

Battery Energy

SunGEL

Installation and Maintenance Manual

Sealed Lead Acid Battery



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1. Introduction

This manual gives an introduction to the technical features of the SunGEL range of batteries, specifically for remote area power applications. This manual is an important part of the battery installation and should remain with the battery throughout its service life for reference and record of maintenance. Read it carefully and store in a safe location.

This manual is written as a general information guide and it is expected that it be used by qualified persons observing all safety requirements outlined by local regulations and those contained herein.

Content in this manual may be updated from time to time without notice when necessary. Please check with Battery Energy Power Solutions to ensure that you have the latest copy.

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2. Safety



This manual is to be used as an installation guide by qualified personnel



Smoking or naked flame within 15 meter area is prohibited



Wear protective glasses and clothing when working on batteries



Treat any splash as an acid burn. Remove from source and remove contaminated clothing immediately. Flush eyes thoroughly with tepid water for 15 minutes or wash skin with soap and water. Obtain urgent medical attention.



Caution: fire and explosion hazard. Avoid short circuit.



Caution: battery electrolyte is corrosive to skin. Treat any splash as an acid burn. Remove from source and remove contaminated clothing immediately. Wash skin with soap and water. Obtain medical attention.



Appropriate lifting equipment must be used when moving, installing or transporting batteries.

Refer to the current Material Safety Data Sheet for additional information.

2.1 Electrical safety

Installation, maintenance and servicing of SunGEL VRLA battery should only be carried out and supervised by personnel knowledgeable of lead acid batteries and the required personal safety and equipment safety precautions. Unauthorised personnel should be kept away from the batteries and maintenance activities. The following precautions should be observed when maintaining VRLA batteries:

1. Remove all personal metal objects (rings, watches etc.).
2. Use insulated tools.
3. Wear full eye protection and rubber gloves.
4. Observe circuit polarities.
5. Do not make or break live circuits.
6. Prior to handling batteries on a metal rack, ensure the battery is not inadvertently grounded by observing the ground fault detector indicator. In its absence, measure the voltage between the battery and the rack. If not zero, determine the cause and correct prior to proceeding.
7. Do not place metal tools and conductive hardware on top of the batteries.
8. Use an insulating blanket, as required, to cover exposed portions of the battery system when performing extended maintenance that could result in personal or equipment contact with the energized conductors.

2.2 Physical

Lead acid batteries by their very nature are heavy items. It is important that correct manual handling procedures and equipment usage are followed.

The specifications relating to the particular models weights and dimensions are on page 7.

The appropriate techniques and equipment must be employed when dealing with the shape and mass of the units to be handled. For specific information regarding materials handling the relevant safety authority in your country or state should be contacted.

Do not use the terminal posts or links for handling or lifting the cells or batteries!

2.3 Lead components

The materials selected to support your SunGEL batteries are designed to complement their high performance and long life. The fasteners and connectors provided are efficient conductors such as copper and brass. In order to maintain the integrity of these items for extended periods in various environments they have been lead plated.

The normal precautions for handling lead based materials are indicated. Gloves should be worn to prevent the accumulation of lead on the skin.

Do not smoke or consume food or drink in the area and always wash your hands thoroughly prior to leaving the work area for any purpose!

2.4 Gases

Under normal circumstances, SunGEL batteries vent very little gas, less than 2 ml/Ah/cell a month on float at 2.26V. They are considered to be fully office compatible. The units are fitted with a safety relief valve set well above the normal operating pressures within the cell. This valve assembly also contains an explosion proof ceramic filter designed to prevent access of any external ignition source to the inside of the cell where gas concentration is elevated under certain conditions. However, where physical damage to the units may have been sustained or charger malfunction occurs, it is possible for these safety features to be bypassed. For that reason the presence of any naked flame or spark source in the vicinity of the battery should be avoided.

2.5 Chemical

SunGEL batteries are sealed for life to prevent egress of internal ingredients and ingress of extraneous, unwanted matter. Do not remove the safety vent cap! Tampering or removal of this will automatically invalidate the warranty! A battery may sustain physical damage through being dropped or may vent through the safety relief valve if overcharged due to charger malfunction etc. These types of conditions under some circumstances can permit access to the acidic electrolyte and lead based salts within the battery. As the gel encapsulates the acid, there is no major risk of acid spillage, but the gel itself is still corrosive and is subject to the usual precautions. It is therefore important to wear appropriate personal protective equipment (PPE) when dealing with batteries and have basic materials on hand to neutralise any acid spillage.

3. Overview

SunGEL batteries are Valve Regulated Lead Acid batteries (VRLA), commonly referred to as sealed batteries, and will not need topping up during the lifetime of the unit. The nominal capacity referred to is, at the 120-hour rate: less capacity will be obtained if discharge currents are higher than that of the 120-hour rate are employed. For example, 2SG650 will give 650 Ah if discharged at 5.4A for 120 hours (5 days). If discharged at 45A, it will only give just over 450 Ah and the discharge will last for 10 hours until a voltage of 1.8V per cell is reached.

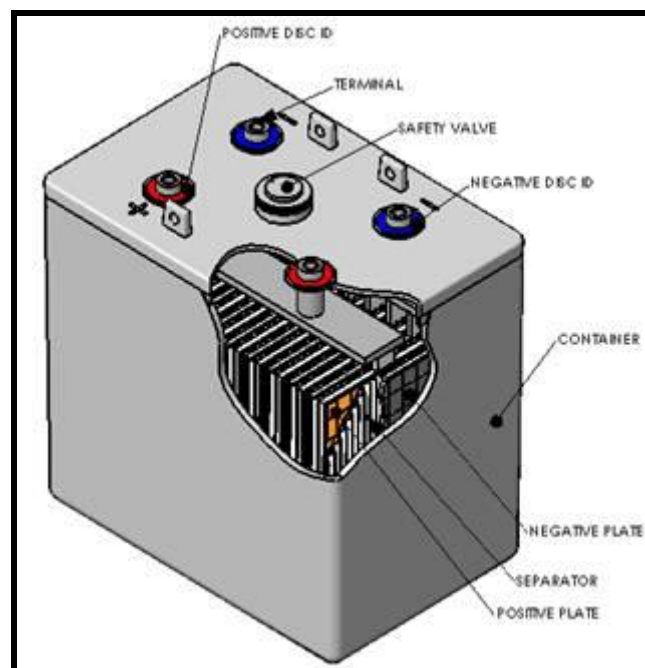
There are numerous operating factors within the system itself, which have a direct influence on the length of service your batteries may provide. The directions and settings provided in this manual are intended to optimise your investment by facilitating the longest possible service life under your particular environmental conditions.

4. General technical considerations

4.1 Production construction

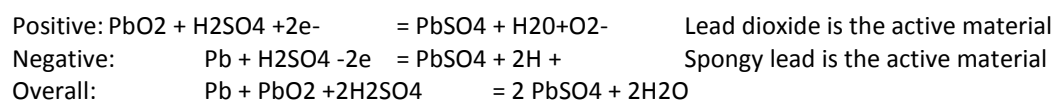
The following features can be noted:

1. The case and cover are flame retardant ABS.
2. The active material is made from ultra-bismuth high purity lead, with sulphuric acid of the requisite very high purity (analytical grade). The nominal finishing density of the acid is 1270 kg / m^3 .
3. The lead calcium alloys used in the SunGEL range are characterized by their high tin content. This improves both the corrosion and the sulphation resistance.
4. The PVC/fiberglass corrugated separator is assembled between the plates under compression to prevent shorting.
5. The safety valve is a special design with a built in ceramic filter to prevent spark ingress, acting as a pressure relief valve.
6. The terminal consists of a female insert which is connected directly to the plate busbar. The whole assembly is encapsulated in special epoxy adhesive, with red for the positive pole and black for the negative. This has the added advantage of providing a very long tortuous path for any electrolyte leakage. "O" rings are present to provide additional protection against electrolyte creep.



4.2 Cell chemistry

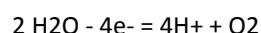
The electrochemical reactions on discharge at the two electrodes (simplified) are as follows:



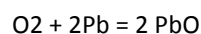
VRLA batteries operate on the oxygen cycle, in a similar manner to sealed Ni / Cd batteries. During the charging cycle the lead sulphate is converted back to lead dioxide at the positive plate.

At the latter end of the charging cycle when most of the active material has been consumed, electrolysis of water commences, producing oxygen, as shown below.

Positive on charge



The oxygen migrates through the glass mat to the negative plate, where it reacts with the negative active material reducing the state of charge of the negative plate.



At the fully charged state these two reactions are balanced. The key to keeping this balance is to minimize the hydrogen evolution from the negative, as this is not recombined and can lead to the dry out of the battery. This is why the purity of the active material is so important.

5. Product specifications and characteristics

5.1 Physical characteristics

The physical characteristics of the SunGEL products are set out below in tabular form.

Model	Nom Volts	Ah @ 10hr rate to 1.80 VPC	Ah @ 120hr rate to 1.80 VPC	Length mm	Width mm	Height mm	Weight kg
4SG100	4	70	100	109	184	265	13.5
6SG150	6	105	157	276	184	265	28
6SG200	6	140	210	276	184	265	32.5
2SG250	2	175	262	109	184	265	13
4SG320	4	269	338	276	184	265	38
2SG450	2	315	472	184	197	265	23
2SG470	2	302	480	206	124	502	25
2SG595	2	380	595	206	124	502	29.5
2SG650	2	455	682	184	276	265	32
2SG720	2	454	714	206	146	502	35
2SG820	2	530	840	206	146	502	40
2SG875	2	555	874	145	206	680	49
2SG1000	2	666	1048	145	206	680	54
2SG1200	2	777	1223	210	191	680	64
2SG1400	2	888	1398	210	191	680	71
2SG1750	2	1110	1747	210	233	680	87
2SG2000	2	1332	2097	210	275	680	103
12SG133FTG	12	103	133	394	125	287	40
12SG200FTG	12	160	200	544	125	317	59

**Information contained in this manual is for general information only.

**For specific information please refer to the product data sheets or contact Battery Energy.

5.2 Technical characteristics-summary

Positive plate thickness	5.4mm (12V products 4.9mm)
Positive plate separation	Micro porous PVC (4.9mm with fiberglass)
Safety vent	Self-resealing 150 mbar
Self-discharge	2.5% per month
Float voltage	2.25 – 2.30 VPC*
Boost charge	2.40 – 2.45 VPC*
Equalisation charge	2.40 – 2.50 VPC*
Seals	Multiple 'O' ring seal with long life adhesive
Terminals	No exposed non lead surfaces
Casing	Flame retardant to UL94V-O and BS6334 FVO
Compliance	IEC 61427 (1999), AS 4086.1 (1993)

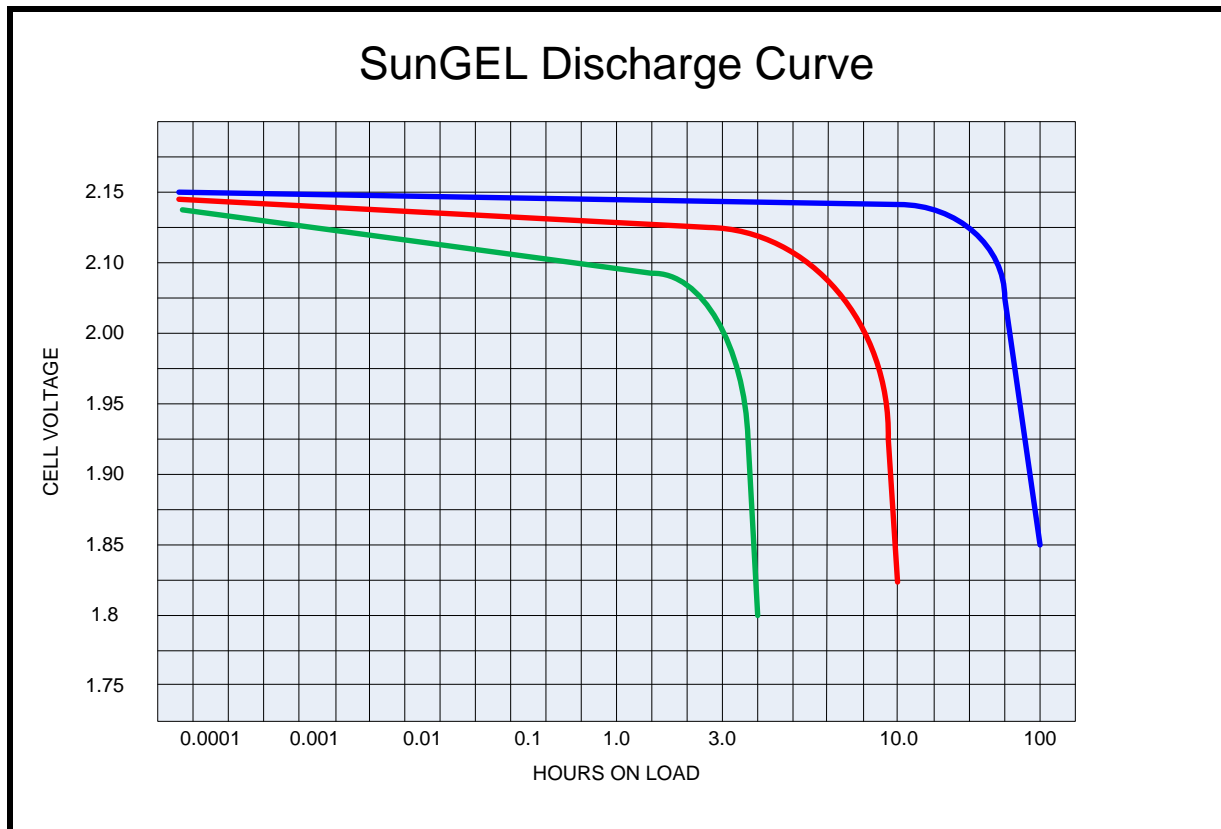
*These settings may be site specific.

