

AGM Valve Regulated Recombination Batteries

HIGHLITE

SP and *FLB*



Engineering Manual

TABLE OF CONTENTS

1 INTRODUCTION	2
2 MAIN APPLICATIONS	2
3 MAIN FEATURES	2
4 RECOMBINATION TECHNOLOGY PRINCIPLES.....	3
5 TECHNICAL CHARACTERISTICS	4
6 OPERATING FEATURES	6
7 INSTALLATION.....	9
8 FLOATING AND CHARGING	20
9 STORAGE AND REFRESH CHARGING.....	23
10 MAINTENANCE AND TESTING	24
11 SAFETY.....	25
12 APPLICABLE STANDARDS	25
13 RECORDS DATA.....	25

1 INTRODUCTION

In a high technological environment it is extremely important to have a backup power source whenever possible. Infact mains power failure could cause severe losses and damages anytime.

FIAMM has been developing throughout years of research and experience several ranges of AGM VRLA batteries utilizing the most advanced technology to ensure the best reliability and quality.

FIAMM AGM (Absorbed Glass Matt) batteries belong to the category of Valve Regulated Lead Acid (VRLA) batteries, also sometimes known as "recombination" or "virtually sealed" batteries.

Fiamm main ranges of AGM VRLA batteries have the following basic characteristics:

- SP (Enerlite): 12 volts blocks of medium capacity, using reinforced grids and medium thickness plates, suitable for general applications;
- FLB (Highlite): 12 volts blocks from small-medium to medium-large capacities suitable for high reliability stand-by applications.

Note: throughout this engineering manual, multi-cell types will be referred as "blocks". If values are given on a per-cell basis (2 volts nominal cells), values for 6 or 12 volts blocks should be multiplied by the number of cells per block (3 cells for a 6 volts blocks, 6 cells for a 12 volts block).

2 MAIN APPLICATIONS

UPS

FIAMM AGM batteries are indeed the best solution for UPS systems to solve room shortage and installation challenges thanks to their high energy/power density. They fit in the most recent power equipment as they can be fully integrated into the UPS systems themselves.

General applications and emergency lighting

The smallest FIAMM AGM batteries guarantee the best proposal in any situation where power or light failure may cause severe problems or inconvenience since they can be installed anywhere.

3 MAIN FEATURES

No topping-up

Fiamm AGM batteries do not require topping-up throughout their service life.

Compatibility

Fiamm AGM batteries are designed to meet the requirements of the most modern electrical equipment. They are compatible with all standard recharging systems without any specific customization.

Energy density

Fiamm AGM batteries have a compact design to provide savings in volume and weight as compared to conventional flooded or vented batteries.

Office compatibility

Fiamm AGM batteries, which are valve regulated and virtually sealed, under normal operating conditions, do not give off perceptible amounts of gas. Thus they can be installed with full confidence in the very same environment where people live and work.

Savings

Fiamm AGM batteries offer substantial savings over the installation and maintenance costs.

Design life

Rigorous laboratory tests and extensive field experience have enabled FIAMM to manufacture highly reliable products, each according to their specific design life.

Installation

FIAMM AGM batteries are delivered charged and ready to be installed in racks or cabinets for an easy commissioning of any system.

Reliability

FIAMM AGM batteries have been tested in the field for many years with respect to charge/discharge characteristics, cyclic life, recombination efficiency, mechanical strength.

4 RECOMBINATION TECHNOLOGY PRINCIPLES

Recombination process

During charging and cycling of conventional lead acid batteries, water is slowly lost due to electrolysis, resulting in a mixed gas releasing of hydrogen and oxygen. Therefore there is a need for periodic topping-up operations to maintain the electrolyte at the proper level.

FIAMM AGM VRLA batteries design, through a chemical process called 'recombination', reduces to the very minimum level any need of inspection/maintenance operations on the batteries throughout their entire service life.

The oxygen recombination process occurs when electrolyte is absorbed into glass fibre matt separator which allows the oxygen to pass easily from the positive to the negative plate where oxygen reacts producing water. Therefore by virtually eliminating water loss there is no need for a periodical topping-up of the batteries.

Recombination formula

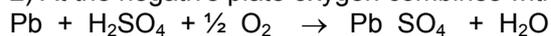
Below a complete description of recombination process.

1) Oxygen is evolved at the positive plate by the reaction

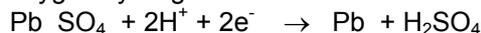


and diffuses through the unfilled pores of the separator to the surface of the negative plate.

2) At the negative plate oxygen combines with Pb and sulphuric acid



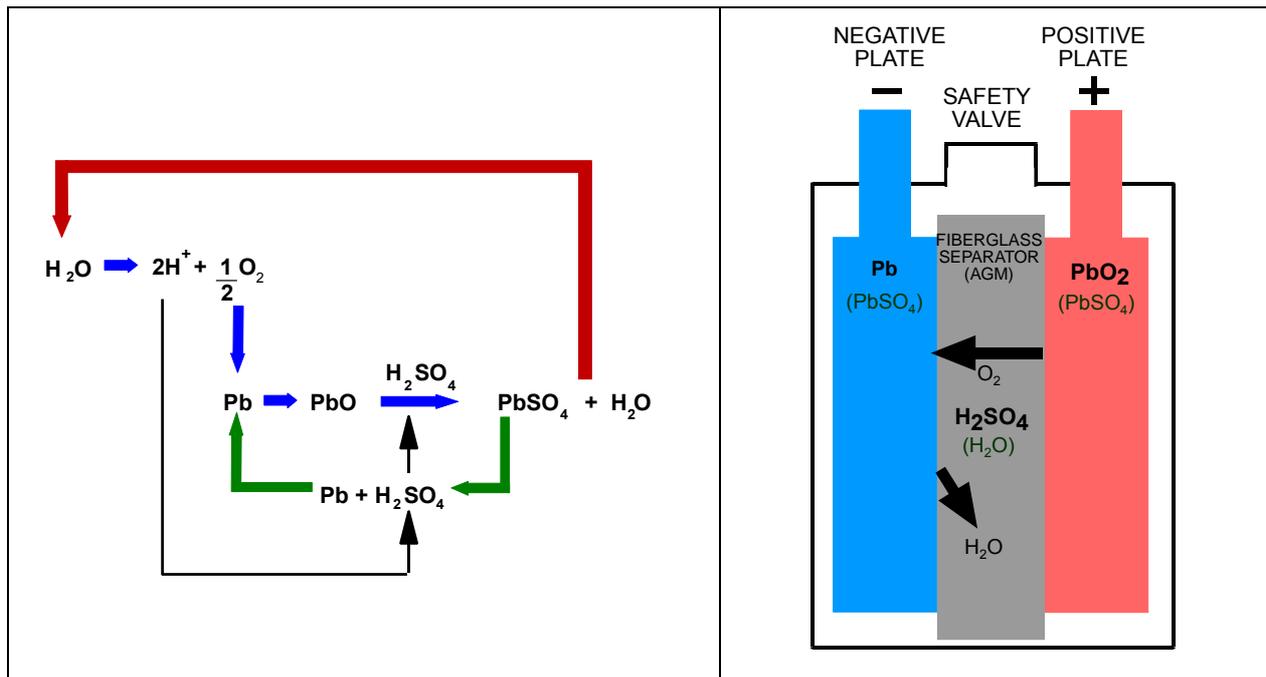
3) The charging process electrochemically regenerates the lead in the negative plate, completing the oxygen cycling.



As a result (see also fig. 1), the recombination process with an efficiency higher than 99% completes and returns the decomposed water.

At the end of the process, the recombination has regenerated the water without having modified the status and the charging level of the plates.

FIG.1 – RECOMBINATION PROCESS



5 TECHNICAL CHARACTERISTICS

The main technical characteristics of FIAMM AGM batteries are shortly described in the below section.

Grids

Fiamm AGM batteries have been using heavy duty grids design. Grids are made of an high quality lead alloy with the best combination of few calcium and tin parts. A very long experience at different environment conditions confirms excellent corrosion resistance and very low creep rate.

Plates

Both positive and negative plates are flat pasted type. The active material is a complex compound of several materials (lead oxide, water, sulphuric acid and other) necessary to obtain from the finished battery consistent performances and reliable stability throughout the battery life.

