FIAMM

Industrial Batteries

Industrial Batteries

Solar

Installation & Operating Instructions
Technical Manual

Lead Acid Batteries

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❖ INTRODUCTION

The evolution in the use of renewable energy brought FIAMM to create a range of products specifically designed for give maximum performance in this type of use.

❖ CONSTRUCTION FEATURES

The main construction features of FIAMM batteries for Solar applications are shortly described in the below section.

♦ Plates A

FIAMM Solar lead acid batteries are offered with positive tubular plates to obtain the best performances in term of cycles and battery life.

♦ Containers B

Battery cases and lids are made of a type of different type of plastic material to fit the characteristic of each single technology.

FIAMM Battery range	Type of Container	Container Material
PMF/S	Translucent	Polypropylene
LM/S	Transparent	SAN
SMG/S	Opaque	ABS

♦ Separators

These separators are made of microporous PVC material which assure a good ionic exchange in the electrochemical process.

♦ Electrolyte

The electrolyte is diluted sulphuric acid with a specific gravity below indicated:

FIAMM Battery range	Electrolite
PMF/S	Liquid Diluited Sulphuric Acid
LM/S	Liquid Diluited Sulphuric Acid
SMG/S	GEL structure

Vent plugs / Valves E

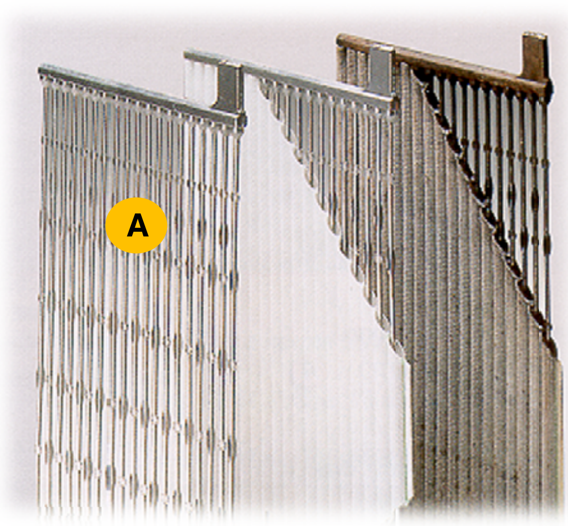
Each cell has one or more plugs to permit the release of gases from the cell during the charging process; the ceramic part prevents explosion of the gases inside the battery; they are fix by bayonet lock or by screw (PMF range).

♦ Terminal posts D

Suitable threaded or flag post are provided to ensure low ohmic losses. Post to lid seals are designed to prevent leakage over a wide range of internal pressures and conditions of thermal cycling.

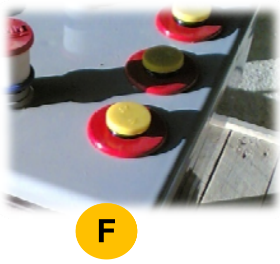
Special plastic terminal caps are provided for transportation assuring a protection against short circuit during transportation. F

♦ Cutaway drawing of FIAMM cells with positive tubular plates



Square Terminal

Female terminal



OPERATING FEATURES

♦ Capacity

The battery capacity is rated in ampere hours (Ah) and is the quantity of electricity which it can supply during discharge. The capacity depends on the quantity of the active materials contained in the battery (thus on dimensions and weight) as well as the discharge rate and temperature.
The nominal capacity of FIAMM Solar batteries refers to the 120 hrs discharge rate (indicated with C_{120}) with constant current at 20°C to 1.85 volt per cell as per CEI EN 61427.

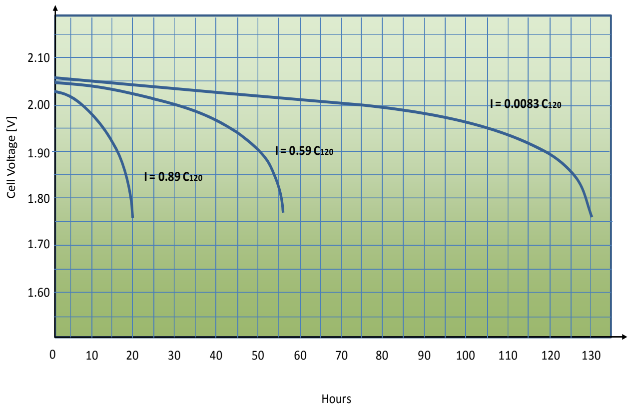


Fig. 1
Tipical discharge curves for FIAMM Solar batteries

♦ Capacity range of FIAMM Flooded Lead Acid Batteries

FIAMM Battery range	Capacity range [Ah]
PMF/S	from 34 to 405
LM/S	from 150 to 5000
SMG/S	from 265 to 3900

FIAMM Battery range	Capacity range [Ah]
PMF/S	Small, medium size photovoltaic application. The availability of multicell container with 6 or 12 volt each assure compact battery arrangement.
LM/S	Medium, Large size photovoltaic application.
SMG/S	Medium, Large size photovoltaic application where maintenance is limited or difficult to provide. .

