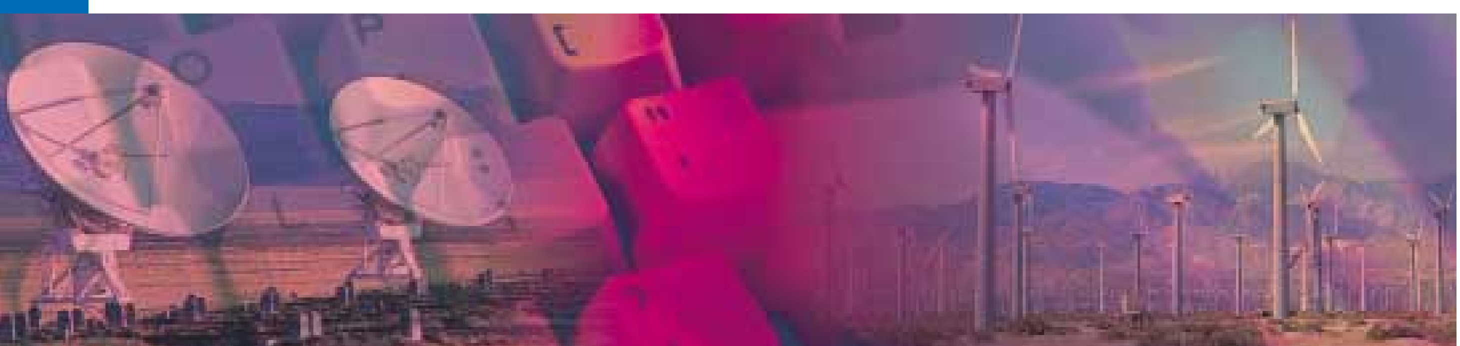
HAWKER

Hawker Batteries Handbook



STANDBY BATTERIES TECHNICAL MANUAL

INTRODUCTION TO HAWKER

INTRODUCTION

The Hawker Group is the largest manufacturer of industrial batteries in the world. It is a global energy business with manufacturing and assembly plants in Europe, North America and Asia, and marketing operations in more than 100 countries. Its formation in 1991 brought together some of the most respected names in the industry, companies with a reputation for innovation and technical achievement. World-wide, they set the standard for battery making continuously pushing forward the technology to deliver even more effective power storage solutions.

Through its membership of Invensys plc, Hawker has the backing and investment strength of the world's premier automation and controls group. Created from the merger of BTR plc and Siebe plc, Invensys is a global electronics and engineering business of more than 500 companies, employing 120,000 people world-wide,

Batteries from Hawker Group companies provide primary and reserve power in almost every aspect of human activity - telecommunications, power generation and distribution, UPS systems, aerospace, defence, marine, automotive and leisure. Working closely with specifiers, power equipment manufacturers and end users, Hawker ensure that the most effective battery solutions are always available.

GROUP PROFILE

As the world's leading supplier of industrial batteries, we operate on all continents with more than 20 state-of-the-art manufacturing plants, backed by local sales, product and service support. Added to this our global network of distributors and agents, means that we are currently active in over 100 countries.

Hawker is one of the largest players in the $3 billion world industrial battery market, providing batteries and power supplies for Standby, Traction, Low and Zero Emission Vehicles, Defence and Aviation and other Special applications.

Hawker has the resources needed to continuously invest in new plant and product development to meet the world's industrial power needs.

And all of this is available to you through your local Hawker Group company listed in this document.

QUALITY

In terms of design and manufacture, the quality of every Hawker battery benefits greatly from the amassed expertise and knowledge of the group, backed by many decades of experience.

Today the Hawker group boasts some of the most modern battery manufacturing facilities in the world. A structured quality management system is in place which satisfies the requirements of ISO 9001 and demonstrates that all customer requirements are identified and satisfied from contract review, through manufacturing, to installation and service.

Computer controlled equipment and quality control techniques have been introduced to ensure that reliable and cost effective products are manufactured to meet the highest international standards.

The Hawker group has also invested heavily in state of the art computerised test and metrology laboratories which carry out routine performance testing, product characterisation testing and equipment calibration.

RESEARCH & DEVELOPMENT

As the world's leading and most innovative industrial battery manufacturer, Hawker naturally recognises the fundamental importance of research and development. Our pre-eminent position in industrial lead-acid technology results from many years' R&D to ensure that our products set the standard by which the competition is judged. This investment is continuing and Hawker engineers and scientists are working on the next generation of batteries and power conversion technology. We work very closely with our customers to develop new products and the right solutions for their specific applications.

In this market Hawker occupies a unique position with pure lead valve regulated lead acid (VRLA) batteries; a mainstream product using lead-calcium-tin grids and Absorptive Glass Mat (AGM) separators; tubular and rod-plate gel batteries; and a full range of traditional flooded battery types.

Current development is focused on the pure lead and lead-calcium-tin/AGM batteries. Pure lead offers excellent service life and recent developments have provided increased reliability, better performance for cyclic duty cycles and higher integrity sealing systems. The range has been redesigned to meet application requirements more precisely and further improvements are in development, with some radical new products at a conceptual stage.

BATTERY DESIGN

TYPES OF BATTERIES AND THEIR USES

Flooded Lead Acid Batteries

Since the battery was first designed way back in the 1880's, many flooded lead acid batteries still use the same basic principles of flat pasted plates immersed in a dilute sulphuric acid electrolyte. This is still by far the most common form of lead acid battery, although other types developed to improve efficiency or life now include planté, tubular and rod types. Water has to be added at regular intervals as it is lost during operation, although there are low maintenance types which have excess electrolyte calculated to compensate for water loss during the normal lifetime of the battery.

Valve Regulated Lead Acid Batteries

This development in battery technology originated in the late 1960's. Here the gases that are produced during operation are recombined which minimises the water loss. The sealed lead battery provides high performance and long life. As such it has become the accepted power source for 'clean' applications including computer backup systems, telecommunications and emergency power. It is also becoming popular for cordless tools and appliances, electric vehicles and applications requiring frequent discharges.

VALVE REGULATED LEAD ACID BATTERIES....
GAS RECOMBINATION EXPLAINED

When a charge current flows through a fully charged conventional lead acid cell, electrolysis of water occurs to produce hydrogen from the negative plate and oxygen from the positive plate. This means that water is lost from the cell and regular topping-up is needed.

However, evolution of oxygen gas and hydrogen gas does not occur simultaneously, because the efficiency of recharge of the positive plate is not as good as the negative plate. This means that oxygen is evolved from the positive plate before hydrogen is evolved from the negative plate.

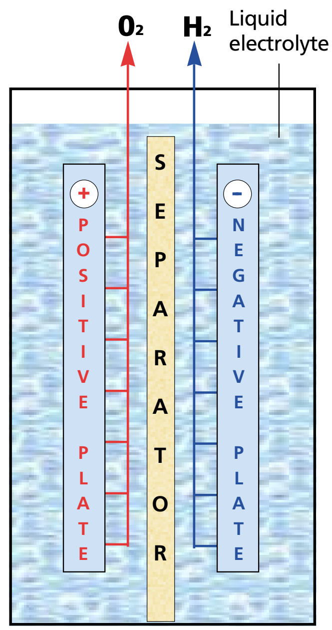
At the same time that oxygen is evolved from the positive plate, a substantial amount of highly active spongy lead exists on the negative plate before it commences hydrogen evolution. Therefore, provided oxygen can be transported to the negative plate, conditions are ideal for a rapid reaction between lead and oxygen: i.e. This oxygen is electro-chemically reduced on the negative plate according to the following scheme,

$$2e^- + 2H^+ + {}^1/_2\,O_2 \longrightarrow H_2O$$

and the final product is water.

The current flowing through the negative plate drives this reaction instead of hydrogen generation which would occur in a flooded cell. This process is called gas recombination.

If the process were 100% efficient, no water would be lost from the cell. By careful design of the constituents within the cell, gas recombination of more than 95% is achieved. An efficient gas recombination cell can be made using either Absorptive Glass Mat (AGM) separators or gelled (gel) electrolyte.