Containers and lids

Battery containers and lids are produced using a plastic polymer called ABS (Acrylonitrile Butadiene Styrene). This material has the best technical characteristics for an industrial use on sealed batteries. Fiamm batteries reinforced ABS parts are designed to fully withstand external shocking/vibrations and the internal pressure variation during battery operation. According to each range design Fiamm AGM batteries may be using flame retardant ABS material complying with UL 94, class V-0 or with IEC 707, method FV0.

Separators

FIAMM AGM batteries use customized separators ensuring with high reliability the efficiency of oxygen recombination cycle. They are mainly built in fibre glass sheets with excellent electrical and mechanical characteristics in order to achieve an high and consistent micro-porosity. While enjoying the best oxygen diffusion they are maintaining an high plates utilization and at the same time a very low internal resistance. Being separators fully wrapping battery plates it is achieved the mechanical consistency of active material to eliminate the risk of short circuits during the service life.

Electrolyte

Electrolyte is high purity sulphuric acid with different specific gravity for each different design. Standard average value is around 1.3 specific gravity.

Valves

Each cell has a one way valve to allow gas releasing whenever the internal pressure exceeds the fixed safety value. Valve opening pressure are rated at 0.15~0.30 atmospheres (15~30 Kpa).

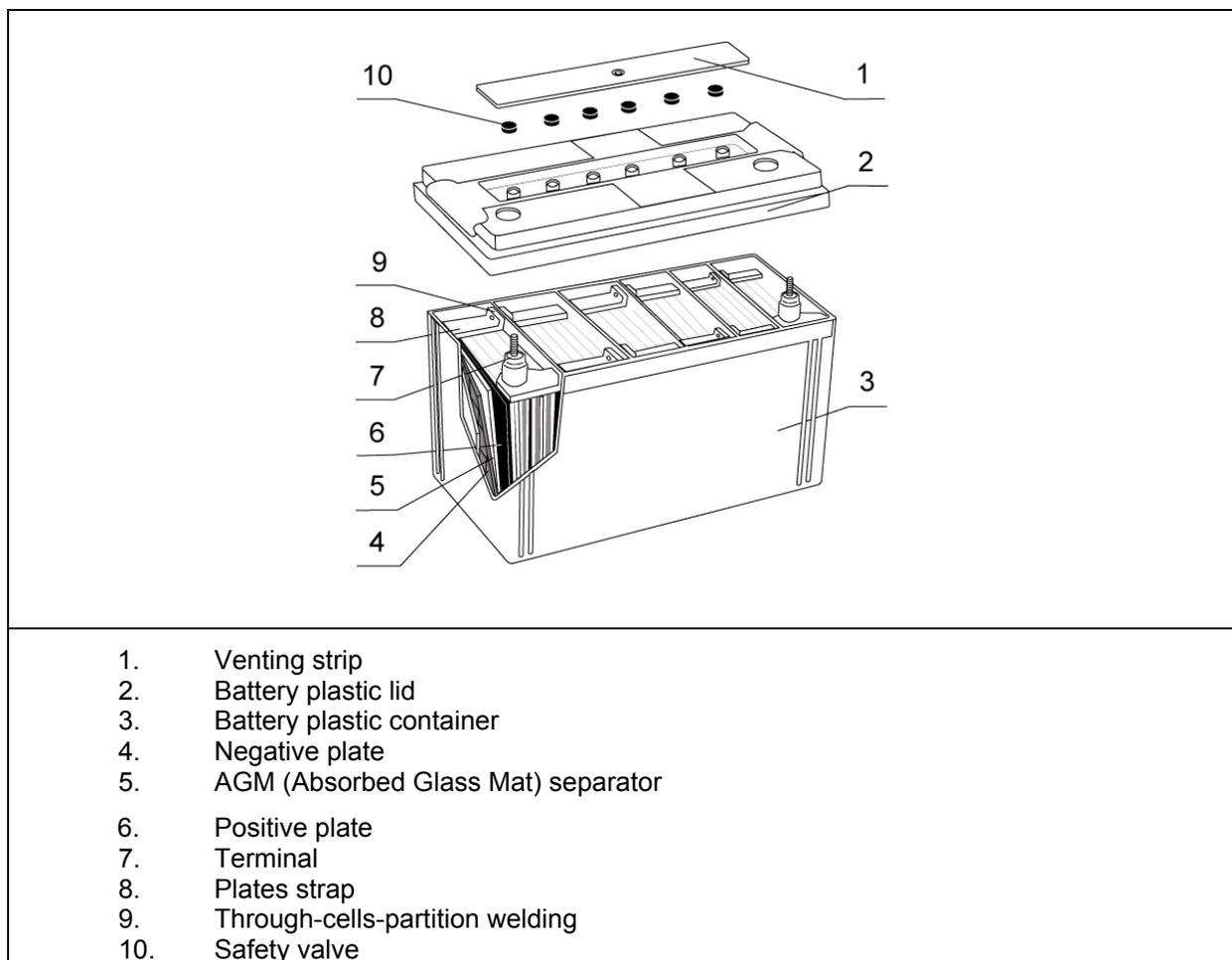
Flame arrestor device

According to each range requirement FIAMM AGM batteries can be supplied with a flame arrestor device on the lid cover. This kind of porous disk ensures a total prevention against sparks or flames from entering the battery.

Terminal posts

FIAMM AGM batteries have either threaded post design ('male' or 'female' pole) or flag post design for an easy connection to other batteries or to the system' mains. Fiamm's seal design, built to prevent any possible leakage, has a very long service history over a wide range of environmental conditions and cycling. Intercell connections in monoblocks are electrically welded to minimize the internal resistance while maintaining a complete separation of each single cell.

FIG.2 – FIAMM AGM BATTERY CUTAWAY DRAWING



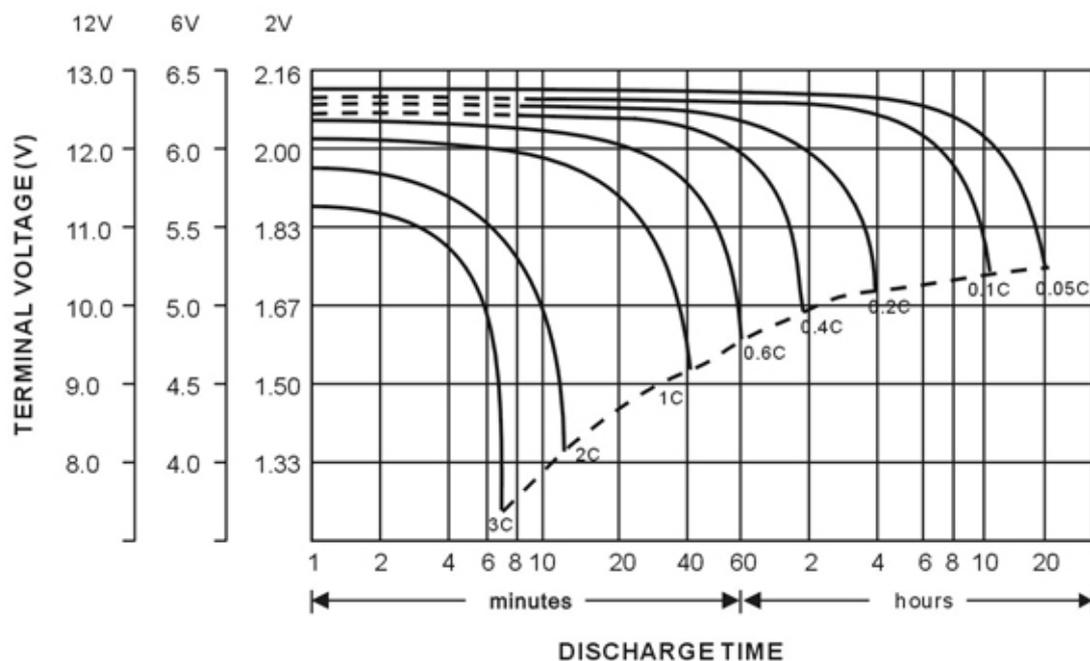
6 OPERATING FEATURES

Capacity and final discharge voltage

Battery capacity is rated in Amperes per hours (Ah). Nominal capacity is usually declared according to discharging rate of C10 (10 hours to 1.80 volt per cell at 20° C) or C20 (20 hours to 1.75 volt per cell at 25° C) for different applications.