6. Performance and technical aspects

6.1 Discharge performance

Illustrative discharge performance at different current rates as set out below. With all lead acid batteries, the ampere hours and watt hours obtained reduces as the current / power is increased.

The discharge temperature should normally be kept within the range -15°C to 45°C. More accurate data for specific types of SunGEL batteries can be provided by Battery Energy on request.

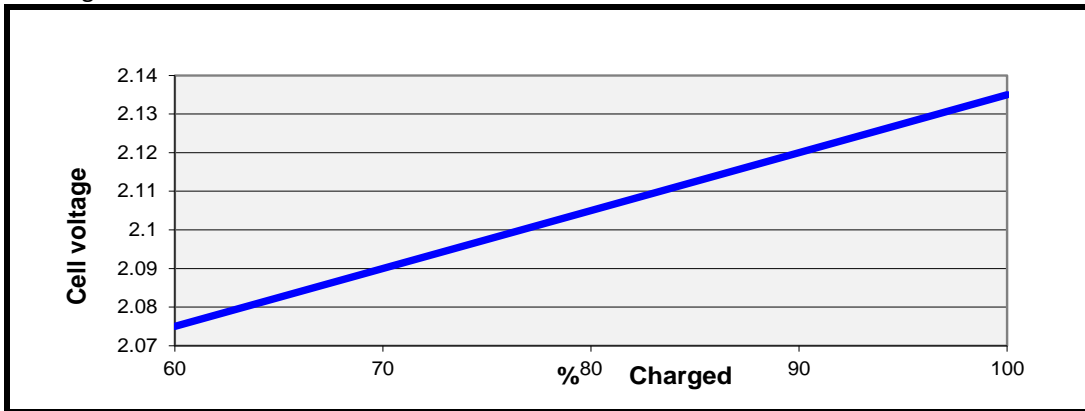


6.2 Capacities at different temperatures

The discharge performance is affected by changes in temperature, at a rate of 0.6% per degree, with less capacity at very low temperatures (below -10°C or 10°F); where the capacity starts to fall off more sharply.

6.3 State of charge

A good indication of the state of charge of the battery can be gained from the open circuit voltage of the cells. The measurement is only meaningful after a minimum 24 hours at rest with no charge applied or after a short discharge.

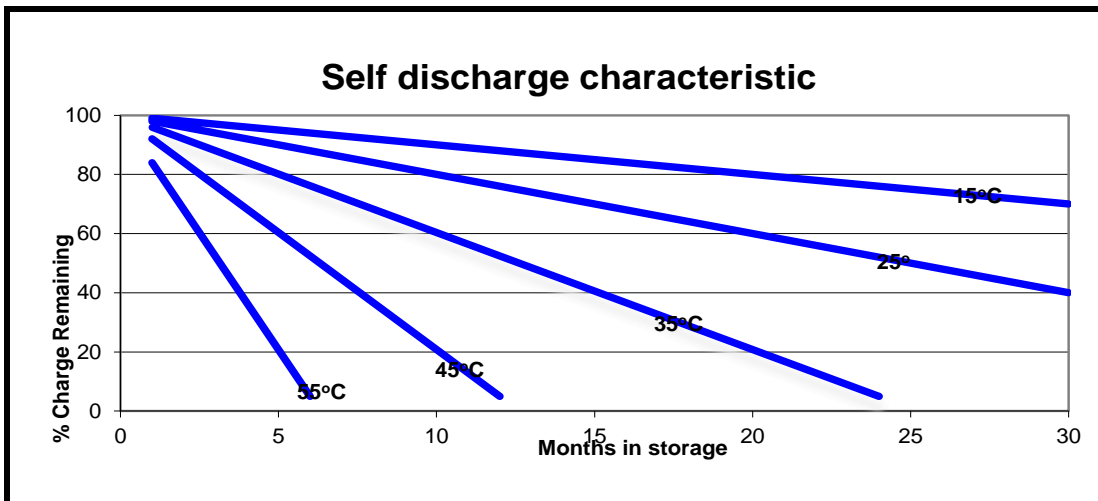


7. Battery installation and commissioning

7.1 Shipping and storage

The batteries are packed in a wooden crate on one level for safe shipping. The batteries must NOT be stored upside down or on the side. The storage temperature should typically be between 0°C and 35°C. Although the crates can be stored in direct sunlight, this is not recommended as it will increase the internal battery temperature. The crates are also not waterproof. Typical self-discharge at 25°C is 2.5% of capacity per month, although this varies with temperature.

If the battery cannot be immediately installed it should be stored in a clean, cool, dry area. A refresher charge should be applied every 6 months at 25°C or every 3 months at 35°C or when the voltage falls below 2.11V and also immediately prior to being placed into active service. This can be achieved by means of a refresher charge at the float voltage of 2.25-2.30V per cell for 48 hours or a boost charge of 2.45V per cell for 4 to 6 hours.



7.2 Unpacking and inspection

When the battery is unpacked from the wooden crate supplied – the top and one side panel of the crate are attached with screws which are easily removed – it should be inspected for damage and missing components. Note: the other sides and bottom are attached with nails, which should not be removed. The crate is designed to be re-usable. Please note: if the batteries are damaged in any way, then Battery Energy should be informed within 7 days, or the associated warranty could be invalid. The minimum open circuit voltage of each cell should exceed 2.10V, although it could be lower if the battery has been kept in storage for several months. The components should be checked against the delivery docket and accessories list. (See page 28)

7.3 Before cell installation

A few simple principles will ensure maximum service life from your battery:

- SunGEL batteries are designed for an extremely long service life even at elevated temperatures. This service life will be extended by correct selection of the final placement of the batteries. As cool a location as possible in hot climates should be chosen. 20°C – 25°C is ideal.
- The cells must be located such that there is as little (<1°C) variation in individual cell temperatures. Temperature effects cell voltages and capacity and the objective is to promote uniformity across all cells in the battery.
- The loading capability of the floor and/or cabinet, which is to support the battery, should be checked.
- Battery access should be limited to experienced personnel.
- Batteries should not be installed directly on a concrete floor to ensure the temperature remains the same across the cell; otherwise the bottom of the cell will be a different temperature to the top of the cell. This is why cabinets, stands and racks are used.

Before proceeding; ensure all safety procedures are observed, all PPE is adequate and correctly worn. Solvent based grease must not be used as they may attack the integrity of the plastic components and seals. Petroleum based grease such as petroleum jelly is not suitable for environments where the connections can get warm. Silicone based greases are normally suitable. Battery Energy recommends a tub of Lanotech.

7.4 Battery orientation

SunGEL batteries are designed to be employed in vertical or horizontal orientations, with the condition that the plates must be in an upright position. See page 29 for installation and layout diagrams.

In the case of the double terminal (one positive, one negative) large format (OPZV) product, up to and including the 2SG1000, the product can be assembled when vertical in two different orientations.

- The one recommended in the vertical orientation is with the cells orientated such that the battery length is minimised with the 146 mm side of the cell being used in the length profile. Without specific instructions to the contrary, this is the orientation for which accessories are supplied.
- The alternative orientation, with the width minimised, requires a different length connector, which can be supplied upon request.

7.5 Battery installation (large cells)

An appropriate cell lifting device, such as a lifting platform is assumed to be available. After removal of the side and top of the crate, the cells can be slid onto the lifting platform, which is set at the appropriate height. The following actions are then assumed:

1. Clean the cell with a dry nonabrasive cloth.
2. Position the cell to the shelf in the required orientation, starting from the bottom shelf.
3. Position two further cells adjacent to the first one on the bottom shelf, with the correct spacing (~6mm) between cells.
4. Fit the appropriate connections to the cells as per the installation and layout diagrams on page 29. The connections should be just finger tight initially. The connections are detailed and include bolts with star washers which fit into the M8 female inserts and M10 in the OPZV Solar cells.
5. Continue the process on the other shelves from the bottom to the top shelf until the batteries installation is complete.
6. Check the open circuit voltage of the cells. If a cell is showing a voltage 40mV or more less than the average (e.g.2.10V against 2.14V), then it should be replaced and Battery Energy contacted for a replacement cell.
7. Tighten the bolts to 10-12 NM.
8. Connect the battery monitoring leads (if present) to the negative post of each of the cells.

7.6 Battery preparation procedure prior to initial capacity test (hybrid systems)

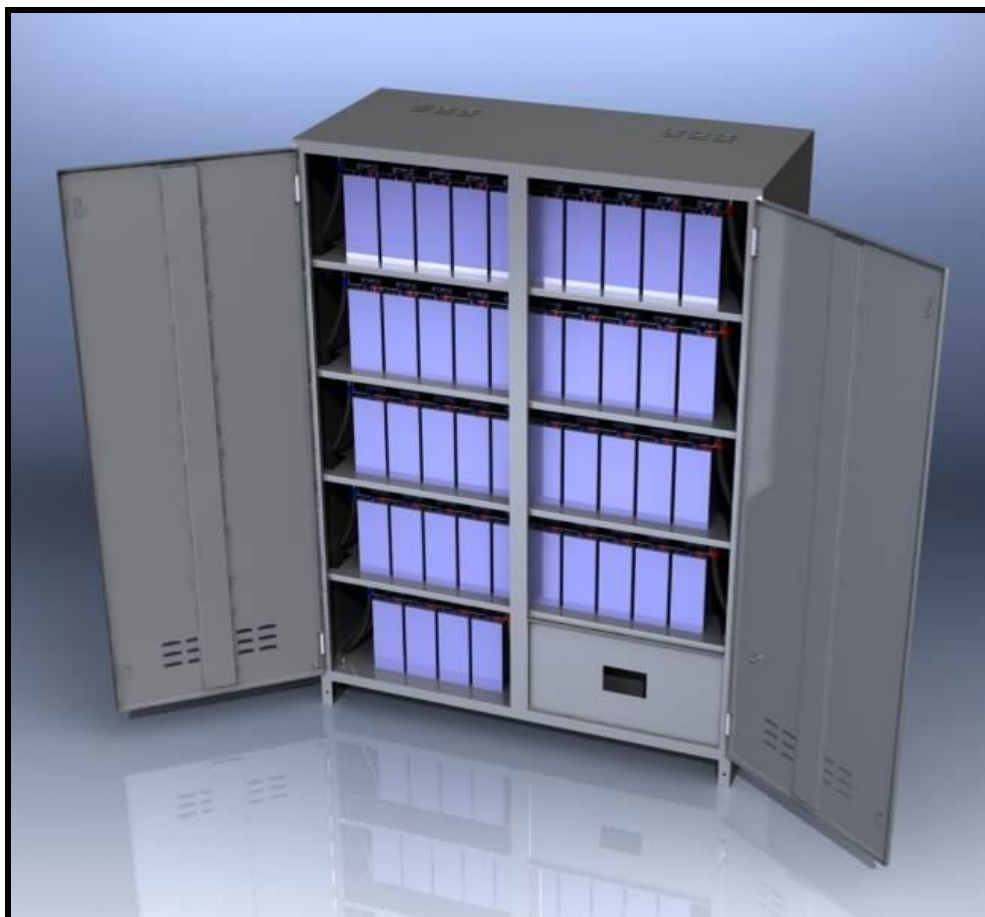
1. Switch the circuit breakers to the **ON** position.
2. Limit the current changes to 10% of the C/10 capacity e.g. 66A for the 2SG1000.
3. Leave the battery for a minimum of 24H on float at 2.275Vpc. If the battery has been stored for a significant period prior to test (see above), then the float period should be extended to 48 hours.
4. Conduct the standard 3 hour capacity test (see below).

7.7 Initial battery test procedure

Please note: the test should not be carried out if the battery temperature exceeds 40°C.

