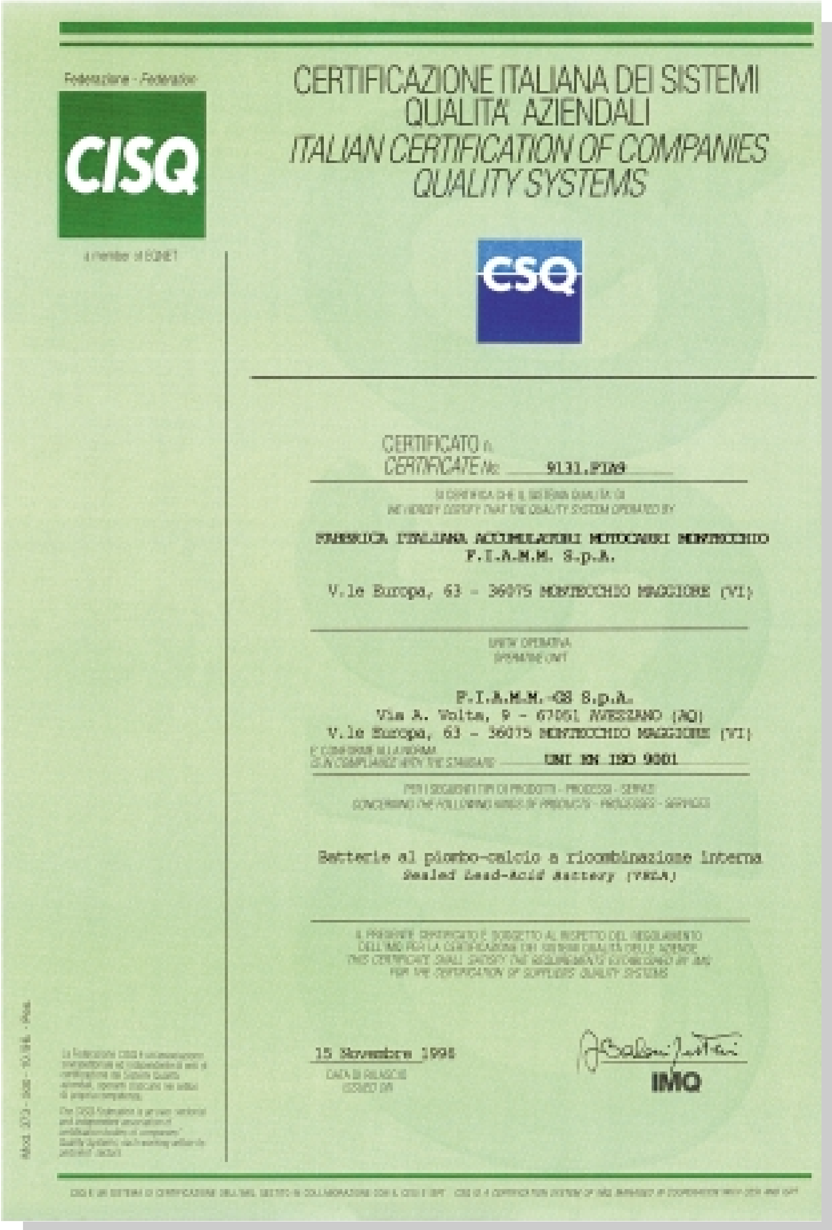
Technical Handbook
Valve-Regulated
Lead-Acid Batteries

FIAMM-GS



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CERTIFICAZIONE ITALIANA DEI SISTEMI QUALITA' AZIENDALI

ITALIAN CERTIFICATION OF COMPANIES QUALITY SYSTEMS

CSQ

CERTIFICATO n.
CERTIFICATE No. 9131.FIA9

SI CERTIFICA CHE IL SISTEMA QUALITÀ DI
WE HEREBY CERTIFY THAT THE QUALITY SYSTEM OPERATED BY

FABBRICA ITALIANA ACCUMULATORI MOTOCARRI MONTECCHIO
F.I.A.M.M. S.p.A.

V.le Europa, 63 - 36075 MONTECCHIO MAGGIORE (VI)

UNITA' OPERATIVA
OPERATIVE UNIT

F.I.A.M.M.-GS S.p.A.
Via A. Volta, 9 - 67051 AVEZZANO (AQ)
V.le Europa, 63 - 36075 MONTECCHIO MAGGIORE (VI)

E' CONFORME ALLA NORMA
IS IN COMPLIANCE WITH THE STANDARD UNI EN ISO 9001

PER I SEGUENTI TIPI DI PRODOTTI - PROCESSI - SERVIZI
CONCERNING THE FOLLOWING KINDS OF PRODUCTS - PROCESSES - SERVICES

Batterie al piombo-calcio a ricombinazione interna
Sealed Lead-Acid Battery (VRLA)

IL PRESENTE CERTIFICATO E' SOGGETTO AL RISPETTO DEL REGOLAMENTO DELL'IMQ PER LA CERTIFICAZIONE DEI SISTEMI QUALITÀ DELLE AZIENDE
THIS CERTIFICATE SHALL SATISFY THE REQUIREMENTS ESTABLISHED BY IMQ FOR THE CERTIFICATION OF SUPPLIERS' QUALITY SYSTEMS

15 Novembre 1998
DATA DI RILASCIO
ISSUED ON

IMQ

Aerial view of the italian factory in Avezzano

All FIAMM-GS batteries have been specifically developed to enhance economy of operation, reliability and energy output.

The values reached in these areas position FIAMM-GS batteries among the very best presently available on the market. They represent the ideal solution for all applications which require a high-density energy source, that is both reliable and maintenance-free for several years.

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1 CHARACTERISTICS

1.1 *Total absence of maintenance.* The gases which are generated by the electrolysis of water, during the period of overcharge, are completely recombined in the elements, thereby eliminating the need for the periodic addition of water.

1.2 *Sealed construction.* The 'sealed' construction, typical of all FIAMM-GS batteries permits a safe use in any position without any leakage of electrolyte and/or reduction of electric capacity.

1.3 *High energy density.* The use of highly porous glass fibre separators permits the maximum possible energy density per unit of volume and/or weight.

1.4 *Recovery after overdischarge.* The glass fibre separators, combined with special electrolyte additives, allow FIAMM-GS batteries to continue to accept charging current, even in cases of overdischarge, or after long storage periods.

1.5 *Low self-discharge.* The perfect sealing of the battery case and the use of pure Pb-Ca alloy grids keep the self-discharge values below 3% of battery capacity per month.