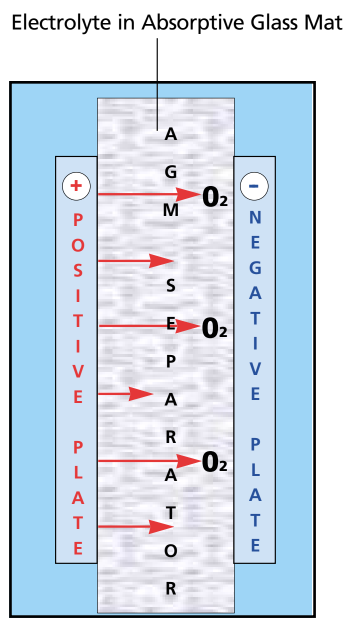
Conventional Cell

ABSORPTIVE GLASS MAT (AGM)

To achieve a satisfactory gas recombination efficiency it is necessary to provide a path between the positive and negative plates. By providing this path, oxygen can pass from the positive to the negative plate where it reacts with the spongy lead negative active material.

In the AGM cell a special, highly porous micro-fibre glass separator is used. By carefully controlling the saturation level and the exact balance between electrolyte quantity and porosity, a continuous path for oxygen transport is obtained. This provides the optimum conditions for gas recombination and an efficiency of over 95% is achieved.

The VRLA AGM battery can be used for all discharge rates from switch closing/tripping and engine starting which requires short duration high currents, to telecom and navigational systems requiring long, stable power occasionally for many days. The special separator used in these batteries results in a very low resistance which makes them particularly good at delivering high currents.

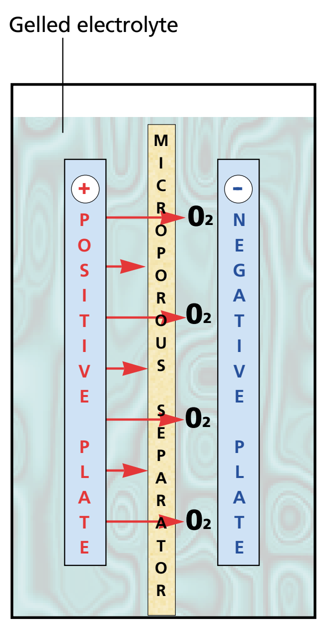


AGM Cell

GELLED ELECTROLYTE (GEL)

For gelled electrolyte cells, a mixture of sulphuric acid with finely dispersed silica is used to produce a gel. By vigorously stirring, the thixotropic mixture stays fluid so that it can be poured into the cells. The mixture then stiffens and forms a firm gel. As the gel stiffens it shrinks and this leads to the formation of numerous micro-fine cracks through which the oxygen generated at the positive plate is able to diffuse to the negative plate.

Because a conventional microporous separator is used in the gelled electrolyte cell, the internal resistance is slightly higher for these cells compared to AGM types. Therefore, they are better suited to medium and long rate discharges. Tubular plate cells with gelled electrolyte are particularly suitable for cyclic applications or where there is a need to supply power to equipment for several hours. The rod plate offers a compromise between tubular plate and pasted plate types by giving a higher power to weight and volume ratio than the tubular type but being more robust than the pasted type because the design is more corrosion resistant.



GEL Cell

PLATE TYPES

There are various types of electrodes which are used in lead-acid batteries. Each offers different characteristics which makes it suitable for specific application.

Planté

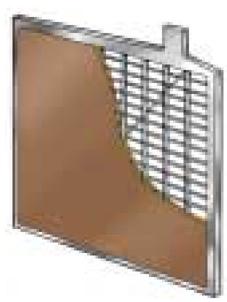
The Planté plate is only used as a positive electrode and is principally used for standby applications. It benefits from being extremely reliable with 25 years or more life and needs very little maintenance. The Planté uses pure lead cast plates and has moderate to good energy density. It has the unique ability to provide a minimum of 100% capacity for its entire lifetime. Normally, the end of life is determined when less than 80% capacity is available.

Tubular

The tubular plate is also only used as a positive electrode. Its principal use is for motive power applications, but it is also used for standby applications. It has a very good cycle life which means it can be discharged heavily for up to 2000 times. It also has a good float life, lasting up to 15 years.

Pasted Plate

The pasted plate electrode can be used both as a positive or negative. It is mainly used for automotive and standby applications. It has very good energy density with thin (1mm - 0.039”) or thick (7mm - 0.27”) plates. Pasted plate electrodes use pure lead, lead antimony, lead calcium or pure lead tin grid alloys. Grids can either be cast or punched and their life is dependant on the grid alloy and plate thickness.



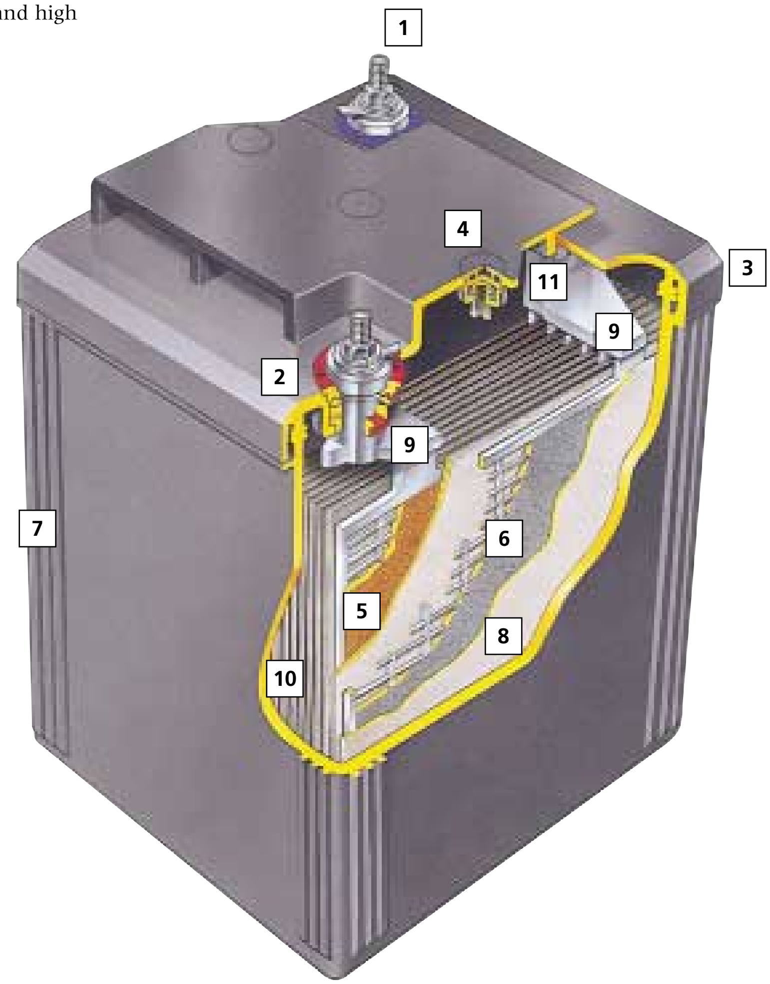
Rod Plate

Rod plate electrodes can be either positive or negative. They are principally used for standby applications and have a life of between 12 and 20 years. Very robust, rod plate electrodes use lead antimony or lead-calcium cast grids with moderate energy density.

VALVE REGULATED LEAD ACID PRODUCT ILLUSTRATIONS

GENERIC AGM BATTERY

1. **High Conductivity Pillars**
   Rolled thread for greater strength and conductivity.
2. **Gas Tight**
   Compressed neoprene rubber grommet for high reliability.
3. **Heat Sealed Lid to Container**
   Welded for life to give leak proof seal.
4. **One Way Valve**
   Prevents oxygen from entering the cell and flame retardant disk to give added integrity.
5. **Thick Positive Plates**
   Manufactured from the highest purity primary lead/tin/calcium alloy for high performance and long life, with active material from 99.99% pure primary lead.
6. **Negative Plates**
   Active material produced from 99.99% pure primary lead for balanced performance and high recombination efficiency.
7. **Container and Lid**
   Manufactured from flame retardant ABS to give protection against fire.
8. **Separators**
   The finest borosilicate fibres ensure maximum absorbtion of acid and provide a path for oxygen recombination.
9. **Thick Group Bars**
   Manufactured by state of the art cast-on-strap process to give maximum conductivity and superior corrosion resistance for long life.
10. **Pure Dilute Sulphuric Acid**
    For maximum performance and life.
11. **Through Partition Weld**
    Minimum resistance and maximum on load voltage.



