AlphaCell™ SMU-HR Series Batteries

Technical Manual

Effective: July 2010

member of The alpha Group™

Power

AlphaCell™ SMU-HR Series Batteries Technical Manual

745-680-B2-002, Rev. B

Effective Date: July, 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

Table of Contents

Figures

Tables

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 many industrial and utility applications. The success of the AlphaCell SMU-HR 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-HR series of batteries. SMU-HR batteries provide easy terminal access for installation and maintenance, and can be upright-, side-, or end-mounted. The SMU-HR series includes eight 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.
- 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.

1.2 Typical Electrical and Mechanical Specifications

Type	Normal Voltage (V)	Rated Capacity C20 (Ah)	Rated Power (15min, 1.67V, W)	Dimensions			Weight
				L (in/mm)	W (in/mm)	H (in/mm)	(lb/kg)
SMU-HR 12-9	12	9.0	35.0	5.9/151	2.6/65	4.0/101	5.9/2.7
SMU-HR 12-18	12	20.4	75.0	7.1/181	3.0/77	6.6/167	13.2/6.0
SMU-HR 12-35	12	35.0	140	7.7/195	5.1/130	7.1/180	24.3/11.0
SMU-HR 12-55	12	55.0	198	9.0/228	5.5/139	8.9/225	38.6/17.5
SMU-HR 12-75	12	75.0	270	10.3/261	6.8/173	8.8/224	57.3/26.0
SMU-HR 12-90	12	92.0	310	12.0/305	6.6/168	8.4/212	63.7/28.9
SMU-HR 12-100	12	100	397	13.4/341	6.8/173	9.5/241	75.0/34.0
SMU-HR 12-150	12	154	461	19.1/485	6.8/172	9.5/240	99.2/245.0

Table 1-1, General Electrical and Mechanical Specifications by Model
(Specifications courtesy of manufacturer)

1.3 Operating Conditions

Because SMU-HR 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 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 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.

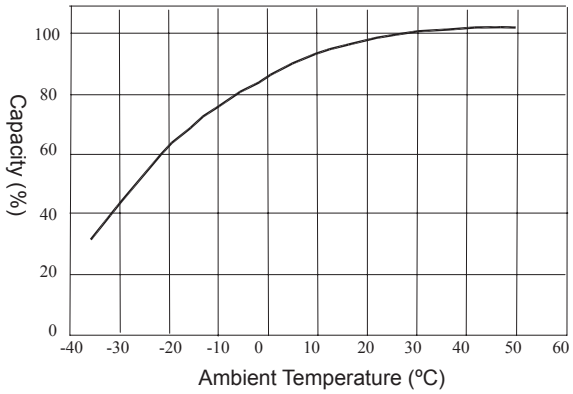

Fig. 1-1, Available Capacity vs. Ambient Temperature

1.5 Temperature and Battery Life

High temperatures can harm the battery and reduce its lifespan. Battery life decreases by 50% every 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 (mΩ)	Short Circuit Current (A)
SMU-HR 12-9	32.4	370
SMU-HR 12-18	15.0	800
SMU-HR 12-35	10.0	1239
SMU-HR 12-55	8.50	1498
SMU-HR 12-75	6.50	1959
SMU-HR 12-90	5.20	2442
SMU-HR 12-100	5.22	2247
SMU-HR 12-150	4.14	3072

Table 1-2, Internal Resistance and Short Circuit Current at 77ºF (25ºC)

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 68°F (20°C) is the recommended voltage for float charge. This voltage ensures the maximum life of SMU-HR batteries. These batteries can operate over a temperature range of -4°F (-20°C) to +140°F (+60°C). Performance and life are greatly reduced outside of this temperature range.

Temperature °F (°C)	Recommended Float (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 1.8F (1C) temperature fluctuation outside of 68F (20C)

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.

Float Current

The normal float current observed in fully charged SMU-HR batteries at 2.27Vpc at a temperature of 68F (20C) is approximately 30mA per 100Ah. Because of the nature of recombination phenomena, the float current observed in SMU-HR 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 chargers1.
2. Never allow the batteries to exceed 131F (55C)2.
3. Make sure cabinets are properly ventilated3.
4. Provide spacing between batteries to enhance convective cooling4.
5. Visit sites annually to check for shorted cells, improperly set voltages, filter cleaning on ventilation 5. 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 68F (20C)) (see Table 2-1) and a maximum charge current of 0.25 C8 amperes.