1.6 *Long life.* Both the positive and negative plates have been optimized, to obtain excellent results in either cyclic or stand-by use.

1.7 *Wide ranging operating temperature.* FIAMM-GS batteries are specially designed to operate within a wide temperature range.

1.8 *International certifications.* FIAMM-GS batteries are tested and certified according to UL 924, section 38. The battery types commonly used in security applications are further certified by the VdS, the German insurance underwriters association. The VdS certification is one of the few product certificates that tests the effective battery capacity. Moreover, FIAMM-GS batteries meet the requirements of provision A 67 of the IATA Dangerous Goods Regulation and can therefore be transported by aircraft.

1.9 *Economy of operation.* FIAMM-GS' highly automated production and the batteries' special design permit many years of safe and trouble-free use.

2 COSTRUCTION

Components	Materials
1 Terminals	Tin-plated brass
2 Safety valve	Lubricated synthetic rubber
3 Separator	Glass fibre
4 Container and cover	ABS synthetic resin
5 Negative plate	Lead and lead oxide
6 Positive plate	Lead and lead oxide
Electrolyte	Diluted sulphuric acid

3 WORKING PRINCIPLES FOR VALVE-REGULATED LEAD ACID BATTERIES

ELECTROCHEMICAL PROCESSES

3.1 *Basic theory*

The following chemical reactions describe the exact transformation which occurs both in the positive and negative plates, due to electrochemical processes:

Positive plate

$$PbO_2 + 4H^+ + SO_4^{--} + 2e^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} PbSO_4 + 2H_2O$$

Negative plate

$$Pb + SO_4^{--} \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} PbSO_4 + 2e^-$$

Combining the two formulae one can therefore obtain:

$$PbO_2 + 2H_2SO_4 + Pb \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} PbSO_4 + 2H_2O + PbSO_4$$

Discharge

During discharge, the PbO_2 (lead dioxide) of the positive plate becomes $PbSO_4$ (lead sulphate); and the Pb (spongy lead) of the negative plate becomes $PbSO_4$ (lead sulphate). This causes a reduction of the specific weight of the electrolyte, as the sulphuric acid contained in the electrolyte passes to the plates during discharge.
These processes are reversed during the charging phase.

Charge

During the charging phase, the $PbSO_4$ (lead sulphate) of the positive plate oxidizes and re-forms as PbO_2, while in the negative plate, the $PbSO_4$ (lead sulphate) re-forms as Pb (spongy lead).

The general formula (see beside), concerning the total transformation occurring during the charge/discharge phases, corresponds to an electric quantity of 2F (Farads) or 53.6 Ah (Ampere/hour).

For a discharge reaction to occur, one would therefore require active materials in a ratio of 239.2 grams of PbO_2, 207.2 grams of Pb, and 196.2 grams of SO_4. The same weight ratio likewise holds true for the charge reaction.

3.2 *Theory of Internal Recombination*

When a traditional open lead-acid cell is charged, a release of gas occurs. This happens when water, through the process of electrolysis, decomposes into its foming elements.
To maintain the chemical balance in the cell, the lost water must therefore be replaced periodically, involving time consuming verification and refilling of the electrolyte.
In the case of Valve-regulated batteries, however, the elements in the gases created are combined anew during the charge phase, through the so-called “cycle of oxygen recombination”, thereby producing water as described in the following cycle:

1) On the positive plates, oxygen is generated by water electrolysis:

$$H_2O \rightarrow 1/2\ O_2 + 2H^+ + 2e^-$$

and is diffused through the separators to the negative plates.

2) On the negative plates, the oxygen combines with a part of the lead contained in these plates producing lead oxide:

$$Pb + 1/2\ O_2 \rightarrow PbO$$

3) The lead oxide combines with the sulphuric

acid of the electrolyte, forming lead sulphate and water:

$$PbO + H_2SO_4 \rightarrow PbSO_4 + H_2O$$

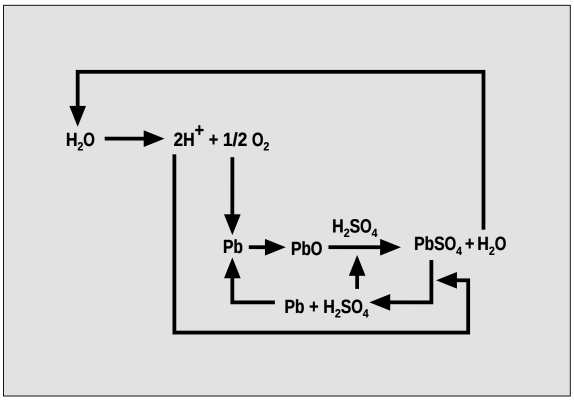
Water is therefore regenerated on the positive plates, while lead sulphate is formed from the partially discharged negative plates.

4) The charge process recharges the partially discharged negative plates, thereby closing the cycle.

$$PbSO_4 + 2H^{+} + 2e^{-} \rightarrow Pb + H_2SO_4$$

The recombination cycle, as described above, is therefore theoretically complete (see also Fig.1).
The constituent parts of water and sulphuric acid in the electrolyte, as well as the amount of lead of the negative plates, reappear at the end of the process in their original state, without having modified the charge conditions of the plates.

Fig. 1



N.B. In everyday circumstances, recombination yields tend to be slightly less than complete, giving approximately 98% efficiency.

Necessary conditions
To facilitate the diffusion of oxygen, highly uniform and porous separators are used.
Furthermore, to avoid saturating the available porosity of these same separators, the quantity of electrolyte must carefully be measured, thereby ensuring that the electrolyte is completely contained inside the plates and the separators, leaving no free electrolyte inside the battery container.
To prevent contact of the lead of the negative plates and the oxygen contained in the surrounding atmosphere, and the consequent chemical oxidation, the electrical elements must be held in fully closed containers. At the same time, it is also necessary to allow the venting of any overpressurization of gases which may be generated within the container during anomalous and/or overly harsh charging conditions.
Every battery cell is therefore equipped with a one-way valve. This valve allows excess gases to be vented when required, but does not permit outside air to enter. The presence of these one-way valves therefore gives rise to the correct “Valve-regulated” classification for FIAMM-GS batteries, instead of the more commonly used, but inaccurate, “sealed” classification.

