FIAMM

Industrial Batteries

Secure
Power
Solutions

Industrial Batteries

FLOODED Installation & Operating Instructions Technical Manual

Lead Acid Batteries

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INTRODUCTION

In a high technological environment it is extremely important to have a backup power source whenever possible. In fact mains power failure could cause severe losses and damages anytime.
FIAMM has been developing throughout years of research and experience several ranges of Flooded Lead Acid Batteries to ensure the best reliability and quality.

❖ CONSTRUCTION FEATURES

The main construction features of FIAMM Flooded batteries are shortly described in the below section.

♦ Plates A

FIAMM flooded lead acid batteries can be offered in three different positive plate types to fit all customer needs as performances and type of application as given below:

FIAMM Battery range	Type of positive plate	Type of negative plate
PMF, LM	Tubular	Flat
SD, SDH	Flat	Flat
SGL SGH	Plantè	Flat

♦ Containers B

Battery cases and lids are made of SAN (Styrene acrylonitrile) with high transparency, very good dimensional stability, heat and chemical resistance (PMF range use polypropylene container).

♦ Separators C

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

♦ Electrolyte

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

FIAMM Battery range	Electrolyte Specific Gravity at 20°C [kg/l]
PMF	1.25
LM	1.24
SD, SDH	1.24 or 1.27
SGL SGH	1.22

Vent plugs E

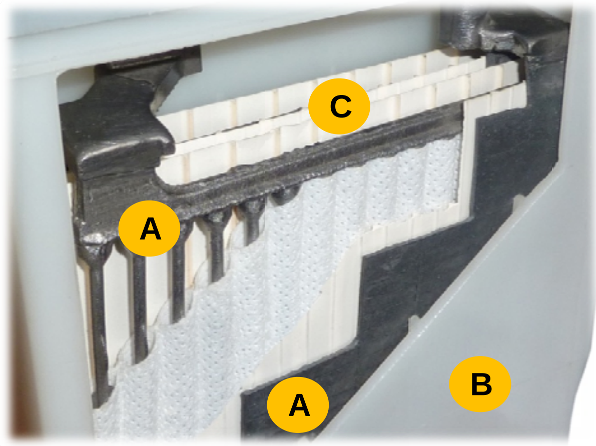
Each cell has one or more vent plugs to permit the release of gases from the cell during the charging process; the ceramic part prevents explosion of the gases inside the battery; they are fix by bayonet lock or by screw (PMF range). A plain vent without the ceramic part is available for some types as an option.

♦ 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.

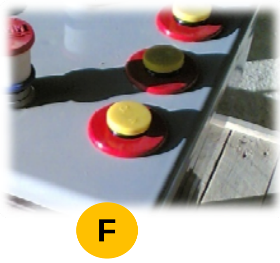
Special plastic terminal caps are provided for transportation assuring a protection against short circuit during transportation. F

♦ Cutaway drawing of FIAMM cells with positive tubular plates



Rectangular "nut and bolt" Terminal

Female (Bolt) 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, and minimum voltage.
The nominal capacity of FIAMM batteries refers to the 10 hrs discharge rate (indicated with C_{10}) with constant current at 20°C to 1.80 volt per cell.

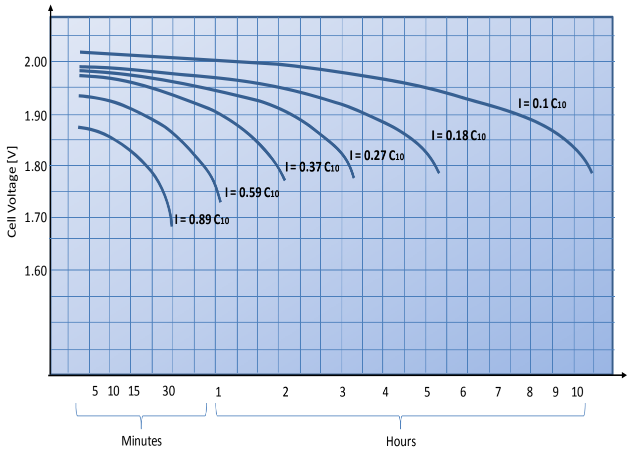


Fig. 1
Typical discharge curves for FIAMM Lead Acid Flooded batteries

♦ Capacity in relation to discharge rate

The available capacity of all lead acid batteries depend on discharge rate (discharge current); this is due to internal electrochemical process and type of construction (i.e. type of positive plate).