♦ Capacity in relation to the temperature

The capacity available from a battery, at any particular discharge rate, varies with temperature. Batteries which have to operate at temperatures different from the nominal (20°C) need an higher/lower capacity as per the factor indicated in the following graph (required capacity has to be multiply by the correction factor stated in the graph).

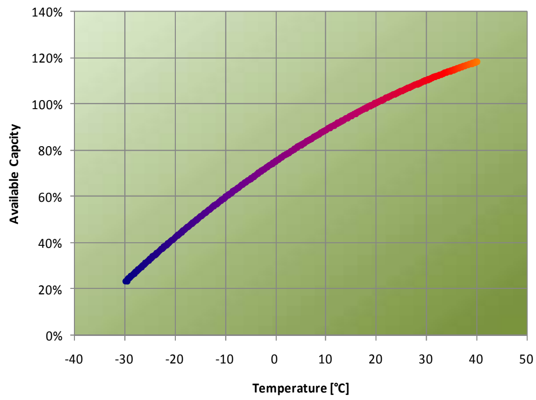


Fig. 3
Capacity Correction factor versus temperature for a 10 hours discharge rate for r FIAMM Lead Acid Flooded batteries

♦ Internal impedance and short circuit current

The internal impedance of a lead acid battery is a direct result of the type of internal construction, plate thickness, number of plates, separator material, electrolyte sp. gr., temperature and state of charge. The internal resistance and the short circuit current of FIAMM flooded at 100% state of charge and 20°C is indicated in the relative Product Sheet. These values are calculated in accordance with IEC 60896 part 11 (LM/S - PMF/S range) and IEC 60896 parts21-22 (SMG/S range).
In the market different instruments are available to detect the internal resistance/impedance of lead acid batteries. These instruments use a different way to determinate these values, in any case can be found small difference with the values stated in FIAMM Product Sheet.

♦ Storage of filled and charged cells

The state of charge of lead acid batteries slowly decreases on open circuit stand due to self discharge. During prolonged storage it is necessary to recharge the battery every 3 months according to the instructions in paragraph "CHARGING" (we suggest a charge at 2.4 volt per cells for 24 hours) to maintain a fully charged condition of the battery; excessive open circuit storage of any lead acid battery without recharge will result in some permanent loss of capacity.

♦ Storage of dry charged cells (only LM/S and PMF/S)

In this situation there is no electrolyte inside the cells so no electrical reaction can take place. In this condition FIAMM batteries can be stored for many years.

♦ Service 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 recommended operating temperature range is between 10°C to 30°C. FIAMM flooded batteries can operate over a temperature range of –20 to +50°C; operation at temperature higher than 20°C reduces life expectancy according to the graph in figure 4.

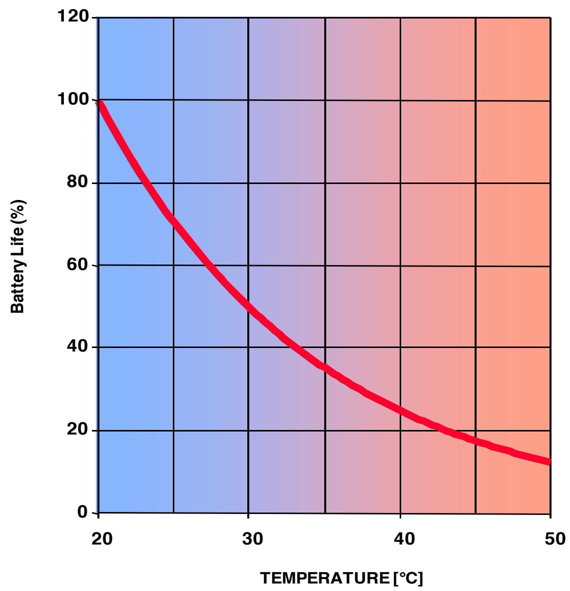


Fig. 4
Expected service life vs working temperature

♦ Gassing

All Lead Acid Batteries emits gases during the charge process. Please refer to “VENTILATION” for information on required air exchange.

♦ 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;
- in the quantity of strings in parallel should be reasonable in terms of layout and application. Usually 4 strings could be connected in parallel, anyway depending on strings voltage and cables length, a higher number of strings could be safely connected to reach required total capacity.