1. Disconnect the circuit breakers and leave the system for a minimum of 30 - 60 minutes.
2. Measure and record the open circuit voltages and the ambient temperature.
3. Select a pilot cell for temperature measurement. Battery Energy recommends a cell in the middle of the battery bank.
4. Ensure the load bank is switched off before connecting to the maintenance terminal of the Battery maintenance Point (BMP).
5. Turn the appropriate circuit breaker to the on position. Switch on the load bank, noting the time for the start of the discharge and the temperature of the pilot cell.
6. The end point for this test is 1.85V / Cell.

8. Battery racks, stands and cabinets



SunGEL Battery Range Installation and Maintenance Manual

Battery Energy offer racks, stands, cabinets and enclosures that can be customised to accommodate any battery application, type or configuration depending on the individual specifications. Our Engineers are capable of designing a cabinet or rack for your specialised needs in AutoCad or SolidWorks formats. We can also modify or adjust existing structure to suit your requirements.

Our racks are Australian made and can be individualised depending on your specifications in:

- Construction - fully welded or site assembled
- Material - mild steel, stainless steel or aluminum.
- Colour - PMS colours
- Coating - powder coated or hot dipped galvanized
- Size - suitable to your application

Ensure the battery accommodation complies with relevant standards for your region or country.

In general terms, however, a few simple principles will ensure maximum service life from your battery:

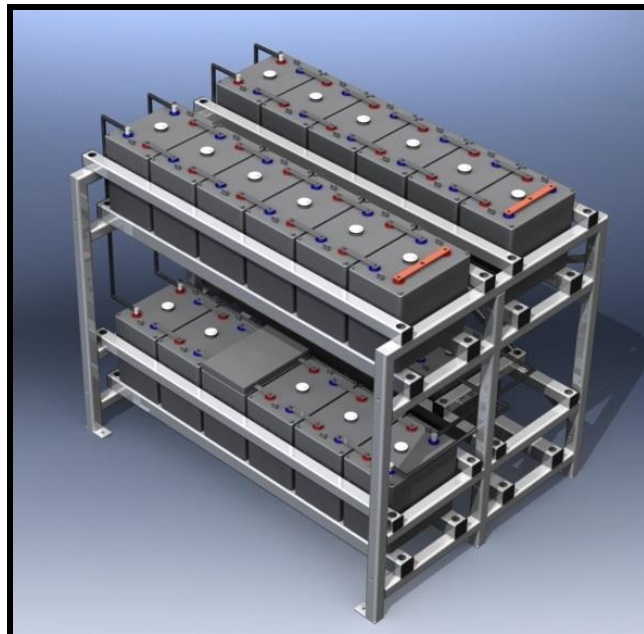
1. SunGEL batteries are designed for extremely long service life even at elevated temperatures. This service life will be extended by correct selection of the final placement of the batteries. As cool a location as possible in hot climates should be chosen. 20°C – 25°C is ideal.
2. The cells must be located such that there is as little (<1°C) variation in individual cell temperatures. Temperature effects cell voltages and capacity and the objective is to promote uniformity across all cells in the battery.
3. The loading capability of the floor and/or cabinet, which is to support the battery, should be checked.
4. Battery access should be limited to experienced personnel.

8.1 Standard vertical orientation

An exploded drawing of a typical Battery Energy rack for vertical installation is given below.

It is constructed from powder coated tubular steel bearers and legs, which are bolted together in the method shown. M8 bolts are employed, which are torqued to 65 NM. The legs are fully welded sections, more than capable of taking the weight over the lifetime of the battery.

The stand is designed in accordance with appropriate standards; such that the maximum bearer deflection is less than 3mm and that there is a minimum of 200mm from the top of one cell to the bottom projection of the tier above. Stands designed for seismic areas can be supplied when request.



SunGEL Battery Range Installation and Maintenance Manual

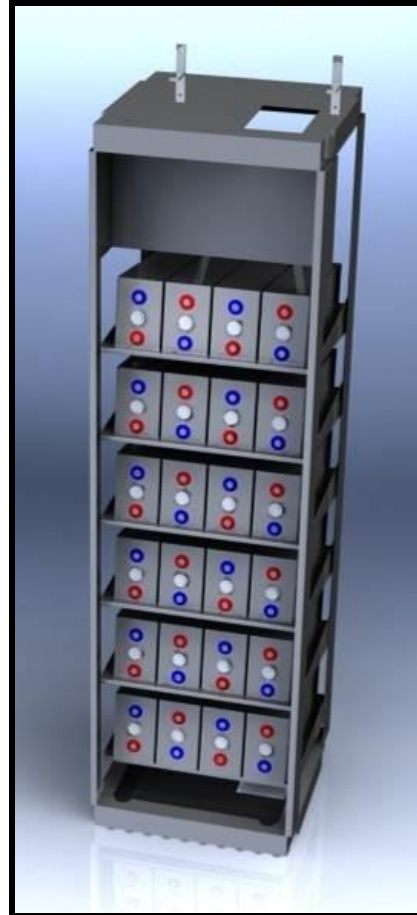
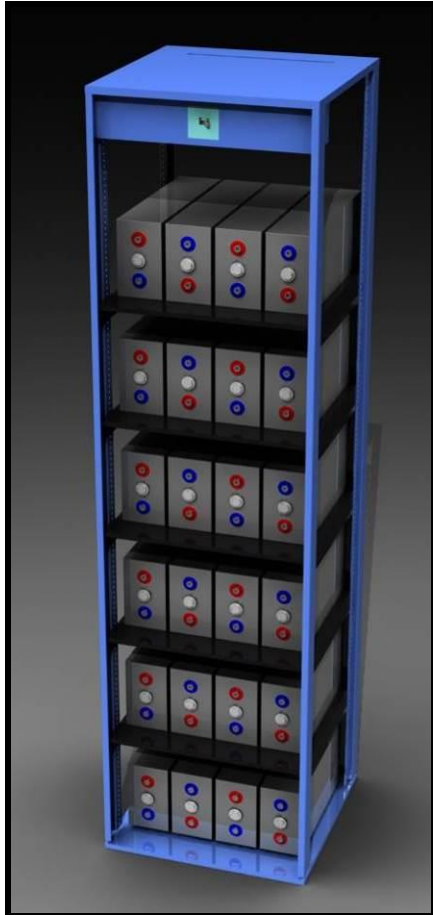
In order to insulate the battery from the floor (ground), special plastic cones insulators and or PVC squares can be employed.

Plastic sheet (PVC) can also be supplied for the batteries to rest on.

In designing the system with circuit breakers etc., it should be borne in mind that the short circuit current of Battery energy gel cells is around half of that of the equivalent Absorbed Glass Mat (AGM) cells. These values are provided in Battery Energy gel technical documentation.

8.2 Horizontal mount layout

Racks are also provided for cells in horizontal orientation. This is particularly recommended for the larger format (OPZV) cells. The cells are typically on a slope of 8° to 15° from the horizontal.



8.3 Cabinets

Cabinets to house batteries with the appropriate ventilation specifications in accordance with local standards can also be supplied upon request.

Because of the lower ventilation requirement for sealed cells, passive ventilation is usually adequate.

Solvent based grease must not be used as they may attack the integrity of the plastic components and seals. Petroleum based grease such as petroleum jelly is not suitable for environments where the connections can get warm.

The bolt torque settings are given below:

- 8 - 10 NM for all M8 bolts (up to and including 2SG650)
- 10 - 12 NM for all M10 bolts (2SG875 and above)

Protective shrouds should be fitted ensuring that all conductive materials are covered.

The details should be completed in the System Installation and Commissioning record sheet attached.

9. Regulators

9.1 Regulator Plasmatronics settings

Regulator Selection:

There are two critical decisions in terms of achieving an extended battery life. The first is to ensure that there is enough energy from solar panels, diesel generators etc. to replace all the energy removed to run appliances etc., bearing in mind efficiency losses etc. The second is the correct choice of regulator. Unfortunately the majority of regulators are not sophisticated enough to effectively control the batteries over a number of years, usually leading to a situation where one or more cells slowly becomes sulphated because the equalisation voltage is not high enough to even out the cells.

The recommended settings for the regulator and or inverter are set out following. For regulators that are not on this table, please contact Battery Energy. Please note that the comments on the variation of the settings with daily depth of discharge. If there are any queries on this, please contact Battery Energy for clarification.

9.2 Plasmatronics PL range

Settings	SunGEL	SunGEL	SunGEL	SunGEL	Volts per cell
System voltage	12V	24V	48V	120V	
Number of cells	6	12	24	60	
BMAX (maximum boost voltage)	14.7	29.4	58.5	147	2.45
EMAX (maximum equalisation voltage)	15	30	60	150	2.5
ETIM (hours at equalisation voltage)	2	2	2	2	
EFRQ (frequency of equalization day)	30	30	30	30	
ABSV (absorption voltage)	14.4	28.8	57.6	144	2.4
ATIM (absorption time)	3	3	3	3	
FLTV (float voltage)	13.8	27.6	55.2	138	2.3
HYST (hysteresis)	0.4	0.4	0.4	0.4	0.4
BRTN (boost return voltage)	12.3	24.6	49.2	123	
CHRG (maximum charge rate)	10% of C/10	10% of C/10	10% of C/10	10% of C/10	
BFRQ (boost frequency once daily)	1 day	1 day	1 day	1 day	
TCMP (temperature compensation setting)	2 (4mV/°)	2(4mV/°)	2(4mV/°)	2(4mV/°)	
LVA (low voltage alarm)	11.4	22.8	45.6	114	1.9
LOFF (low volts off)	11.1	22.2	44.4	111	1.85

The larger systems such as Outback are usually fully programmable and so don't suffer from the problem of fixed settings that may not be appropriate. Some of them have sophisticated programmes to correct sulphation if it occurs (e.g. the newer version of the PSA inverters)

9.3 Variation of settings with depth of discharge

The settings have been formulated on an average daily depth of discharge (DOD) of 20% of the 120 hour capacity, which is the maximum recommended for standalone solar systems.

Where lower average DODs are anticipated, it is recommended that the adsorption time (ATIM for the Plasmatronics regulator) be reduced, as set out below.

Daily DOD	ATIM
20% (standard)	3 hours
10%	1 hour
5%	0.25 hour

For higher depths of discharge, the equalisation frequency should be increased therefore with a 30% DOD; the equalisation frequency should be increased to once every 15 days from once every 30 days.

9.4 Plasmatronics functions and settings

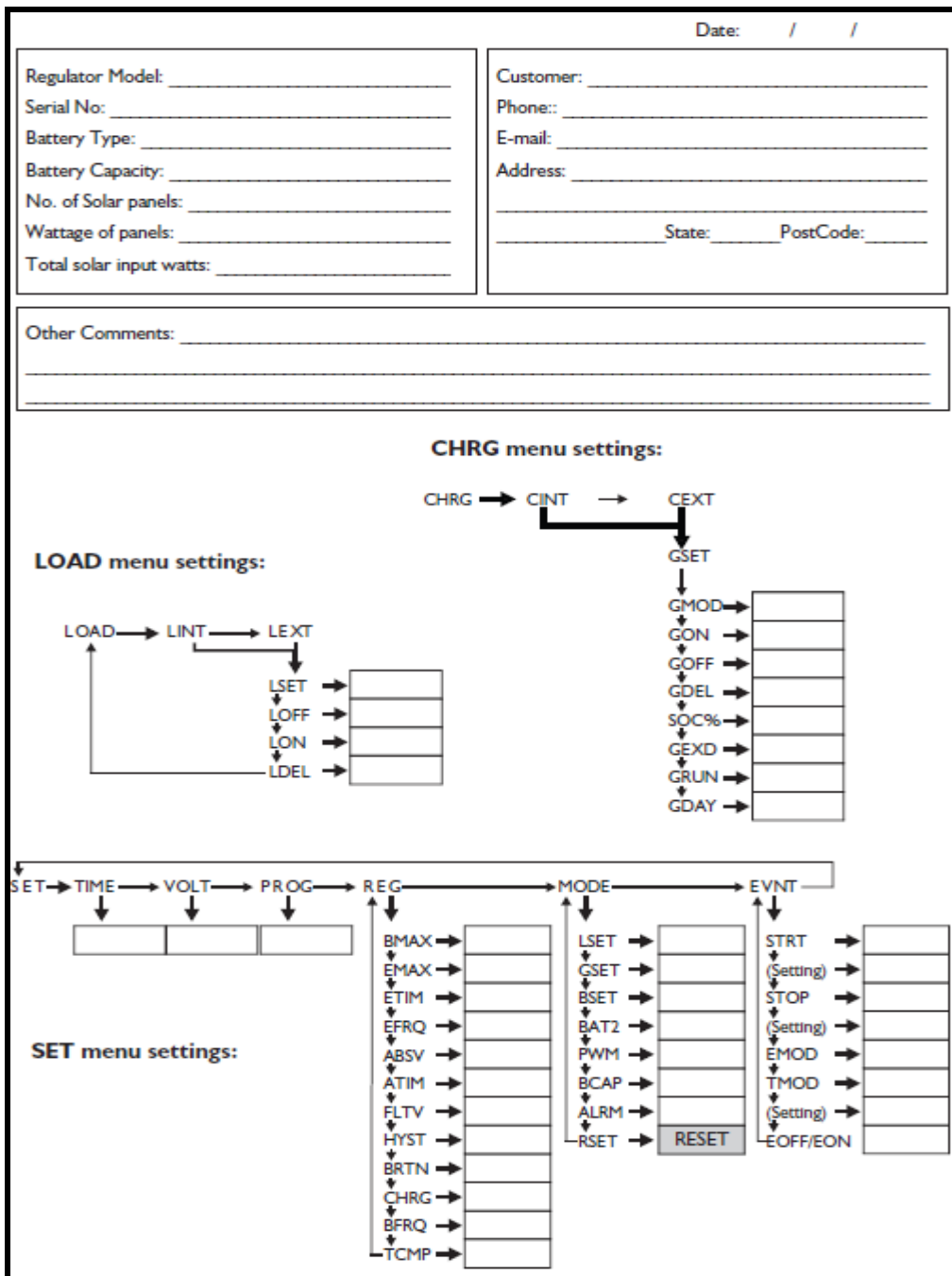
9.4.1 Setting lockout

In some cases it is desirable to restrict the ability to adjust settings, so as to prevent unwanted tampering. Setting lockout is done via the TEMP screen under the DATA menu. (The TEMP screen shows the battery temperature if the optional external temperature sensor is installed or "0.0" if it's not.)