Battery can be discharged to lower voltage using higher discharge current or vice versa. In figure 3 there are few possible design curves.

FIG.3 – DISCHARGE CURVES AT DIFFERENT CURRENT/FINAL VOLTAGE



Internal resistance and short circuit current

The internal resistance and short circuit current of a battery are functions of its construction design, plate thickness, number of plates, separator material, electrolyte specific gravity, temperature, state of charge and other variables.

Their values are determined model by model performing a test according to the method described in IEC or BS standards.

Voltage

The voltage of lead acid cells is related to the electrochemical potential difference in between the active electrode materials (PbO_2 and Pb) in the presence of electrolyte (sulphuric acid). Its value depends on the electrolyte concentration in contact with these electrodes and the state of charging of the battery.

Design life

According to the main international standards a battery is considered at the end of its service life whenever delivering less than 80% of its nominal capacity. The expected service life of FIAMM AGM batteries is in accordance with Eurobat Guide's different categories. Confirmation of service life comes not only from a consistent feed-back from the field, but also from an extensive basis of accelerated thermal testing based on Arrhenius equation.

Operation at temperature higher than 20°C reduces life expectancy according to the table in figure 5. Service life of the battery is affected as well by the floating voltage range chosen for the charging as showed in figure 6.

FIG.5 – EXPECTED SERVICE LIFE VS WORKING TEMPERATURE

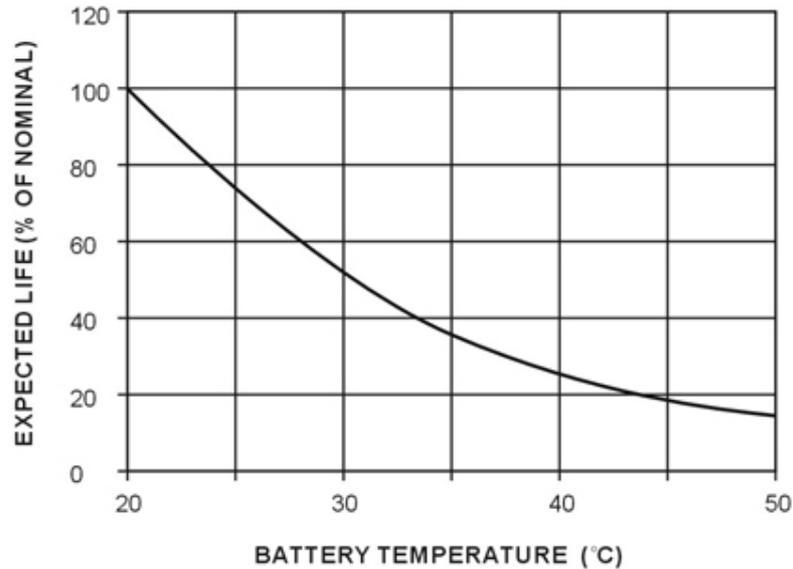
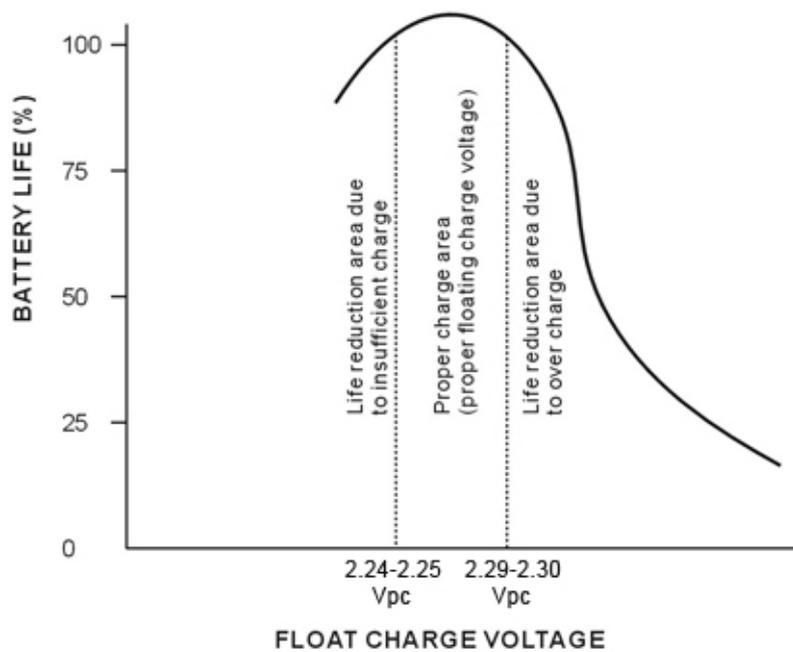


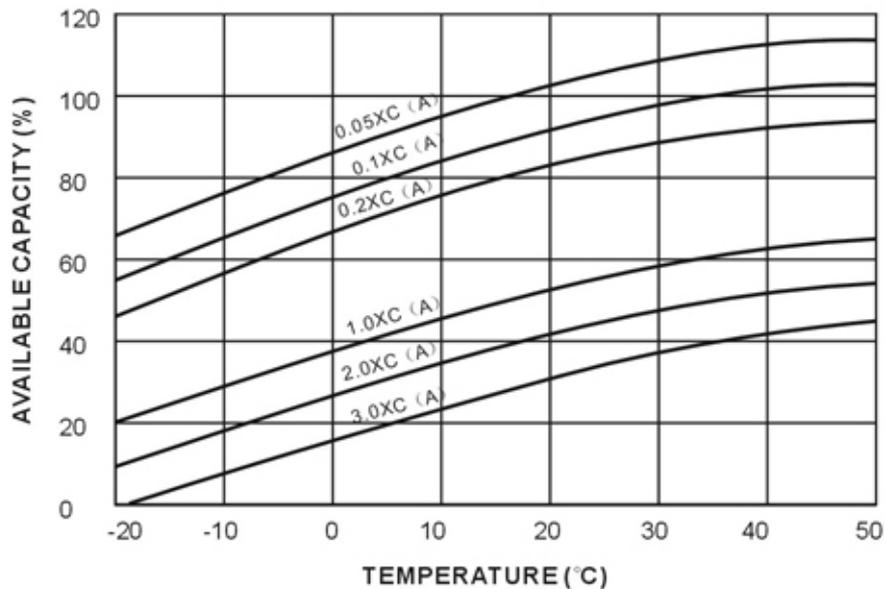
FIG.6 – EXPECTED SERVICE LIFE VS FLOATING VOLTAGE RANGE



Capacity in relation to the temperature

The capacity available from a battery, at any particular discharge rate, changes according to the working temperature. The following graph in figure 7 shows the available capacity at different temperatures versus discharge rates.

FIG.7 – AVAILABLE CAPACITY VS WORKING TEMPERATURE



Capacity in relation to the discharge rate

The capacity available from a battery depends also on the rate of discharge. For Fiamm AGM batteries at 20°C please refer to table 1.

Table 1 – AVERAGE CAPACITY VS DISCHARGING RATIO

DISCHARGE RATE (hours)	END VOLTAGE	CAPACITY (% of C20 Ah)	CAPACITY (% of C20 Ah)	CAPACITY (% of C10 Ah)
		SSP	SP	SLA, GM, UMTB, FFT, FIT
20	1.75	100	100	105
10	1.80	90	90	100
5	1.80	85	85	87
3	1.80	77	75	75
1	1.75	63	61	61

Self discharge

The state of charge of lead acid batteries slowly decreases on open circuit due to self discharge. In FIAMM AGM batteries, the rate of self discharge is approximately 2% per month at 20° C (+/- 5° C). In case of extended storage it is necessary to refresh the batteries every 6 months to avoid a permanent loss of capacity.

Cycling

FIAMM AGM batteries have been tested successfully according to the latest cycle life test specified in the main standards for VRLA batteries (IEC and BS).