TUBULAR GEL (OPzV) PRODUCT

1 **Pressure Relief Valve**

2 **Coloured Polarity Rings**
Blue = Negative
Red = Positive

3 **Microporous Separator**

4 **Flat Pasted Plate - Negative**

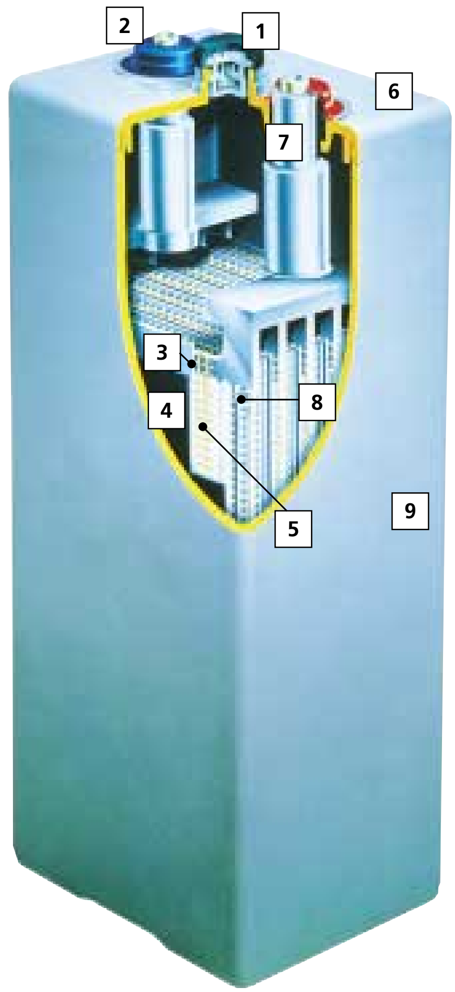
5 **Positive Grid Coating**

6 **ABS Lid**

7 **Terminals with brass insert for improved conductivity**

8 **Diecast Positive Grid Spines**

9 **ABS Container**



FLOODED LEAD ACID PRODUCT ILLUSTRATION

1 Vent Plugs
Designed to eliminate spray but give free exit of gasses.

2 Cell Lids
SAN material.
Completely sealed container means no leakage.

3 Cell Pillars and Connectors
Each one designed specifically for the job.
Give minimum resistance - maximum current flow.

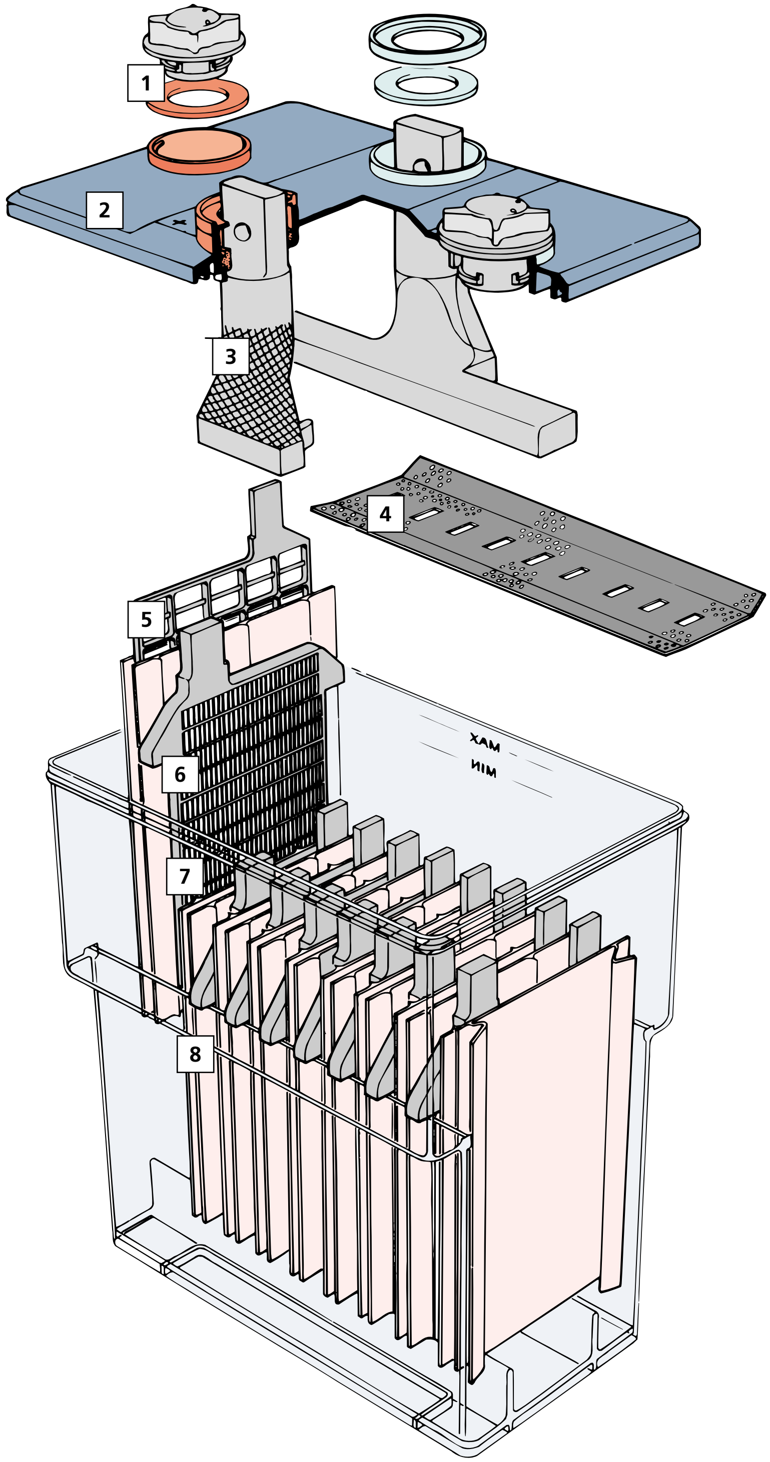
4 Bar Guard
Safeguards against short circuits.

5 Negative Plates
Pasted grids. Provide perfect balance with the positive to give maximum performance.

6 Separators
Sintered micro p.v.c. gives minimum resistance.

7 Planté Positive Plates
Pure lead. Ensures full initial capacity and long life.

8 Plastic Containers
Transparent SAN.
Electrolyte level and cell condition can be clearly seen.
Good electrolyte reserve to reduce periods of maintenance.



BATTERY SIZING

BATTERY SIZING

All the Hawker product literature contains performance data in tabular format, which allows simple battery sizing calculations to be made.

Battery sizing at constant current discharge

Example A

To demonstrate constant current calculation and also the effect of temperature.

A nominal 50V telecommunications system using a 24 cell battery and requiring 102 amps constant current will operate satisfactorily at a minimum battery terminal volts level of 42 volts.

Calculate the battery type required for 2 hours standby duration on the basis of:

(a) 20°C (68°F) operating temperature

(b) 5°C (41°F) operating temperature

Method

(1) minimum allowable volts per cell

$\frac{42 \text{ volts}}{24 \text{ cells}} = 1.75$ Vpc

(2) hence, cell performance requirement is 102 amps constant current to 1.75 Vpc;

(3) by reference to constant current performance table relating to 1.75 volts per cell level:

(a) at 20°C (68°F)

The P cell size is smallest available size to use (110 amps available) .

Conclusion: Use 24 - P cells

(b) at 5°C (41°F) by reference to the table 1 below available current output at 20°C is reduced by factor 0.9.

Therefore at 5°C (41°F) - 2 hours output is reduced to, on the P size, 110 amps x 0.9 = 99 amps.

Hence the P cell size too small!