To disable settings, long push on the TEMP screen, the "A" indicator will disappear. (A useful memory aid is to consider that "A" stands for "Adjust" on this screen.). Note that the same "A" indicator is used on other screens to mean Amps.

To enable adjustment of settings again, long push on the TEMP screen again. If you have successfully enabled settings adjustment, the "A" will reappear while TEMP is showing.

9.4.2 System settings

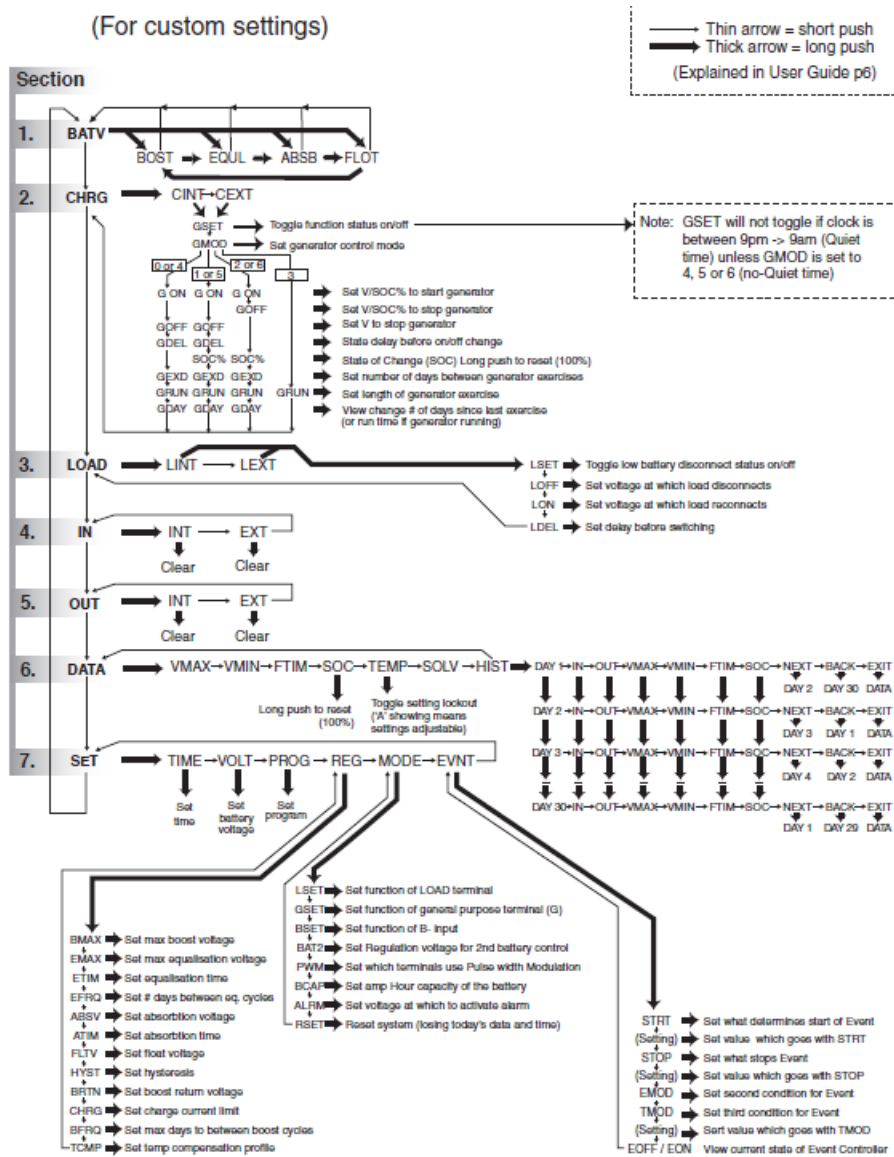


9.4.3 Set/MODE selection summary

The MODE submenu contains the settings for the configuration of the IPL.

Name	Description	Range
LSET	Select the use of the LOAD-	0-11
SGET	Select the use of the "G" terminal	0-11
BSET	Select the use of the B- sense input	0-2
BAT2	Regulation voltage for 2 nd battery control	13.0-16.0V
PWM	Select which terminals use PWM (SOL-, LOAD-)	0-3
BCAP	Amp hour capacity of the battery bank	20-20,000Ah
ALRM	Alarm voltage	10.0-18.0V
RSET	Resets today's performance data to zero	

9.4.4 Program 4 menu system (for custom settings)



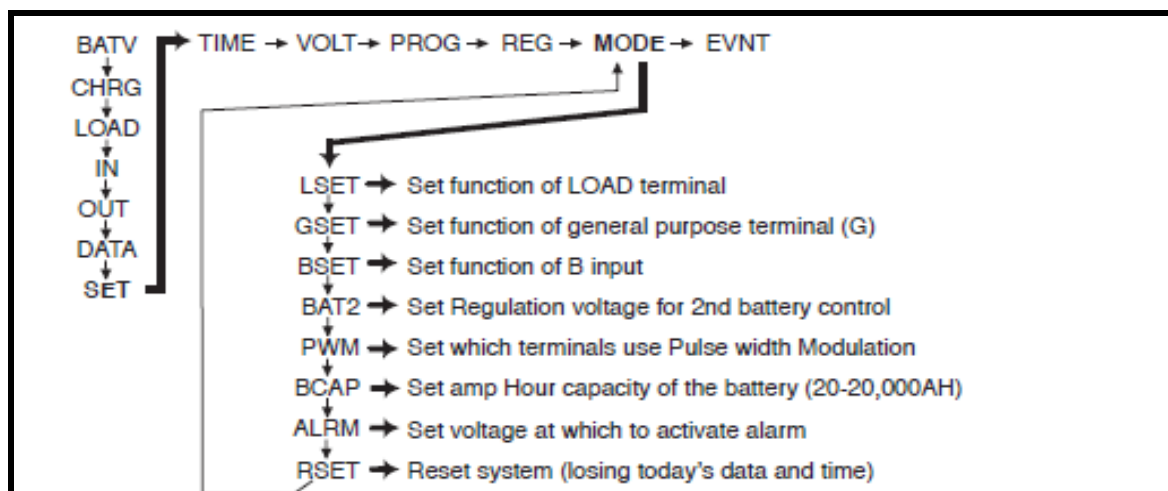
9.5 Selectronix SP Pro settings

Selectronix SP Pro settings are outlined below.

	60 cells	24 cells	12 cells	1 cell
	120 V	48 V	24 V	VPC
battery shutdown - no load	117	46.8	23.4	1.95
battery shutdown - 100% load	106.2	42.48	21.24	1.77
recovery voltage	122.4	48.96	24.48	2.04
SOC shutdown	33%	33%	33%	33%
Maximum voltage setting	150	60	30	2.5
high voltage alert	151.8	60.72	30.36	2.53
high battery alert clear	150.6	60.24	30.12	2.51
Periodic equalize	enabled	enabled	enabled	enabled
periodic equalize period*	30 days	30 days	30 days	30 days
periodic recharge	disabled	disabled	disabled	disabled
Mid-point monitoring	enabled	enabled	enabled	enabled
Mid-point range	5%	5%	5%	5%
Peukert's exponent	1.5	1.5	1.5	1.5
Over temp protection	45	45	45	45
Limit rate	10%	10%	10%	10%
Maximum charge current	10%	10%	10%	10%
Initial return	126	50.4	25.2	2.1
Initial stage	135	54	27	2.25
% of maximum current	100	100	100	100
time	5 mins	5 mins	5 mins	5 mins
bulk stage	141	56.4	28.2	2.35
current	48	19.2	9.6	80%
time	10 mins	10 mins	10 mins	10 mins
adsorption stage	144	57.6	28.8	2.4
Adsorption current	36	14.4	7.2	60%
Net change	1%	1%	1%	1%
Change time	30 mins	30 mins	30 mins	30 mins
Max time **				
	daily DOD 20%	180 mins	180 mins	180 mins
	daily DOD 15%	120 mins	120 mins	120 mins
	daily DOD 10%	60mins	60mins	60mins
	daily DOD 5%	15 mins	15 mins	15 mins
Float stage	136.8	54.72	27.36	2.28
Float current	12	4.8	2.4	20%
Long term float voltage	135.9	54.36	27.18	2.265
equalization voltage	150	60	30	2.5
Current	12	4.8	2.4	20%
time	120 mins	120 mins	120 mins	120 mins
Battery Temperature Compensation				
Reference temperature	25	25	25	25
reference temperature compensation	-4mV/	-4mV/deg°	-4mV/deg°	-4mV/deg°
* Note: warranty will be altered for DODs > 20%				
	frequency			
frequency	DOD 40%	7 days		
frequency	DOD 30%	15 days		

** Change for average daily depth of discharge different to standard (20%)

9.5.1 MODE menu (Adjusting configuration settings) [PROG=4}



9.6 Other regulators

There are a number of other regulators on the market that can be used with Battery Energy products. The main Morningstar units are briefly outlined below – if it is not possible to use or adapt the settings above, then Battery Energy should be contacted. In general, Battery Energy gel settings are similar to vented settings rather than standard gel settings.

- Tri-Star MPPT – use Type 4 (AGM/flooded settings)
- Tri-Star – selection 4 (P40)
- Sunsaver MPPT Flooded settings

9.7 Summary of other settings for SunGEL batteries

Minimum cell voltage on receipt	2.10 volts
Storage charging requirement	Every 6 months at 25°C
Connector torque settings-M8	8 – 10 Newton metres
Connector torque settings-M10	10 – 12 Newton metres
Float voltage	2.250 – 2.3 volts per cell at 25°C (Table 3)
Charging temperature compensation factor	4 mV/oC
Boost / Equalisation voltage	2.43 – 2.50 volts per cell (Table 3)
Cell variation on float initially	250 mV
Cell variation on float after 3 years	+/- 30 mV
Minimum cell voltage on float	100 mV less than average
Cell capacity variation	+/- 5% of nominal on receipt
Capacity adjustment factor for temperature	0.6% per °C
Max charge rate limited to 2.5V	C/20 (20 hour rate in amps)
Max charge rate when limited to float volts	C/8

9.8 Charging maximum charge current

SunGEL batteries can be charged outside of the solar system using a diesel generator or other equipment. The normal method is to use constant voltage, with the current limited to ~ C/8 rate i.e. for the 2SG650; this is around 50A, for the 2SG1000, about 80A. This should be applied with the voltage setting at the float level of 2.3V per cell. If higher voltages are applied and then the maximum current should be reduced i.e. at 2.5V, the maximum is C/20 or 25A in the case of the 2SG650. Higher currents can be tolerated, but we strongly advise contacting Battery Energy to discuss the particular case.

Unregulated charging such as constant current with no voltage control can destroy the battery! Taking the battery above 2.7V invalidates the warranty!

9.9 Float performance

SunGEL batteries are designed to operate as a standby battery under float and they have a design life of 20 years under these conditions. The normal float voltage is employed when there are few or very intermittent interruptions to the supply and is set at between 2.25 and 2.275V per cell.

Bear in mind that there can be significant variation in the float voltage for new cells, of up to 250 mV, with the possibility of a few cells attaining over 2.4V. This is normal and the cell-to-cell variation will reduce to acceptable limits (+/- 30 mV) over the first 2-3 years of operation.