♦ Electrolyte Specific Gravity - State of charge

The measurement of the specific gravity of the electrolyte (when it is at the MAX level) provides an approximate indication of the state of charge of the cells. THIS IS VALID ONLY FOR LM/S AND PMF/S BATTERIES.

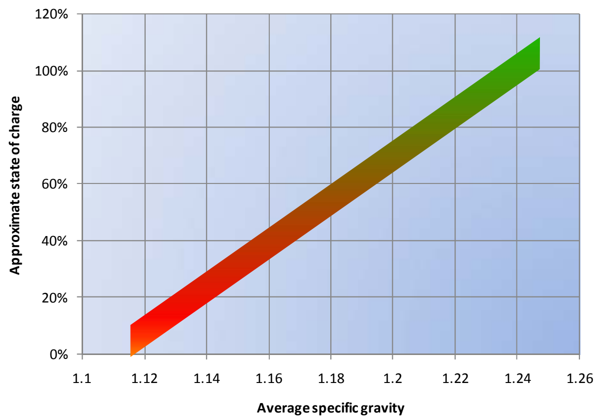


Fig. 5
Electrolyte specific gravity in relation to the state of charge of the cell

Reserve of electrolyte – LM/S, PMF/S range

FIAMM Solar batteries have been designed with large reserve of electrolyte over the plates which offer a very large reserve of electrolyte limiting the topping up intervals

Water consumption LM/S – PMF/S range

Water consumption, in battery for solar application is usually higher than normal; the following graph gives an indication of water refilling at different conditions.

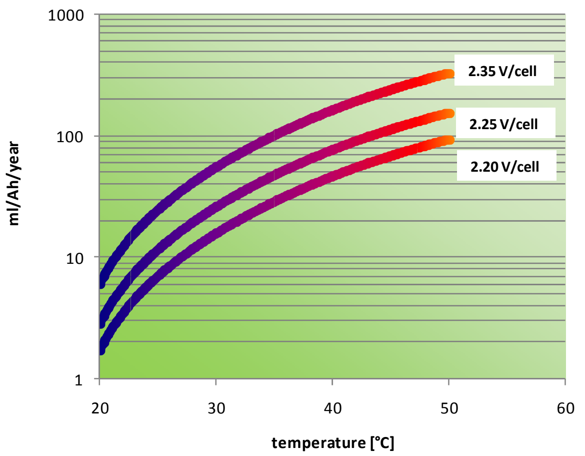


Fig. 4
Expected water consumption for new battery at different voltages and temperatures

Cyclic life

Cyclic life depends on many factors which could affect negatively the battery life; the following graph give you some information on the expected cyclic life based on laboratory test.

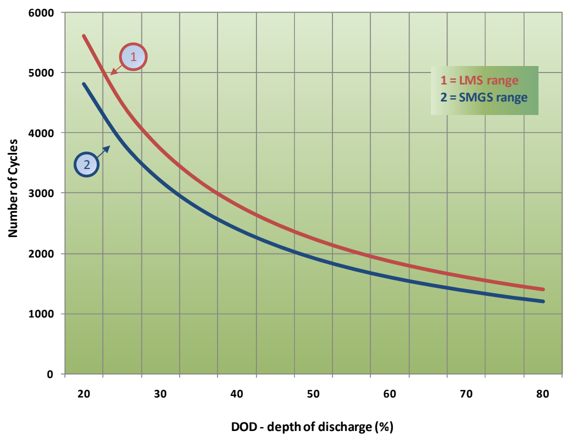


Fig. 5 Expected number of cycles at 20°C

❖ COMMISSIONING CHARGE / FIRST CHARGE (LM/S-PMF/S Range)

LM/S and PMF/S FIAMM Battery ranges belong to Lead Acid Flooded technology and they can be supplied in two different conditions:

- Dry Charge Cell
- Filled with electrolyte

Dry charge cells can be storage for long time (many years).
Filled and charged cells should be installed and connected to a rectifier within 3 months.

Be sure that ventilation equipment is on when charging a battery.

Dry charge cells

Electrolyte obtained locally. Please refer to paragraph “electrolyte” for information about specific gravity for first filling and impurities; we recommend that an additional 10% spare is purchased to allow for losses and spillage when handling and filling.
Electrolyte supplied by FIAMM. Check the specific gravity of the electrolyte before filling the cells. Minor adjustments may be made by adding water to lower the specific gravity or by adding acid to raise the specific gravity.