Try the next largest cell size - Q. At 5°C (41°F) available current output is 124 amps x 0.9 = 111.6 amps

Conclusion: Use 24-Q cells

Discharge rate (duration)	Temperature Correction Factor to be applied to 20°C (68°F) data at:								
	32°F	41°F	50°F	59°F	68°F	77°F	86°F	95°F	104°F
	0°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C
5 mins to 59 mins	0.8	0.86	0.91	0.96	1	1.037	1.063	1.085	1.10
1 hour to 24 hours	0.86	0.90	0.93	0.97	1	1.028	1.05	1.063	1.07

CELL TYPE	DISCHARGE CURRENTS (AMPERES PER CELL) AT 20°C (68°F) TO 1.75 VOLTS PER CELL													
	1	1.5	2	2.5	3	4	5	6	7	8	9	10	12	24
A	12.7	9.3	7.4	6.3	5.4	4.3	3.5	3.1	2.7	2.4	2.1	1.97	1.66	0.85
B	19	13.9	11.2	9.4	8.1	6.4	5.3	4.6	4	3.6	3.2	2.95	2.49	1.27
C	25.3	18.5	14.8	12.5	10.7	8.5	7	6.1	5.3	4.8	4.2	3.93	3.32	1.7
D	31.7	23.2	18.6	15.6	13.4	10.7	8.8	7.7	6.7	6	5.3	4.9	4.15	2.1
E	38	27.8	22.3	18.8	16.1	12.8	10.6	9.1	7.9	7.1	6.4	5.9	4.99	2.54
F	52	37.6	30	25.2	21.6	17.2	14.4	12.4	10.8	10	9.2	8.4	7	3.6
G	65	47	37.5	31.5	27	21.5	18	15.5	13.5	12.5	11.5	10.5	8.8	4.5
H	71.3	51.6	41.4	34.9	30.4	24.2	20.1	17.5	15.6	14.1	12.8	11.7	9.9	5.1
I	83.2	60.2	48.3	40.7	35.4	28.3	23.5	20.4	18.2	16.4	14.9	13.7	11.5	6.0
J	95.0	68.8	55.2	46.6	40.5	32.3	26.9	23.4	20.8	18.8	17.1	15.6	13.2	6.8
K	119	86.0	69.0	58.2	50.6	40.4	33.6	29.2	26.0	23.5	21.3	19.5	16.5	8.5
L	131	94.5	75.9	64.0	55.7	44.4	36.9	32.1	28.6	25.8	23.5	21.5	18.1	9.4
M	143	103	82.8	69.9	60.8	48.4	40.3	35.0	31.2	28.2	25.6	23.4	19.8	10.2
N	143	103	82.8	69.9	60.8	48.4	40.3	35.0	31.2	28.2	25.6	23.4	19.8	10.2
O	166	120	96.6	81.5	70.9	56.5	47.0	40.9	36.4	32.9	29.9	27.3	23.1	12.0
P	190	138	110	93.1	81.0	64.6	53.7	46.7	41.6	37.6	34.1	31.2	26.4	13.7
Q	214	155	124	105	91.1	72.7	60.4	52.6	46.8	42.3	38.4	35.1	29.7	15.4
R	238	172	138	116	101	80.7	67.2	58.4	52.0	47.0	42.7	39.0	33.0	17.1
S	250	180	145	122	106	84.8	70.5	61.3	54.6	49.3	44.8	41.0	34.6	17.9
T	262	189	152	128	111	88.8	73.9	64.2	57.2	51.7	46.9	42.9	36.3	18.8
U	285	206	166	140	122	96.9	80.6	70.1	62.4	56.4	51.2	46.9	39.6	20.5
W	285	206	166	140	122	96.9	80.6	70.1	62.4	56.4	51.2	46.9	39.6	20.5

Battery sizing at constant power discharge

Example

To demonstrate constant power calculation.
A 70kVA rated inverter system requires a d.c. constant power input of 60.5kW in the voltage range 266 volts maximum, 197 volts minimum.

Under full load conditions, there is approximately 3 volts drop between battery terminals and inverter due to cable resistance. Calculate the optimum battery size required for 20°C (68°F) operation for a 5 minutes standby period.

Method

(1) The maximum number of cells required is calculated from the maximum battery voltage ÷ the cell float voltage. Therefore in this case the maximum number of cells

$$= \frac{266V}{2.27\ Vpc} = 117\ cells$$

(2) The minimum battery voltage is the minimum system voltage plus the voltage drop due to cable resistance, which in this case is 266V + 3V = 200V.

The minimum cell voltage therefore is the minimum battery voltage ÷ the maximum number of cells, which in this case

$$= \frac{200V}{117\ cells} = 1.709\ Vpc$$

(3) Total d.c. power required is 60.5kw, therefore using 117 cells

watts per cell required

$$= \frac{60500\ watts}{117\ cells} = 517\ watts\ per\ cell$$

(4) Hence cell performance requirement is 517 watts to 1.709 Vpc at 20°C (68°F).

(5) by reference to the Constant Power performance table relating to 1.71 volts per cell level:

G cell size is the smallest available size to use on the basis that the battery comprises 117 cells in series.

NB! In order to check the optimisation of battery selection (because available performance of 524 watts per cell is in excess of required performance 517 watts per cell), the calculation should be repeated to consider a reduced number of cells as follows:

using 116 cells:

(2) minimum allowable volts per cell

$$= \frac{200V}{116\ cells} = 1.724\ Vpc$$

(3) watts per cell required

$$= \frac{60,500\ watts}{116\ cells} = 522\ watts\ per\ cell$$

(4) Hence, cell performance requirement is 522 watts to 1.724 Vpc at 20°C (68°F).

(5) by reference to the Constant Power performance table relating to 1.73 volts per cell level:

P cell size is now too small - it will only provide 507 watts per cell to 1.73 volts per cell level.

THEREFORE, the initial calculation gives optimum battery size for the duty specified.

Conclusion: Use 117 G cells

CONSTANT POWER DISCHARGE (IN WATTS PER CELL) AT 20°C (68°F) TO 1.73 VOLTS PER CELL

CELL TYPE	STANDBY TIME MINUTES										
	5	10	15	20	25	30	35	40	45	50	55
A	120	86	65	54	46	40	36	32	29	27	25
B	180	129	98	81	69	60	54	48	44	41	38
C	240	172	131	108	92	80	72	64	59	55	51
D	300	215	163	135	115	100	90	80	73	68	63
E	360	258	196	162	138	120	108	96	88	82	76
F	406	306	244	208	181	160	146	134	122	112	106
G	507	382	304	259	226	200	182	167	152	140	132
H	578	444	361	304	263	231	207	187	170	156	144
I	675	518	421	355	307	270	241	218	198	182	168
J	771	592	482	406	350	308	275	249	227	208	192
K	964	740	602	507	438	386	344	311	283	260	240
L	1061	814	662	558	482	424	379	342	312	286	264
M	1157	888	722	608	526	463	413	373	340	312	288
N	1189	902	730	613	529	465	414	374	340	312	289
O	1388	1053	851	715	617	542	483	436	397	365	337
P	1586	1203	973	817	705	620	552	499	454	417	385
Q	1784	1353	1094	919	793	697	622	561	511	469	433
R	1982	1504	1216	1021	881	774	691	623	567	521	481
S	2082	1579	1277	1073	925	813	725	654	596	547	505
T	2181	1654	1338	1124	969	852	760	685	624	573	529
U	2379	1804	1459	1226	1057	929	829	748	681	625	578
V	2379	1804	1459	1226	1057	929	829	748	681	625	578