9.10 Temperature compensation

The float voltage of the battery should be set according to the expected average temperature of the battery according to the following chart. If there are large seasonal fluctuations, it is possible to set this manually, however this requires constant monitoring and evaluation and it is greatly preferred if the charging unit has temperature compensation adjustment built in. The probe should be placed on the battery, either on the case surface (optimal) or the terminal.

10. Maintenance

10.1 Battery periodic maintenance preparation

The regularity and requirement of maintenance will depend to a certain degree upon the criticality of the installation. The items laid out below are considered the minimum requirement.

Prior to starting the periodic maintenance activities assure that all required maintenance tools, maintenance equipment and safety equipment is available and functional. Notify anyone who will be affected by the intended maintenance or troubleshooting activities.

At a minimum, the following tools and equipment are required to maintain and troubleshoot the SunGEL batteries:

1. Calibrated Digital multimeter capable of 3.5 digit accuracy or above
2. Insulated socket spanners (preferably with torque settings)
3. Insulated box end spanners
4. Calibrated Torque wrench
5. Thermometer
6. Calibrated Load bank (for large commercial systems)

10.2 Monthly inspections

The batteries should be inspected at a minimum monthly check for any signs of damage, such as swollen cases etc. The batteries should be cleaned if required see point 10.4.

10.3 Quarterly maintenance

Check and record quarterly maintenance results on record sheets provided at the back of this Installation and Maintenance Manual.

The following checks should be completed quarterly:

- a. Ensure battery cleanliness and physical appearance
- b. Temperature of pilot cell
- c. Overall battery voltage measured at battery terminals
- d. All cell voltages on load

Record all the cell voltages and temperatures on one cell – called the pilot cell - on discharge. This should be done at a specific time of day or night so that if possible the conditions are as similar as possible. Trends in terms of voltage can then be observed. Clearly if a period of low solar input caused by cloudy weather or rain had been experienced, then one would expect a lower voltage from the system.

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It should be noted that some variance is normal and a cell showing a voltage of 20mV below the mean for the bank is not unusual. If this difference increases to say 50 mV, then it is an indication of either a faulty cell or that the cell is slowly exhibiting a lower state of charge compared to the rest of the bank. Under these circumstances, the bank should be given an equalisation charge to try and bring the cells into uniformity.

1. The cell voltages can be accessed through the holes in the shroud using the probes of the multi-meter. (For cell sizes up to 2SG650). It is essential that the shrouds be removed to check for the cleanliness of the cell.
2. The time when the measurements are made is important. It is critical to keep to the same time for comparative purposes, preferably the same day of the week. The best time to measure the batteries on load is shortly after the end of the charging session. It is particularly valuable after the monthly equalisation cycle, as the battery should then be at 100% state of charge (SOC).
3. The pilot cell is one chosen to be representative of the entire bank. Outer cells are not normally employed.

10.4 Annual maintenance

- a. Repeat the Quarterly maintenance checks.
- b. Test torque on all connections.
- c. Conduct discharge test (where recommended for large commercial systems)

The connections should be checked if possible with a torque wrench, to a setting of 8-10 NM for the small plate range (up to 2SG650) and 10-12 NM for the larger range.

Cleaning of cells should be undertaken with due care and a soft dry cloth or slightly water dampened cloth. Under no circumstances should the cells be cleaned with any product containing solvents of any description or abrasive materials.

Solvent based grease must not be used as they may attack the integrity of the plastic components and seals.

10.5 Battery maintenance report

There are several valid reasons for ensuring that battery maintenance as prescribed is undertaken and recorded.

- To maintain the reliability of your system.
- To optimise the service life of your battery.
- To retain the validity of your warranty.

The subsequent documents will allow early identification of any malfunction within the system, which has an effect on the battery, and thereby provide for timely intervention.

See page 30 for periodic maintenance records.

10.6 Discharge testing

The accepted point indicating battery replacement is when the capacity has dropped to 60% of nameplate (nominal) capacity for solar installations (80% for standby applications). The temperature of the cell must be measured at the start of the discharge and temperature correction factors used to calculate the capacity at the standard temperature of 25°C.

Capacity testing can either be carried out using the system load, which is standard in UPS installations, or using a defined current, usually at the 3H rate to 1.85 or 1.8V. These discharge values are set out in Table 2 Appendix 2. It should be noted that all values are subject to a spread of +/- 5%.

In relevant cases, the capacity obtained should be temperature corrected to 25°C using a factor of 0.6% increase in capacity for every degree that the initial temperature of the discharge is below 25° C and 0.6% decreases for every degree above 25°C.

Batteries are also occasionally tested on receipt, where many of the same factors apply. It should be noted that the capacities for Battery Energy Sungel products are assumed after repeated cycling as per the quoted standards; the capacities on delivery can be on average 5% lower than this.

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It is critical to understand that, for a discharge test to have any value, the battery must be 100% charged prior to the test being carried out. This will mean that, in the case of a solar battery, the battery being given an equalisation charge, in addition to it being brought up to a 100% state of charge.(SOC). With a standby battery, it is normally assumed that the battery is at 100% SOC, unless there is evidence, such as uneven cell voltages, to the contrary.

It should be noted as well that it is common practice for cells to improve on cycling as this converts back sulphate into active material on the plates, a task that equalisation itself will not do.

10.7 Other testing methods

Impedance or conductance testing is now frequently employed by maintenance staff as an adjunct or as an alternative to discharge testing, as it has major advantages in terms of time and is a non-invasive test. Battery Energy's view is that it is a useful tool, particularly in predicting lifetimes, but that it will not pick up all the failure modes of lead acid batteries. It is not recommended as an alternative to discharge testing. Approximate values for the internal resistance of Battery Energy product is given in Battery Energy technical document.

Please note that warranties will not be given on the basis of impedance or conductance testing. It should also be noted that the impedance or conductance will vary sharply according to the state of charge.

11. Other aspects of testing

11.1 Data analysis and corrective actions

An explanation of how the data can be interpreted and the recommended corrective action follows. However, it is strongly suggested that this is carried out by personnel familiar with VRLA batteries and their operation and failure modes, as there could be other factors not mentioned following.

11.2 Environment ambient and battery temperature

While the VRLA battery will function at the extremes of temperature, it is rated at 25°C. The ideal operating temperature ranges from 20°C to 27°C. Operation at cooler temperatures will reduce the anticipated standby operating time while operation at warmer temperatures will reduce battery life and will increase the potential of thermal runaway.

The battery will experience a 50% reduction of life for each 10°C above 25°C. High ambient room temperatures should be corrected through the use of appropriate ventilation and air conditioning, as well as the use of temperature sensing voltage correction probes.

The VRLA battery should not be charged at temperatures exceeding 50°C. A thermal runaway condition could result.

The individual batteries within the string should not exceed the ambient temperature by more than 1-2°C. If the entire battery temperature is excessively high (> 10°C above ambient), the units may be experiencing thermal runaway. In this situation, the charging current should be terminated and the cause of the situation should be determined and corrected.

If thermal runaway has occurred, the battery system should be replaced.

11.3 Capacity test preparation

If the float / system supply voltages are normal and there have been no outages, then this test can be carried out immediately. **If in doubt, an equalisation charge should be given.**

12. System selection and sizing

Under normal operation with proper system maintenance, SunGEL batteries will last well in excess of 10 years and continue to provide an ultra-high reliability power. As solar standalone systems are by necessity complex – and hybrid systems even more so - there is, however, considerable scope for problems to arise that naturally impinge on the batteries. In the great majority of cases, the fault does not lie with the batteries. These can range from sizing problems to problems with other electrical equipment, maintenance problems to incorrect settings on the battery regulator. They are all observed as battery “faults”, for instance the battery dropping out once the low voltage disconnect has been reached soon after the start of the discharge.

In terms of the battery operation and the settings, the aim is to operate from the 90-100% charged mark on a daily basis. This will inevitably mean overcharging the battery to some extent. There are more efficient methods of control, such as partial state of charge (PSOC), but this involves specific controls and accurate ampere hour counting.

The first step, of course, if there are any battery problems is to contact the installer/supplier of the system. As a first step, the following questions should be asked.

Is the system sized correctly – as a very approximate rule of thumb, the following calculations should be done for a standalone solar system (not a hybrid, which typically has a diesel generator to top up the battery on a daily basis.)

- a) Calculate the load of the system in watts and the approximate time of use over a 24 hour period to calculate the average daily watt-hours. This is done by constructing a load analysis table with the time of use of each item of electrical equipment. This will also give the maximum usage in watts.
- b) An inverter will be required to convert the battery voltage to 240V a.c., which is the voltage that most household goods operate at. This should be sized both to handle the maximum load and the average load at continuous usage.
- c) The battery size than be calculated by the following calculations.
 1. Estimate the daily average required from the battery – this is a function of the average watt hours divided by the efficiency of the inverter.
 2. Estimate the required day’s autonomy from the battery. For a standalone system, this is usually a minimum of 5. With hybrid systems, this can be reduced, although it will impact on battery life.
 3. Estimate the minimum depth of discharge that the battery is designed to go to. For most deep cycle batteries, including the SunGEL, this is 75-80%, although, with some batteries, it is only 50%.
 4. Calculate the Wh that is required from the battery. The general rule of thumb is that 12V systems are recommended for Wh less than 1000, 24V systems for less than 2500Wh and 48V systems for less than 5000 Wh. Larger systems tend to be hybrid. These figures correlate with the commonly available battery sizes. The required Ah can then be calculated by dividing the Wh figure by the voltage chosen. The battery selected is then the one with the closest capacity at; in this case, the 120H rate, above the required Ah. Bear in mind that all the calculations are carried out at 25°C. If the likely temperature of the system is significantly less than this when the battery is likely to be called upon to provide its full autonomy, then a temperature correction factor of 0.6% per degree should be applied. Thus if the battery will have to operate at say 5°C, which is a strong possibility in certain conditions in Australia (Snowy Mountains, Tasmania etc.), then the required Ah from the battery should be increased by 12% (20 x 0.6)

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Calculate the panel requirement by taking the average watt-hour figure and divide by a factor to allow for the efficiency of the battery (typically 80% - 0.8). This gives a corrected load. You then need to calculate the number of peak sun hours per day, which will vary significantly according to location. Insolation data is usually available, certainly across Australia, to be able to calculate this figure more accurately. In locations where there is significant variation between summer and winter, though needs to be given as to how to maintain the battery capacity throughout winter or periods of low sun. This can be done by either assuming a conservative value as far as the panels are concerned - so that the excess in summer greatly exceeds the deficit in winter - or by attaching some form of additional charging means, such as a diesel generator or a wind based system, which can charge the battery during the low periods. The output from the panels can of course be altered by use of devices such as trackers, which orient the panels according to the position of the sun.

A numerical example of these calculations is given below.

- Average load per day – 2500 Wh
- Allowing for Inverter efficiency (85%) – $2500 / 0.85 = 2941$ Wh
- Nominal system voltage 24V
- Autonomy required 5 days
- Minimum depth of discharge 25% (75% discharged)
- Battery capacity $+2941 / 24 / 0.75 \times 5 = 817$ Ah
- Battery Selected 2 SG 875
- Average daily depth of discharge (DOD) = $2941 / 24 / 875 \times 100 = 14\%$

Panel selection:

Average number of peak sun hours per day - 4 (typical of Victoria)

Corrected load: $+2941 / 24 / 0.75 / 4 = 817 / 4 = 204$ Ah per day, after allowing for battery efficiency = 204 Ah

Dividing by the average peak sun hours $204 / 4 = 51$ A

For a typical 80 watt panel with a peak current of 4.6A and a nominal voltage of 12V, the minimum number of panels required would be $51 / 4.6 = 11.1$. The nearest value is 12. It should be noted that solar panels are less efficient at high temperatures (operating at 45°C will lead up to a 10% loss of performance as compared to the rated value, which is typically at 25°C). The panel will also slowly age with time.

As each panel is 12V, the total panels required would be 12×2 , as the system is 24V.

The battery selection in terms of depth of discharge is also important from the life expected from the battery. As an approximate rule of thumb, the Ah obtained from a battery are a constant – in other words, if you get 2000 cycles at 20% depth of discharge (DOD), you will get 1000 cycles at 40% DOD.

You should, however, not expect more than 13-15 years of life from a battery, as other aging factors apart from depth of discharge start to play a role. The sizing example of 5 day autonomy at 14% DOD will mean that the battery should attain these lifetimes, obviously assuming that it is properly controlled. . Manufacturers who claim 20 years plus life based on over 7000 shallow cycle capability are not being accurate or truthful

If you then look at the table giving depth of discharge against life for the SunGEL range (see Table 5), you will be able to calculate the number of cycles obtained. Please note that the depth of discharge as defined here is at the 10H rate (C/10). A 20% DOD at the 120H rate is approximately equivalent to a 32% DOD at the 10H rate, so a life of ~ 4200 cycles or 11 years would be anticipated.