1. **Filling the cells**. It is recommended that the cells are filled with electrolyte after installation on battery racks.
2. The quantity of electrolyte required to fill each cell is given “product sheet” document.
3. Remove vent plugs.
4. Fill with the electrolyte. Use glass or plastic jugs and funnels for filling the cells. DO NOT use metallic materials.
5. Fill the cells with electrolyte to the "MAX" level line and leave to allow the acid to soak into the separators and plates.
6. In case of electrolyte spilling, neutralize it using 1kg of soda to 10 litres of water. Be careful, the soda DOES NOT entry in the cells.
7. After approximately 3 hours, if necessary, top up the electrolyte to the "MAX" level line.
8. Give the initial charge as soon as possible after 3 hours stand, cells must not stand longer than 18 hours before initial charge is started.
9. Take individual cell readings of voltage, specific gravity and temperature before starting initial charge.
10. **Charge the battery** setting the rectifier voltage at Vn where Vn = 2.7 x N (N= number of cells connected in series).
    Charge with a current rate to 0.10 C10 Amps for approx. 15 to 16 hours. Higher or lower current will reduce or increase the recharge time. During charging it is suggested that voltage as well as sp. gr. readings are taken at least at 3 hour intervals. Voltage readings should be taken on each cell whilst sp. gr. may be taken on sample cells (one out of five).
11. At the end of this process, the Ah delivered to the battery must be 1.5 to 1.6 times the C10 rated capacity (i.e. 150 to 160 Ah for a 100 Ah cell).
12. set the battery voltage to the FIAMM recommended float voltage.

Filled and Charged Cells

For batteries which have been supplied in a filled and charged condition, we suggest a charge at 2.4 volt per cells for 24 hours (set rectifier at 2.4 x N ; N= number of cells connected in series).
The initial charge may be terminated when the specific gravity readings of all cells have remained constant for at least 2 hours.

Alternatively a constant current equal to 5% to 10% of the cell Ah capacity should be used. Using this method, the charging time will be reduced.

In all cases the cells must have constant voltages and specific gravities for at least two hours before the charge is complete.

At the end of this initial charge, set the battery voltage to the FIAMM recommended float voltage.

Important notes

<u>Make sure that the electrolyte temperature does not exceed 40°C during the charge process</u>. Should the electrolyte temperature exceed 40°C then decrease the charging current to a lower rate (half the current) or discontinue the charger. In this case allow to stand on open circuit until the temperature falls to 35°C. After that the charging process has to be resumed.

Charging is to be regarded as completed when:

- the gravity readings in the cells have reached the nominal specific gravity (see product sheet of specific battery range)
- the cell voltages is equal or greater than 2.6 VPC
- the values of individual cell voltage and specific gravity must remain constant for at least two more hours under charge.

❖ CHARGING

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.

Shallow Cycle

In this case only few shallow cycles are requested from the battery and so the recharge can be set at the floating voltage value. The "float" setting will maintain the battery in a fully charged state with minimal water consumption. The recommended float voltage setting for FIAMM lead-acid cells is indicated in the following table:

Cell type	Float Voltage at 20°C
PMF/S, LM/S	2.23 Volts per cell
SMG/S	2.23 Volts per cell

The nominal voltage to apply to the batteries should be number of cells connected in series multiplied by cell float voltage.
For float voltages below what is indicated in the above table, periodic equalizing charges should be given.

III. Deep Cycle-Standby (few deep cycles, mainly float)
IV. Deep Cycle - Little Float (predominantly deep cycling)

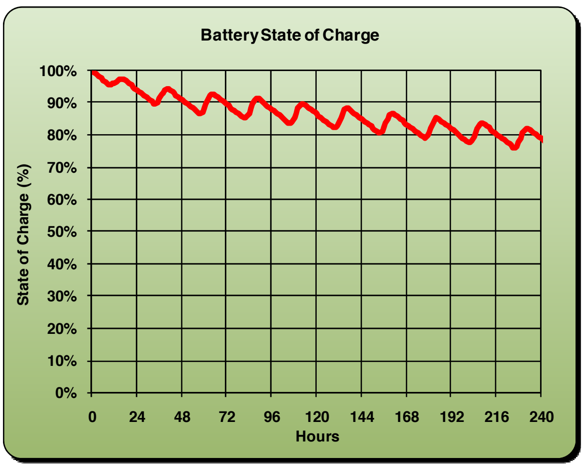
Temperature compensation (SMG/S cells)

The ion exchange between the plate and electrolyte is conditioned by the temperature. The charging voltage must therefore be compensated by a value equal to 2.5 mV for °C as indicated in the following table :

