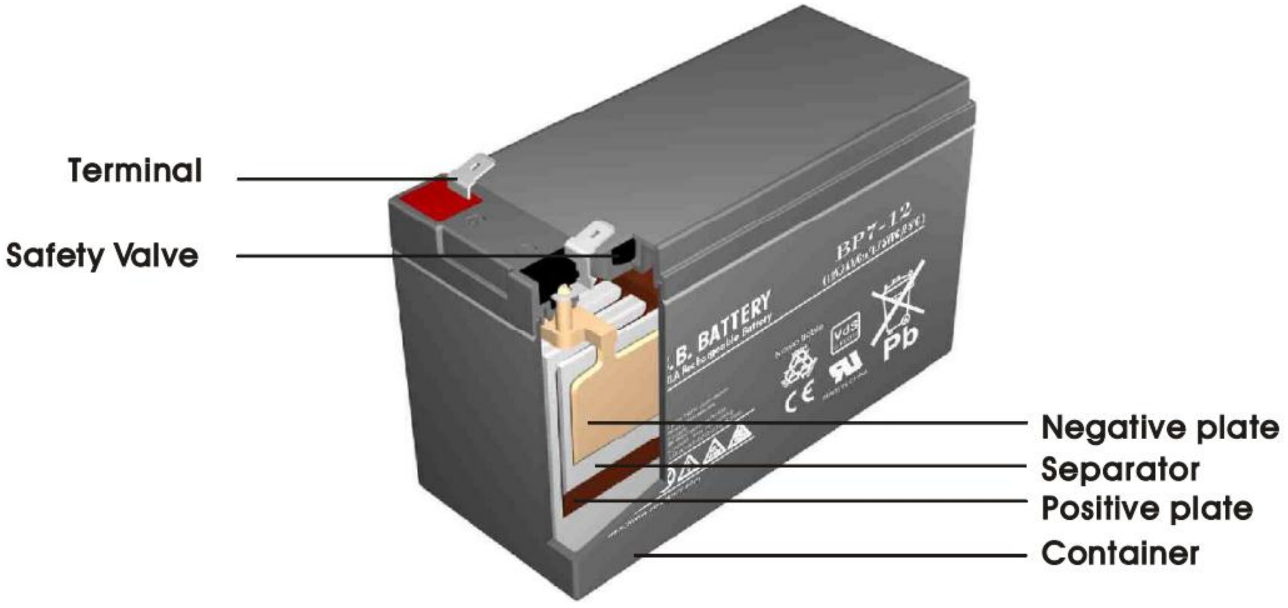
GE
Industrial Solutions

Application Guide # 7

VRLA Battery Characteristics and Behaviour



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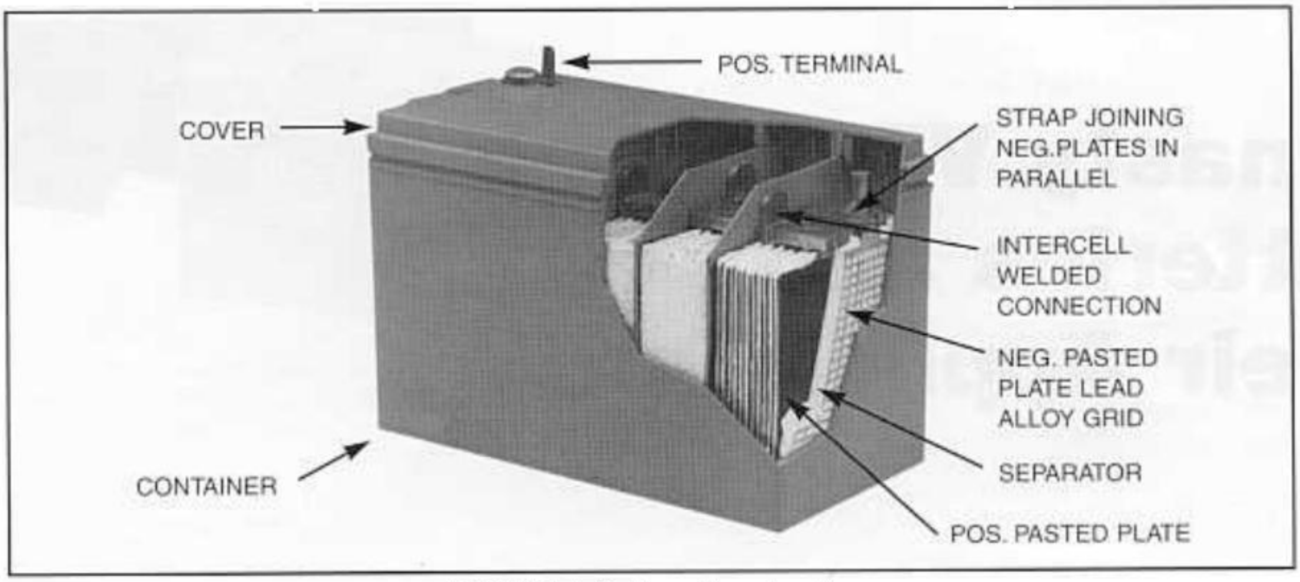
1 TYPE

AGM VRLA BATTERY CONSTRUCTION

The AGM VRLA battery utilizes a separator of glass fibres which serves to both isolate the negative and positive plates and act as a blotter to absorb all the electrolyte within the cell. This AGM separator is somewhat fragile, highly porous and absorbent, and of very low resistance. The AGM separator is maintained under compression between the plates to assure complete contact with the plates surface since it provides the source of electrolyte essential to the cell's electrochemical reaction. Actually the separator is not completely saturated with electrolyte and it is the 5 to 10% void space that allows the oxygen gas generated at the positive plate to diffuse to the negative plate where the oxygen recombination cycle occurs.