4 ELECTRICAL CHARACTERISTICS

4.1 *Capacity*

The capacity of a battery (Ah) is the product between the discharge current (expressed in Amperes) and the time that passes before the final discharge tension is reached (expressed in hours).
The capacity varies according to the intensity of the output current. The rated capacity (C) is conventionaly calculated by discharging the battery at a stable temperature of 20-25° C, in such a way as to reach a final discharge tension of 1.75 V per cell after 20 hours.

4.2 *Discharge*

Figures 2 and 3 represent the discharge curves with currents from 0.05 C, up to 2 C. In the case of a 12V-7,2Ah battery, for instance, the discharge current is expressed according to the following formula:

0,05 C = 0,05 x 7,2 = 0,36 A
2 C = 2 x 7,2 = 14,4 A

Due to the internal resistance of the battery, the voltage decreases faster when the discharge, currents are higher (see figures 2 and 3).

In order to avoid shortening the battery life, it is recommended not to discharge the battery beyond the indicated minimum tensions (see table 1).
The maximum permissible continuous discharge current depends on the type of terminal which is used (faston or screw/bolt terminal). As a rule of thumb, it is generally given as 6 times the capacity of the battery.

Fig. 2

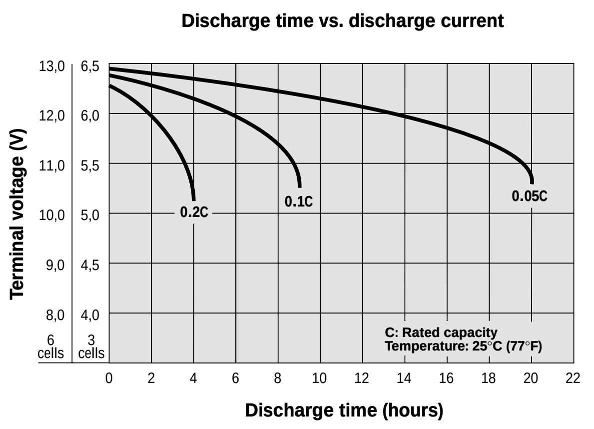
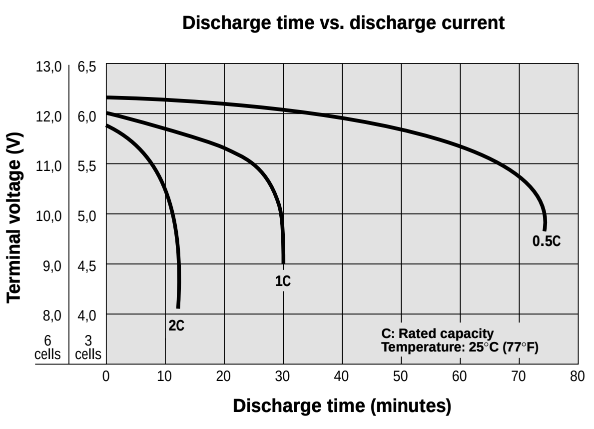


Fig. 3



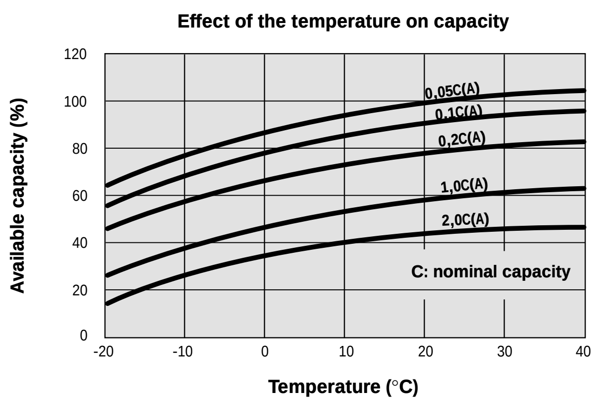
For cable-terminals, the maximum permissible discharge current is generally accepted to be approximately 3 times the capacity of the battery.

Table 1 - *Discharge current and final discharge voltage*

Discharge current	Final discharge voltage
Less than 0.2 C	1.75 V/cell
0.2 C - 0.5 C	1.70 V/cell
0.5 C - 1.0 C	1.60 V/cell
1.0 C - 2.0 C	1.50 V/cell
2.0 C - 3.0 C	1.35 V/cell
Over 3.0 C	1.00 V/cell

Battery discharge is an electrochemical reaction between the electrodes (the plates) and the diluted sulphuric acid.
When the discharge current is particularly high, or the temperature is very low, thereby causing a greater viscosity of the acid, the diffusion rate of the acid through the plates can no longer keep up with the discharge, reducing the capacity, as shown in figure 4.

Fig. 4



4.3 *Self-discharge*

The loss of battery capacity over a period of time is called self-discharge. Through the use of Pb-Ca alloys, self-discharge caused by the sulphating of the plates has been greatly reduced. Batteries can therefore be stored for long periods, or used only occasionally.

Under normal conditions, at about 20°C-25°C, self-discharge is around 0.1% of the nominal capacity per day. This is 25-30% less than conventional open lead-acid batteries.
The relationship between self-discharge and temperature is shown in figures 5 and 6. For every 10°C increase in the temperature, the self-discharge rate doubles.

Fig. 5

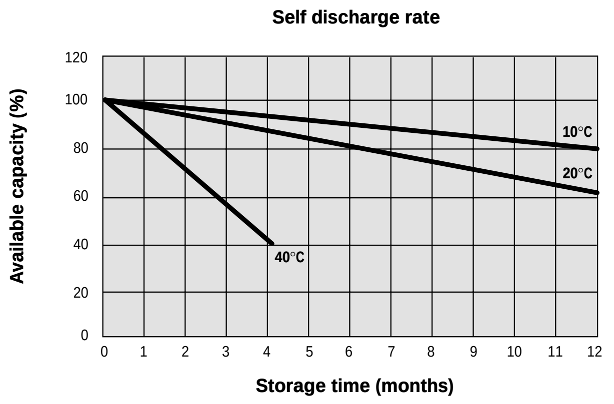
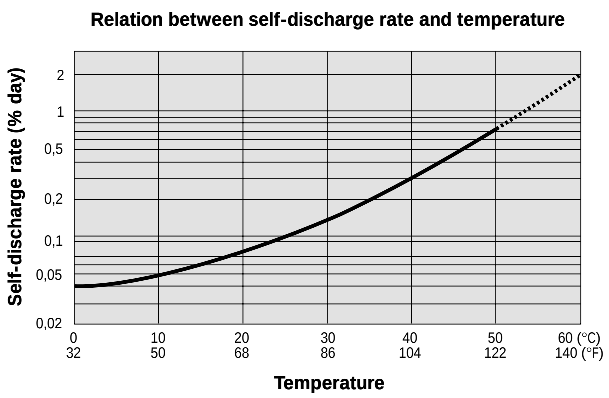