Fast Charge

If it is necessary to reduce the recharge time, charge with a maximum voltage of 2.4Vpc at 68F (20C) and a maximum current of 0.25 C8(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 C10, 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 C10, 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.

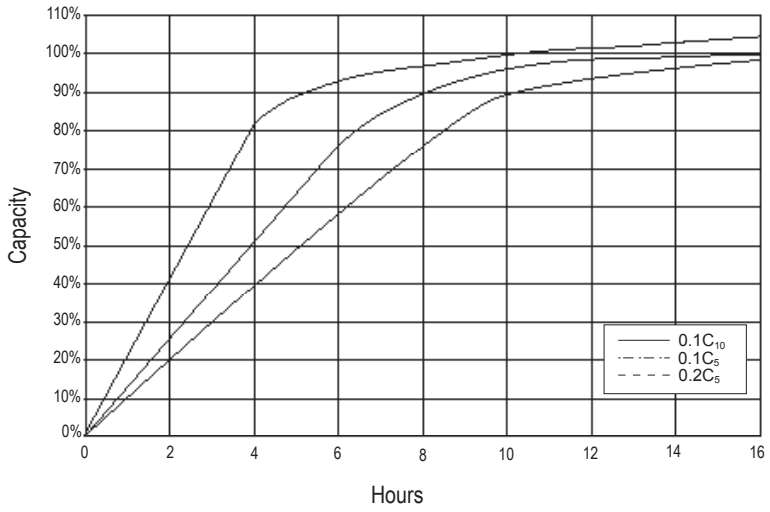

Fig. 2-1, Recharge Time and Capacity Restored as a Function of Current Limit

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-HR batteries, the rate of self-discharge is about 23% per month at 77F (25C). 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 °F (°C)	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).

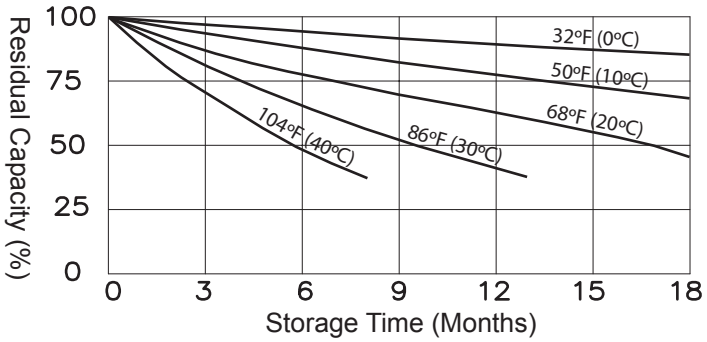

Fig. 3-1, Capacity vs. Storage Time

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		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:			

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.

SMU-HR 12-9									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	41.4	25.7	19.4	11.8	5.69	2.50	1.53	0.83	0.48
1.67V	38.8	24.4	18.7	11.3	5.61	2.40	1.49	0.82	0.46
1.70V	35.6	23.5	18.2	10.3	5.44	2.24	1.46	0.82	0.45
1.75V	34.9	22.8	17.6	9.78	5.18	2.17	1.43	0.81	0.44
1.80V	31.2	21.8	16.0	9.06	4.85	2.08	1.34	0.80	0.43
1.85V	27.5	20.7	14.4	8.34	4.52	2.01	1.26	0.78	0.42

SMU-HR 12-18									
End voltage	5Min	10Min	15Min	30Min	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	5.60	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 12-35									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	165	103	77.6	47.4	23.5	10.3	6.29	3.43	1.85
1.67V	155	97.6	74.7	45.3	23.1	9.90	6.16	3.39	1.79
1.70V	142	94.1	72.9	41.2	22.4	9.24	6.03	3.38	1.76
1.75V	139	91.2	70.6	39.1	21.4	8.93	5.90	3.37	1.71
1.80V	125	87.1	64.1	36.2	20.0	8.58	5.54	3.30	1.67
1.85V	110	82.9	57.6	33.4	18.7	8.27	5.19	3.26	1.64

SMU-HR 12-55									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	177	122	97.0	62.5	38.8	15.5	10.0	5.44	2.90
1.67V	173	121	92.0	60.0	38.5	15.4	9.80	5.12	2.85
1.70V	173	121	90.0	60.0	38.5	15.4	9.70	5.12	2.80
1.75V	172	121	89.0	60.0	38.5	15.3	9.70	5.12	2.75
1.80V	163	117	88.0	58.7	37.5	15.3	9.70	4.96	2.70
1.85V	153	110	85.0	56.7	35.8	14.7	9.50	4.75	2.60