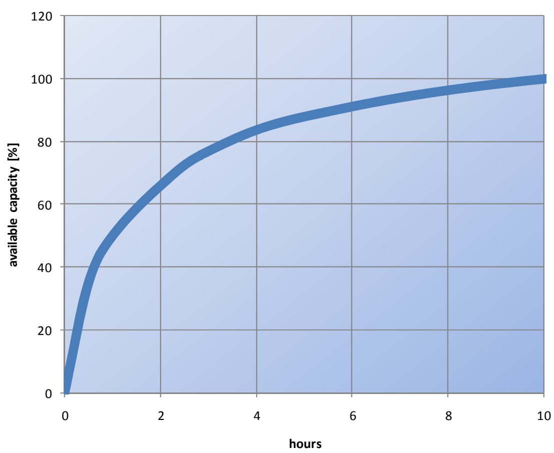


Fig. 2
Average available capacity versus discharge rates for FIAMM Lead Acid Flooded batteries

♦ Capacity range of FIAMM Flooded Lead Acid Batteries

FIAMM Battery range	Capacity range [Ah]
PMF	from 25 to 300
LM	from 100 to 3500
SD	from 80 to 440
SDH	from 480 to 2320
SGL	from 75 to 450
SGH	from 500 to 2600

♦ 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 a higher or 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).

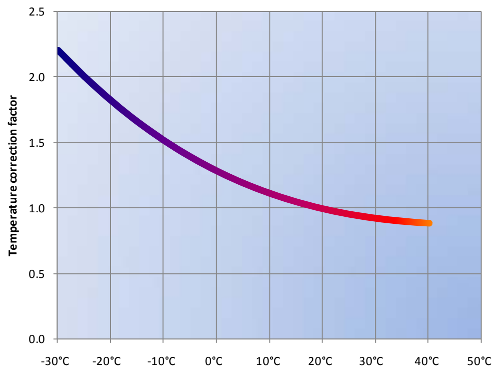


Fig. 3
Capacity Correction factor versus temperature for a 10 hours discharge rate for FIAMM Lead Acid Flooded batteries

♦ 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.
Different instruments are available to detect the internal resistance or impedance of lead acid batteries. These instruments use a different way to determinate these values. The values obtained from these instruments will be different to 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 when the storage temperature is 20°C or lower. When the storage temperature is above 20ºC a shorter storage time will result. Contact FIAMM for further details. The charging shall be 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

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.

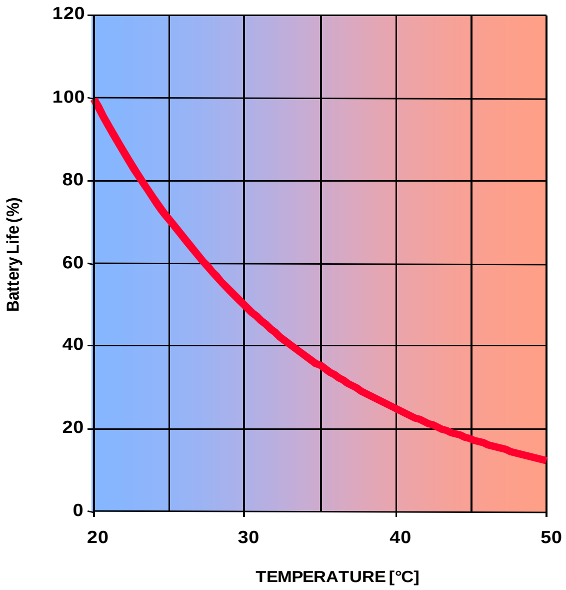


Fig. 4
Expected service life vs working temperature

♦ 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 cells or monoblocs 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. However, 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.

