	295.1	239.8	221.4	202.9	175	134	89	67.3	43.3	24
1.80V	600	466	410	341.3	285.9	235.2	216.7	198.3	172	131	88.5	66.4	42.9	23.1
1.85V	565	446	397	336	277	226	212	194	168	129	86.7	64.6	41.5	22.1

SMU-HR 12-150

End voltage	5Min	10Min	15Min	20Min	30Min	40Min	45Min	50Min	1h	1.5h	2h	3h	5h	10h
1.50V	790	595	530	395	330	270	250	230	196	146	98	74	48	26.5
1.60V	780	590	525	390	325	265	245	225	195	145	97	73.5	47.5	26
1.63V	765	580	520	390	325	265	245	225	195	145	97	73.5	47.5	26
1.65V	750	575	520	390	325	265	245	225	195	145	97	73.5	47.5	26
1.67V	745	565	515	390	325	265	245	225	195	145	97	73.5	47.5	26
1.70V	725	555	475	385	325	265	245	225	195	145	97	73.5	47.5	26
1.75V	685	515	460	375	320	260	240	220	190	145	96.5	73	47	26
1.80V	615	485	445	370	310	255	235	215	187	142	96	72	46.5	25
1.85V	580	462	430	364	300	245	230	210	182	140	94	70	45	24

6.0 Forms

6.1 Charging Recording Form

Record before charging and two hours after.

Model of Battery	<input type="text"/>	Date	<input type="text"/>
Battery Bank No.	<input type="text"/>	Room Temperature	<input type="text"/>
Charging Current	<input type="text"/>	Total Battery Voltage	<input type="text"/>
Remarks	<input type="text"/>		

Cell #	Voltage	S.G. of Electrolyte	Electrolyte Temperature



NOTE:

Wait two hours before taking final readings to allow the electrolyte to cool.

6.0 Forms, continued

6.2 Discharge Recording Form

Model of Battery	<input type="text"/>	Date	<input type="text"/>
Battery No.	<input type="text"/>	Room Temperature	<input type="text"/>
Charging Current	<input type="text"/>	Total Battery Voltage	<input type="text"/>
Remarks	<input type="text"/>		
	<input type="text"/>		

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

Power

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