CONSTANT POWER DISCHARGE (IN WATTS PER CELL) AT 20°C (68°F) TO 1.71 VOLTS PER CELL

CELL TYPE	STANDBY TIME MINUTES										
	5	10	15	20	25	30	35	40	45	50	55
A	124	87	66	54	46	40	36	32	29	27	25
B	186	130	99	81	69	60	54	48	44	41	38
C	248	173	132	108	92	80	72	64	59	55	51
D	310	217	165	135	115	100	90	80	73	68	63
E	372	260	198	162	138	120	108	96	88	82	76
F	420	312	245	209	183	161	147	135	123	113	106
G	524	389	306	261	228	201	183	168	153	141	132
H	596	453	366	308	265	233	207	187	170	156	144
I	695	529	427	359	309	271	242	218	198	182	168
J	795	604	489	410	353	310	276	249	227	208	192
K	993	755	611	513	442	388	345	311	283	260	240
L	1093	831	672	564	486	427	380	342	312	286	264
M	1192	906	733	615	530	465	414	373	340	312	288
N	1222	919	740	619	532	466	415	374	340	312	289
O	1425	1073	863	722	621	544	484	436	397	365	337
P	1629	1226	986	826	709	622	553	499	454	417	385
Q	1832	1379	1110	929	798	699	623	561	511	469	433
R	2036	1532	1233	1032	887	777	692	623	567	521	481
S	2138	1609	1295	1084	931	816	726	654	596	547	505
T	2240	1685	1356	1135	975	855	761	685	624	573	529
U	2443	1839	1479	1238	1064	933	830	748	681	625	578
V	2443	1839	1479	1238	1064	933	830	748	681	625	578

ENVIRONMENT

ENVIRONMENT

The Hawker Group is committed to the environment in all that we do. We seek to conserve natural resources, promote the more efficient use of energy, minimise water use, reduce waste, reduce emissions and increase the recycling and re-use of materials. Our policy is to operate in an environmentally responsible manner designed to meet all applicable legislation and one that strives to further reduce any adverse effects of its operations upon the environment.

Manufacturing

Hawker manufacturing plants throughout the world employ state of the art production processes which are more efficient and environmentally-benign. A programme of continuous development and investment ensures that all Hawker plants are as environmentally friendly as it is possible to make them.

Recognition

Companies in the Hawker Group are working towards the international environmental standard ISO14001 which has already been awarded to Hawker Energy Products Inc in the USA.

Environmental Awards

Our commitment to the environment can be seen by the fact that Hawker companies have won awards for envionmental excellence.

Hawker Energy Products Inc, for example, has won awards recognising the treatment of waste water at their battery plant for three years running. The company has been able to minimize water use and maximise water reuse, while at the same time doubling manufacturing capacity.

Recycling

Hawker is working with other companies and trade organisations to look into, and make recommendations about, the most effective means of recycling batteries. The majority of lead acid batteries, including those produced by Hawker, are already efficiently recycled, primarily to remove the valuable lead.

Hawker provides a complete disposal service for both standby and traction batteries following installation of new or replacement batteries. We also operate a sealed lead recycling programme, which recycles all components of Hawker VRLA batteries - metals, plastics and acids.

Many Hawker factories operate programmes to recycle process waste back into the manufacturing operation wherever possible. For example, the waste water which is recovered at the effluent plant is re-used for cooling and cleaning. We also recover the waste lead slurry from pasting departments. The slurry is then sent to a smelter for recycling.

HEALTH AND SAFETY GUIDELINES

HEALTH AND SAFETY GUIDELINES

Batteries are powerful sources of electrical energy and as such, should be handled with care and respect. The guidelines below are meant for general reference and although refer to lead acid battery technology, do not differentiate between the various types of lead acid batteries available. As such you should:

ALWAYS consult the relevant instruction manual before installation or service of your batteries.

ALWAYS refer to safety recommendations required by national/international standards in your local country.

ALWAYS ensure that only authorised personnel carry out work on batteries.

This objective of this guide is:

- To demonstrate the potential hazards that may arise when using lead acid batteries.
- To outline the precautions you should take to minimise such hazards.
- To indicate the action that you should take in the event of an accident or emergency situation.

The guidelines are in 2 sections:

SYMBOLS and HANDLING BATTERIES

SYMBOLS

You will see all or some of the following symbols (depending on the battery type) on the batteries themselves. Ensure that you are aware of the meaning of each symbol.

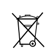
 Note operating instructions

 Explosive gas

 Shield eyes

Pb Batteries contain lead

 Keep away from children

 Never dispose of old batteries as domestic waste

 Battery acid

 Batteries are recyclable - please follow your local recycling regulations

 No smoking, no naked flames, no sparks

 Warning - Electric energy / high voltages

HANDLING BATTERIES

1. SULPHURIC ACID

Batteries contain sulphuric acid (dry charge batteries prior to filling with acid excluded) which may leak for a number of reasons and may be given off as droplets and/or a fine mist during charging.

Nature of the Hazard

Battery acid is a poisonous and corrosive liquid which will cause burns and irritation to the skin and eyes and could burn clothing.

Precautions

1. Always handle batteries with care and keep upright.
2. Do not overfill batteries.
3. Always charge in a well ventilated area.
4. Always use eye protection (must comply with national / international standards) and protective clothing where there is any risk from splashes.
5. Always keep away from children.
6. Keep an eyewash bottle available at all times.

Accident or Emergency Action/Treatment

- **Skin Contact**
  Cool the burned area with large amounts of water. Do this for at least 10 minutes but do not allow this process to delay the calling of an ambulance or the removal of the patient to hospital, if possible. Remove any contaminated clothing. Do not remove any clothing which is sticking.

- **Eye Contact**
  Immediately wash out the eyes with an eye wash bottle or clean water for at least 10 minutes and seek prompt medical attention.

- **Ingestion**
  Do NOT induce vomiting, but make the patient drink as much water or milk of magnesia as possible and seek immediate medical attention.

Spillages

Small spillages can quite simply be dealt with by swilling away with plenty of water. For larger spillages, absorb onto an inert material e.g. earth, sand or vermiculite. Neutralise the mixture with soda ash and arrange for disposal by a registered waste carrier.

Disposal

Suitable acid resistant, labelled containers should be used.

See also Section 6.

Note - Additional Information

The above section applies particularly to flooded, wet batteries such as wet planté, tubular and flat plate cells, where dilute sulphuric acid circulates freely within the cell/battery.

Valve regulated AGM (absorptive glass mat) types such as Powersafe, Espace, XT™, SBS and Cyclon® from the Hawker Group, are classed as non hazardous. This is because in VRLA AGM cells, the dilute sulphuric acid is absorbed in a special, highly porous micro-fibre glass separator. This, together with high density pillar seals and hermetic container-to-lid bonding, ensures that acid is unable to leak out.

Gelled electrolyte cells (such as the OPzV type manufactured by the Hawker Group) are also classified as non hazardous.

2. ELECTRICAL ENERGY

Electrical energy can be supplied from batteries and charging equipment.

Nature of the Hazard

Burns may occur from the heating effect on tools and conductive objects in contact with live battery terminals or conductors. In addition sparks and molten metal may be ejected and combustible materials ignited. It is possible to receive a severe electric shock from charging equipment and from a number of batteries connected in series, i.e. five or more 12 volt batteries - 60 volt nominal.

Precautions

1 Before using conductive tools on a battery remove metallic personal adornments from the hands and wrists, e.g. watches and rings.
2 Switch off circuit before connecting or disconnecting the battery otherwise a spark could cause an explosion.
3 Always use insulated tools.
4 Do not place tools or conductive objects on top of batteries.
5 Before using a battery charger consult manufacturer's literature.
6 Remember to switch the charger off before connecting or disconnecting a battery.
7 Do not wear coats or overalls made from pure synthetic fibre materials as these can hold static electric charge under certain circumstances.
8 Ensure connections are tight and circuit is safe before switching on battery.

See also Section 3.

Accident or Emergency Action/Treatment

- **Burns**

  Cool the burned area with large amounts of water. Do this for at least 10 minutes but do not allow this process to delay the calling of an ambulance or the removal of the patient to hospital. Remove any contaminated clothing. Do not remove any clothing which is sticking.

- **Electric Shock**
  - Immediate action is essential in cases of severe electric shock as the nerves controlling breathing and heart action may be affected. Do not delay treatment by calling for a doctor; this should be done quickly if help is available or when the casualty recovers.
  - Make sure it is safe to approach. If the casualty is not clear of a live conductor, break the contact. Switch off the current, remove the plug, or wrench the cable free. If this is not possible, stand on dry insulating material (wood, rubber, brick, thickly folded newspaper, book) and try push or pull the casualty clear of contact using similar insulating material as a lever. Do **NOT** touch them with bare hands.
  - If necessary give artificial respiration.