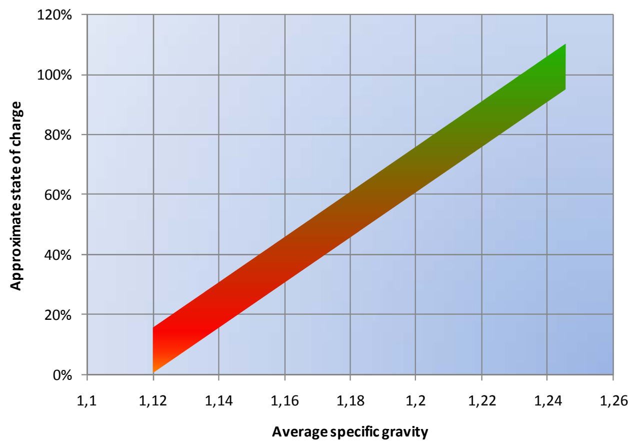


Fig. 5
Electrolyte specific gravity in relation to the state of charge of the cell (PMF-LM- SD- SDH cells)

❖ COMMISSIONING CHARGE / FIRST CHARGE

Lead acid flooded batteries can be offered 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.

♦ Floating charge

Floating battery systems are those where the charger, the battery and the load are connected in parallel.
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
SD - SDH – PMF, LM	2.23 Volts per cell
SGL – SGH	2.23 Volts per cell

♦ Boost charge (Recharge following a discharge)

Boost charge has to be used to recharge a battery after a discharge it will restore the battery to a fully charged state within relatively short period).
Boost charge has to be carry out at 2.4 volt per cell with a current limited to 0.15 C_{10}. Lower current will increase the recharge time. Recharge time is usually 24 hours or when the current passing through the battery has decreased to 5% of the C_{10}. Temperature has to remain lower than 40°C. Electrolyte density has to reach the nominal value and remain constant for at least 2 hours; in case provide an equalize charge to the battery.

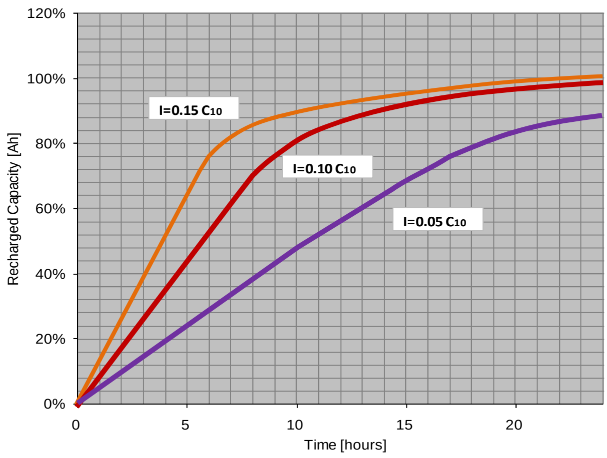


Fig. 6
Recharge curves at 2.4 volt per cell with different limit of current

♦ Equalize charge

Equalizing is required to reduce the spread of float voltage 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.
The equalizing charge could also be used for fast recharging after an emergency discharge.
Equalizing should be carried out at 2.7 Volts per cell, or at a constant current of between 5% nd 10% of the cell capacity in Ah. The time 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 must be kept lower than 40°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. Synthetic cleaning cloths must not be used. To clean the cell lids and containers, use only cotton cloths soaked in a solution of mild soap and completely “wrung” out.
3. Clean the flat contact-making surfaces of the terminal posts with a soft clean dry cotton cloth If there is evidence of acid having been spilled, the whole length of the posts should be wiped down with a cotton cloth soaked in a solution of mild soap and completely “wrung” out or a non-caustic alkali solution, preferably dilute ammonia or baking soda. This will neutralize any acid on these parts. Do not allow any of this solution to get into the cells. Wipe the posts dry.
4. 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.
5. 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.
6. Place the cells or blocs in position on the rack at the correct spacing which will accommodate the inter-cell connectors supplied (usually the clearance between the battery cells or monoblocs has to be between 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.
7. 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 where the rack sections meet. Any unused rack space should be on the upper tier.
8. For batteries on stepped racks, leave any unused rack space on the back (top) step.
9. 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 lead plating.
10. 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).
11. Fasten the inter-cell and inter-tier connectors in place using the bolts, nuts and washers supplied. Use the insulated wrenches supplied to tighten the parts firmly together.