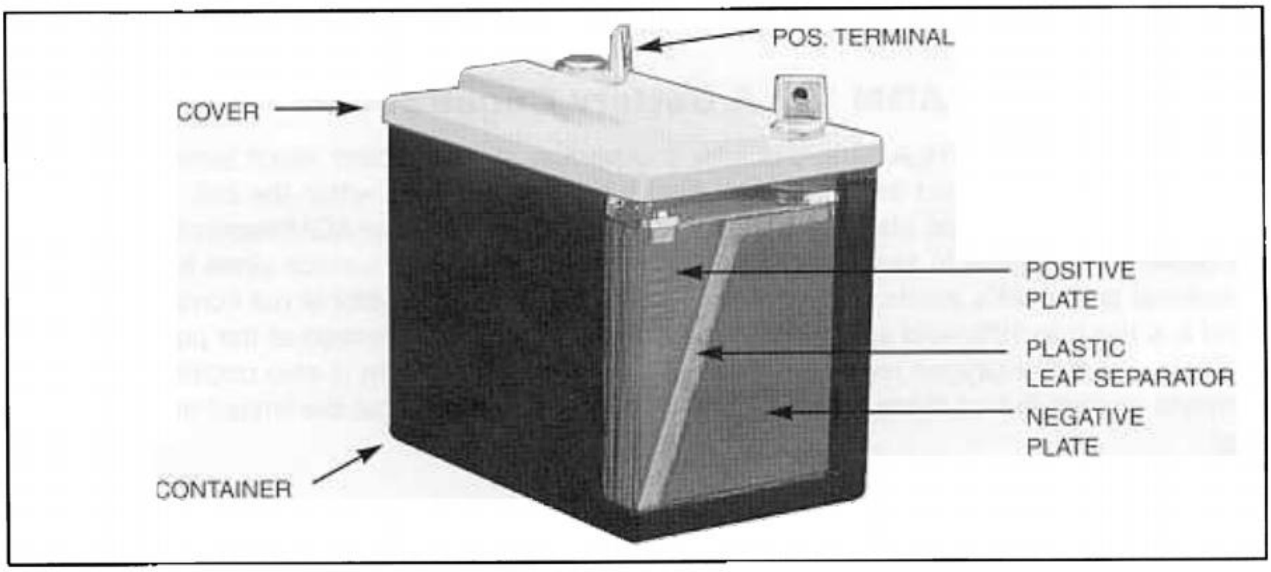
This system is also occasionally referred to as a starved electrolyte system in that there is more plate active material than what the limited amount of electrolyte can fully react.



AGM VRLA Battery Construction
Figure 1

GELLED ELECTROLYTE VRLA BATTERY CONSTRUCTION

The gelled electrolyte VRLA battery utilizes a tobust plastic or glass leaf separator. This leaf separator is not relied upon to absorb the electrolyte, since the electrolyte is gelled, but strictly performs the function of separating and resisting the development of shorts between the plates, In some designs, the leaf separator contains an integral glass mat retainer which lies against the positive plate active material and “retains” sloughed material and consequently imporves the cell’s cycle life. This durable leaf separator and the galled electrolyte are of relatively high resistance and introduce additional voltage drop during high rate discharge. The cell is between the plates the allow for the transport of the oxygen from the positive to the negative plate allowing for the oxygen recombination cycle.