Fig. 6

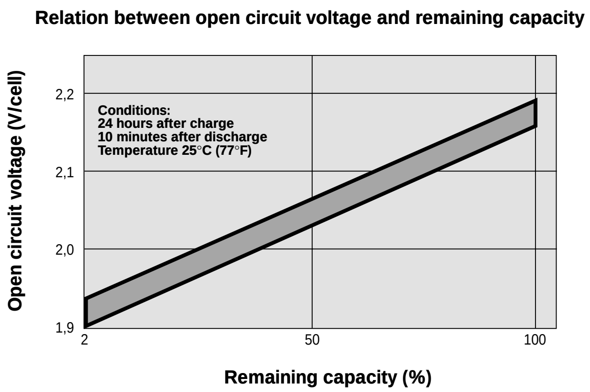


4.4 *Open circuit voltage*

In traditional open lead-acid batteries with filling caps, where free acid is used, it is possible to estimate the residual capacity of the battery by measuring the density of the acid.

This is however not possible with valve-regulated batteries, thus leaving a comparison of the value of the open circuit tension as the only method to approximate the residual capacity. The result of a measurement of the open circuit tension, taken either 24 hours after a full charge, or at least 10 minutes after discharge, when plotted on the curve found in figure 7 allows an approximation of the residual capacity.

Fig. 7



4.5 *Charge*

A proper charge is among the most important elements that help ensure long life to FIAMM-GS batteries.

4.5.1 *Constant tension charge*

This is the most commonly used method of charging. Generally, a constant tension charger is used together with a current limiter. In this way, the charging current cannot pass the suggested limit of 0.25C during the initial charge phase. When the battery tension reaches the fixed level (see figures 8 and 9), the charger switches from constant current to constant voltage. During this phase, the charging current begins to decrease until it reaches a level of minimum charging current, also known as maintenance current which generally equals 0.3 mA/Ah.

The recommended values for charging voltage, with a temperature of 20-25°C, are the following:
cyclic use: 2.40 - 2.45 V/cell - charging current 0,25C
stand-by use: 2.25 - 2.30 V/cell - charging current 0,25C

Fig. 8

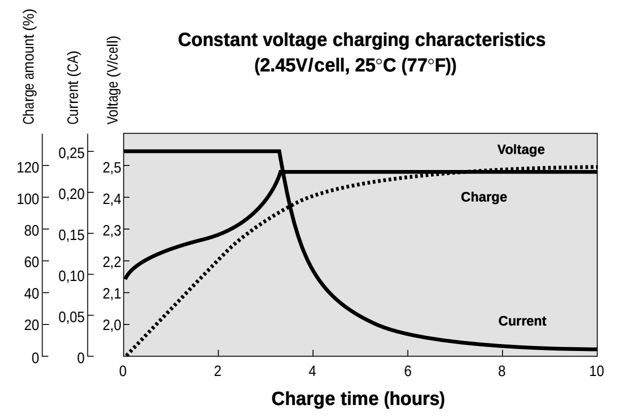
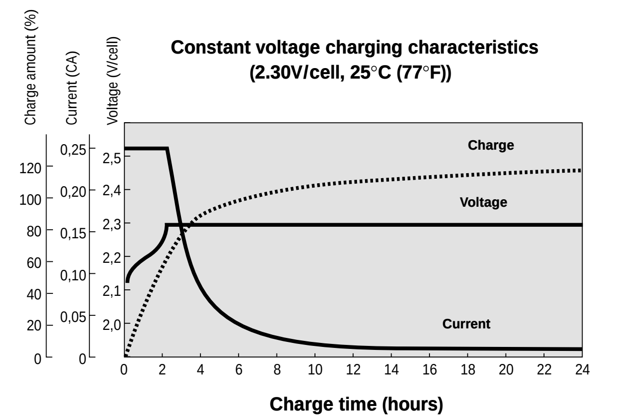


Fig. 9



With temperatures lower or higher than 10°C-30°C, it is necessary to modify the charging tension, by applying a thermal compensation factor. Otherwise, there is the risk of undercharging at low temperatures, or overcharging at high temperatures.

The thermal compensation factors to be applied are:

- 3 mV/cell/°C for stand-by - 5 mV/cell/°C for cyclic use

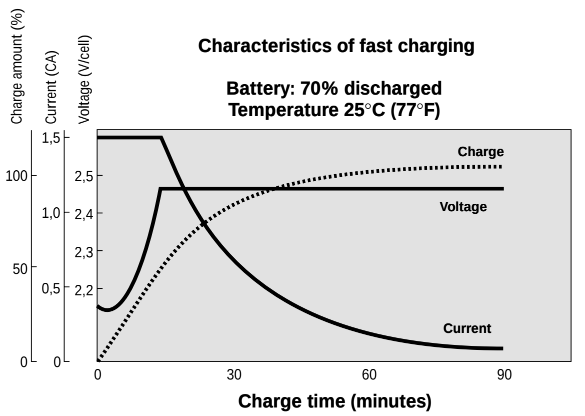
If the temperature is between 10°C and 30°C, it is generally not necessary to take the compensation factor into account.

Caution: in cyclic use it is recommended to use either a timer to interrupt charging at the preset voltage or a sensor.

4.5.2 *Fast charge*

Higher than normal tensions and currents are used to fast charge batteries. By increasing the limit of initial current to 1.5 C, it is possible to recharge previously 70% discharged batteries in about 1,5 hours (see figure 10). In the case of batteries with over 10 Ah capacity, it is however necessary to keep the initial current to a maximum of 1 C in order to avoid a temperature increase during the charging phase. Beyond thermal compensation (see 4.5.1), the installation of a thermal fuse is also recommended to immediately halt the charge should the batteries reach overly high temperatures.