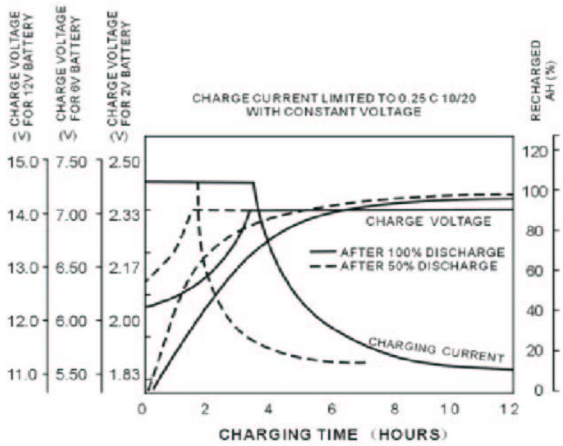
TEMP. °C ELECTROLYTE	FLOAT VOLTAGE PER CELL	TEMP. °C ELECTROLYTE	FLOAT VOLTAGE PER CELL
-10	2,305	25	2,218
0	2,280	30	2,205
5	2,268	35	2,193
10	2,255	40	2,180
15	2,243	45	2,168
20	**2,230**	50	2,155

♦ Deep Cycles

In solar-type/cyclic applications, many different situations could occur because it is not possible to fix recharge time, and discharge time, so very often the battery is not in fully charge conditions and a typical situation is indicated in the graph below.



The battery capacity decrease cycle by cycle in these applications and a periodical boost charge is suggested to restore the full capacity. Because usually there is not fixed data it is difficult to indicate how often to fully recharge the battery. We could suggest monthly but it depends from discharge/recharge amperhours profile of the system. Use a constant voltage between 2.35 to 2.4 V/cell at 20°C with a maximum current of 0.25 C_{10}. However this recharge should be limited to ensure the maximum service life of the battery.



♦ Equalize voltage (only LM/S-PMF/S Ranges)

Equalizing is required when to reduce the spread voltage/specific gravity among the cells under float charging conditions.
A short equalizing charge is also required after addition of distilled water to make sure the acid and water are well mixed. Equalizing should be carried out at 2.7 Volts per cell. Current should be limited to 0.07 C_{120}. The length of the equalizing charge required will depend on, temperature and voltage level. The best guideline is to continue equalizing until the specific gravity of the electrolyte in the pilot cell has been constant for at least 2 hours; please check electrolyte temperature which have to be lower than 45°C.

❖ BATTERY INSTALLATION

All necessary precaution must be taken when working with lead acid batteries as per electrical risk, explosives gasses, heavy components, corrosive liquids. Use insulated tools and wear protective equipment.

♦ Installation

1. Make sure that all cell jars and covers are thoroughly clean and dry.
2. Clean the flat contact-making surfaces of the terminal posts with a soft clean rag. If there is evidence of acid having been spilled, wipe the posts a rag. Wipe the posts dry.
3. Should the terminal posts have a white film on them, lightly abrade their contact surfaces, using a Scotchbrite pad or fine grit abrasive paper, to remove any surface oxidation. Wipe off any loose particles and cover the whole length of the post, down to the cover, with a thin coating of "No-oxide" grease.
4. Batteries are heavy, we recommend to lift the cells using lifting straps together with suitable mechanical lifting device to prevent injury to personnel or damage to the cells, whenever possible we suggest to avoid to lift cells by its terminals.
5. Place the cells or blocs in position on the rack at the correct spacing which will accommodate the intercell connectors supplied (usually beween 10 and 15 mm). Most batteries have cells connected in a simple series arrangement, so the cells should be arranged to preserve the sequence: positive (marked "+"), negative (marked "-"), positive (marked "+"), negative (marked "-") etc., throughout the battery.
6. For batteries on multiple section, double tier racks, start by placing the cells or blocs on the lower tier on either side of the upright. Any unused rack space should be on the upper tier.
7. Prepare the connectors by lightly abrading the contact surfaces with a Scotchbrite pad or fine grit abrasive paper. DO NOT use a wire brush and be especially careful not to break through the plating.
8. Apply a light coating of "No-oxide" grease to the contact-making areas of each connector. This is best done by carefully melting the grease and dipping the connector ends (it is not necessary to coat the central part of the connector).
9. Fasten the intercell and intertier connectors in place using the bolts, nuts and washers supplied. Use the insulated wrenches supplied to tighten the parts firmly together.