Gelled Electrolyte VRLA Battery Construction
Figure 2

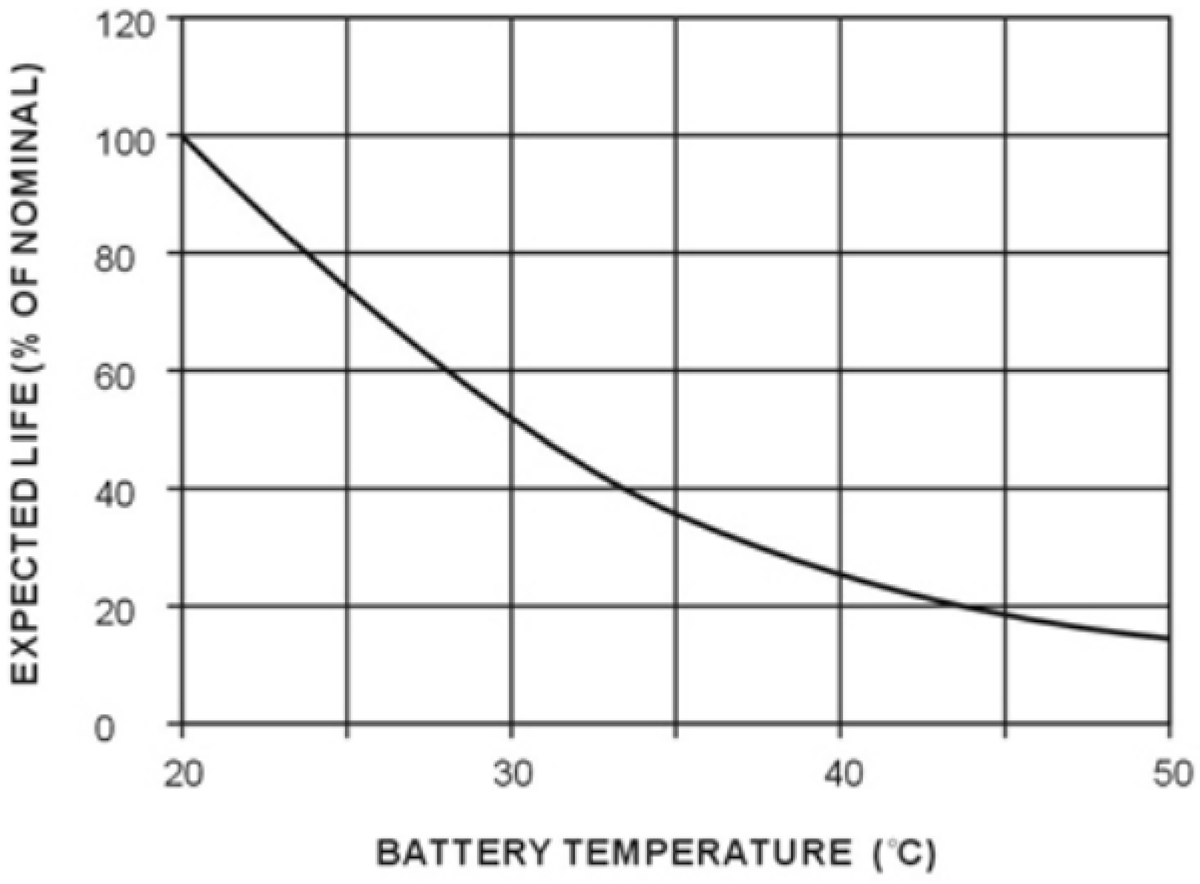
2 AGING

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

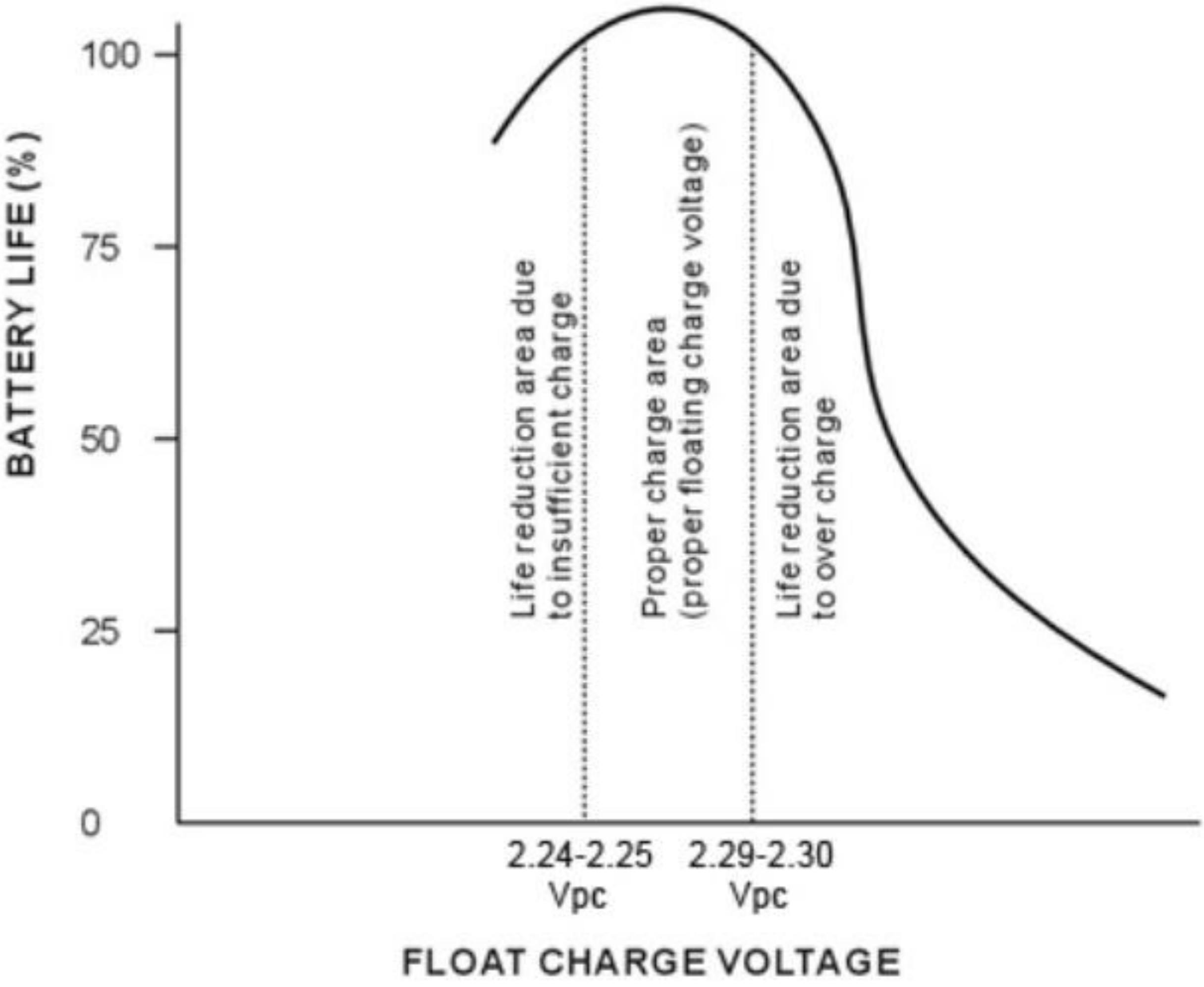
Operation at temperature higher than 20°C reduces life expectancy according to the table in below figures.

Service life of the battery is affected as well by the floating voltage range chosen for the charging as showed in below figures.