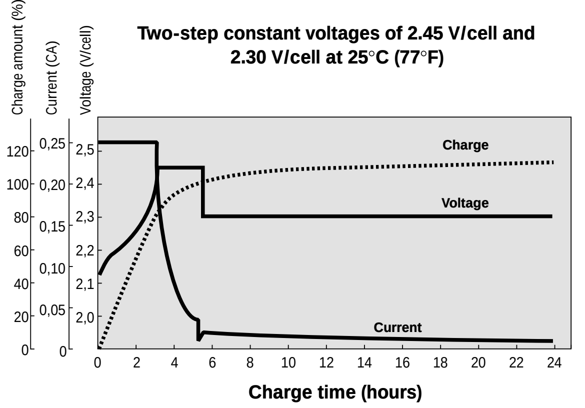
Fig. 10



4.5.3 *Two-stage charge*

The use of a two-stage charger can also be used to accelerate the charge. Figure 11 represents the functioning of a two-stage charger.

Fig. 11



4.5.4 *Parallel charge*

- Use only batteries of the same type and brand.
- Ensure that the connecting cables have the same electric resistance value.
- Use only batteries with the same production date and usage history.

5 LIFETIME

After being used for a longer period, the electric capacity of a battery begins to deteriorate, until it reaches a point where it can no longer be restored through recharging. This indicates that the end of the battery's useful life has been reached. It is very difficult to forecast the lifetime of a battery, as many factors can have a great influence thereon.
The main factors which negatively affect battery life are:

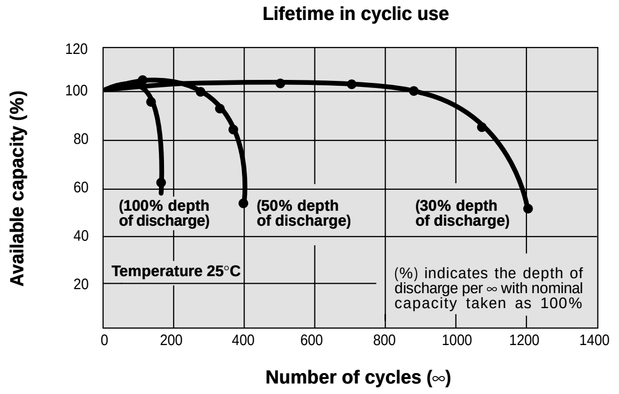
- **Deep discharge**
- **High quantity of overcharge**
- **Charging current and voltage**
  During the charging phase, a high initial current can generate excessive heat. This phenomenon may cause both assembled and non-assembled batteries to swell if they are placed in an insufficiently ventilated space. The same can happen when the charging tension is too high.
- **Surrounding temperature**
  The higher the surrounding temperature, the more the battery deteriorates.

5.1 *Lifetime in cyclic use*

Figure 12 shows the lifetime of FIAMM-GS batteries in cyclic use. Initially, the capacity tends to increase. The number of usable cycles decreases if the depth of discharge increases.

A battery with a higher capacity will have a much longer lifetime, if compared to a smaller capacity battery using the same load.

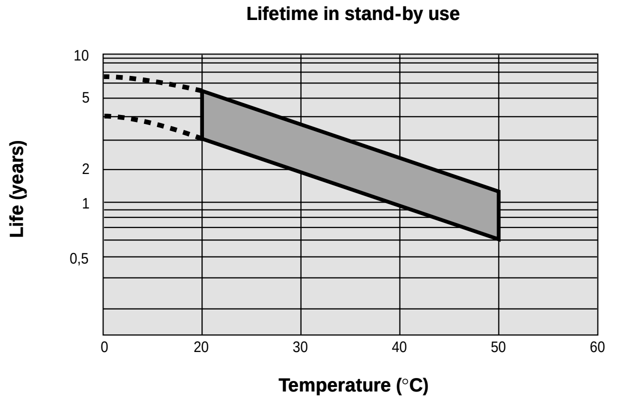
Fig. 12



5.2 *Lifetime in stand-by use*

Figure 13 shows the lifetime of FIAMM-GS batteries in stand-by use. The width of the curve indicates the normal tolerance of the battery capacity. As the lifetime is considerably affected by the charging voltage, it is important to remain within the limits of 2.25 - 2.30 V/cell (+ the thermal compensation factor). As can be seen in the figure, a tremendous reduction of battery lifetime is caused by an increase in the surrounding temperature.

Fig. 13



5.3 *Lifetime in deep discharge*

The lifetime of a FIAMM-GS battery is seriously reduced if discharged too deeply or if stored in a discharged state.

Fig. 14

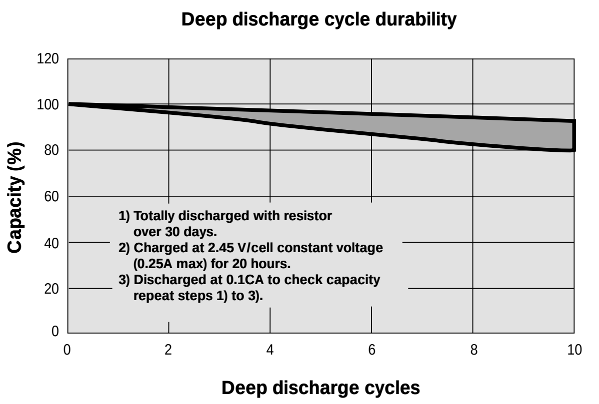
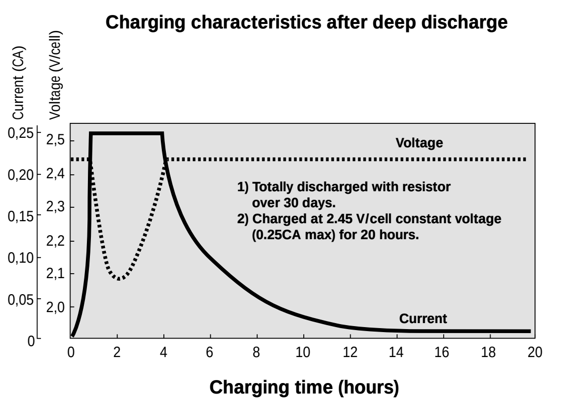


Figure 14 demonstrates the relationship between the number of overdischarges and the percentage of rated capacity which can be obtained after the recharge of FIAMM-GS batteries.
Figure 15 shows the charge after an overly severe discharge.