As can be seen from the above calculation, the potential reasons for battery capacities falling are numerous. This includes: -

- a) Incorrect initial sizing – 1) too few panels (most common) 2) Too small a battery.
- b) Additional load added to system – new electrical equipment installed. This is very common.

Weather substantially different to insolation data used. E.g. a long period of cloudy or rainy weather which was not allowed for in the sizing process

Note: The warranty given for SunGEL batteries is based on a maximum average daily discharge of around 20% of the 120hour rate, equivalent to 5 days autonomy. Operation at a higher percentage than this will void the warranty unless Battery energy is informed and an appropriate adjustment to the warranty is made.

12.1 Hybrid operation

In larger systems, the mode of operation is usually called hybrid, to signify that there is significant energy input from a controllable source, such as a diesel generator. Under these circumstances, the battery autonomy requirement is usually less, often of the order of 15-20 hours. Under these circumstances, the battery control can be more sophisticated, including using partial state of charge (PSOC) and does not necessarily involve bringing the battery up to 95-100 % SOC on a daily basis. For hybrid applications it may be more appropriate to use EnerGEL cells instead of SunGEL cells. In any case, Battery Energy should be contacted if the average daily depth of discharge is going to exceed 30% of the 120 hour rating to recommend appropriate settings.

12.2 System reliability – non battery

The next area of potential concern is poor system maintenance or reliability. This includes: -

- Maintenance items – inverter not working properly or with reduced efficiency.
- Solar panels not working to full output e.g. dirty, reduced output due to aging, tracker (if used) not working properly etc.
- Wiring problems.
- Regulator reliability problems.

Both these items and the sizing concerns need to be checked, preferably by the installer, before the battery is blamed. If the bank is low and all the cells are even in terms of voltage, it is almost certain that the problem does NOT lie with the batteries.

12.3 Troubleshooting -battery

As noted previously, system problems are almost always observed as problems with the battery, although the actual fault is not necessarily with the battery itself. A list of potential problems is given below.

Item	Fault	Cause	Action
1	Batteries damaged on receipt	Transportation damaged batteries	Contact your Battery Energy representatives
2	Components or accessories not received.	Items not dispatched	Contact your Battery Energy representatives
3	Individual cells less than 2.09V		Contact your Battery Energy representatives
4	Battery state of charge is falling as measured by voltage, not explainable by poor weather. Batteries are relatively even in voltage	System is incorrectly configured – too few panels, too much load or problems with other elements of the system.	Check with distributor. See section 12
5	Battery is regularly not in the 80 - 100% state of charge window at the start of discharge	System is incorrectly configured – too few panels, too much load or problems with other elements of the system.	Check with wholesaler, distributor or installer. See section 12
6	System does not support load – cutting out.	Any number of reasons including incorrect settings used for regulator or inverter.	Check the voltage on load. If cells low and even, look at (2). If one cell is much lower than others see 8 -11
7	System does not support load – cutting out.	Incorrect settings used for regulator or inverter.	Check and change if necessary.
8	One cell giving much lower voltage on discharge than others (> 30mV)	System has been run at too low a state of charge and cells are starting to sulphate	Contact your distributor: depending upon state of cells, either equalisation or individual charging will be required
9	One cell giving much lower voltage on discharge than others (> 30mV)	Cells are dirty with electrolyte between terminals and tracking has occurred	Clean cells and equalise
10	One cell much lower than others, all other voltages on load indicate 90-100% state of charge	Possibly cell short – needs to be replaced	Contact your distributor
Item	Fault	Cause	Action
11	Cell has lower voltage on charge than others and is significantly warmer	Possibly cell short – needs to be replaced	Contact your distributor
12	Cell goes very high voltage (> 2.8V) on charge	Cell is grossly sulphated and probably unrecoverable	Contact your distributor for cell replacement
13	Low voltage on float (> 100mV from average)	Possibly faulty cell due to short	Monitor and if increasing, contact your distributor
14	Temperature differences between cells (> 1 degree centigrade)	Cell environment not even –e.g. some cells in sunlight or too close to source of heat	Cells MUST be in shade and even in temperature – change placement or control climate
15	Temperature differences between cells (> 1 degree centigrade)	Cells getting hot due to poor connections	Check and clean if necessary
16	Temperature differences between cells (> 1 degree centigrade)	Symptom of short (see 5) or over discharge	Contact your distributor
17	Case swelling, buckling or discolouring	Cell getting very hot – see 8.2	Contact your distributor – remove cell from on line if possible
18	Case swelling, buckling or discolouring	Plate growth – a symptom of overcharging	Check system parameters – contact your distributor.
19	Mist around vent cap	Evidence of vent release due to pressure build up – likely overcharging	Check system parameters, check all cell voltages

12.4 Comments on problems (low capacity)

One of the most common problems – referenced in most of the fault conditions mentioned above – is the battery not holding load. This problem is usually caused over a significant period of time of not operating the batteries in the correct manner, usually undercharging them, without regular equalization.

Operation of the batteries for extended periods of time at reduced states of charge (>6 months) will cause irreversible loss of capacity. This is not a warrantable claim.

If this is happening, then the following sequence of events should take place.

1. Are the regulator settings correct? The regulator is a key item as far as the battery is concerned and attempts to purchase a cheap regulator are a classic case of false economy. This is because the cheaper regulators suffer from both problems of reliability and lack of capability of controlling the battery properly. The best types are those that have battery settings, which are fully programmable, such as the Plasmatronics PL range. A number of regulators have specially defined settings, such as vented or gel: these are not recommended, as the actual settings are significantly different from those recommended for the SunGEL range.

Please note that if a regulator is not mentioned earlier in Sections 9.4 to 9.6, you should contact Battery Energy for approved settings; you should, however, be aware that there are a number of regulators that are NOT approved and that use of this regulator will invalidate or reduce the warranty. If the regulator settings are not to BE approved values, they should be immediately altered and a manual equalization change given to the batteries to bring the system into balance.

2. Is a low voltage disconnect (LVD) fitted? This is a system that automatically disconnects the system from the load once a certain voltage is reached. It is normally set for solar installations at around 1.9V per cell (which equates approximately to the maximum depth of discharge allowed of 75-80%) and is standard in most reputable regulators, such as Plasmatronics and Selectronix. If no disconnect is fitted, then the risk is run of completely flattening the system to 0V, in which case it will be very difficult to resuscitate the batteries and almost certainly a number of them will have suffered irreversible damage. This failure is NOT warrantable. Therefore it is very strongly recommended that a low disconnect system be fitted.
3. Is the system operating under normal temperature conditions? This is normally accepted as 15° to 35° degrees. Bear in mind that the battery does not follow ambient temperatures and will usually average out day and night temperatures to some degree. It should also be noted that one possible reason for low capacity is operation of the batteries under very low temperature conditions. This affects the batteries in two ways.
 - a) The capacity falls off as the temperature reduces by around 0.6% per degree. As all capacities are rated at 25°C, this means that at say – 5°C, there will be 18% less capacity available from the cells. (See earlier comments on sizing)
 - b) The voltage levels are affected more, although this is very dependent upon the rate of the discharge as well as the state of charge. At a rate of discharge of ~ C/5 (around 80A for a SG 1000), the battery voltage could fall by ~ 150mV on going from 25°C to – 5°C. This could mean that the limit of 1.9V is reached after possibly only 1/3 of the normal time. Charge voltages are also affected, such that at lower temperatures a higher voltage is required to charge the batteries. Again, most regulators have temperature compensation features – 4mV per degree for BE gel products – which will automatically adapt the voltage to the temperature. The probe for this must be placed either on the battery terminals (usual) or on the outer case of the battery.

12.5 Voltage reading for estimating State of Charge (SOC)

If any problems in operation are to be recognised and dealt with before any harm is done to the cell, then it is critical to determine the operating parameters of the battery bank. As noted before, the battery should operate under normal conditions between 95-100% State of charge (SOC) at the end of the charge cycle and say 70% SOC at the end of the discharge cycle (this will depend upon the average daily depth of discharge) on a daily basis, with a regular equalisation cycle to bring the battery up to 100% SOC. This will mean in practice at least an average 5% overcharge into the battery (Ah input on charge/Ah on discharge). This state of charge should be maintained except under poor weather conditions. (See below)

Unfortunately, the state of charge estimators built into most inverters/regulators are not accurate and can give very misleading results, as they are based on simple electrical models of the battery.

There are several methods of checking the state of charge apart from using the system incorporated into the regulator. This can either be done by reading the open circuit voltage, which MUST be done after a period of discharge, not charge. The values are given from 60% SOC to 100% SOC on p8.

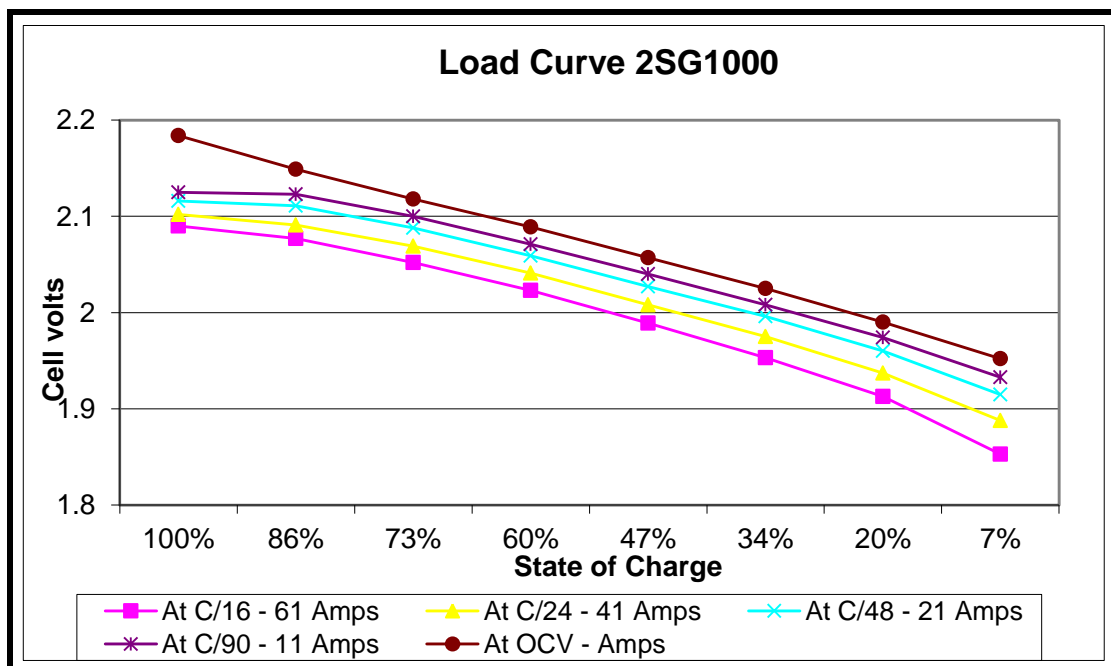
The other method of checking the state of charge is to measure the voltage of the individual cells on load, at the beginning of the load cycle – typically when the solar input stops. The current provided by the battery must also be measured – normally from the ammeter on the inverter or obviously other methods are available. The temperature of the battery should also be noted.

You can then use the chart to determine the actual state of charge of the battery. In the chart, the voltages on load vary with current and SOC. The appropriate current line should be chosen, based on the measured current (see example below). Temperature correction should also be used if appropriate if the cell temperature is significantly different to the standard 25°C.

12.6 Typical state of charge curve

Comments on the following typical state of charge curve are:

1. The currents are as factors of the rated capacity at the 120H rate. So C/12 is the battery capacity divided by 12 (1000/12 or 83A in the case of the 2SG1000).
2. The battery voltage will fall as the current increases, as can be seen from the examples. This is why it is necessary to measure the discharge current from the batteries.
3. The measured voltage will increase as the temperature rises and this effect will again depend upon the current. The appropriate value should be taken away from the reading if the temperature is above 25°C and added if it is below 25°C.



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The appropriate temperature correction factors are:

	C/12	C/12	C/50	C/100
15°C	-10	-6	-4	-2
25°C	0	0	0	0
35°C	10	6	4	2
45°C	18	9	6	3

Example: A 2SG1000 was measured at 30A with a voltage of 2.05V at 35°C degrees 15 minutes after the beginning of the load period. Find the state of charge and if low, measure the Ah extra input required to bring the battery up to 100%.

30A is C/33 (1000/30), between C/50 and C/25. 2.05 Temperature corrected is 2.044 (6 mV for the 10°C difference). The voltage at 60% is ~ 2.033, at 73% 2.055, so the most accurate value is 66% SOC.

This means that a charge input from that point of 340 Ah would be required to restore the battery to a full state of charge.

It should be noted that these values will slowly deteriorate as the battery ages, so they are only to be used as a guide, possibly +/- 10%.