Gassing and Remote Venting System (RVS)

Having a very high recombination efficiency (>99%), for batteries operated at 20°C under normal operating conditions, gas release is virtually negligible. Laboratory test measurements show the following gassing rates:

- 2 ml/Ah/cell/month at a float voltage from 2.25 up to 2.27 Volt per cell;
- 3 ml/Ah/cell/month at a float voltage between 2.28 and 2.30 Volt per cell;
- 10 ml/Ah/cell/month at a recharge boost voltage from 2.35 up to 2.40 Volt per cell.

Even if the quantity of gas released through operating valves, consisting by 80-90% of hydrogen, is almost negligible, batteries rooms or cabinets should have a natural ventilation and they should not be fully sealed. In case of specific requirement FIAMM AGM batteries can be customized with a Remote Venting System to avoid any gas releasing inside batteries installation site.

Operation of batteries in parallel

When the required capacity exceeds the capacity of a single string of batteries, it is possible to connect more strings in parallel, paying attention to the following guidelines:

- in each string only batteries of the same type, model and quantity should be used;
- a symmetrical layout of the batteries should be designed (i.e. length and type of connector) to minimize possible resistance variations;
- number of strings in parallel should be reasonable in terms of layout and application. Usually 4 strings could be connected in parallel, anyway depending on string voltage and cables length, a higher number of strings could be safely connected to reach required total capacity.

7 INSTALLATION

Unpacking and inspection

Upon receiving a shipment of batteries it is advisable to check it carefully against related packing list. Even though each consignment is certified and inspected by manufacturer before delivering, missing parts or damages could be caused by mishandling during transportation. Any damage or any specific problem found must be reported immediately by the consignee to the carrier and to the manufacturer for further insurance or legal actions.

FIAMM AGM batteries are shipped fully charged with terminal posts insulated to avoid any possible short circuit.

Batteries delivered in cabinets

For safety reasons, it is not advisable to pre-assemble batteries strings into cabinets before despatching equipment to the site. However, if this is necessary, it is strongly recommended to protect the battery system from mechanical stress and vibrations occurring during transportation. Batteries should be properly fastened to the relevant cabinet shelves by means of plastic band and/or other adequate methods. Furthermore the cabinets should be protected using shock-absorbing packaging material. Special precautions must be taken to avoid accidental short circuits.

Handling requirements

Batteries are heavy so they require a proper care in handling. Always lift each single cell/block from underneath or whenever available by the lifting handles. Never apply force to, or drop anything on the terminal posts: doing so the threads or the sealing of the terminal posts may be damaged.

Room Requirements

Batteries should be installed in a clean, cool, dry room on insulated racks or cabinet. Care must be taken in providing adequate floor loading capability and sufficient aisle space for servicing. Good lighting is also important to carry out visual inspections. Access to the battery room must be restricted to qualified personnel only.

Ventilation in batteries room

Under normal operating conditions, the gassing rate of AGM VRLA batteries is extremely low. No acid fumes are emitted. However, the battery room should have sufficient ventilation to avoid temperature rising in case of unexpected events such as overcharge due to charger malfunction. As an accelerated recombination reaction generates heating, it is important that there is an easy dissipation allowance in the installation site.

Temperature control in batteries room

Battery life and performance are optimal at a temperature of 20-25°C. Operation at lower temperature will reduce temporarily available capacity (for the period of time that the battery remains at low temperature). Higher operating temperatures do not affect battery performances but will shorten battery service life. Air circulation within the battery room must be sufficient to avoid hot or cold spots. The total temperature spread between the hottest and the coldest cell of the same string should be maintained inside a narrow window of 3°C.

Racks

Battery racks should be made by resistant and insulated material. They should be installed as level as possible for safety reasons. The depth and the height of the racks, along with servicing headroom, should allow both an adequate ventilation and a satisfactory servicing.

Cabinets

Good ventilation is extremely important for battery cabinets. Ventilation openings should be both at the bottom of the cabinet, and as close as possible to the top, to prevent any hydrogen accumulation in an abusive situation. Cabinets should be placed/fastened steadily to the floor.

Blocks placing procedure

For a proper installation clean the blocks with a soft dry antistatic cloth or soft water-moistened cloth. Place first each cell/block at their correct position according to the electrical layout. Start with the lowest shelf to ensure stability. Carefully preserve the exact sequence: positive, negative, positive, negative throughout the whole string. Inter-tier and inter-row connections should be applied only once all blocks have been connected properly. It is advisable to ensure an inter-block empty space (5-15 mm) for a proper ventilation.

Interblock connecting procedure

It is extremely important to ensure a proper surface contact between batteries terminal post and cables or rigid connectors used to complete each string. So each connecting surface must be clean and without oxidation. In case it is required a specific cleaning just use very fine grit abrasive paper to remove any dirty on each surface. Don't use wire brushes or similar tools that may damage the plating film around terminals' and connectors' copper.

Installation Layouts

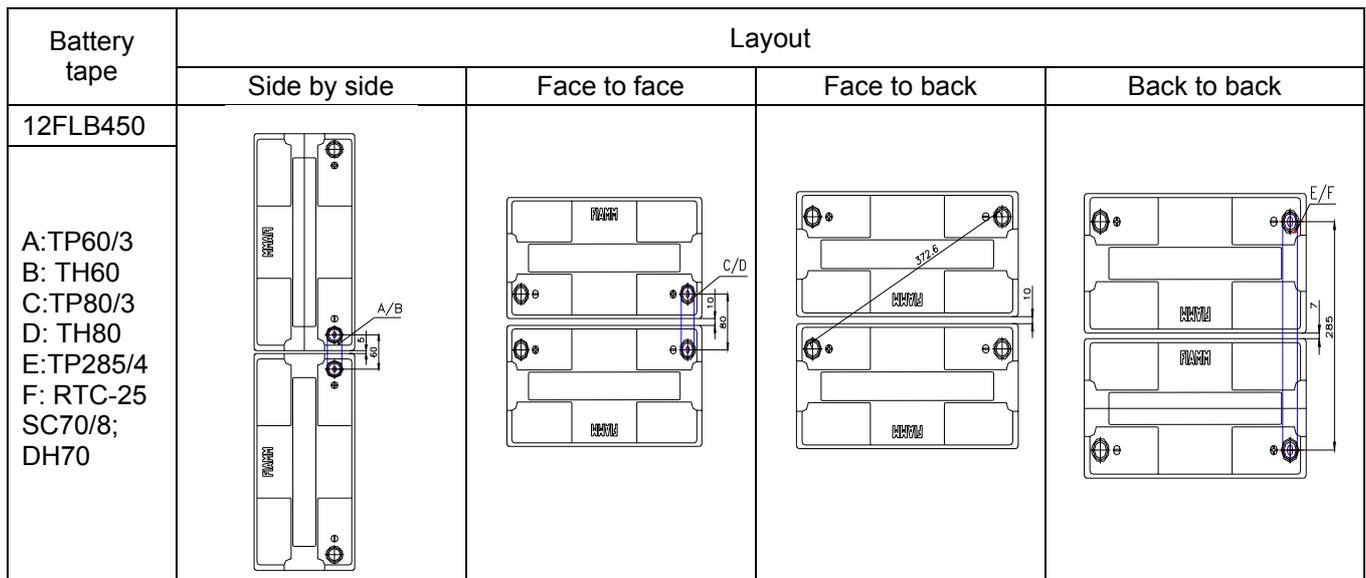
Battery type	Layout			
	Side by side	Face to face	Face to back	Back to back
12SP26/ 12FLB100 A: TP47/2-M6 B: TH47 C: FC400/25-6 D: DH25 SC25/6; DH25 L: 166mm W: 175 T.H.: 125				
12SP33 A: TP47/2-M6 B: TH47 C: TP70/2-M6 D: TH60 E: FC400/25-6 F: DH25 SC25/6; DH25 L: 198mm W: 130 T.H.: 178				
12SP40/ 12FLB150 A: TP47/2-M6 B: TH47 C: FC400/25-6 D: DH25 SC25/6; DH25 L: 197mm W: 165 T.H.: 170				
12SP55/ 12FLB200 A: TP60/2-M6 B: TH60 C: TP70/2-M6 D: TP220/2-M6 E: RTC-25 SC25/6; DH25 L: 229mm W: 138 T.H.: 211				