Fig. 15



6 OPERATING INSTRUCTIONS

6.1 *Assembling and connecting*

- Never put the batteries in a sealed container during charging.
- Secure the battery well, and protect from vibrations and impacts.
- If the battery is installed inside a cabinet, fasten it well at the lowest possible level.
- Do not install the battery near sources of heat or sources of possible sparks.
- It is common for slight temperature differences to exist between batteries installed in series or parallel. It is however important to avoid that such differences exceed 3°C.
- Do not place the battery in contact with objects containing plasticizers, organic solvents or soft PVC, as they may damage the ABS battery case.
- Do not compress and/or bend the terminals, and do not overheat them (do not weld or solder!).
- It is not recommended to install the batteries in an upside-down position.
- Batteries should be installed in a dry cool and well-ventilated location.
- Always leave sufficient space between batteries (preferably 10 mm).
- Always discharge all batteries contemporaneously.
- Avoid using the batteries in places where, due to temperature changes, water may condense on the batteries.
- For batteries used in series, ensure the interconnection of the batteries before connecting them to the load.
- Due to the self-discharge process, it is likely that batteries will have lower capacity following transportation and/or storage, it is therefore necessary to recharge the batteries well before their installation.

N.B. The manufacturing date code is shown on all batteries.

6.2 *Storage*

- Storage temperature must be between -20°C and +40°C.
- Before storing the battery, disconnect from any electric circuit, and place in a cool, dry place.
- During the storage period, recharge the battery at least once every six months.
- Batteries also age during storage, it is therefore recommended to use them as soon as possible.

6.3 *General comments*

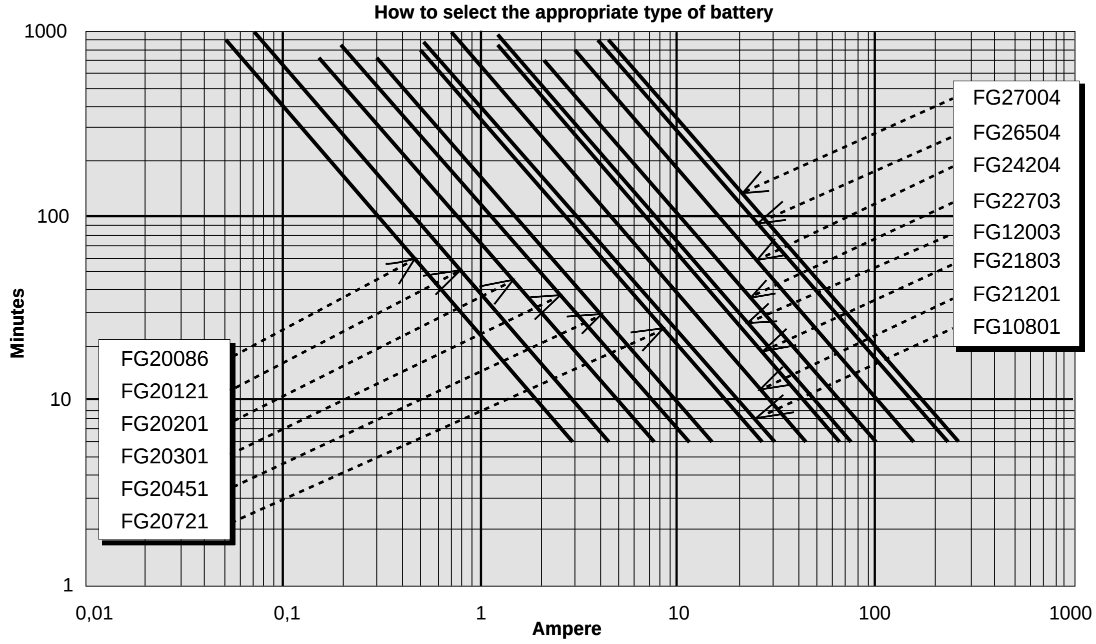
- Never short-circuit the terminals.
- Use a cloth for the cleaning of the batteries. Never use gasoline, oils, or solvents, and never use cloths impregnated with the aforementioned.
- Avoid any sparks or flames near the batteries.
- Do not attempt to open the batteries. In the event that the diluted sulphuric acid electrolyte happens to come in contact with skin and/or clothes, wash immediately with water. Should the acid come in contact with eyes, wash them thoroughly, and immediately consult a doctor.
- Never incinerate batteries, they may explode.
- Never employ batteries having different capacities and/or coming from different manufacturers or production batches. Differences in battery characteristics can cause damage to the batteries and/or to the equipment they serve.

Upon reaching the end of their useful life, batteries should be disposed of using appropriate collection and/or recycling channels (please consult local authorities for information).
Do not dispose of with household waste.

6 HOW TO SELECT THE APPROPRIATE TYPE OF BATTERY

The required battery capacity can be determined by plotting the point where the needed discharge current combines with that of the needed discharge time on figure 16.

Fig. 16



Any battery type depicted by a curve that falls to the right of the value calculated will provide the needed capacity.

Constant power discharge (W)

• Final Voltage: 1.6V/Cell

Time	5'	7'	10'	15'	20'	30'	45'	1h	2h	3h	5h	10h	20h
FG20721	298,3 W	243,2 W	193,8 W	147,7 W	120,9 W	90,2 W	66,5 W	53,2 W	30,4 W	21,6 W	13,9 W	7,5 W	4,0 W
FG21202	359,0 W	307,8 W	256,1 W	202,9 W	169,5 W	129,3 W	96,7 W	77,9 W	44,9 W	32,0 W	20,6 W	11,2 W	6,0 W
FG21803	680,8 W	556,5 W	445,5 W	342,3 W	282,0 W	212,7 W	158,7 W	128,2 W	75,0 W	54,1 W	35,4 W	19,5 W	10,5 W
FG22703	808,2 W	702,3 W	590,3 W	471,1 W	394,8 W	301,5 W	225,4 W	181,3 W	104,1 W	74,2 W	47,9 W	26,3 W	14,6 W
FG24204	1620,8 W	1322,8 W	1060,0 W	817,4 W	676,1 W	513,3 W	386,1 W	313,6 W	186,0 W	135,1 W	88,9 W	48,9 W	26,0 W
FG27004	2474,9 W	2092,3 W	1723,5 W	1357,0 W	1132,5 W	864,9 W	650,1 W	526,3 W	308,1 W	221,9 W	144,9 W	79,8 W	43,3 W