5.1 Discharge Data with Constant Current, *continued*

SMU-HR 12-75									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	196	136	105	77.0	49.5	23.3	14.8	7.50	3.83
1.67V	192	135	103	76.0	49.2	23.1	14.7	7.40	3.80
1.70V	192	135	103	76.0	49.2	23.0	14.6	7.40	3.78
1.75V	190	135	103	76.0	49.0	23.0	14.4	7.30	3.75
1.80V	188	135	103	75.0	47.0	22.5	14.0	7.20	3.70
1.85V	175	123	99.0	67.5	45.8	20.7	14.0	7.10	3.65

SMU-HR 12-90									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	366	228	172	105	65.4	28.7	17.5	9.55	5.16
1.67V	344	216	165	100	64.5	27.6	17.2	9.46	4.98
1.70V	315	208	162	91.2	62.6	25.8	16.8	9.42	4.90
1.75V	309	202	156	86.6	59.6	24.9	16.4	9.39	4.78
1.80V	276	193	142	80.2	55.8	23.9	15.5	9.20	4.65
1.85V	244	184	128	73.9	52.0	23.1	14.5	9.07	4.52

SMU-HR 12-100									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	320	218	180	114	75.0	30.0	19.1	10.0	5.25
1.67V	290	215	173	113	74.0	29.7	18.9	9.90	5.20
1.70V	280	213	172	113	73.0	29.5	18.7	9.80	5.07
1.75V	275	212	170	112	72.0	29.0	18.5	9.80	5.00
1.80V	250	208	168	110	70.0	28.5	18.3	9.70	4.85
1.85V	228	200	164	103	68.0	27.9	18.0	9.70	4.80

SMU-HR 12-150									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	525	360	263	158	99.0	41.0	28.6	15.9	7.91
1.67V	473	329	255	153	98.9	40.8	28.4	15.7	7.88
1.70V	449	317	246	150	98.6	40.8	28.4	15.5	7.88
1.75V	399	293	233	147	97.5	40.5	28.2	15.3	7.84
1.80V	360	272	222	143	96.3	40.4	27.9	15.0	7.56
1.85V	273	224	192	131	95.3	40.2	27.7	14.7	7.11

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.

SMU-HR 12-9									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	72.6	46.5	35.4	21.3	10.3	4.43	2.58	1.71	0.95
1.67V	70.0	45.3	35.0	20.9	10.2	4.29	2.57	1.70	0.92
1.70V	66.4	44.9	34.7	19.6	10.0	4.10	2.53	1.69	0.91
1.75V	65.9	44.7	34.4	19.0	9.83	4.00	2.51	1.65	0.88
1.80V	60.7	44.0	31.9	18.1	9.27	3.88	2.43	1.60	0.86
1.85V	55.1	41.8	28.9	16.9	8.71	3.77	2.36	1.56	0.83

SMU-HR 12-18									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	156	99.6	75.9	45.7	25.7	11.1	6.44	4.27	2.24
1.67V	150	97.1	75.0	44.7	25.5	10.7	6.42	4.24	2.16
1.70V	142	96.1	74.4	41.9	25.0	10.2	6.33	4.21	2.13
1.75V	141	95.8	73.7	40.7	24.6	10.0	6.28	4.16	2.08
1.80V	130	94.4	68.4	38.8	23.2	9.71	6.08	4.11	2.06
1.85V	118	89.5	62.0	36.3	21.8	9.41	5.89	4.05	2.03

SMU-HR 12-35									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	290	186	142	85.3	42.3	18.3	10.6	7.04	3.70
1.67V	280	181	140	83.5	42.1	17.7	10.6	7.00	3.56
1.70V	265	179	139	78.2	41.3	16.9	10.5	6.95	3.52
1.75V	264	179	138	75.9	40.6	16.5	10.4	6.86	3.43
1.80V	243	176	128	72.4	38.2	16.0	10.0	6.70	3.36
1.85V	220	167	116	67.8	35.9	15.5	9.72	6.56	3.30

SMU-HR 12-55									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	385	257	203	125	74.1	31.4	20.3	11.2	5.87
1.67V	373	253	198	124	73.7	31.3	20.2	11.1	5.82
1.70V	360	252	197	124	73.6	31.2	20.1	11.0	5.77
1.75V	353	245	194	123	73.3	31.1	19.8	10.9	5.71
1.80V	345	239	191	122	72.6	30.9	19.5	10.8	5.66
1.85V	327	224	152	114	68.2	28.5	17.7	10.4	5.45