The state of charge and the current ratings are all based on the 120 hour rate (1000 Ah in this case).

12.7 Battery fault finding (low capacity)

If all of these items have been checked and no problems determined, then the next step is to check the battery. This should be done on a sequential basis.

1. Check that the battery has been properly maintained. This involves keeping the surfaces clean and the bolts tight. A maintenance schedule is given in Section 10. If the battery is allowed to get dirty with electrolyte etc. on the top of the cell, then a phenomenon called "tracking" can occur. This is a small current which operates between the opposite polarity terminals and the net result is that the cell where this occurs will be lower in voltage and capacity than the other cells.
2. Check that there are no major differences in positioning of the cells in a stack, which could lead to different ambient temperatures being experienced. The cells should all be positioned with a minimum of a 6 mm between adjacent cells under shaded conditions, such that there is no more than one degree difference in temperature between the cells under rest conditions.
3. Check the voltages of the cells under load, preferably towards the end of the load period. I.e. where under worst conditions the bank voltage is approaching 11.4 for a nominal 12V system and 22.8 for a nominal 24V system. It is strongly recommended that a digital voltmeter of at least 3.5 digits be used for this task. At this stage there should be no more than 50 mV between the cells i.e. between 1.88 and 1.93V. At higher voltages on load, which would be the normal case, then the voltage gap should be less i.e. with voltages above 2V per cell, the gap between cells. If one cell is reading significantly less than this i.e. < 1.6V, then further action needs to be taken. If the voltages of the cells are all fairly even, i.e. within a 50mV band as outlined above, then it is highly unlikely that the batteries are faulty. They could, however, have become low in capacity because of undercharging - a deficit between the Ah going in to the battery as against the Ah going out. The danger is then that the cells can get slowly sulphated, a process where the discharged active material is slowly converted to large sulphate crystals, which cannot be converted back to charged active material on the charge cycle. This can happen either to individual cells because of small differences in efficiency between cells in the bank or to the whole bank for reasons outlined above. Sulphation can only be reversed by slow charging of the battery and keeping the voltage below, say, 2.35V per cell. If all the cells are low and relatively even, then the battery should be charged with the proviso that all the cells remain under 2.35 until the battery is 70-80% charged; if one cell is significantly lower than the others, then, if possible this should be isolated and charged separately.

12.8 Bad weather conditions

One key aspect to note is that if the batteries become low due to adverse weather conditions or the load exceeding the charge input, then extra charge will have to be put into the batteries as soon as possible as there is no function in the regulator to account for this. If, for example, the low voltage disconnect is reached – typically set at 1.9V per cell- then the bulk of the nominal capacity would have to be returned to the cell. For instance, for a 2SG1000, 800-900 Ah would have to be put back in to return the cell to approaching 100% state of charge. This is normally not possible with diesel generators, which are normally set to an equalisation cycle, which is totally inadequate for charging the battery. As noted above, extended operation of the battery (> 6 months) in reduced states of charge will damage it! This is often observed as initially one cell becoming low as once a cell becomes sulphated; it is less efficient at accepting charge and rapidly falls in voltage. As noted before, most battery systems are designed to reach 95-100% on a daily basis, with a five day autonomy designed in to allow for bad weather conditions. Note: this may have to be revised for areas under annual monsoonal conditions.

The evidence for sulphation can be observed from a number of factors.

1. That the battery has reached the defined adsorption voltage (2.45V per cell on a daily basis)
2. That the discharge voltage at the commencement of discharge is much lower than the value expected for a fully charged cell (at a typical load of ~ C/30 or 30A for a 2SG1000 this would be 2.10 V at the start of the discharge period).

In both cases contact your installer or distributor!

To correct problems with low capacity/sulphation, the only solution is to put more charge into the system, such that the Ah deficit is reversed. This can mean putting back significant charge back into the system – a solution that might not be possible, certainly in the short term. As noted above, the cell (say the 2SG1000) is discharging at 1.9V (equivalent to 75-80% discharged) at a current of 8-10A, then it will have to have a net 800-900 Ah put back into it to reach a full state of charge. Unfortunately, if the battery has extended periods (many months) without reaching a full state of charge, then charging it to a voltage limit –say 2.45V – will not necessarily help, as this point could be reached with the battery only 50% or less charged. This is a function of sulphate formation, which reduces the capability of the battery to accept charge at a high rate.

If a period of poor weather has reduced the battery state of charge but no sulphation has occurred, the matter can be corrected by increasing the adsorption time by several hours over several months until the original values are restored. As noted before, it is important to determine if one or more cells are lower in the string, as opposed to the entire bank being low.

If the battery is sulphated, the charging voltage must be kept at 2.4V or below!

One method of determining the state of charge (SOC) of the battery is to disconnect it during a net discharge phase for 5 or so minutes and then measure the voltage. This can be compared with the chart shown on p8 to determine the SOC. There are other methods for determining SOC, such as impedance or conductance, but field equipment is not readily available. Battery Energy should be contacted in this case. See also section 12.5 for determining the state of charge from the on load performance.

If one or more cells are significantly low in the stack, this can again mean several things.

- a) That the cells have gradually over time diverged from one another due to small differences in efficiency/capacity or both. The low cell or cells can then, if they are not treated, gradually sulphate which in turn will cause more rapid failure. This process will, however, take several years and it should be possible to correct the problem before then.
- b) That there is a manufacturing problem with the cell or cells. This can be seen as a short etc.

12.9 Battery fault finding (others)

As noted in the troubleshooting guide page 19, apart from low capacity, other problems can manifest themselves with battery systems. These are outlined below in more detail.

12.10 Case swelling or buckling

This is almost certainly due to the battery reaching elevated temperatures (>80°C) in the preceding operations. At this point, the softening point of the plastic is reached and inbuilt stresses in the material are let out. Swelling due to internal gas pressure has never been observed in practice and swelling due to plate growth only happens under exceptional circumstances. This could be due to several reasons.

- a) During a discharge, the battery goes into extended reversal – because of some failure of the cell.
- b) The charging current becomes elevated due to charger malfunction. This can in turn lead to thermal runaway, where a significant proportion of the current (as gassing) is converted to heat by means of recombination of the gases generated. In cells, which do not contain fire retardant materials (unlike BE products), this can lead to serious fires.

Thermal runaway can also be caused by cells being at elevated temperatures (>50°C degrees) with no temperature compensation for the charger. The elevated temperatures can in turn be caused by incorrect installation – for instance leaving no air gap between the cells – or by being in very high ambient temperatures or by a combination of the two. Again, although the SunGEL range is very resistant to thermal runaway, it can happen under extremely adverse conditions. In a standard home solar system, this is of course highly unlikely, but it is possible in a hybrid system where there is a diesel generator charging backup.

12.11 Sulphation with Battery Energy cells

As noted in the troubleshooting guide, cells with a high charge voltage are a strong indication of major sulphation – formation of large lead sulphate crystals that are very difficult to convert back to active material – and are, as such, not a warrantable condition. There are many signs to isolate cells before they reach this condition. It is caused by prolonged operation of the cell over many months in a low state of charge.

Although Battery Energy cells are designed to be more tolerant to abuse than any other commercially available VRLA battery, they will slowly form hard sulphate under these conditions. If the cells are totally flattened to the extent of a discharge voltage of <1V, it is also mandatory that cells be recharged within 24 hours to maintain the warranty. Depending upon the degree of discharge, there could be a period when the charge current and voltage need to be limited to a maximum of 2.35 to 2.4V per cell. If the battery is accepting charge, the current flowing should increase until normal levels of current and voltage are reached. It is strongly recommended that Battery Energy be contacted under these conditions.

In cases where the batteries are left for an extended period of time in the fully discharged condition, care has again to be taken when recharging that the voltage per cell is below the point where any gases are evolved. This means that the maximum voltage per cell tolerated would be 2.3-2.35V. In order to break down the hard sulphate layers which will have formed, extended periods of low charge are required – often several weeks. Even then, it is extremely difficult to ensure that all the cells will reach full capacity, as there is a tendency at very low gravities for lead dendrites and subsequent shorts to form. Battery Energy experience is that if cells are below 1V on open circuit prior to charging, the chances of recovery are not good.

12.12 Disposal of spent batteries

All used batteries are to be disposed of in a compliant and environmentally responsible manner. SunGEL batteries are 100% recyclable with numerous depots licensed to receive them.

Please contact Battery Energy if further assistance is required in this regard.

13. References

13.1 Reference documents

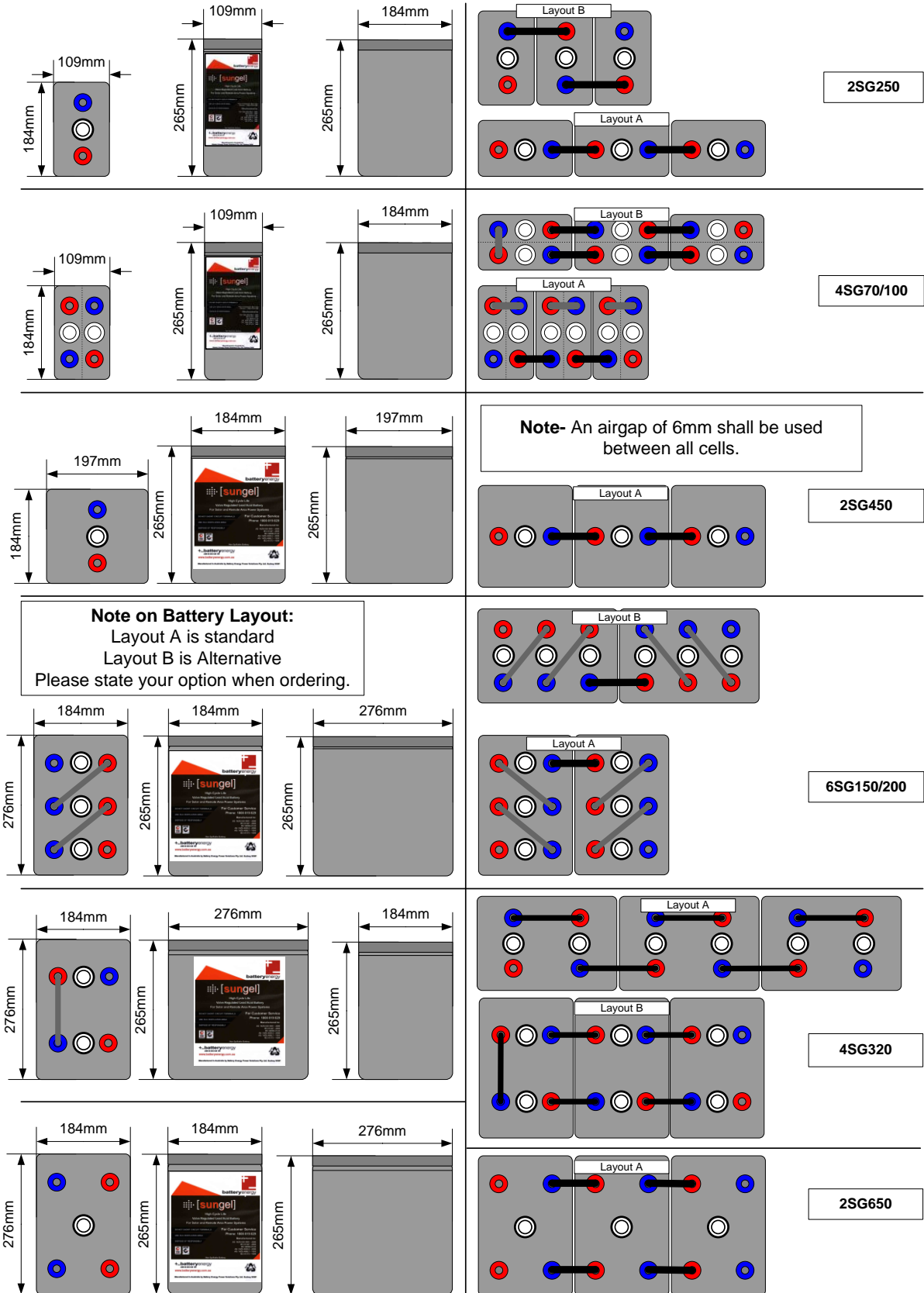
- AS 2676.2: 1992 Guide to the installation, maintenance testing and replacement of secondary batteries in buildings – Sealed cells.
- AS/NZS 3000: 2000 Electrical installations known as the Australian /New Zealand Wiring Rules
- AS 3011.2: 1992 Electrical Installations – Secondary batteries installed in buildings – Sealed cells Part 2
- AS/NZS 4029.2: 2000 Stationary batteries – Lead-acid Part 2: Valve-regulated type (IEC 6089-2: 1995, MOD)
- AS 4044: 1992 Battery chargers for stationary batteries
- AS 4086.1: 1993 Secondary batteries for use with stand-alone power systems
General requirements
- ISO 9001 Quality management systems – Requirements
- IEC 60896-21: 2004 Stationary lead-acid batteries – Part 21: Valve regulated types –
Methods of test
- IEC 60896-22: 2004 Stationary lead-acid batteries – Part 22: Valve regulated types –
Requirements
- IEC 61427: 2005 Secondary cells and batteries for photovoltaic energy systems (PVES) –
General requirements and methods of test