BATTERY TYPE	THREAD TYPE	STANDARD VALUE Nm	STANDARD VALUE Lbs
LMS - SMGS	M10 Female	20÷25	175÷220
PMFS	Flag Ø 8/10	6÷7 / 8÷9	53÷62

10. Care must be taken to avoid short circuiting the cells with any of the battery hardware.
11. Make sure that the positive terminal of one cell is connected to the negative terminal of the next throughout the battery leaving the main positive and negative terminals of the battery free for connection to the charging source. Take particular care to preserve the positive to negative sequence when using flexible intertier or interstep connectors between rows of cells.
12. Insulate all the connectors by means of the plastic covers being supplied with the battery accessories. Connect the positive terminal of the battery to the positive terminal of the charger and the battery negative to the charger negative.
13. Some batteries may have been shipped with plastic pre-vents caps for shipping purpose. These caps should be removed and discarded.
14. Install the FIAMM standard explosion proof vents.
15. Affix the cell number stickers to the cell jars making sure that the surfaces are dry and clean. It is usual to number the cells beginning with #1 at the positive end of the battery, numbering consecutively in the same order as the cells are connected electrically, through to the negative end of the battery.

♦ Battery room requirements

- The battery room should be dry, well ventilated and have its temperature as moderate as the climate will allow, preferably between 10°C and 30°C.
- **DO NOT permit smoking or the use of open flames in the battery room.**
- Adequate ventilation to change the air in the battery room is essential to prevent an accumulation of the gases given off during charge (for further information please refer to "VENTILATION" paragraph).
- The battery will give the best results and battery life when working in a room temperature of 20°C, but will function satisfactorily when operating in temperatures between about -20°C and +60°C. High temperatures increase the performance, but decrease the life of the cells; low temperatures reduce the performance.
- Do not allow direct sunlight to fall on any part of the battery.
- If a rack is not supplied by FIAMM, suitable racks should be provided to support the cells. These should be arranged to provide easy access to each cell for inspection, topping up and general maintenance. Suitable racks may be made of wood or metal with a coating of acid resistant paint. If metal racks are used, they must be fitted with rubber or plastic insulators to prevent the cells coming into contact with the metal.

❖ MAINTENANCE

♦ Battery care

GASES GIVEN OFF BY BATTERIES ON CHARGE ARE EXPLOSIVE!
DO NOT SMOKE OR PERMIT OPEN FLAMES NEAR BATTERIES OR DO ANYTHING TO CAUSE SPARKS.

1. Check the electrolyte levels in all cells regularly and if necessary top up with distilled water. Never allow the electrolyte level to fall below the "MIN" line. Do not overfill the cells. For information about quality of water to beaded please refer to When water has been added, set the charger to "equalize" for about 30 minutes to help mix the electrolyte.
2. Keep the battery and surroundings clean and dry. Wipe the cells with an antistatic clean soft cloth dampened with clean water. If necessary, a small amount of mild detergent may be added to the cleaning water to remove any greasy film. Do not use any special powders or solvents for cleaning the battery cells, as scratching or damage to the plastic could occur.
3. Make sure that bolted connections are properly tightened (see table in section 6).
4. Keep connectors, posts and bolted connections covered with "No-oxide" grease for protection against corrosion.
5. Should any corrosion of the connections occur because of spilled acid, etc., carefully remove corrosion materials, thoroughly clean and neutralize with diluted ammonia or baking soda.
6. Dry the parts before coating them with "No-oxide" grease to protect from further corrosion. Do not let the neutralizing solution enter the cell.
7. Keep the battery at the recommended charge voltage (see CHARGING section). Give the battery an equalizing charge whenever necessary.
8. The room in which the battery is installed should be well ventilated and its temperature as close as possible to 20°C.

♦ Cleaning

When necessary, batteries could be cleaned using a soft dry antistatic cloth or water-moistened soft antistatic 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 2,23 $^{+0,1}/_{-0,08}$ V. particularly in the first year of operation. In the following time the tolerance of the voltage of each cell could be in the narrower range of 2,23 $^{+0,1}/_{-0,05}$ V. 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.

♦ Specific gravity reading (if applicable)

When taking specific gravity readings, care must be taken to make sure that the electrolyte level in the cell to be measured is at the "MAX" line and that any distilled water added recently has been properly mixed in, by equalizing for about 30 minutes.
The specific gravity of the electrolyte varies with temperature; consequently, hydrometer readings should be corrected as indicate in Electrolyte Chapter.

The specific gravity may range ± 0.01 points within a cells at the nominal values of 20°C. during the first year of operation a wider tolerance range of ± 0,02 kg/l could be noted.

NEVER ADD ACID TO INCREASE SPECIFIC GRAVITY READINGS.