EXPECTED SERVICE LIFE VS WORKING TEMPERATURE (DATA FIAMM FLB BATTERY 10-12 YEARS)



EXPECTED SERVICE LIFE VS FLOATING VOLTAGE RANGE (DATA FIAMM FLB BATTERY 10-12 YEARS)



EXPECTED SERVICE LIFE VS WORKING TEMPERATURE (DATA BB BATTERY 5 YEARS)

The battery life is reduced by 50% for every 10 degrees °C increase in temperature.

Average relationship is:

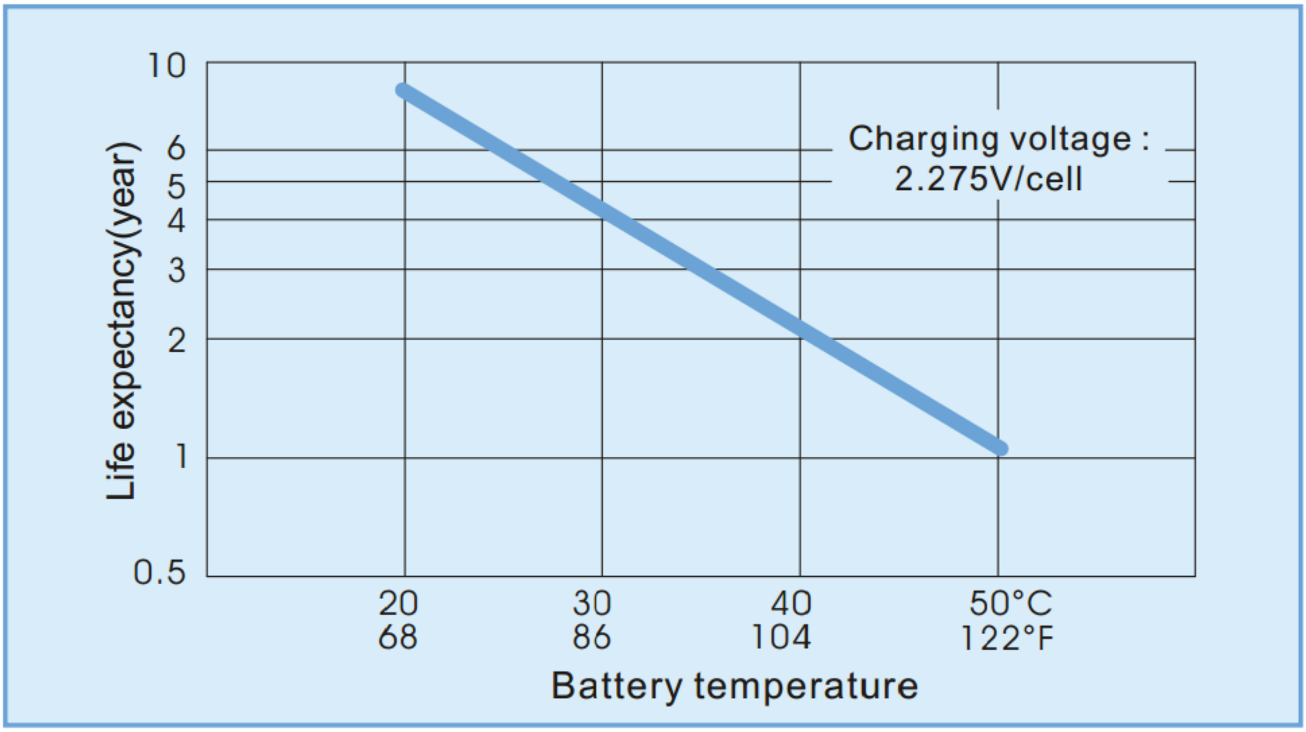
20 degrees C ------ 100% life

30 degrees C ------ 50% life

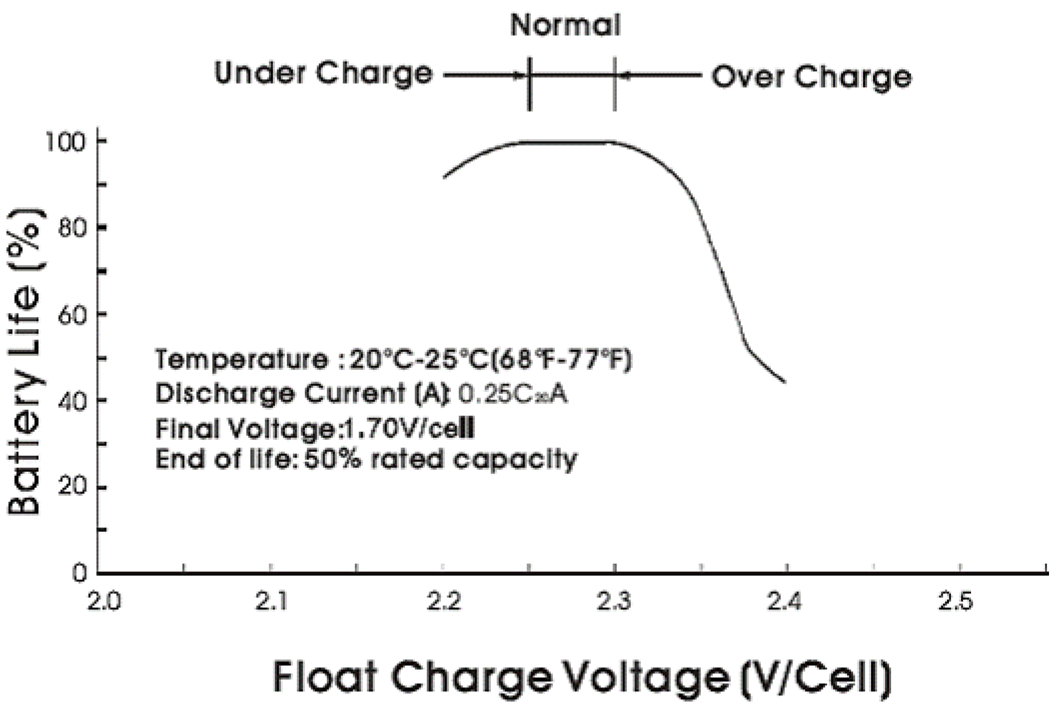
40 degrees C ------ 25% life

50 degrees C ------ 12.5% life