Battery type	Layout			
	Side by side	Face to face	Face to back	Back to back
12SP70/ 12FLB250 A: TP60/3 B: TH60 C: TP80/3 D: TH80 E: TP264/3 F: RTC-25 SC50/8; DH50/P L: 272mm W: 166 T.H.: 195				
12SP70L A: TP70/3 B: TH60 C: TP60/3 D: TP300/3 E: RTC-25 SC50/8; DH50/P L: 325mm W: 166 T.H.: 174				
12SP80 A: TP60/3 B: TH60 C: TP92/3 D: TH92 E: TP257/3 F: RTC-25 SC70/8; DH70 L: 260mm W: 169 T.H.: 212				
12SP90/ 12FLB330 A: TP70/3 B: TH60 C: TP92/3 D: TH92 E: TP257/3 F: RTC-25 SC70/8; DH70 L: 305mm W: 168 T.H.: 212				

Battery type	Layout			
	Side by side	Face to face	Face to back	Back to back
12SP100 A: TP70/3 B: TH60 C: TP100/3 D: TH100 E: TP257/3 F: RTC-25 SC70/8; DH70 L: 329mm W: 172 T.H.: 221				
12SP120 A: TP80/3 B: TH80 C: TP275/3 D: RTC-25 SC70/8; DH70 L: 407mm W: 173 T.H.: 225				
12SP135/ 12FLB500 A: TP92/3 B: TH92 C: TP100/3 D: TH100 E: TP257/3 F: RTC-25 SC95/8; DH95 L: 345 W: 172 TH: 221				

Battery tape	Layout			
	Side by side	Face to face	Face to back	Back to back
12SP150 A: TP100/4 B: TH100 C: TP70/4 D: TH60 E: TP280/4 F: RTC-25 SC95/8; DH95 L: 485mm W: 170 T.H.: 241				
12SP200 12SP230 A: TP128/4 B: TH128 C: FC1000/ 95-8 D: DH95 SC95/8; DH95 L: 520mm W: 260 T.H.: 214				

Battery type	Layout			
	Side by side	Face to face	Face to back	Back to back
12FLB300 A: TP60/3 B: TH60 C: TP80/3 D: TH80 E: TP285/4 F: RTC-25 SC70/8; DH70				
12FLB350 A: TP60/3 B: TH60 C: TP80/3 D: TH80 E: TP285/4 F: RTC-25 SC70/8; DH70				
12FLB400 A: TP60/3 B: TH60 C: TP80/3 D: TH80 E: TP285/4 F: RTC-25 SC70/8; DH70				



Terminal torque settings

To ensure a tight electrical contact between the flat surface of each terminal and the connector avoiding any damages by an excessive torque strength, a torque spanner set as per Table 2 should be available during installation.

Table 2 – TORQUE SETTING VALUES

Terminal type	Torque value (Nm)
M6 Female	5-6
M8 Female	8-9
M10 Female	20-25

Rigid Connectors

On the Table 3 there are all the dimensional features, code and features of the rigid connector. The type is indicated also on the rigid connector itself to facilitate the installation procedure.

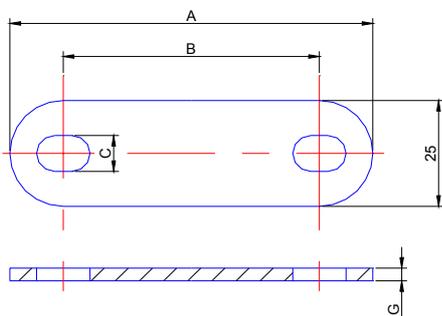


Fig. A

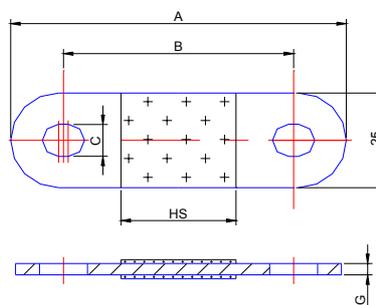


Fig. B

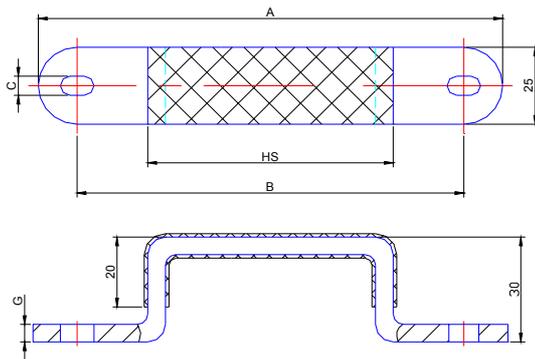


Fig. C

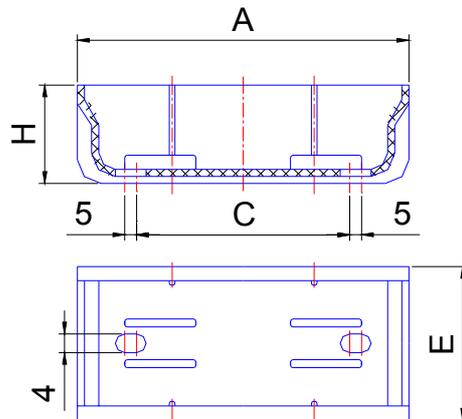
Material: Lead or Tin plated copper
 HS: Black Heat-shrinking protection

Table 3 – Rigid Connector features and code

Code	Type	Fig.	A	B	C	G	HS	Battery Models
9104110	TP47/2-M6	A	70	47	6.5	2	/	12SP26; 12SP33; 12SP40 12FLB100; 12FLB150
9104112	TP60/2-M6	A	85	60	6.5	2	/	12SP55; 12FLB200
9104113	TP70/2-M6	A	95	70	6.5	2	/	12SP33; 12SP55; 12FLB200
9104116	TP220/2-M6	B	245	220	6.5	2	195	12SP55; 12FLB200
9104311	TP60/3-M8	A	85	60	8.5	3	/	12SP70;12SP70L;12SP80; 12FLB250;12FLB300;12FLB350; 12FLB400;12FLB450
9104312	TP70/3-M8	A	95	70	8.5	3	/	12SP70L; 12SP90; 12SP100 12FLB 330
9104313	TP80/3-M8	A	105	80	8.5	3	/	12SP70; 12SP120;12FLB250 12FLB300;12FLB350;12FLB400; 12FLB450
9104314	TP92/3-M8	A	117	92	8.5	3	/	12SP80; 12SP90; 12SP135 12FLB330; 12FLB500
9104315	TP100/3-M8	A	125	100	8.5	3	/	12SP100; 12SP135;12FLB500
9104319	TP257/3-M8	B	282	257	8.5	3	232	12SP80; 12SP90; 12SP100 12SP135; 12FLB 330; 12FLB 500
9104321	TP264/3-M8	B	289	264	6.5	3	239	12SP70;12FLB250
9104320	TP275/3-M8	B	300	275	8.5	3	250	12SP120
9104322	TP300/3-M8	C	325	300	8.5	3	275	12SP70L
9104316	TP70/4-M8	A	95	70	8.5	4	/	12SP150
9104317	TP100/4-M8	A	125	100	8.5	4	/	12SP150
9104318	TP128/4-M8	A	153	128	8.5	4	103	12SP200
9104323	TP280/4-M8	C	305	280	8.5	4	255	12SP150
9104324	TP285/4-M8	B	310	285	8.5	4	260	12FLB300;12FLB350;12FLB400; 12FLB450

Rigid Connector Covers

On the Table 4 there are all the dimensional features, code and features of the rigid connector.



Material: ABS Colour: Black

Table 4 – Rigid Connector Covers

Code	Type	Rigid Connector Type	Inter-holes Distance (mm)	Length (mm)	Height (mm)	Width (mm)	Battery Models
			C	A	H	E	
9105017	TH47	TP47/2-M6	47	77	15	30.8	12SP26; 12SP33 12SP40, 12FLB 100 12FLB150
9105018	TH60	TP60/2-M6 TP70/2-M6 TP60/3 TP70/3 TP70/4	60	100	21	32.8	12SP33; 12SP55 12SP70; 12SP70L 12SP80; 12SP90 12SP100; 12SP150 12FLB200 ;12FLB250; 12FLB300;12FLB330 12FLB350;12FLB400 12FLB450
9105019	TH80	TP80/3	80	120	21	32.8	12SP70; 12SP120 12FLB250;12FLB300 12FLB350;12FLB400 12FLB450
9105020	TH92	TP92/3	92	120	21	32.8	12SP80;12SP90; 12SP135;12FLB330; 12FLB500
9105021	TH100	TP100/3 TP100/4	100	130	21	32.8	12FLB500; 12SP100 12SP135; 12SP150
9105022	TH128	TP128/4	128	168	21	32.8	12SP200

Final checking of connections

To perform a final checking of the connection procedure it is advisable to measure the overall battery voltage and make sure that this value is equal to the open circuit voltage of an individual block multiplied by the number of blocks.