♦ Cell Appearance

Healthy cells, when fully charged, show a marked contrast between the dark brown positive and the light grey negative plates. For cells in transparent jars (LM, SD, SDH, SGL, SGH), it is extremely useful to inspect the appearance of each cell in the battery at regular intervals.
Any cells not showing a healthy plate coloration, or having a specific gravity or voltage noticeably lower than the other cells, or in which the plates bubble unevenly or not at all, should be regarded as suspect. Such cells should be carefully examined for internal short-circuits, such as may be caused by small pieces of scale bridging across the plates.
An equalize charge will normally restore such cells to the condition of the remainder of the battery, but if it does not, expert advice should be obtained immediately from FIAMM.

♦ Pilot Cell

For regular monitoring of the battery condition, select one or more cells of the battery as a "pilot" cells (for batteries comprising more than 60 cells, select one pilot cell for every 60 cells). The electrolyte specific gravity of the pilot cell(s) will be indicative of the state of charge of the whole battery.

Maintenance records

Written records should be kept of battery maintenance, so that long-term changes in battery condition may be monitored. The following inspection procedures are recommended:

EVERY SIX MONTHS:

- Check and record the overall float/recharge voltage at the battery terminals (not at the charger!),
- visual inspection on cells / rack (electrolyte level, corrosion signs…)
- measure the pilot cell(s) voltage.
- measure the pilot cell(s) electrolyte specific gravity (if applicable)
- measure the pilot cell(s) electrolyte temperature
- electrolyte level (if applicable)

YEARLY:

- Check and record the voltage of all cells.
- measure electrolyte specific gravity of all cells.
- measure the pilot cell(s) electrolyte temperature
- check and in case torque the bolt connection (refer to connection torque table)
- visual inspection on cells / rack (electrolyte level, corrosion signs…)
- clean the cells

BATTERY TEST

Test must be conducted in accordance with EN 60896-11 (for LM/S-PMF batteries) and EN 60896-21/22 (for SMG/S batteries). Before any dischare test, batteries have to be properly prepared with a boost charge to ensure they are in a fully charge condition. For any information about test procedures please refer to proper Battery Instruction Manual;

— "Flooded Instruction Manual" for LM/S-PMF/S battery ranges
— "Gel Instruction Manual" for SMG/S battery range

APPLICABLE STANDARDS

- IEC 60896 Stationary lead-acid battery – Part 11: Vented Types – General requirements and methods of tests.
- IEC 60896 –Part 21 Stationary lead-acid battery Valve Regulated Type – Methods of tests;
- IEC 60896 –Part 22 S Stationary lead-acid battery Valve Regulated Type - Requirements
- EN 50272-2 Safety requirements for secondary batteries and battery installations Part 2: Stationary batteries.
- DIN 40736-1 Lead acid batteries; stationary cells with positive tubular plates; cells in plastic-containers; rated capacities, main dimensions, weights (for LM range).
- BS 6290-1 Lead-acid stationary cells and batteries. Specification for general requirements
- CEI EN 61427 Secondary cells and batteries for Photovoltaic Energy Systems (PVES) – General Requirements and Methods of test

❖ ELECTROLYTE (only for LM/S, PMF/S battery Ranges)

High quality electrolyte for Stationary Standby Batteries (which is a solution of pure sulphuric acid diluited with distiller water to the correct specific gravity) is required for filling dry charged cells

The following table gives specific gravity (Sp.Gr.) data at 20°C for fully charged cells with the electrolyte at the maximum level and for electrolyte filling:

Nominal Sp. Gr.	Sp. Gr. Range for filled cells [kg/l] at 20°C	Sp.Gr. for Filling Dry Charged Cells [kg/l] at 20°C	Cell Type
1.24	1.230 - 1.250	1.225	PMF, LM

NEVER ADD ACID TO INCREASE SPECIFIC GRAVITY of electrolite.

Here below please find the max impurities for new electrolyte and refilling water.

Impurityes		Unit	Max Value DIN 43 530 Teil 2
Iron	(Fe^{2+})	mg/l	30
copper	(Cu^{2+})	mg/l	0.5
Antimony	(Sb^{3+})	mg/l	1.0
Arsenic	(As^{3+})	mg/l	1.0
Bismuth	(Bi^{3+})	mg/l	1.0
Tin	(Sn^{2+})	mg/l	1.0
Chromium	(Cr^{3+})	mg/l	0.2
Nichel	(Ni^{2+})	mg/l	1
Ammonium Ions	(NH_4^+	mg/l	50
Nitratw ions	(NO_3^-	mg/l	10
Chlorine Ions	(Cl^-)	mg/l	5
Organic Substances	(O_2)	mg/l	30
Other Impurityes		mg/l	250