EFFECT OF TEMPERATURE ON LONG TERM FLOAT LIFE



RELATIONSHIP BETWEEN FLOAT CHARGE VOLTAGE AND BATTERY LIFE (DATA BB BATTERY 5 YEARS)



3 BATTERY CAPACITY VS WORKING TEMPERATURE

VRLA BATTERY (DATA FIAMM BATTERY 10-12 YEARS)

The battery capacity measurement depends by the temperature.

If the battery capacity is measured according to IEC 60896-21-22 between 3 and 10 hours and between 18 and 27 °C, the capacity has to be corrected with the following calculation:

$$C_{20} = \frac{C}{1+0.006(\theta-20)}$$

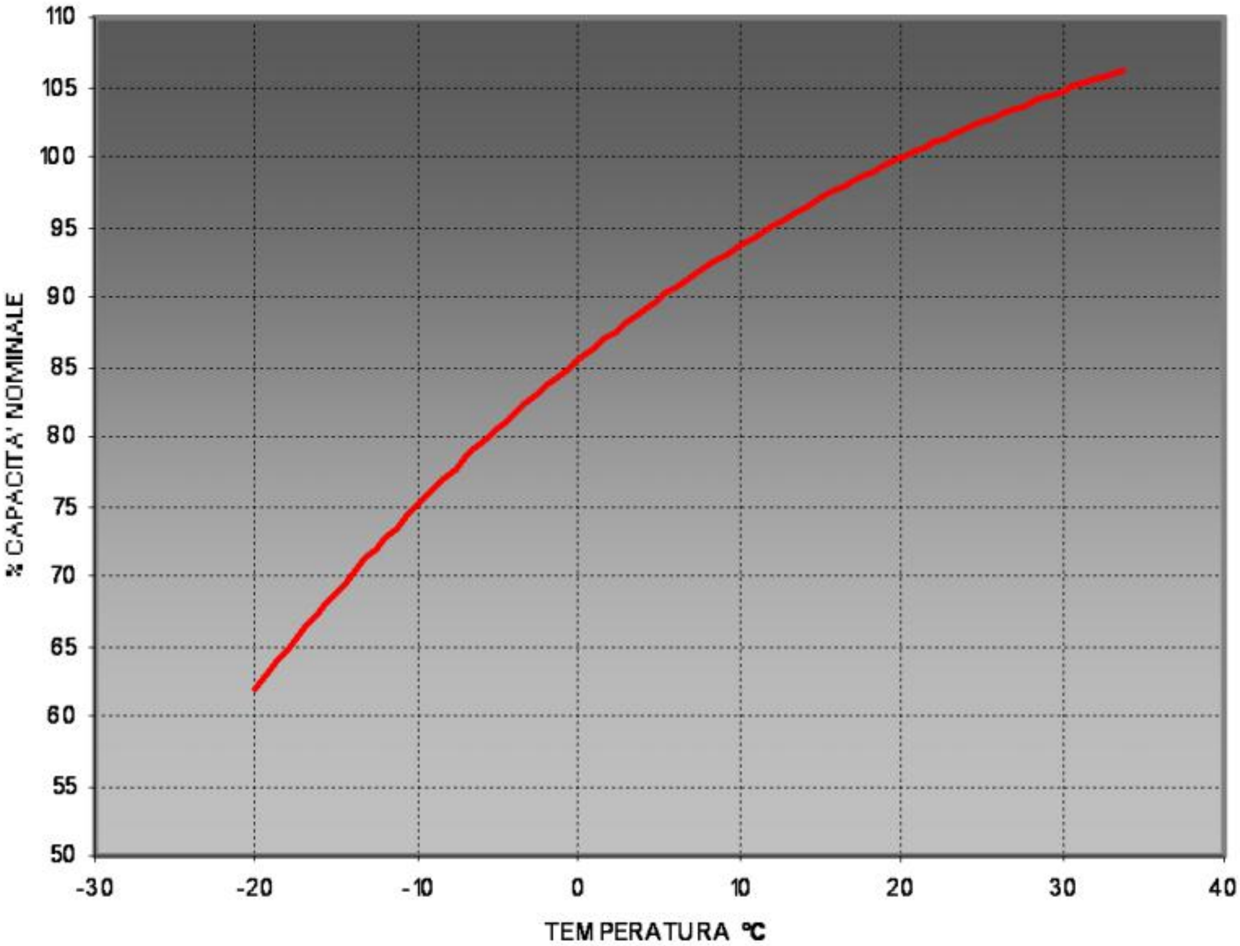
Where:

$C_{20} = capacity\ at\ 20°C$

$C = capacity\ measured\ with\ the\ average\ temperature\ present\ during\ test$

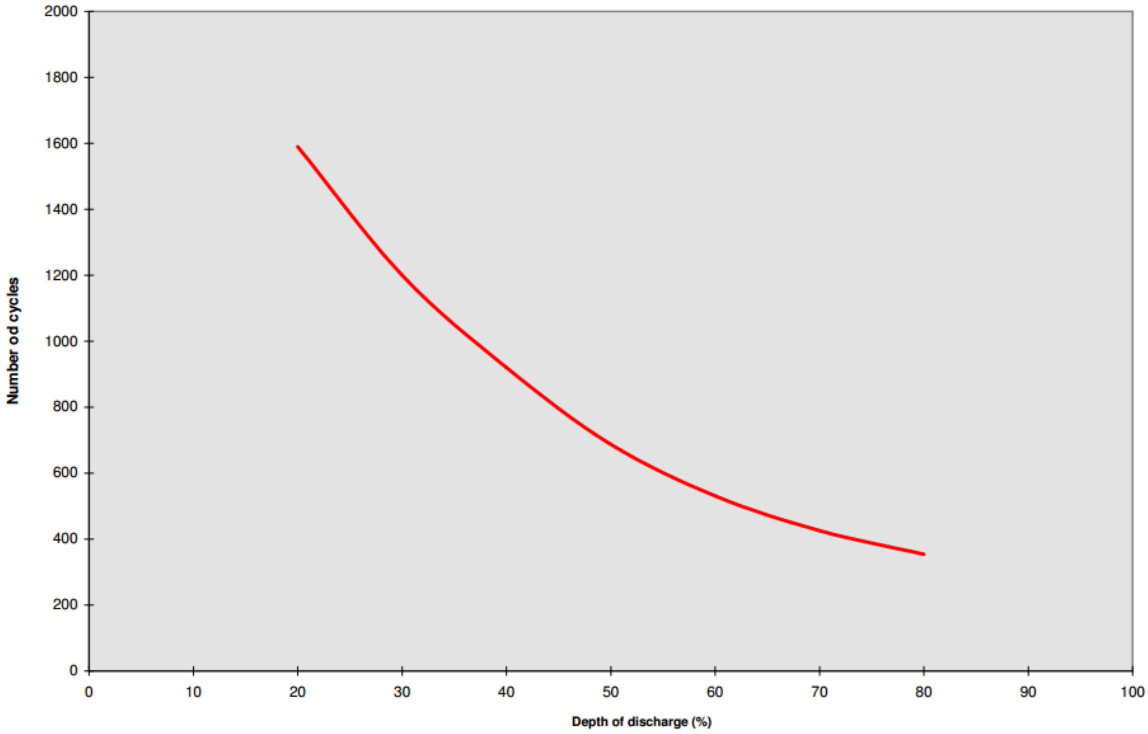
$\theta = average\ temperature\ present\ during\ test$

Measured capacity at different temperature follow the below curve.



4 NUMBER OF CYCLES VS DEPTH OF DISCHARGE

VRLA BATTERY (DATA FIAMM BATTERY 10-12 YEARS)



5 BATTERY CHARGE AND DISCHARGE CHARACTERISTICS

BATTERY CHARGING CHARACTERISTICS

To choose and properly size a battery capacity and a battery charger, some basic information are necessary.

Capacity [Ah]

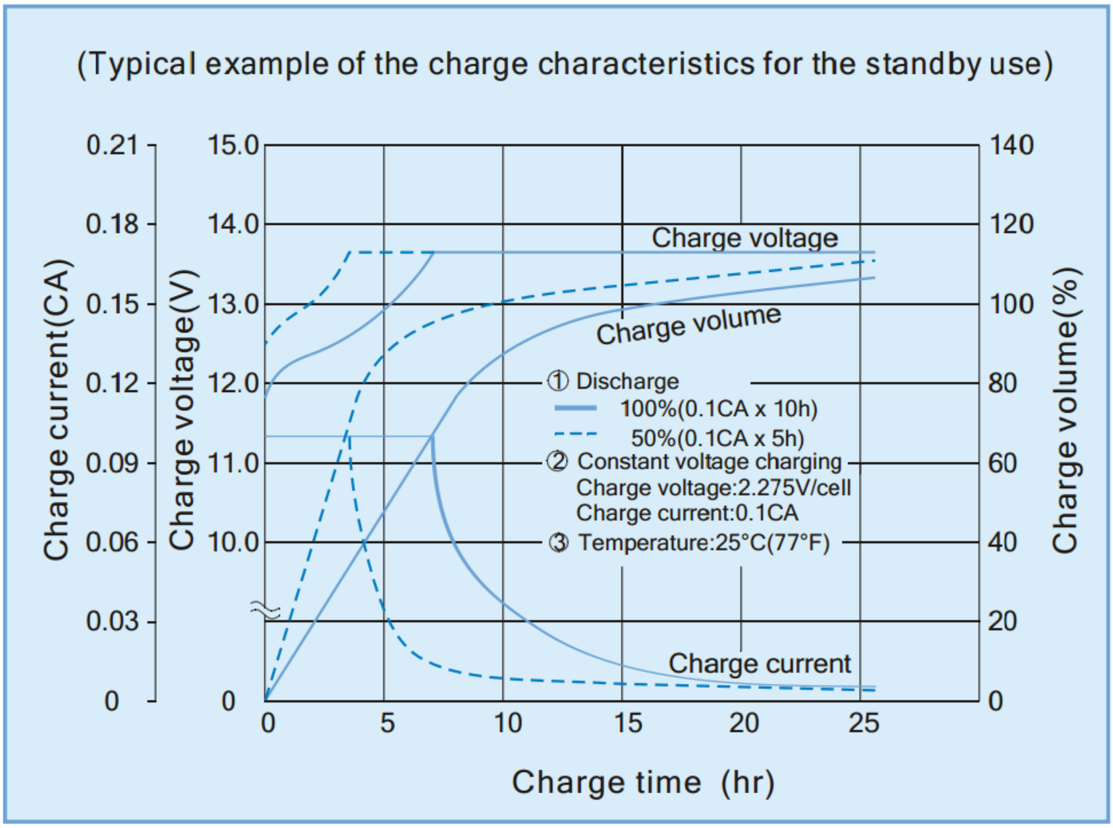
First of all, to compare different battery brands, the main important thing is to compare the same Capacity [Ah] value; the Ah capacity is the current a battery can provide over a specified period, for example a 100Ah C10 end of discharge 1.75V/cell, can provide 10 A for 10 hours to an end discharge voltage of 1.75V per cell.
Different battery manufacturers will use different CXX rates depending on the market or application at which their batteries are targeted. Typical rates used are C3, C5, C8, C10 and C20.