Paste a sticker with a progressive number to each block, making sure that the surfaces are dry and clean. It is a good practice to number the blocks beginning with #1 at the positive end of each string.

Connection of the battery to the rectifier/load

The end positive terminal of each string of batteries should be connected to the positive terminal of the charger, and the battery negative to the charger negative. Same procedure needs to be used for load connections. A proper section in cables and connectors should be used to avoid excessive drop voltage, as well as overheating in case of high rate discharge. If large section cables are used their weight should not stress cell/block terminals. A good method to use is to fix cables on the rack or the nearby wall.

8 FLOATING AND CHARGING

Introduction

After installation, in order to ensure the best protection against power failures in any moment, it is necessary that batteries are kept in the following conditions:

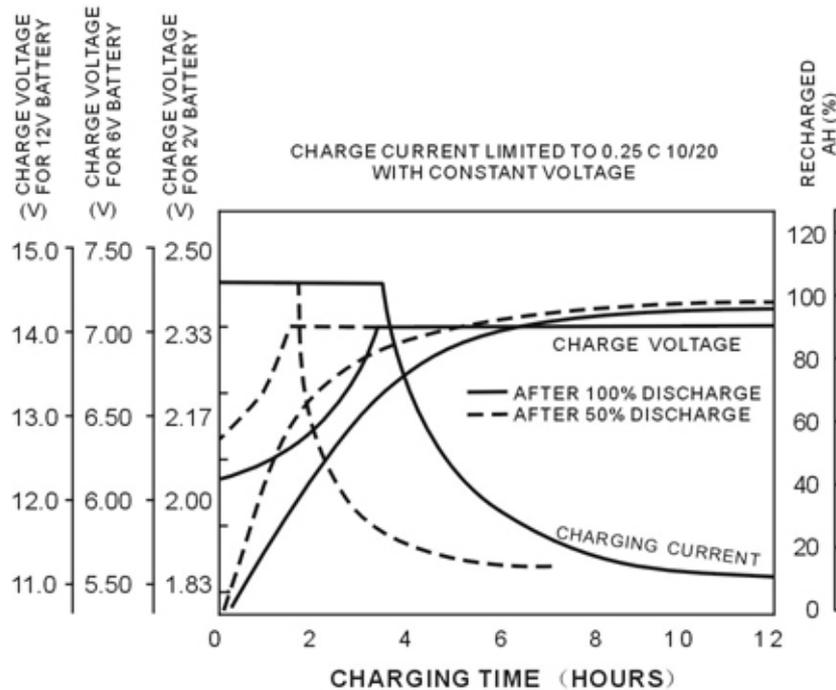
- in float charging throughout all their standby period;
- fully recharged soon after a discharge.

Recharging process can be performed in several ways, depending on the site and equipment conditions, but there are two main methods:

- floating voltage recharge
- boost charge

The IU recharge method, also known as modified constant potential, has been used for many years and in a variety of applications, as it combines the need of having the battery quickly recharged while ensuring maximum battery life. With this method, recharge starts at a constant current rate. The voltage increases up to a pre-set value. The pre-set voltage is maintained and the current then decreases to a minimum defined value. Finally, the recharge is completed at a final constant voltage value equal to or less than that defined for float charge with the current decreasing to the value used in float.

FIG.8 – IU CHARGING CURVES



Recommended procedure for initial charging

For a safe installation of FIAMM AGM batteries only constant voltage chargers should be used. It is as well important to recharge VRLA batteries using methods which do not cause excessive water loss through gas releasing. The best charging method operates with a preset constant voltage value supplying an automatically limited charging current. It is called constant voltage charging with current limit and automatic crossover.

A boost charge for at least 48 hours (at 20°C) is suggested during commissioning or before a capacity test in order to be sure that the battery is in fully charge condition.

Float operation for standby use

For standby applications the recommended floating voltage window is between 2.25 to 2.30 volt per cell depending on model and on site temperature, as showed in table 3 (charger's floating voltage tolerance is within ± 0.005 volt per cell).

Charging current should be set up in a range between 5% and 25% of each model's nominal capacity (never exceeding anyway 30%, i.e. 30Amps for a 100Ah block).

Table 3 – FLOATING VOLTAGE FOR STANDBY APPLICATIONS

RANGE	FLOATING VOLTAGE AT 20°C (Volt per cell +/- 0.005 V)	FLOATING VOLTAGE AT 25°C (Volt per cell +/- 0.005 V)
SP-FLB	2.28	2.27

Residual current

Whenever batteries charger is working properly according to manufacturer instructions it is normal to have a residual float current in fully charged batteries (see table 4). Residual floating current anyway may vary during batteries life and according to cycles frequency. Although the charger is set on a fixed average voltage, it is normal to record a spread in voltage between each block inside a string. Voltage variation within ± 60 mV/cell is considered as a normal value particularly in the first 12 months from initial installation.

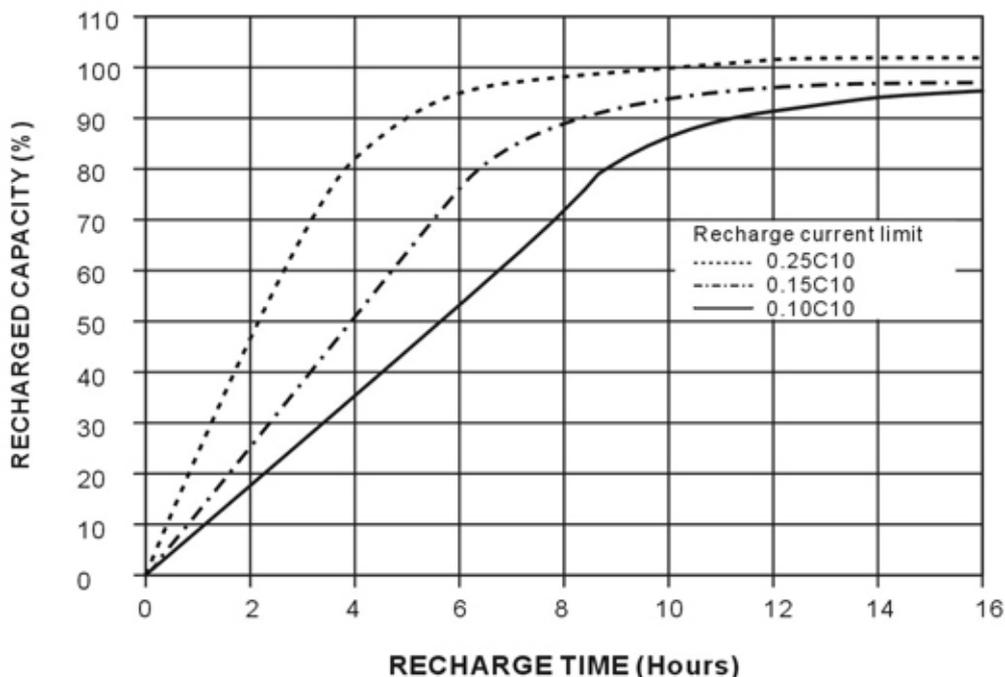
Table 4– RESIDUAL AVERAGE CURRENT IN CHARGED BATTERIES DURING FLOATING

RANGE	RESIDUAL CURRENT (mA/ Ah at 20-25 C)
SP-FLB	0.35

Recharge following discharge for standby use and boost charge

At the first installation or soon after a discharge the recommended recharge method is to use a constant voltage equal to the float charge voltage with a maximum charge current of 25% of nominal capacity. Using this procedure, the recharge times at different values of maximum current, are shown in figure 9. To reduce the recharge time, the IU recharge method can be used with a higher voltage of 2.35-2.40 V/cell at 20°C and a current limit of 0.25 C₁₀. This process, called also boost charge, should be applied only when batteries are not in fully charge conditions and need to be recovered in a short time. The battery should be placed back on floating as soon as possible, ideally as soon as the charge current has dropped below 20 mA/Ah (or lower if the application has frequent power failures). Boost charge should be used only when necessary. Frequent equalizing charge can result in more water consumption, which will lead to reduced capacity and shortened battery life.