13.2 Glossary of terms

Accessories	Items supplied with a battery on delivery including connectors, shrouds and connecting nuts and bolts.
Available capacity	The total number of ampere hours that can be withdrawn from a cell or battery for a specific set of operating conditions, including current, end voltage, state of charge, age of battery and temperature.
Battery	A unit consisting of one or more cells, connected in a series, parallel or series/parallel array, to supply the voltage and current characteristics of the connected load.
BMP	Battery maintenance point
Capacity	The quantity of electric charge (electricity) usually expressed in ampere hours (Ah), which a fully charged battery can deliver under specified conditions.
Cell	A cell is an assembly of electrodes and electrolyte which constitute the basic unit of a battery. With lead acid, the cell has a nominal voltage of 2V.
Charge	The electrical energy contained within or being introduced to the battery.
DOD	Depth of discharge
Discharge rate	Discharge rate is the current at which the battery is discharged. It is often referenced to the capacity at a given rate, e.g. C/10 is the current for a particular battery which will give 10 hours capacity. It is also referred to as the hour rate, which is the length of time a fully charged new cell or battery can be discharged at a specific current, before reaching a specified end voltage. For instance, if a 200 Ah cell is discharged at 20A for 10 hours, then the 20A is referred to as the 10 hour rate.
Discharge	The removal of electrical energy stored within the battery.
Horizontally mounted cell	A cell designed to operate with its terminals and valves on a vertical face.
LVD	Low voltage disconnect
NM	Newton metres
PPE	Personal protection equipment
PSOC	Partial state of charge
Rated capacity	As above, specified by Battery Energy for a given discharge time and end voltage at a specified temperature. This is normally 25 degrees centigrade. Values for all the SunGEL range is given in Battery Energy technical literature. The capacity of a cell or battery is denoted by the symbol C. As the capacity varies with the rate of discharge, the symbol C is followed by a numerical sub fix giving the rate of discharge. Thus C10 is the capacity in Ah at the 10 hour rate of discharge.
SOC	State of charge
UPS	Uninterrupted power supply
Vertically mounted cell	A cell designed to operate with its terminals and valves mounted on its upper horizontal surface.
Voltage	The nominal voltage of a lead acid cell is 2V. In practice, on open circuit with no load, it is around 2.1V.
VRLA	Valve regulated lead acid.

14. Installation and layout diagrams

Installation and layout diagrams are set out below for the SunGEL range.

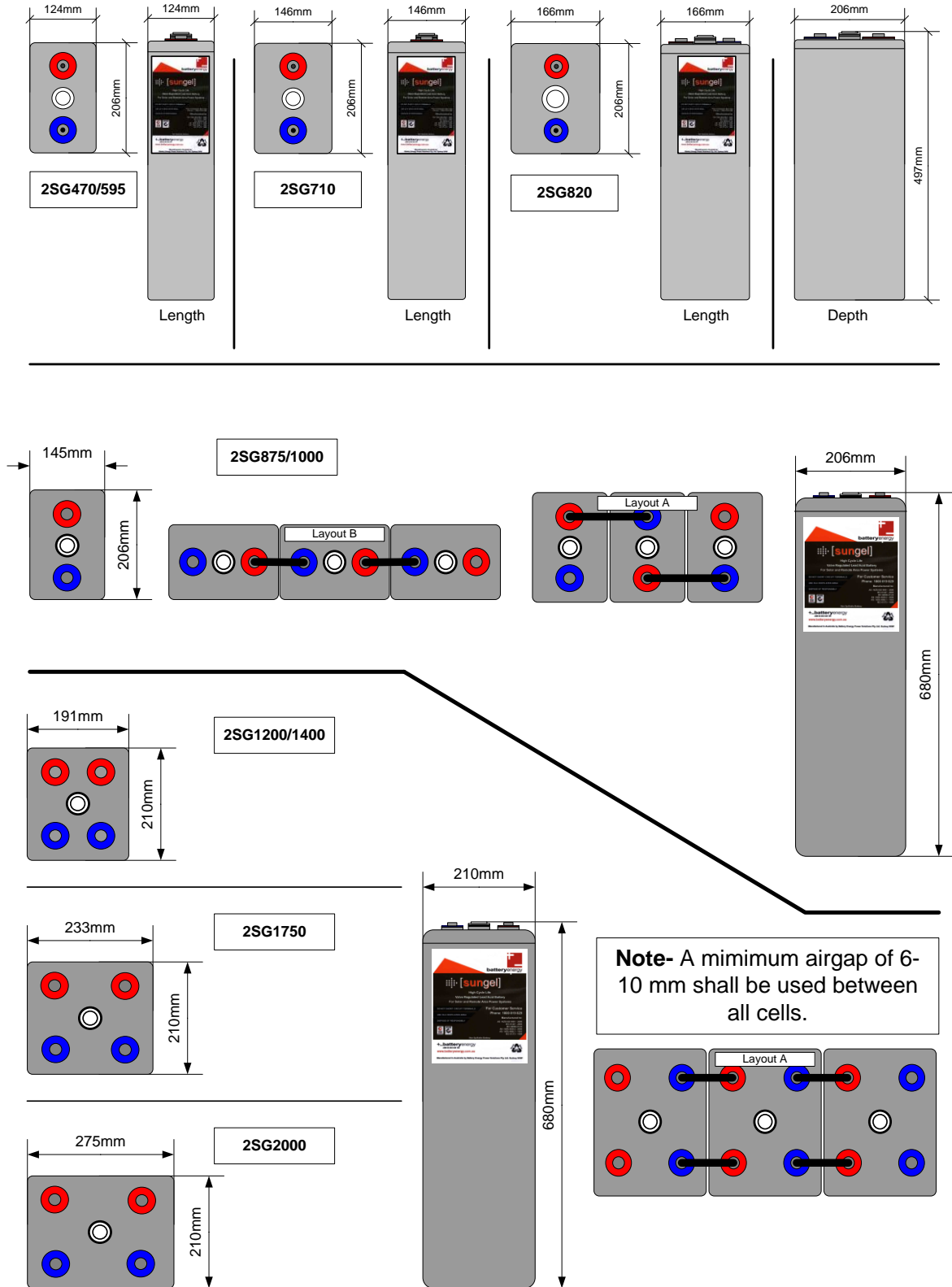


The product layouts shown here are for alternative link layouts on the battery in vertical arrangement only.
For horizontal installation please consult Battery Energy 1800 819 829.

SunGEL Battery Range Installation and Maintenance Manual

Installation and layout diagrams

Installation and layout diagrams continue for the SunGEL range.

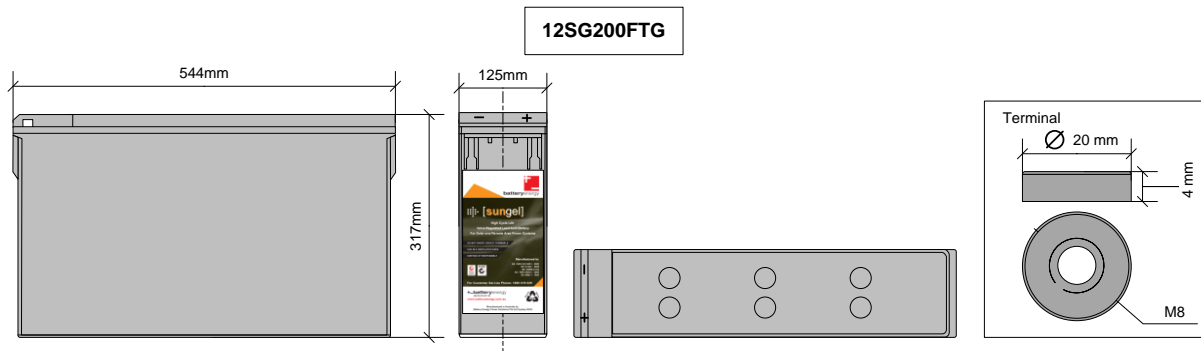
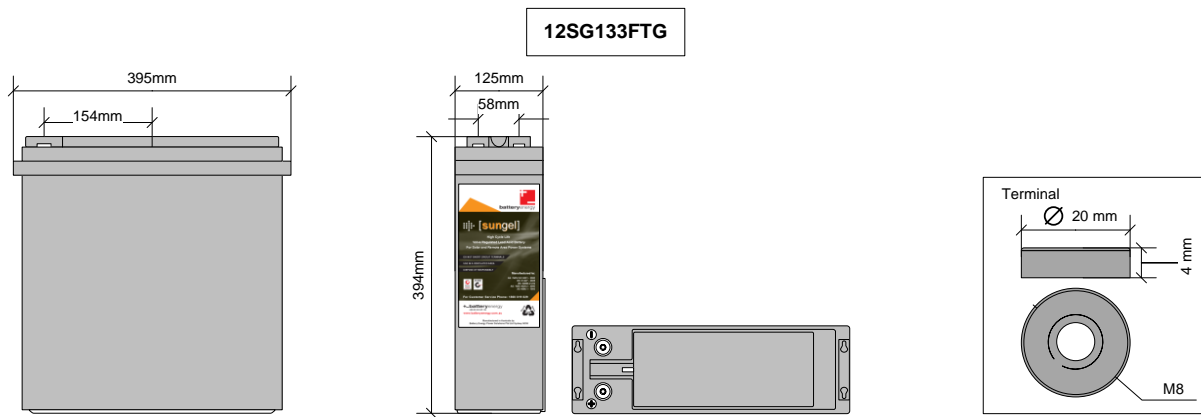


The product layouts shown here are for link layout on the battery in vertical arrangement only. For horizontal installation please consult Battery Energy 1800 819 829.

SunGEL Battery Range Installation and Maintenance Manual

Installation and layout diagrams

Installation and layout diagrams are set out below for the SunGEL range.



15. Accessories

Except in the case of specific request, all SunGEL batteries are delivered complete with inter-cell connections, lead plated brass bolts, washers and protective shrouds. Inter-cell connections can either be lead plated copper links or sheathed flexible copper cable with moulded in ends including caps. An itemised bill of materials is outlined below for all SunGEL battery types:

2SG250 C01-000022

2SG450 C01-000022

2 x Screw	Brass set lead plated M8 x 16mm
2 x Washer	Brass lead plated M8 x 17mm
1 x Link	Lead plated copper 16 x 3mm x 132mm L

2SG650 C01-000023

4 x Screw	Brass set lead plated M8 x 16mm
4 x Washer	Brass lead plated M8 x 17mm
2 x Link	Lead plated copper 16 x 3 x 132mm L

2SG875 C01-000020

2SG1000 C01-000020

2 x Screw	Brass lead plated M10 x 21mm
2 x Washer	Brass lead plated M10 x 19mm
1 x Link	Lead plated copper 25 x 3 x 170mm L
2 x Washer	Spring 316SS M10
1 x Shroud	Large Gel link 180mm

2SG1400 C01-000026

2SG1750 C01-000026

2SG2000 C01-000026

4 x Screw	Brass lead plated M10 x 21mm
4 x Washer	Brass lead plated M10 x 19mm
2 x Link	Lead plated copper 25 x 3 x 134mm L
2 x Shroud	Large Gel link 140mm

4SG320 C01-000028

4 x Screw	Brass set lead plated M8 x 16mm
4 x Washer	Brass lead plated M8 x 17mm
1 x Link	Lead plated copper 16 x 3 x 158mm L
1 x Link	Lead plated copper 16 x 3 x 174mm L

6SG100 C01-000025

6SG150 C01-000025

6SG200 C01-000025

6 x Screw	Brass set lead plated M8 x 16mm
6 x Washer	Brass lead plated M8 x 17mm
2 x Link	Lead plated copper 16 x 3 x 150mm L
1 x Link	Lead plated copper 16 x 3 x 132mm L

12SG113FTG C01-0000

12SG200FTG C01-0000

4 x Screw	Brass set lead plated M8 x 16mm
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Periodic maintenance records

Customer: _____
 Location: _____
 Telephone No: _____

Battery Type: _____
 Capacity: _____
 No. Of Cells: _____

Pilot Cell No: _____
 Date Installed: _____
 Purchased From: _____

Monthly

Year Three

Six Monthly

Month	Date & Initial of reader	Charger Volts	Pilot Cell	
			Volts	Temp °C
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
<p><u>Annual Checks:</u></p> <p>Clean Surface of Batteries</p> <p>Re-torque battery connector bolts.</p>				

Date			
Cell No.	Volts	C°	Comment

Date		
Volts	C°	Comments