In the following example both manufacturers can offer a 100Ah battery but, *Manufacturer A* can supply the 100Ah at C3 (and 135Ah at C10) and *Manufacturer B* can supply the 100Ah only at C10; in this case the *Manufacturer A* battery is better than the one offered by *Manufacturer B*.

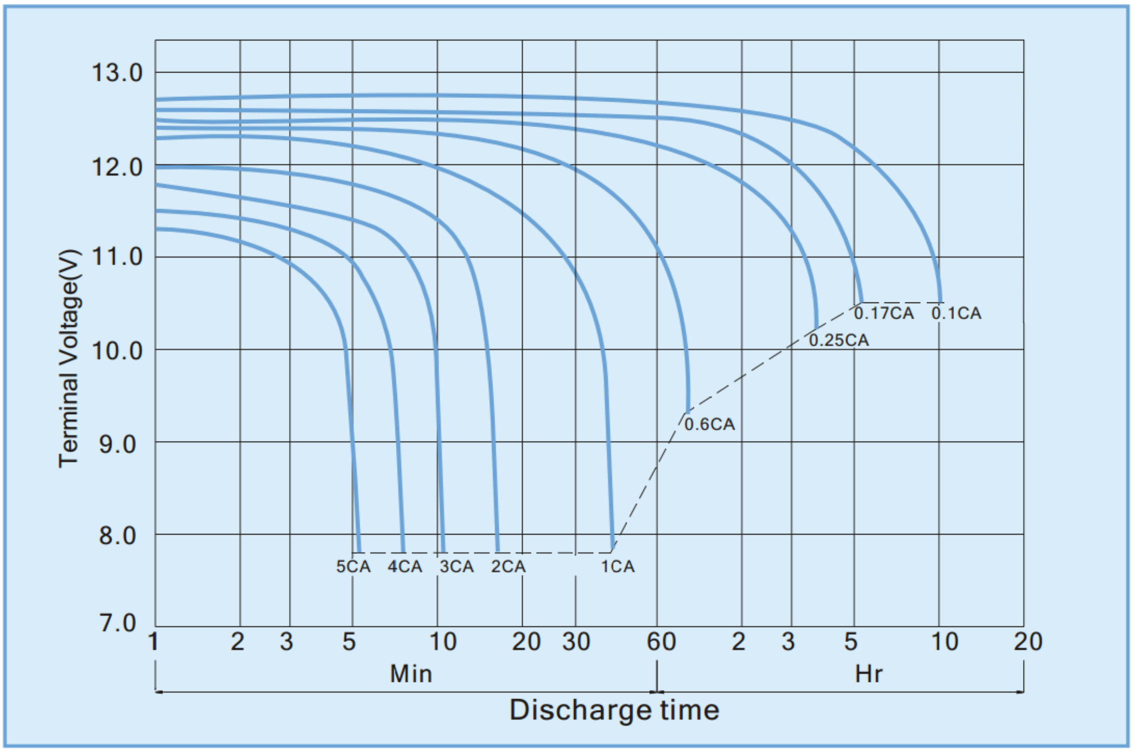
		Standby Time (Hrs)							
		1	**2**	**3**	**5**	**8**	**10**	**12**	**20**
Manufacturer 'A'	**Current**	80.9	47.4	**35.0**	23.2	16.2	13.57	11.4	5.9
	Ah (Cxx rate)	80.9	94.8	**105.0**	116.0	129.6	135.7	136.8	138.0
Manufacturer 'B'	**Current**	66.9	38.5	27.7	18.2	12.3	**10.2**	8.6	5.77
	Ah (Cxx rate)	66.9	77.0	83.1	91.0	98.4	**102.0**	103.2	115.4

Battery charging current

For standard UPS standby applications the batteries are charged at floating voltage and the required charging time depends by the type of installation (number of charging/discharging phases, runtime, etc).
Usually, VRLA batteries charging current is limited to 0.3 C10, and 0.1 C10 is the normal recommended charging current during normal UPS operation.
Charging current value is strictly connected to the required recharging time, for example to charge a battery from up to 80% the following charging times are needed:
- 4 hours with 0.2 C10
- 8 hours with 0.1 C10
- 16 hours with 0.05 C10