Electrolyte specific gravity change with temperature, for a correct reading the reading value must be corrected to the nominal electrolyte temperature (usually 20°C).
Here below the formula for correction

$$d = d_t - 0.0007 \times (t - 20)$$

Where d_t=specific gravity at "t" temperature

Electrolyte Temperature		Specific Gravity at full charge
[°C]	[°F]	[kg/l]
-20	-4	**1,2680**
-15	5	**1,2645**
-10	14	**1,2610**
-5	23	**1,2575**
0	32	**1,2540**
5	41	**1,2505**
10	50	**1,2470**
15	59	**1,2435**
20	68	**1,2400**
25	77	**1,2365**
30	86	**1,2330**
35	95	**1,2295**
40	104	**1,2260**
45	113	**1,2225**
50	122	**1,2190**

❖ VENTILATION

During normal operating conditions, lead acid batteries emits low quantity of gases which can reach an explosive mixture when hydrogen concentration is higher than Lower Explosion Limit (LEL) threshold which is 4%vol

The purpose of ventilating a battery location or enclosure by natural or forced (artificial) ventilation is to maintain the hydrogen concentration below the above stated limit. Battery locations and enclosures are to be considered as safe from explosions, when the concentration of hydrogen is kept below this safe limit.

The minimum air flow rate for ventilation of a battery location or compartment shall be in accordance with International Standard EN 50272 calculated by the following formula:

$$Q = 0{,}05 \text{ x } N \text{ x } I_{gas} \text{ x } C_{rt} \text{ x } \text{ x } 10^{-3}$$

where:

Q = ventilation air flow in m^3/h

N = number of cells (each 2 Volt)

C_{rt}= capacity C_{10} [Ah] at 1.80 volt/cell. at 20°C.

The current I_{gas} [mA/Ah] producing gas as indicated in the table of the above mentioned standard con be assumed as:

	I_{gas} for batteries on float	I_{gas} for batteries on boost charge
LM/S	5	20
PMF/S	5	20
SMG/S	1	8

♦ Determination of openings

The amount of ventilation air flow shall preferably be ensured by natural ventilation, otherwise by forced (artificial) ventilation. Battery rooms or enclosures require an air inlet and an air outlet with a minimum free area of opening calculated by the following formula:

$$A = 28 \text{ x } Q$$

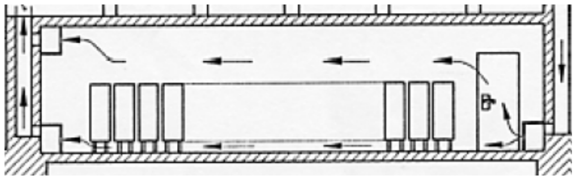
with Q = ventilation flow rate of fresh air [m^3/h]
A = free area of opening in air inlet and outlet [cm^2]

Note: For the purpose of this calculation the air velocity is assumed to be 0,1 m/s.

The air inlet and outlet shall be located at the best possible location to create best conditions for exchange of air, i.e.

- openings on opposite walls,
- minimum separation distance of 2 m when openings on the same wall.

The following picture gives an indication of the correct opening to assure a complete battery room air exchange



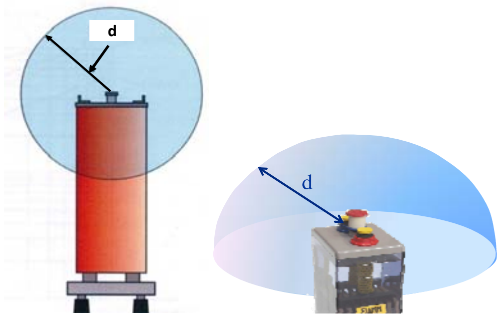
♦ Forced ventilation

Where an adequate air flow Q cannot be obtained by natural ventilation and forced ventilation is applied, the charger shall be interlocked with the ventilation system or an alarm shall be actuated to secure the required air flow for the mode of charging selected. The air extracted from the battery room shall be exhausted to the atmosphere outside the building.

♦ Close vicinity to the battery

In the close vicinity of the battery the dilution of explosive gases is not always secured. Therefore a safety distance extending through air must be observed within which sparking or glowing devices (max. surface temperature 300 °C) are prohibited. The dispersion of explosive gas depends on the gas release rate and the ventilation close to the source of release. For calculation of the safety distance d from the source of release the following formula applies assuming a hemispherical dispersal of gas. The safety distance d is given from the following formula:

$$d = 28{,}8 \text{ x } \sqrt[3]{N} \text{ x } \sqrt[3]{I_{gas}} \text{ x } \sqrt[3]{C_{rt}}$$



where N depends on the number of cells per monoblock battery (N) or vents openings per cell involved (1/N).

❖ For further information please refer to EN50272 Standard or contact FIAMM at: info.standby@fiamm.com

FIAMM

Industrial Batteries

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