BATTERY RANGE	TRHEAD TYPE	STANDARD VALUE Nm	STANDARD VALUE Lbs
LM (OPzS) SGL - SGH	M10 Female	20÷25	175÷220
SGL -SGH SD-SDH	Bolt M8	10÷12	88÷106

12. Care must be taken to avoid short circuiting the cells with any of the battery hardware.
13. 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 inter-tier or inter-step connectors between rows of cells.
14. 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.
15. Some batteries may have been shipped with plastic pre-vents caps for shipping purpose. These caps should be removed and discarded.
16. Install the FIAMM standard explosion proof vents.
17. 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 life when working in a room temperature of 20°C, but will function satisfactorily when operating in temperatures between -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.
- To facilitate proper battery operation, maintenance, and care, post a battery data card/ instruction table in a conspicuous place near the battery to provide the attendant with service information and data

❖ SAFETY

It is recommended that full precautions be taken at all times when working on batteries. The safety standards of the country of installation must be risk, explosives gasses, heavy components,

♦ Protective Equipment

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

- Instructions manual.
- Tools with insulated handles.
- Fire extinguisher.
- PPE (Personal Protective Equipment) must be worn (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

❖ APPLICABLE STANDARDS

FIAMM flooded batteries comply with:

- IEC 60896 Stationary lead-acid battery – Part 11: Vented Types – General requirements and methods of tests.

- 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).

- DIN 40738 Lead storage batteries; stationary cells with positive Plante plates, narrow plate distance; rated capacities, main dimensions (SGL, SGH ranges).

- BS 6290-3 Lead-acid stationary cells and batteries. Specification for lead-acid pasted positive plate type (SD-SDH range) .

- BS 6290-2 Lead-acid stationary cells and batteries. Specification for lead-acid high performance Planté positive type (SGL, SGH ranges).

- BS 6290-1 Lead-acid stationary cells and batteries. Specification for general requirements

❖ MAINTENANCE

♦ Battery care

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

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 “Electrolyte” chapter. 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

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 $\pm$ 0.01 points within a cells at the nominal values of 20°C; during the first year of operation a wider range 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" cell(s); 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.

♦ Periodic Inspections

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

MONTLY:

- check and record the overall float voltage at the battery terminals (not at the charger!),

EVERY SIX MONTHS:

- Visual inspection on cells/racks (appearance, cracks or corrosion signs, electrolyte leakage….)
- check and record the overall float voltage at the battery terminals (not at the charger!),
- measure and record the pilot cell(s) voltage.
- measure and record the pilot cell(s) electrolyte specific gravity
- measure and record the pilot cell(s) electrolyte temperature
- electrolyte level
- room ventilation

YEARLY:

- all the controls indicated at six months
- check and record the voltage of all cells.
- measure and record electrolyte specific gravity of all cells.
- measure and record the pilot cell(s) electrolyte temperature
- check and in case torque the bolt connection (refer to connection torque table); in case of frequent high discharge current please consider to check the bolt torque at least every six months
- visual inspection on cells/rack (electrolyte level, corrosion signs…)
- clean the cells
- in case coat the connection with no-oxide grease

BATTERY TEST

Test must be conducted in accordance with EN 60896-11.
Before any discharging test batteries have to be properly prepared with a boost charge (2.4 volt per cell for 24 hours at 20°C) 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 cell or 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 cell 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
Here below some precaution to be taken:

- Discharge must be stopped at the final discharge voltage.
- Deeper discharges must not be carried out unless specifically agreed with FIAMM.
- Recharge immediately the battery after each (full or partial) discharge test.

Service/Functional test

This is a test of the battery's ability, to satisfy the design requirements of the system. It means to discharge the battery directly to the load (in this case take precautions to ensure that a battery failure does not jeopardise other equipment) or dummy load to simulate a main failure.