• Final Voltage: 1.7V/Cell

Time	5'	7'	10'	15'	20'	30'	45'	1h	2h	3h	5h	10h	20h
FG20721	281,4 W	233,3 W	188,3 W	145,1 W	119,4 W	89,5 W	66,1 W	52,8 W	30,1 W	21,4 W	13,8 W	7,5 W	4,0 W
FG21202	333,3 W	288,7 W	242,7 W	194,3 W	163,4 W	125,7 W	94,7 W	76,6 W	44,5 W	31,8 W	20,5 W	11,2 W	6,0 W
FG21803	628,9 W	525,9 W	429,0 W	334,8 W	278,1 W	211,2 W	158,2 W	127,8 W	74,6 W	53,7 W	35,1 W	19,3 W	10,5 W
FG22703	756,1 W	664,3 W	564,4 W	455,5 W	384,5 W	296,3 W	223,2 W	180,4 W	104,5 W	74,6 W	48,2 W	26,4 W	14,5 W
FG24204	1482,2 W	1243,8 W	1019,8 W	801,3 W	669,0 W	512,1 W	386,5 W	314,0 W	185,4 W	134,1 W	87,8 W	48,2 W	25,8 W
FG27004	2292,4 W	1981,4 W	1662,5 W	1329,2 W	1117,9 W	859,8 W	648,5 W	525,4 W	306,9 W	220,4 W	143,5 W	78,9 W	43,2 W

• Final Voltage: 1.8V/Cell

Time	5'	7'	10'	15'	20'	30'	45'	1h	2h	3h	5h	10h	20h
FG20721	250,4 W	211,6 W	174,0 W	136,4 W	113,4 W	85,9 W	64,0 W	51,5 W	29,6 W	21,1 W	13,6 W	7,3 W	3,9 W
FG21202	286,6 W	253,9 W	217,9 W	178,0 W	151,6 W	118,3 W	90,2 W	73,5 W	43,2 W	31,0 W	20,1 W	11,0 W	5,9 W
FG21803	540,3 W	464,7 W	388,6 W	310,2 W	261,0 W	201,1 W	152,1 W	123,6 W	72,7 W	52,4 W	34,3 W	18,9 W	10,3 W
FG22703	660,4 W	593,3 W	514,8 W	423,9 W	362,3 W	283,2 W	215,7 W	175,3 W	102,2 W	73,0 W	47,0 W	25,4 W	13,7 W
FG24204	1296,0 W	1122,1 W	944,9 W	760,1 W	642,5 W	498,2 W	379,0 W	308,9 W	182,8 W	132,1 W	86,3 W	47,5 W	25,7 W
FG27004	1996,7 W	1760,7 W	1506,0 W	1227,8 W	1045,5 W	816,6 W	624,1 W	509,6 W	302,0 W	218,1 W	142,6 W	78,5 W	42,7 W

Constant current discharge (A)

• Final Voltage: 1.6V/Cell

Time	5'	10'	15'	20'	30'	45'	1h	2h	3h	5h	10h	20h
FG20721	29 A	17,8 A	13,2 A	10,7 A	7,8 A	5,7 A	4,6 A	2,6 A	1,86 A	1,21 A	0,66 A	0,38 A
FG21202	48 A	31 A	23 A	18,5 A	13,5 A	9,7 A	7,7 A	4,3 A	3,0 A	1,92 A	1,04 A	0,64 A
FG21803	67 A	41 A	31 A	25 A	18,6 A	13,7 A	11,0 A	6,4 A	4,6 A	3,0 A	1,65 A	0,93 A
FG22703	97 A	60 A	45 A	37 A	27 A	21,5 A	17,2 A	10,7 A	7,4 A	4,8 A	2,67 A	1,43 A
FG24204	156 A	100 A	76 A	63 A	47 A	35 A	28 A	16,1 A	11,6 A	7,5 A	4,09 A	2,16 A
FG27004	246 A	168 A	129 A	106 A	79 A	58 A	46 A	26 A	18,3 A	11,8 A	6,50 A	3,59 A

• Final Voltage: 1.7V/Cell

Time	5'	10'	15'	20'	30'	45'	1h	2h	3h	5h	10h	20h
FG20721	27 A	17,2 A	13,1 A	10,6 A	7,9 A	5,8 A	4,6 A	2,6 A	1,84 A	1,18 A	0,65 A	0,37 A
FG21202	45 A	29 A	22 A	18,2 A	13,3 A	9,7 A	7,6 A	4,2 A	3,0 A	1,89 A	1,03 A	0,64 A
FG21803	62 A	40 A	30 A	25 A	18,6 A	13,8 A	11,0 A	6,4 A	4,6 A	3,0 A	1,62 A	0,92 A
FG22703	95 A	59 A	44 A	36 A	27 A	21,1 A	16,9 A	10,5 A	7,3 A	4,7 A	2,62 A	1,42 A
FG24204	140 A	96 A	75 A	62 A	47 A	35 A	28 A	16,0 A	11,4 A	7,4 A	4,02 A	2,15 A
FG27004	226 A	160 A	125 A	103 A	78 A	57 A	45 A	26 A	18,1 A	11,7 A	6,44 A	3,58 A

• Final Voltage: 1.8V/Cell

Time	5'	10'	15'	20'	30'	45'	1h	2h	3h	5h	10h	20h
FG20721	23 A	15,6 A	12,1 A	10,0 A	7,5 A	5,6 A	4,4 A	2,5 A	1,80 A	1,16 A	0,63 A	0,36 A
FG21202	39 A	27 A	20 A	16,8 A	12,5 A	9,2 A	7,3 A	4,1 A	2,9 A	1,86 A	1,01 A	0,60 A
FG21803	54 A	37 A	29 A	24 A	18,0 A	13,5 A	10,9 A	6,3 A	4,5 A	2,9 A	1,59 A	0,90 A
FG22703	78 A	48 A	39 A	33 A	24 A	19,3 A	15,6 A	9,8 A	6,9 A	4,5 A	2,46 A	1,41 A
FG24204	119 A	86 A	68 A	57 A	44 A	33 A	27 A	15,7 A	11,2 A	7,3 A	3,96 A	2,14 A
FG27004	194 A	142 A	113 A	95 A	73 A	55 A	44 A	26 A	18,3 A	11,9 A	6,48 A	3,58 A