5.2 Discharge Data with Constant Power, *continued*

SMU-HR 12-75									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	537	368	284	181	108	49.7	33.3	16.2	7.91
1.67V	512	359	270	178	106	46.3	32.0	16.0	7.88
1.70V	500	350	268	177	105	45.7	31.3	15.8	7.88
1.75V	484	342	265	172	103	45.0	30.8	15.8	7.84
1.80V	470	330	263	162	103	43.3	30.0	15.7	7.56
1.85V	420	300	258	158	102	42.5	28.7	15.0	7.37

SMU-HR 12-90									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	643	412	314	189	118	50.9	29.6	19.6	10.3
1.67V	620	401	310	185	117	49.3	29.5	19.5	9.94
1.70V	588	397	307	173	115	47.1	29.1	19.4	9.81
1.75V	584	396	305	168	113	46.0	28.9	19.1	9.57
1.80V	538	390	283	160	107	44.7	28.0	18.9	9.32
1.85V	488	370	256	150	100	43.3	27.1	18.6	8.95

SMU-HR 12-100									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	740	518	405	254	154	58.0	43.3	23.7	10.5
1.67V	714	505	397	253	153	57.7	43.2	23.3	10.5
1.70V	700	496	390	253	152	57.7	43.2	23.2	10.5
1.75V	662	475	378	245	152	57.5	43.0	23.2	10.5
1.80V	594	462	369	240	150	57.2	42.7	23.0	10.2
1.85V	560	441	358	230	146	56.3	41.5	22.7	9.90

SMU-HR 12-150									
End voltage	5Min	10Min	15Min	30Min	1h	3h	5h	10h	20h
1.60V	866	597	465	297	195	78.6	54.8	31.8	15.8
1.67V	821	590	461	291	189	78.6	54.8	31.3	15.8
1.70V	767	575	453	284	184	78.6	54.8	31.1	15.8
1.75V	714	537	426	276	182	77.4	54.2	30.6	15.7
1.80V	641	500	401	269	179	76.4	53.3	30.0	15.1
1.85V	513	414	350	246	177	76.1	52.5	29.5	14.2

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

Alpha Technologies Inc.
3767 Alpha Way
Bellingham, WA 98226
United States
Tel: +1 360 647 2360
Fax: +1 360 671 4936

Alpha Energy
1628 W Williams Drive
Phoenix, AZ 85027
United States
Tel: +1 602 997 1007
Fax: +1 623 249 7833

Alpha Technologies Europe Ltd.
Twyford House Thorley
Bishop's Stortford
Hertfordshire, CM22 7PA
United Kingdom
Tel: +44 1279 501110
Fax: +44 1279 659870

Alpha Technologies
Suite 1903, 19/F., Tower 1
33 Canton Road, Tsim Sha Tsui
China Hong Kong City, Kowloon
Hong Kong
Phone: +852 2736 8663
Fax: +852 2199 7988

Alpha Technologies Ltd.
7700 Riverfront Gate
Burnaby, BC V5J 5M4
Canada
Tel: +1 604 436 5900
Fax: +1 604 436 1233
Toll Free: +1 800 667 8743

Alpha Technologies GmbH
Hansastrasse 8
D-91126
Schwabach, Germany
Tel: +49 9122 79889 0
Fax: +49 9122 79889 21

Alphatec Ltd.
339 St. Andrews St.
Suite 101 Andrea Chambers
P.O. Box 56468
3307 Limassol, Cyprus
Tel: +357 25 375 675
Fax: +357 25 359 595

Alpha Innovations Brasil
Avenida Ibirapuera,
2120 – Cj 76
Moema - 04028-001
Santos SP, Brazil
Tel: +55 11 2476 0150
Fax: +55 11 2476 0150

Alpha Industrial Power Inc.
1075 Satellite Blvd NW,
Suite 400
Suwanee, GA 30024
United States
Tel: +1 678 475 3995
Fax: +1 678 584 9259

Technologies Argus First de Mexico
Anatole France Num. 17
Colonia Polanco
11560, México D.F.
Tel: +52 55 5280 6990

Alpha TEK ooo
Khokhlovskiy Pereulok 16
Stroenie 1, Office 403
Moscow, 109028
Russia
Tel: +7 495 916 1854
Fax: +7 495 916 1349

Alphatec Baltic
S. Konarskio Street 49-201
Vilnius, LT-03123
Lithuania
Tel: +370 5 210 5291
Fax: +370 5 210 5292

Visit us at www.alpha.com

Power

745-680-B2-002 Rev. B (07/2010)