1. Record the floating voltage of each cell, as well as the total system voltage
2. Check the actual load (A or W), as well as the minimum admissible voltage of the system
3. On FIAMM discharge tables you can approx. determinate the discharge rate (minutes of discharge) **Please note that battery performances change (decrease) with battery age.** After switching off the rectifier, discharge the battery for a time of 20% of that calculated discharge rate
4. During the discharge, record at regular intervals, cell/block voltage, battery temperature, discharge current, total battery voltage
5. For safety reason, during the test assure that the total battery voltage remains above the minimum depending on discharging rate in order to avoid any failure to the system (please note that approaching to the final voltage, the voltage curve decreases rapidly)
6. For particular comments on test's data, please refer to FIAMM technical offices

Capacity test

Please carry out this test only when complete information on the quantity of energy inside the battery is requested. Take precautions because after this test battery SHOULD NOT BE ABLE TO SUPPLY ENERGY IN CASE OF MAIN FAILURE.
Dummy load is usually necessary to provide the request discharge current. Test is usually carried out to verify the battery capacity to a specify end voltage and discharge rate (usually 1, 3 or 10 hours).
Test must be conducted in accordance with EN 60896-11. Please refer to prescription indicated in the above standard. Record at regular intervals cell/bloc voltage, battery temperature on pilot cell, discharge current, total battery voltage (readings have to be made at least at 25%, 50% and 80% of the discharge time and then at the suitable time intervals which permits the detection oft he transition tot he final discharge voltage).

According IEC60896-11 the discharge shall be terminated when one of the following values t_{disch}, whichever comes first, has been recorded:

1. t_{disch} = the elapsed time of discharge of the string, with n cells, to a voltage of $n \times U_{final}$ (V)
2. t_{disch} = the elapsed time when a cell or monobloc in the string reached a voltage of

$$U = \left(U_{\text{final}} - \sqrt{\frac{\text{cell or monobloc voltage}}{2}} \right) \times 0.2$$

At the end of discharging test, batteries have to be recharged immediately.

The following formula determinates the battery capacity:

$$C = discharge\ current \times t_{disch}$$

(where t_{disch} is indicated in hours)

For temperatures different from the nominal (20°C) and discharge rates between 3 to 10 hours, the battery capacity shall be corrected as follows:

$$C_{20°C} = \frac{C}{1 + \lambda(\theta - 20)}$$

Where:
θ = initial pilot cell temperature (°C)
λ= 0.006 for tests > 1 hour
λ= 0.01 for tests ≤ 1 hour

A new battery shall supply at least

C_a=0.95 Nominal capacity at the first cycle
C_a= Nominal capacity at the fifth cycle

Trending battery capacity during years will provide information in predicting when the battery will no longer meet design requirements.

❖ ELECTROLYTE

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
1,27	1,26 - 1,28	1,26	SD, SDH
1.24	1.230 - 1.250	1.225	PMF, LM
1.22	1.210 - 1.230	1.210	SGL, SGH

NEVER ADD ACID TO INCREASE SPECIFIC GRAVITY of electrolyte.

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 [°C]	Electrolyte Temperature [°F]	Specific Gravity at full charge [kg/l]
-20	*-4*	**1.2120**
-15	*5*	**1.2155**
-10	*14*	**1.2190**
-5	*23*	**1.2225**
0	*32*	**1.2260**
5	*41*	**1.2295**
10	*50*	**1.2330**
15	*59*	**1.2365**
20	*68*	**1.2400**
25	*77*	**1.2435**
30	*86*	**1.2470**
35	*95*	**1.2505**
40	*104*	**1.2540**
45	*113*	**1.2575**
50	*122*	**1.2610**
55	*131*	**1.2645**
60	*140*	**1.2680**

VENTILATION (in accordance with EN 50272-2)

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 European Standard EN 50272 calculated by the following formula:

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

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:

$I_{gas} = 5$	For batteries on float
$I_{gas} = 20$	For batteries on boost charge

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:

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

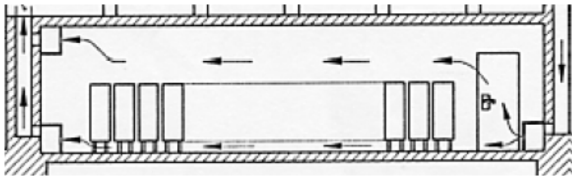
with Q = ventilation flow rate of fresh air [m^3/h]
A = free area of opening in air inlet and outlet [cm^2]

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



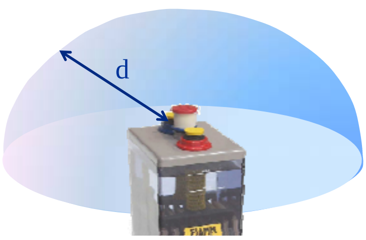
Forced ventilation

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*

Industrial Batteries

General brochure EMEA 2012-05

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