3. EMISSION OF GASES

WARNING - batteries, in particular wet flooded batteries, can give off explosive gases. Adequate ventilation MUST be provided.

Hydrogen and oxygen are emitted during charging and can be emitted at other times, particularly if a battery is moved or shaken.

Gas recombination cells under normal operating conditions release only very small quantities of hydrogen and so any explosion risk is greatly reduced compared to flooded cells. Gas recombination cells should not however be installed in containers or cubicles without adequate ventilation.

Nature of the Hazard

An explosive atmosphere is created if the concentration of hydrogen in air exceeds 4%.

Precautions
Always use eye protection (must comply with national/ international standards) where there may be any foreseeable risk. Charge in a well ventilated area. Avoid sources of ignition close to batteries.

In particular:
- No smoking - No naked flames
- Always switch off current before making or breaking electrical connection.
- Avoid sparks caused by accidental short circuits.

See also Section 2.

Accident or Emergency Action/Treatment

Explosion

Seek any necessary medical attention and remember that sulphuric acid may have been ejected.

See also Section 1.

4. WEIGHT

Batteries are generally heavy, awkward units to handle and correct lifting techniques must therefore be used.

5. DAMAGED BATTERIES

Battery plates consist of lead and its compounds, but can only be exposed if a battery is broken open. In the unlikely event of this happening any spillage should be well damped, swept up and placed in a suitable acid resistant, labelled container prior to disposal.

Normal personal hygiene precautions should be observed.

See also Section 1 and Section 6.

6. DISPOSAL

Batteries, battery cases, battery acid, lead and lead compounds must not be burned, but must be disposed of in accordance with the appropriate national / international legislation, and Local Waste Disposal Authority rules and regulations.

7. FIRE

Since batteries contain combustible materials the Local Fire Authority should be consulted where a quantity of batteries are stored together.

The boxes and lids of batteries are made of various types of plastic components which under normal usage, are inert. In the case of fire the plastic components could decompose and may give off toxic vapours and consequently suitable self-contained respiratory protection should be used during fire fighting.

8. GENERAL

Familiarise yourself with the location of your health centre and how to contact your works nurse, first aider or appointed person.

Remember to report any accident, involving personal injury, in your official accident book.

Should any repair or other work on batteries be required, the relevant national/international codes of practice MUST be referred to.

Any additional information, including battery labelling, that is provided to cover specific battery types and applications must be used in conjunction with this guide.

INSTALLATION

INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS

For typical VRLA Cells

This leaflet is intended as a guide only. For detailed instructions refer to the relevant installation, operating and maintenance manual of the battery in question.

Safety Precautions

Handling

Batteries are normally supplied charged: they must be unpacked carefully. Avoid all short-circuits between opposite polarity poles as the cell will produce very high short-circuit currents.

Keep Flames Away

In case of accidental overcharge a flammable gas can leak from the safety vent.
Discharge any possible static electricity from clothes by touching an earth connected part.

Tools

Use tools with insulated handles. Do not place or drop metal objects on top of the battery. Remove rings, wristwatch and articles of clothing with metal parts that might come in contact with the battery terminals.

Receiving the shipment

Unpack the batteries immediately upon arrival. Inspect for possible damage in shipment. Ensure that no accessories are discarded with the packing material.

Warning

The batteries contain immobilised sulphuric acid.

Batteries with broken lids or containers may lose small amounts of acid when deformed. Wear rubber gloves when handling broken batteries.

Storage

Store the battery in a dry, clean and preferably cool location.

As the batteries are supplied charged, storage time is limited. In order to easily charge the batteries after prolonged storage, it is advisable not to store it more than:

6 months at 20°C (68°F)

4 months at 30°C (86°F)

2 months at 40°C (104°F)

A refreshing charge shall be performed after this time at 2.27V per cell at 20˚C (68°F) for 96 hours or until the charging current does not vary for a 3 hour period.

The necessity of a refreshing charge can also be determined by measuring the open circuit voltage of a stored battery.

Refreshing charge is advised according to the relevant product literature.

Failure to observe these conditions may result in greatly reduced capacity and service life.

Installation

The battery should be installed in a clean, dry area. VRLA cells with very low gas release in normal operation (recombination ratio≥ 95%) can be installed together with other electrical equipment.

It is important that the battery is installed on a stable floor (without deformation).

Temperature

Avoid placing the battery in a warm place or against a window. The battery will give the best performance and service life when working at a temperature between 20°C (68°F) and 25°C (77°F).

Ventilation

Under normal conditions the gas release is very low and natural ventilation is sufficient for cooling purposes and inadvertent overcharge, enabling VRLA batteries to be used safely in offices and equipment.

However care must be taken to ensure ventilation when placed in closed cabinets.

Security

All installation and ventilation must comply with the current regional regulations and standards.

Mounting

Hawker battery racks or cabinets are recommended for proper installation.

Assemble the rack according to instructions supplied. Place the battery blocs or cells on the rack and arrange the positive and negative terminals for connection according the wiring diagram supplied. Check that all contact surfaces are clean and fit the bloc or cell connectors and the terminal bolts.

Tighten the bolts securely. Check the polarity to avoid short circuiting of cell groups. Finally connect the battery terminals to the charger.

Terminal Bolt Tightening

The maximum torque load for intercell connector bolts should be adhered to, and values are given in the relevant product literature.

A loose connector can cause trouble in adjusting the charger, erratic battery performance, possible damage to the battery and/or personal injury.

Finally fit the connector covers.
It is important that the battery is mounted securely.

Cells in parallel strings

VRLA cells of the same ampere hour rating may be connected in parallel to give higher current capability. However precautions must be taken.

- equipotential wiring is required; that means connectors are designed such that the current is distributed equally between each string
- to prevent any recharge problem, it is better to have a separate supply for each parallel string.

Charging

Float Voltage

The float/charge voltage is 2.27V per cell at 20°C (68°F).

When the average ambient temperature deviates more than ± 5°C (± 41°F) from the reference, it is necessary to adjust the float voltage.

The relevant values for adjustment are given in the appropriate product literature.

Due to the phenomena of gas recombination a difference of ± 4% for an individual cell voltage can be observed.

Charging Current

For maximum service life, VRLA batteries should only be used with constant potential float chargers.

Fast Recharge

Occasionally (4 or 5 times a year) the battery may be recharged at 2.40V per cell.

Details are given in the appropriate product literature.

Ripple Current

Unacceptable levels of ripple current from the charger of the load can cause permanent damage and a reduction in service life.

For recommendations refer to the appropriate product literature.

State of Charge

The state of charge of VRLA cells can be determined approximately by measuring the open circuit voltage after the battery has been at rest for a minimum of 24 hours, at 20°C (68°F).

The actual values vary according to the design of the VRLA battery and reference should be made to type specific literature.

Discharging

Discharged Cells

VRLA batteries must not be left in a discharged condition after supplying the load, but must be immediately returned to float recharge mode.

Failure to observe these conditions may result in greatly reduced service life and unreliability.

Accidental Deep Discharge

When the VRLA battery is completely discharged the consumption of sulphuric acid reduces the electrolyte strength to nearly water. The sulphation of the plates is a maximum, increasing considerably the cell's internal resistance.

The battery must then be recharged at a constant voltage of 2.27V per cell. As the internal resistance is high in the beginning, a minimum charge time of 96 hours may be necessary.

Important notice:

This type of deep discharge is abusive, and could affect the life expectancy.

The effect of temperature

on capacity

Capacity is enhanced at temperatures >20°C (68°F).

Capacity correction factors for VRLA batteries can be found in the appropriate product literature.

on life

Operation of valve regulated batteries at temperatures higher than 20°C (68°F) will reduce life expectancy.

Maintenance/Checks

VRLA batteries do not have to be topped up.

The containers and lids shall be kept dry and free from dust. Cleaning must be carried out with a damp cotton cloth (no man-made fibres).

Every month check that the total voltage at battery terminals is (N x 2.27V) for a temperature of 20°C (68°F). (N being the number of cells in the battery). Once a year, take a reading of the individual cell voltages constituting the battery.

Keep a logbook in which the measured values can be noted as well as power cuts, discharge tests, etc.

A full autonomy test can be carried out once a year.