FIG.9 – RECHARGE CURVES AT DIFFERENT CURRENT LIMIT



Floating voltage and recharge procedures for frequent discharge applications

Whenever FIAMM AGM batteries are used in applications with frequent power failures (such as several discharges a month) float voltage should be set at a higher range compared with standby applications range (i.e. from 2.27 to 2.31 volt per cell at 20-25°C, see table 5). The recommended floating voltage

values to maximize the battery life at different temperature are shown in figure 10. The most important target in this kind of environment is to have batteries recovering promptly after a discharge, in any case before a further power failure.

To reduce the recharge time, the IU recharge method can be used with a maximum voltage of 2.4 V/cell at 20-25°C for 24 hours. Current should not be over than 25% of nominal capacity, especially in sites where temperature may exceeds 30°C to avoid thermal runaway, overheating or overcharging of the batteries.

For very deep cyclic applications recharge voltage should be in the range of 2.40~2.45 V/cell for 16 to 24 hrs after every discharge.

Table 5 – FLOATING VOLTAGE FOR FREQUENT DISCHARGE APPLICATIONS

RANGE	FLOATING VOLTAGE AT 20°C (Volt per cell +/- 0.005)	FLOATING VOLTAGE AT 25°C (Volt per cell +/- 0.005)
SP-FLB	2.29	2.28

Temperature compensation of the float voltage

FIAMM AGM batteries can operate properly within a temperature range of -20 up to +60°C.

To optimise battery life and performance over the normal operating temperature range, the float voltage should be adjusted in accordance with the graph shown in figure 10 and table 6.

In environments where temperature fluctuation is very limited floating voltage could be adjusted manually time by time, but for most of sites without a real climate controlling system it is advisable to have batteries connected to a charger having a built-in temperature compensation circuit.

Temperature sensor needs to be positioned over the batteries and not in the charger.

Table 6 – FLOATING VOLTAGE VS SITE TEMPERATURE

Site Temperature (°C)	Float voltage per cell SP - FLB
16	2.29
18	2.285
20	2.28
22	2.275
24	2.27
25	2.27-2.265
26	2.265
28	2.26
30	2.255
32	2.25
34	2.245
36	2.24
38	2.235
40	2.23

Ripple

Excessive ripple currents can cause battery overheating, which will lead to shorter life expectancy and reduced performances. Therefore it is recommended that voltage regulation across the system (including the load, but with battery disconnected), under steady state conditions, shall be better than ± 1% through 5% to 100% load. Transient and other ripple type excursions can be accommodated provided that, with the battery disconnected but the load connected, the system peak to peak voltage, including the regulation limits, falls within ± 2.5% of the recommended float voltage of the battery. Under no circumstances should the current flowing through the battery, when it is operating under float conditions, reverse into the discharge mode.

9 STORAGE AND REFRESH CHARGING

Storage

Batteries are delivered filled and charged ready for installation. If they cannot be installed immediately, batteries need to be kept in fresh, clean dry rooms.

Refreshing charge procedure

As during storage batteries will lose part of their capacity (figure 11) due to self discharge (2% per month at 20°C), a freshening charge is recommended at least every 6 months (at 20°C storage temperature).

Batteries should be refreshed, even if kept in storage at 20 C, when the cell voltage drops below the values listed in table 7. A freshening charge could be carried out by charging at 2.4 V/cell for about 24 hours at 20°C (boost). If the charging system can not meet the above requirement (lower than 2.4 Vpc, it is necessary to extend the charging time 24 hrs for every 0.03V/cell lower than 2.40V/cell, for example, 120 hours at 2.28 V/cell).

FIG.11- CAPACITY LOSS DURING STORAGE AT DIFFERENT TEMPERATURES

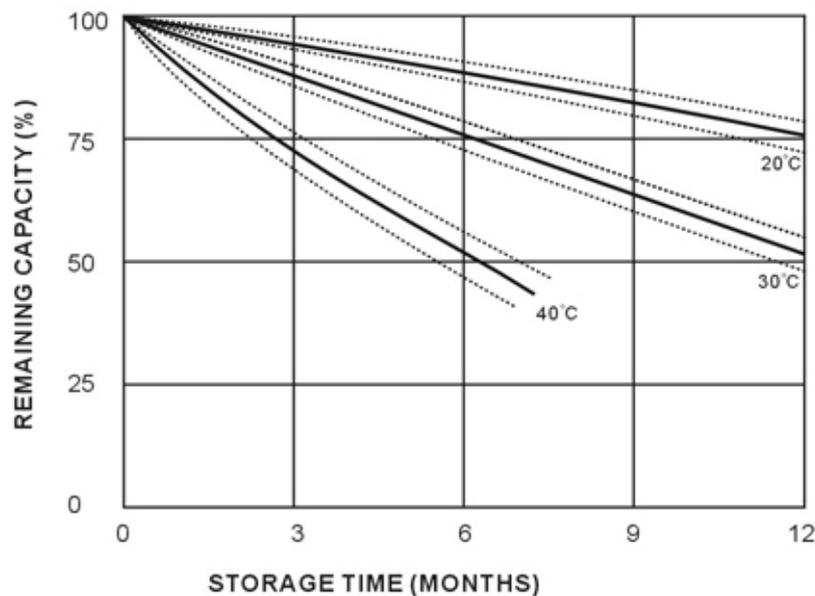


Table 7 – OPEN CIRCUIT VOLTAGE VALUES REQUIRING A RECHARGE (WHEN STORAGE AT 20°C)

RANGE	OPEN CIRCUIT VOLTAGE (PER CELL)	
	SP-FLB	
2 months	2.12	
4 months	2.105	
6 months	2.095	

10 MAINTENANCE AND TESTING

VRLA batteries are maintenance-free with respect to the electrolyte topping-up, but it is important to carry out few standard maintenance procedures to ensure the longevity and the reliability of the battery.

Visual inspection

AGM VRLA batteries should go through a visual inspection on a periodical basis according to user needs to verify following parameters:

- cleanliness of the battery and surrounding area;
- signs of corrosion at the terminals, connections, or support structure (rack or cabinet);
- block integrity (cracks, or excessive jar/cover distortion, or signs of electrolyte leaks or seepage);
- tightness of the connectors fastening.

If any block shows whatsoever physical damage it is necessary to check immediately its floating voltage and/or temperature.

Cleaning

When necessary, batteries could be cleaned using a soft dry cloth or water-moistened soft cloth paying attention not to cause any ground faults.

No detergent nor solvent-based cleaning agents nor abrasive cleaners should be used as they may cause a permanent damage to the battery plastic container and lid .

Voltage checks

All voltage measurements should be made when the whole battery has stabilized on floating, at least 7 days after battery installation or after a discharge cycle. To facilitate voltage reading in the correspondence of each block terminal protection covers are designed with a safe and proper hole.

Measure and record individual block voltages on float once a year. It is normal to have a spread of block voltages up to ± 60 mV/cell, particularly in the first year of operation. No corrective action is required in this case.

Maintaining a correct battery charging voltage is extremely important for the reliability and life of the battery. So it is advisable to carry out a periodical checking of the overall float voltage to verify any possible defect of charger or connections.

Capacity Test

Before any discharging test batteries should be properly prepared with a boost charge to ensure they are in a fully charge condition. In order to take temperature readings of a battery, one pilot cell or block shall be chosen. The surface temperature of the container wall centre of each pilot block shall be measured immediately prior to the discharge test. The individual readings shall be between 15°C and 30°C. The temperature of the selected block shall be considered as representative of the average temperature of the battery. It is desirable that the average basal surface temperature and the ambient temperature fall as nearer to the reference temperature of 20°C or 25°C as possible.