FG Series

Type	VdS	Nominal voltage (V)	CAPACITY (Ah) Discharge 20 h rate 1,75V/cell	Discharge 10 h rate 1,75V/cell	Discharge 5 h rate 1,70V/cell	Discharge 1,5 h rate 1,60V/cell	Weight gr	Terminal position figure	DIMENSIONS (mm) L	W	H	TH	Max discharge current (A)	TEMPERAT. (°C) Charge	Discharge	Storage	Max charge current (A)	Terminal
FG10121		6	1,20	1,08	1,00	0,78	300	6	97	24,5	50,5	55	7,2	0 ÷ 40	-20 ÷ 50	-20 ÷ 50	0,300	FASTON 4,8
FG10301		6	3,00	2,70	2,55	1,95	680	2	134	34	60	65	18,0				0,750	FASTON 4,8
FG10321		6	3,20	2,88	2,72	2,08	750	3	66	33	118	124	19,2				0,800	FASTON 4,8
FG10451		6	4,00	3,60	3,40	2,60	890	1	70	48	102	106	24,0				1,000	FASTON 4,8
FG10721		6	7,00	6,30	5,95	4,55	1380	3	151	34	94	98	36,0				1,500	FASTON 4,8
● ❑ FG11201	■	6	12,00	10,80	9,60	7,50	2100	2	151	50	94	99	72,0				3,000	FASTON 4,8
● FG11202	■	6	12,00	10,80	9,60	7,50	2100	2	151	50	94	99	72,0				3,000	FASTON 6,3
FG12003		6	20,00	18,00	16,50	13,40	3700	8	157	83	125	125	120,0				5,000	BOLT+NUT TYPE M5
FG20086		12	0,80	0,72	0,63	0,53	360	7	96	25	61,5	61,5	3,2				0,200	LEAD WIRE+SOCKET
● ❑ FG20121	■	12	1,20	1,06	0,98	0,80	580	4	97	48,5	50,5	55	7,2				0,300	FASTON 4,8
FG20121A		12	1,20	1,08	1,00	0,78	550	4	97	42	51	55	7,2				0,300	FASTON 4,8
● ❑ FG20201	■	12	2,00	1,83	1,65	1,37	890	2	178	34	60	65	12,0				0,500	FASTON 4,8
FG20271		12	2,70	2,43	2,25	1,76	1100	3	79	55,5	102	106	16,2				0,670	FASTON 4,8
FG20301		12	3,00	2,70	2,55	1,95	1300	4	134	68	61	65	18,0				0,750	FASTON 4,8
FG20451		12	4,00	3,60	3,40	2,60	1750	3	90	70	102	106	24,0				1,000	FASTON 4,8
● ❑ FG20721	■	12	7,20	6,50	5,90	4,60	2650	4	151	65	94	99	43,2				1,800	FASTON 4,8
● FG20722	■	12	7,20	6,50	5,90	4,60	2650	4	151	65	94	99	43,2				1,800	FASTON 6,3
● ❑ FG21201	■	12	12,00	10,80	9,60	7,50	4200	4	151	98	94	99	72,0				3,000	FASTON 4,8
● ❑ FG21202	■	12	12,00	10,80	9,60	7,50	4200	4	151	98	94	99	72,0				3,000	FASTON 6,3
● FG21503	■	12	15,00	13,70	12,30	9,90	6100	8	181	76	167	167	108,0				4,500	BOLT+NUT TYPE M5
● ❑ FG21803		12	18,00	16,20	14,76	11,86	6200	8	181	76	167	167	156,0				6,500	BOLT+NUT TYPE M5
● ❑ FG22703	■	12	27,00	25,00	23,00	18,00	9000	8	166	175	125	125	162,0				6,750	BOLT+NUT TYPE M5
● ❑ FG24204	■	12	42,00	38,50	34,50	28,50	15000	8	196	163	174	174	252,0				10,500	BOLT+NUT TYPE M6
FG26504	■	12	65,00	62,00	55,80	46,10	22600	8	271	166	190	190	390,0				16,250	BOLT+NUT TYPE M6
● ❑ FG27004	■	12	70,00	66,70	60,00	50,00	24000	8	350	166	174	174	420,0				17,500	BOLT+NUT TYPE M6

Technical data may be subject to variations

● Batteries produced in Italian factory of Avezzano

❑ Batteries also available with a case that responds to UL-94 V0 flame retardant standards; these models carry an FGV prefix

■ VdS homologated batteries

▲ Under VdS homologation

How to read the code number

The code number of FIAMM-GS batteries indicates voltage, capacity and type of terminal.

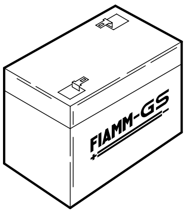
FG ☐ ☐☐☐ ☐ **A** —— "A" indicates a different form compared to the standard type of same capacity and voltage

Voltage
1: 6V
2: 12V

Capacity
in tenths
of Ah
at 20 hours
rate

Terminal type
1: faston type 4,8
2: faston type 6,3
3: bolt type M5
4: bolt type M6
6: lead wire with socket

TERMINAL POSITION



⇐ Front side

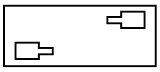


Fig. 1

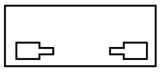


Fig. 2

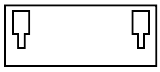


Fig. 3

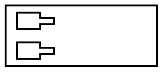


Fig. 4

Terminal position

Connector + wire

Bolt and nut

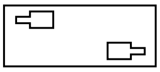


Fig. 5

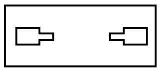
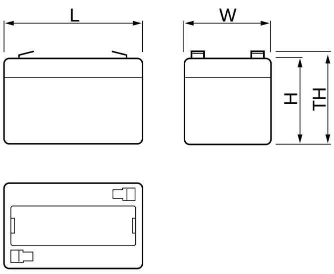


Fig. 6


Fig. 7

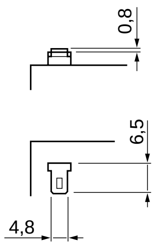

Fig. 8

MAXIMUM DIMENSIONS

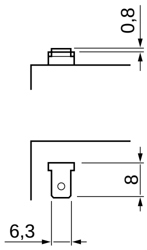


TERMINAL TYPE

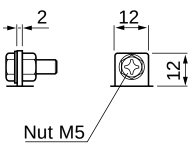
■ **Terminal 1**
Terminal type



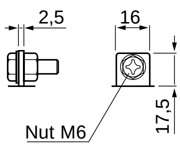
■ **Terminal 2**
Terminal type



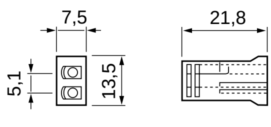
■ **Terminal 3**
Bolt and nut type M5



■ **Terminal 4**
Bolt and nut type M6



■ **Terminal 6**
Lead wire with connector



MALE
AMP. INC.
N. 1-480318-0

FEMALE
AMP. INC.
N. 60617-1

Wire length
105 (D. 4134) ÷ 10 (D. 0394)

NOTES:

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