Special Applications

Please contact your local sales office for advice when planning to use VRLA batteries in special applications such as repeated cycling or extreme ambient conditions.

INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS

For typical tubular Gel-OPzV Cells

This leaflet is intended as a guide only. For detailed instructions refer to the relevant installation, operating and maintenance manual of the battery in question.

Safety Precautions

Handling

Gel tubular batteries are supplied charged: they must be unpacked carefully. Avoid all short-circuits between opposite polarity poles as the cell will produce very high short-circuit currents.

Keep away fom flames

In case of accidental overcharge, flammable gas can leak from the safety vent.
Discharge any possible static electricity from clothes by touching an earth connected part.

Tools

Use tools with insulated handles. Do not place or drop metal objects on top of the battery. Remove rings, wristwatch and articles of clothing with metal parts that might come into contact with the battery terminals.

Receiving the shipment

Unpack the batteries immediately upon arrival. Inspect for possible damage in shipment. Ensure no accessories are concealed in the packing materials before disposal.

Warning

The batteries contain immobilised sulphuric acid.

Batteries with broken lids or containers may lose small amounts of acid when deformed. Wear rubber gloves when handling broken batteries.

Storage

Store the battery in a dry, clean and preferably cool location.

As the batteries are supplied charged, storage time is limited. In order to easily charge the batteries after prolonged storage, it is advisable not to store them more than:

6 months at 20°C (68°F)
4 months at 30°C (86°F)
2 months at 40°C (104°F)

A refreshing charge should be performed after this time at 2.23V per cell at 20°C (68°F) for 96 hours or until the charging current does not vary for a 3 hour period.

Failure to observe these conditions may result in greatly reduced capacity and service life.

Installation

The battery should be installed in a clean, dry area. It does not give off corrosive gas in normal operation and therefore can be installed together with other electrical equipment. It is important that the battery is mounted securely.

Temperature

Avoid placing the battery in a warm place or against a sunny window. The battery will give best performance and service life when working at a temperature between 20°C (68°F) and 25°C (77°F).

Ventilation

Under normal conditions gas release is negligible and natural ventilation is sufficient for cooling purposes, even when inadvertently overcharged, enabling batteries to be used safely in offices and with other electrical equipment.

Stands

Battery racks are recommended for proper installation.

Assemble the rack according to the instructions supplied. Place the battery blocs or cells on the rack and arrange the positive and the negative terminals for connection according to the wiring diagram.

Check that all contact surfaces are clean and fit the bloc or cell connectors and the terminal bolts.

Tighten the bolts securely. Check the polarity sequence to avoid short circuiting of cell groups. Finally connect the battery terminals to the charger.

Terminal Bolt Tightening

The maximum torque load for intercell connector bolts is 23Nm (2.3 Mkg) to 25 Nm (2.5Mkg). A loose connector can cause trouble during discharge or charge and voltage drop or heating, which can cause damage to the battery or injury to persons.

Finally fit on the connector covers (insulation).

Cells in parallel strings

Gel cells of the same ampere hour rating may be connected in parallel to give higher current capability. Do not exceed 4 parallel strings. However equipotential wiring is required. Connectors must be designed so that the current is distributed equally between each string.

Charging

Float Voltage

The recommended float/charge voltage is 2.23 V per cell at 20°C (68°F).

When the average ambient temperature deviates more than ± 5˚C (± 41°F) from the reference, it is recommended to adjust the float voltage as follows:

2.35Vpc at 0°C (32°F)
2.28Vpc at 10°C (50°F)
2.23Vpc at 20°C (68°F) (standard)
2.20Vpc at 30°C (86°F)
2.17Vpc at 35°C (95°F)

Due to the phenomena of gas recombination a difference of ± 2.5% for an individual cell voltage may be observed.

Charging Current

For maximum service life, gel tubular batteries should only be used with current limited constant potential float chargers, current limited to 10% of 10 hour capacity. In practice the charging current must not exceed $0.3C_{10}$. However if the application guarantees a depth of discharge (DOD) less than 40% of the rated capacity, then the charging current limits itself and current limitation may be omitted.

Fast Recharge

The battery may be recharged at 2.35V per cell with current limited to 10% of the 10 hour capacity. Fast charging should be discontinued after approximately 10 or 15 hours.

Quality of the charging current under floating voltage

The nature of the charging current has an influence on the life expectancy of the batteries. The rms value of the alternating component (fundamental and harmonic) must not exceed $0.1C_{10}$. on continuous charge.

State of Charge

The battery state of charge can be determined approximately by measuring the open circuit voltage after the battery has been at rest for a minimum of 24 hours.

State of charge	Voltage
100%	2.13 Vpc
70%	2.09 Vpc
50%	2.06 Vpc
20%	2.02 Vpc

Discharging

End of Discharge Voltage according to the discharge time

The end of discharge voltage must be limited to the values listed below.

Discharge time (t)	End voltage (Volts)
1h < t < 5h	1.70V
5h < t < 8h	1.75V
8h < t < 24h	1.80V

A low voltage disconnect or timer is recommended to prevent deep discharge.

Special attention should be given to small loads that are not automatically disconnected at the end of discharge.

Discharged Cells

Gel batteries must not be left in a discharged condition after supplying the load, but must be immediately returned to float recharge mode.

Failure to observe these conditions may result in greatly reduced service life and unreliability.

Accidental Deep Discharge

The battery must then be recharged at a constant voltage of 2.23V per cell, with a current limited to $0.1C_{10}$ capacity in order to prevent excessive heating. As the internal resistance is high at first, a minimum charge time of 96 hours may be necessary.

Important notice:

This type of deep discharge is abusive, and could affect the life expectancy.

The effect of temperature on capacity

Correction factor for capacity, according to temperature, the reference temperature being 20°C (68°F):

Discharge time (hour)	End voltage (Volt)	Temperature 14°F -10°C	32°F 0°C	50°F 10°C	68°F 20°C	86°F 30°C
1	1.67	0.39	0.59	0.80	1	1.05
3	1.75	0.55	0.70	0.85	1	1.05
5	1.77	0.60	0.74	0.87	1	1.04
10	1.80	0.60	0.74	0.87	1	1.04

Maintenance/Checks

Gel cells are maintenance free, sealed, lead acid batteries and do not have to be topped up.

The containers and lids should be kept dry and free from dust. Cleaning must be undertaken with a damp cotton cloth without man-made fibres.

Every month, check that the total voltage at battery terminals is (N x 2.23V) at a temperature of 20°C (68°F). (N being the number of cells in the battery). Once a year, take readings of individual cell voltages.

Keep a logbook in which the measured values can be noted as well as power cuts, discharge tests, etc.

A discharge test for full automony can be carried out once a year.

Special Applications

Whenever gel tubular cells are to be used for special applications such as repeated cycling or under extreme ambient conditions, please contact your local sales office.

INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS

For typical Vented, Pasted and Tubular Positive Plate Cells

This leaflet is intended as a guide only. For detailed instructions refer to the relevant installation, operating and maintenance manual of the battery in question.

Safety Rules during installation, test or work on batteries

1 Before installing a battery, make sure that first-aid material is available, ie:
- **Water**
- **Water filled eye wash**

In case of electrolyte spillage, rinse affected parts of the body with a lot of cold water. If electrolyte gets into the eyes, rinse thoroughly with eye-wash. In all cases, seek medical advice urgently.

NOTE: For remote installations provide a first aid kit on site.

2 Always wear protective glasses, gloves and preferably protective clothing when the battery is to be filled with electrolyte.

Electrolyte is a corrosive sulphuric acid solution

3 **To avoid electostatic charges and explosion risks**
Whether cells are dry or filled, charged or discharged, they may contain explosive gases (hydrogen and oxygen) which can, in the presence of a spark or flame, cause an explosion. It is therefore forbidden:-
- to smoke in a battery room
- to create electric sparks
- to use soldering equipment
- to use portable machines plugged into an electric plug
- to wear clothes likely to acquire an electrostatic charge (nylon)
- to use unprotected tools
- to store metallic objects near the battery

When working on the battery, first 'discharge' yourself of static electricity by touching an earthed metallic part (door, water pipe, etc). Repeat this action occasionally until the work is complete.