In case of batteries having a capacity lower than 80% of the nominal rating it is advisable to replace them within 12 months.

11 SAFETY

Under normal operating conditions AGM VRLA batteries are considered 'office compatible'. However, under abusive conditions, such as chargers malfunction or physical damages, there is potential danger of corrosion or fire. Therefore it is strongly recommended to read carefully the instructions contained in this manual to avoid any critical situation. In any case local safety regulations for electrical equipment sites must be regarded as a basic requirement.

Protective material list

Make sure that the following equipment is available to personnel working with batteries:

- engineering/installation manual;
- insulated spanners and tools;
- fire extinguishers;
- proper protective clothing.

Safety Precautions

Batteries are no more dangerous than any other equipment when handled properly.

So for safety reasons it is necessary to follow few important precautions below reported:

- do not allow metal objects to rest on the battery or fall across the terminal posts;
- never wear rings or metal wristbands when working on batteries;
- do not try to remove the battery cap to add water or acid into the cell(s);
- do not touch non-insulated terminals or connectors as there is a risk of electric shock;
- do not allow naked flames, hot objects or sparks near the battery;
- do not smoke near the battery or in the battery room.

The electrolyte (diluted sulphuric acid) is extremely corrosive. Any contact with eyes can cause eye damages. Contact with skin could result in severe burns. In case of severe physical contact with electrolyte wash it over with running water immediately and go to the closest hospital to see a doctor.

Decommissioning of the batteries

Most components of the battery are recyclable. Lead acid batteries must be disposed according to the local regulations. It is strongly recommended at the end of their service life to deliver batteries for recycling to a lead smelter.

12 APPLICABLE STANDARDS

FIAMM AGM batteries comply with the main International Standards. Furthermore, FIAMM valve regulated recombination batteries are approved since long by most major Telecom Operators worldwide, as well as by the most important UPS and Power Equipment manufacturers.

13 RECORDS DATA

Complete written records of all installation, maintenance and testing operations are important to ensure a proper understanding of the actual situation of the batteries.

If properly reviewed all the records would be useful for the manufacturer/user to realize when corrective actions should be taken. Main data required for a proper engineering review are production date of batteries, installation date, historical average temperature of the site, floating voltage, discharge frequency, load applied during each discharge.

Battery type: _____

Nominal Voltage (V): _____

Number of cells / monoblocs: _____

Nominal Capacity (Ah): _____

Installed by: _____

Installation date: _____



Only qualified personnel



WARNING! Metal parts of the battery cell are always live. Never place foreign object or tools on the battery



No smoking. No open flame, embers or sparks nearby the battery, to avoid risk of explosion and fire



Wear eye protection and protective clothing when working with batteries.
Observe accident prevention regulations



Accumulators are heavy object. Use lifting aids and proper lifting techniques when removing or replacing.



Observe operating instructions and display it visibly in the vicinity of the battery. Work on batteries only after instruction by qualified staff



HAZARDOUS VOLTAGE Risk of electric shock or burn. Authorized personnel only.



Wear protective gloves and clothing when working with batteries



Electrolyte is highly corrosive.



Splashes in the eyes or in the skin must be washed out or off with plenty of water. Then see a doctor immediately. Acid splashes on clothing should be washed out with water.
Explosion and fire risk, avoid short circuit!

1. Unpacking

Clear the packing material from batteries and accessories, and check that all parts are included. Examine carefully for damage during transit. Damage or loss should be reported immediately to the carrier. The Company or its agents should be informed that this has been done.

2. Storage

The batteries are delivered ready to be installed. Usually no commission charge is requested; only connect in series and/or parallel as requested.
If the monoblocs cannot be installed immediately, they must be stored in a clean, cool and dry place.
For long storage time, the monoblocs must be trickle charged at least every 6 months at 20°C according to the instructions in item 4. Never exceed the 6 months period, i.e. never allow the open circuit voltage of each cell to fall below 2.11 V/cell.

3. Installation

The battery should be installed in a clean, cool, dry room. Care must be taken in providing adequate floor loading capability and sufficient aisle space for servicing. Good lighting is also important for carrying out visual inspections. Access to the battery should be restricted to qualified personnel only

- Place the cells/blocs according to the correct sequence of polarity, starting from lower rack/cabinet shelf. Leave some mm. of free space between cells/blocs.
- Connect cells/blocs using bolt and connectors supplied. Tightening torque for different types of terminals: M6 female = 5-6 Nm; M8 female = 8-9 Nm; M10 female = 20-25 Nm.

If batteries are installed into cabinets, please verify that they comply with Local Standards. The cubicle must have sufficient natural ventilation to avoid rises in temperature, and to remove any gas from the battery

4. Charging

Only constant voltage rectifiers should be used. The recommended floating voltage is 2.28 V/cell at 20°C for FLB and SP. This is also the voltage recommended for refreshing charge. At this voltage value, no current limitation is required, even although it is recommended to reduce the current charge to 25% of the battery nominal capacity (given in Ah). In order to lower the recharging times, it is possible to increase the voltage from 2.27 to max. 2.4 V/cell for maximum 24 hours. When the current charge is reduced to 30mA/Ah the current voltage must be reduced to 2.27-2.28 V/cell. It is recommended to recharge batteries within 24 hours after discharge. Discharge voltage shall not fall below 1.6V/cell. Before any capacity test be sure that battery is in fully charge conditions. We do suggest a recharge at 2.4 volt per cell for other 24 hours. Such recharge method should be limited to avoid shorter battery life.

5. Maintenance

- Keep the batteries clean using an antistatic cloth moistened with clean water. Don't use solvent or abrasive powders.
- Ensure all nuts are firmly tightened.
- This type of batteries don't require any electrolyte topping up during its life.
- Once a year, check and record single cell/bloc voltage and temperature. (voltage difference of ± 60mV/cell are acceptable)

6. Safety

Under normal operating conditions, batteries vent very little gas and emit no acid fumes. They are therefore safer than "vented" or "wet" battery types, and in fact are normally considered to be "office compatible". However, under abusive conditions, such as a charger malfunction or physical damage, the potential exists for explosive gas mixtures to be produced, or for corrosive acid fumes or leaks to be present. For this reason, it is recommended that full precautions be taken at all times when working on batteries. In any case safety standards of the country of installation must be applied.

Protective Equipment

- Make sure that the following equipment is available to personnel working with batteries:
- Instructions manual
 - Tools with insulated handles
 - Fire extinguisher.
 - Wear protective clothing (glasses, gloves, aprons etc...)
 - First aid equipment must be available

Safety Precautions

- Observe the following precautions at all times. Batteries are no more dangerous than any other equipment when handled correctly
- Do not allow metal objects to rest on the battery or fall across the terminals. Never wear rings or metal wrist bands when working on batteries
 - Do not smoke or permit open flames near batteries or do anything to cause sparks
 - Do not try to remove the battery cap to add water or acid into the cell(s).
 - Air exchange must be provided to prevent the formation of explosive hydrogen concentration.

Battery Disposal : Lead acid batteries must be disposed according to the country law. It is strongly recommended to send batteries for recycling to a lead smelter. Please refer to the local Standards for any information

Not compliance with operating instructions , repairs made with other than original parts, make the warranty null and void



Errore.

BATTERY MAINTENANCE REPORT

Installation Date:.....

Battery Location:.....

Battery/Cell Type:.....

Pilot Block No.:.....

Other:.....

MONTHLY READINGS			
Date	String voltage (V)	Pilot cell/block	
		Volts	Temperature (C)

INDIVIDUAL CELL/BLOCK READINGS			
Date:			
Time:			
String voltage (V):			
Charge current (A):			
Block No.	Volt	Block No.	Volt
1		31	
2		32	
3		33	
4		34	
5		35	
6		36	
7		37	
8		38	
9		39	
10		40	
11		41	
12		42	
13		43	
14		44	
15		45	
16		46	
17		47	
18		48	
19		49	
20		50	
21		51	
22		52	
23		53	
24		54	
25		55	
26		56	
27		57	
28		58	
29		59	
30		60	

String Discharged:

Date : Duration :

Date : Duration :

String Equalized:

Date : Duration :

Date : Duration :

Remarks:

Blocks temperature: #01....., #12....., #24.....

Blocks temperature: #36....., #48....., #60.....

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