4 Take care not to create accidental short-circuits by dropping metallic objects onto intercell connectors.

Unpacking

Unpack the batteries as soon as they are delivered.

Verify that the equipment has been delivered in good condition, if it has not, notify the forwarding agent and/or sales office.

Battery storage

Store the battery in a dry, cool and clean place.

Storage times

Storage times for stationary batteries depend on temperature.

To recharge the battery more easily and rapidly, the following storage times are recommended:

Temperature	Time
20°C (68°F)	3 months
30°C(86°F)	2 months
40°C(104°F)	1 month

Recharge of stored batteries

2 types of charging are possible:

Constant Current Charge

Must be carried out under surveillance.

The charging current should, if possible, be restricted to 0.3°C_{10}. If the electrolyte temperature reaches 45°C (113°F), charging must be stopped and resumed when it has fallen to 35°C (95°F).

The battery is charged when every cell without exception reaches the nominal specific gravity value at 20°C (68°F) with the electrolyte level midway between the maximum and minimum line.

Installation

Battery Room

The layout and contents of a battery room must comply with all standards in force in the country.

The layout of the battery room must allow for easy access to the batteries.

Battery Installation

Stand Installation

- Assemble stand according to the instructions supplied
- Fit insulators (compulsory for high voltage batteries)
- Fit braces and cross beams
- Check that the stand is level
- Use appropriate wedges when packing under insulators
- Make sure that all insulators are in contact with the stand
- The battery can then be installed

Installation of Cells

- Battery cells should be installed in series
- Assemble battery on stand making sure that the positive terminal of one cell is connected to the negative terminal of the adjacent cell and continue in the same fashion
- Check cell alignment
- Fit connectors and bolts (check tightness and cleanliness)
- Use the insulators provided
- Make sure that all vent caps are closed

Bolt Torque Limits

10-25 Nm (dependent on type) - see individual product manual.

Ventilation

The battery installation must allow natural or artificial ventilation both at the top and bottom of the battery to eliminate any explosive gas mixture.

Calculation of ventilation

The quality of air required in litres per hour is calculated as follows:

Q = 55 x i x n
Q in litres/hour
n = number of cells
i = max. current of charge
* example only - national standards vary

Note

For installation and commissioning of dry charged batteries, please follow instructions given in the appropriate product literature

Operating instructions

Float Voltage

- A float voltage of 2.23Vpc to 2.30Vpc is normal. Consult technical literature for adjustments according to temperature and other variations

Charging current

- Should be restricted to $0.3C_{10}$
- Charging current quality affects battery life. Charging current must be filtered so that the value of the alternating component is minimised

Recharge after discharge

Every battery must be recharged, immediately after use; do not store a battery discharged.

A charging voltage of 2.23V to 2.30V per cell is generally used to recharge a battery.

A voltage of 2.30V to 2.40V can be applied to recharge the battery more rapidly.

Equalizing charge

When must equalizing charges be applied?

- When electrolyte levels have been adjusted
- When all specific gravities recorded at a temperature of 20°C (68°F) are less than 0.010 units compared to nominal specific gravity.
- When individual cells show a voltage difference of +/-0.02 Volts with the average cell voltage

Duration

- Depends on the voltage applied, on cell temperature and room temperature, but is normally 24-36 hours
- Continue charging until the cells specific gravities have reached nominal values. Begin the charge in the morning, ensure that after 1 to 2 hours of charging the current value is below $0.2C_{10}$

Check electrolyte temperature on 3 or 4 cells during charge. If the temperature remains below 30°C (86°F) cells may be left under equalizing charge voltage for 24 hours.

The end of charge signal is when nominal specific gravity is obtained.

Note: In all cases charging must be suspended if the electrolyte temperature reaches 45°C (113°F).

Technical data

Effect of temperature on capacity

If the battery operating temperature is different from 20°C (68°F) a correcting factor will have to be applied to capacity value taking into account discharge time.

1 Pasted positive plate

Recharge time	32°F 0°C	41°F 5°C	50°F 10°C	59°F 15°C	68°F 20°C	77°F 25°C	86°F 30°C	95°F 35°C	104°F 40°C
5 - 58 minutes	0.68	0.77	0.85	0.94	1	1.03	1.06	-.09	1.11
1 - 24 hours	0.74	0.61	0.88	0.95	1	1.02	1.05	1.07	1.06

Example: A battery with a 200Ah capacity at 20°C (68°F) for a 5 hour autonomy will have a capacity of 176Ah when discharged at 10°C (200 x 0.88)

2 Tubular positive plate

Recharge time	32°F 0°C	41°F 5°C	50°F 10°C	59°F 15°C	68°F 20°C	77°F 25°C	86°F 30°C	95°F 35°C	104°F 40°C
5 - 58 minutes	0.58	0.68	0.79	0.91	1	1.05	1.09	1.12	1.14
1 - 24 hours	0.81	0.86	0.91	0.96	1	1.03	1.05	1.06	1.07

Example: A battery with a 1000Ah capacity at 20°C (68°F) for a 10 hour autonomy will have a capacity of 850Ah when discharged at 5°C (41°F) (1000 x 0.86)

Correction of specific gravity according to temperature

Electrolyte specific gravity varies with temperature; if temperature is above or below 20°C (68°F) specific gravity readings must be corrected using the table below:

Specific gravity					
59°F	68°F	77°F	86°F	95°F	104°F
15°C	20°C	25°C	30°C	35°C	40°C
1.147	1.144	1.142	1.140	1.138	1.134
1.167	1.164	1.162	1.159	1.157	1.153
1.186	1.183	1.180	1.197	1.176	1.172
1.206	1.203	1.200	1.197	1.194	1.190
1.217	1.213	1.210	1.207	1.204	1.200
1.222	1.218	1.215	1.212	1.209	1.205
1.227	1.223	1.220	1.217	1.214	1.210
1.237	1.233	1.230	1.227	1.224	1.220
1.248	1.244	1.241	1.238	1.234	1.230
1.259	1.255	1.252	1.249	1.245	1.240
1.269	1.265	1.262	1.259	1.255	1.250

Maintenance/Tests

Equipment

- Hydrometer
- Thermometer
- Filler
- Voltmeter

Maintenance

- Keep containers, lids and battery rooms clean
- Wipe out salt and acid stains on terminals, connections and lids with a wet sponge
- Never clean containers and lids with solvents, detergents, oils or similar products

Every 3 months

1 Check total voltage at battery terminals. It must equal:

N x U
N = number of battery cells
U = floating voltage per cell to be applied according to cell type and annual average room temperature.

2 Measure voltage, specific gravity and temperature of a few reference cells.

3 Check electrolyte levels

4 Measure room temperature

Every 6 months

1 Measure total voltage of battery and ambient temperature

2 Measure all cells voltages

3 Measure specific gravity of a few cells with varying voltages as well as electrolyte level and temperature

4 Apply equalizing charge

An autonomy test can be applied one or twice a year

Water topping

- Top up with distilled or de-ionized water on a charged battery, before the electrolyte reaches minimum level
- When adding water, never exceed maximum level

The time interval between topping up varies from 1 to 8 years depending on:

- type of alloy
- cell type
- room temperature
- battery age

After having checked electrolyte levels, apply an equalizing charge until normal electrolyte specific gravity is restored

Log book

We recommend that a log book is kept in which the following information is recorded:

- periodical measurements
- capacity tests
- storage times and conditions
- topping up dates
- discharges due to power-cuts, etc

Advice for greater reliability and longer life of batteries

A battery is generally the last protective barrier against power cuts; battery maintenance is therefore very important in prolonging cell life.

- Correctly adjust the float voltage
- Top-up with distilled or de-ionized water at periodic intervals (dependent on cell technology)
- Never add sulphuric acid
- Keep the battery clean and dry
- Keep connectors clean
- Apply an equalizing charge periodically (essential to maintain a proper state of charge and homogeneous electrolyte)

Hawker Group
PO Box 227
Avon House
The Westinghouse Site
Chippenham
Wiltshire SN15 1SJ

Tel: +44 1249 442 551
Fax: +44 1249 442 550

www.hawker-batteries.com

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