AVERAGE BATTERY DISCHARGE CHARACTERISTICS



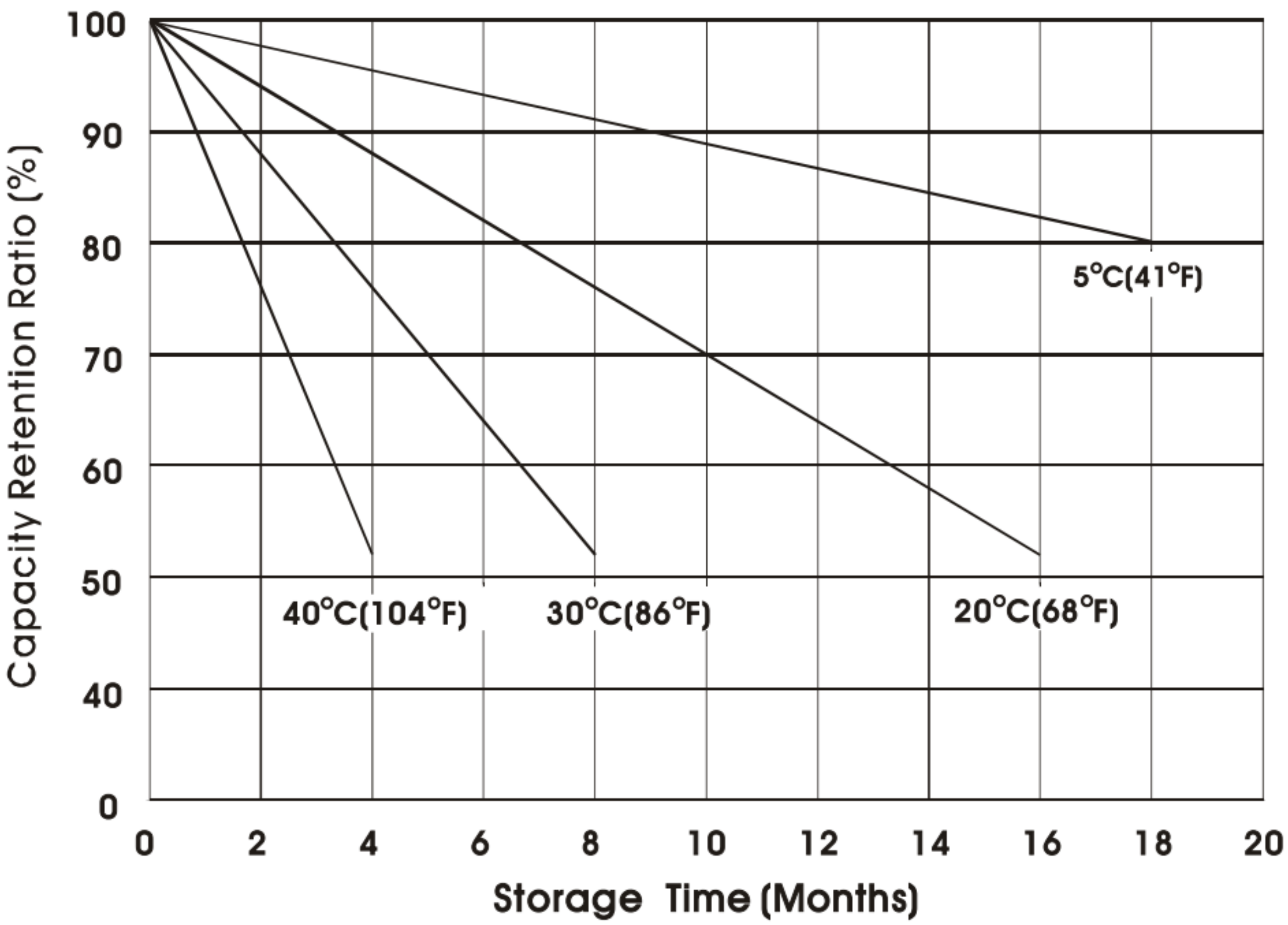
6 BATTERY SELF DISCHARGE

The self discharge rate of VRLA battery is approximately 3% per month when stored at an ambient temperature of 20°C.

The self discharge rate will vary as a function of ambient storage temperature.

Figure below shows the relationship between storage times at various temperatures and the remaining capacity

BATTERY SELF DISCHARGE CHARACTERISTICS



SHELF LIFE

When VRLA batteries are stored for extended periods of time, lead sulphate is formed on the negative plates of the batteries. This phenomenon is referred to as "sulphation".
Since the lead sulphate acts as an insulator, it has a direct detrimental effect on charge acceptance. The more advanced the sulphation, the lower the charge acceptance. Table below shows the normal storage time or shelf life at various ambient temperatures.

Brief excursions, a few days, at temperatures higher than the ranges recommended above will have no adverse effect on storage time or service life. However, should the higher ambient temperature persist for one month or more, the storage time must be determined by referring to the new ambient temperature. Ideally VRLA battery should be stored in dry, cool conditions.

SHELF LIFE AT VARIOUS TEMPERATURES

Temperature	Life
Below 20°C(68°F)	9 months
21°C(70°F) to 30°C(86°F)	6 months
31°C(88°F) to 40°C(104°F)	3 months
41°C(106°F) to 50°C(122°F)	1.5 months

RECHARGING STORED BATTERIES

To optimize performance and service life, it is recommended that VRLA batteries which are to be stored for extended periods of time be given a supplementary charge, commonly referred to as a "top charge", periodically.

Battery Age	*Top Charging Recommendations*
Within 6 *months after manufacture*	4 *to* 6 *hours at constant current of* 0.1 *C Amps or* 15 *to* 20 *hours at constant voltage of* 2.45 *Vpc*

GE PROCEDURES

General Electric has introduce the following label when a battery is present in the UPS or in a Battery Cabinet

Maximum storage time without charging the batteries is 6 months.	*** WARNING!** Maximum storage without charging the batteries for different environment conditions
Expiring Data* (Month / Year) … … / 20 … … (for storage conditions +20°C/68°F)	❑ 5 MONTHS at 25°C / 77°F ❑ 3 MONTHS at 30°C / 86°F ❑ 2 MONTHS at 35°C / 95°F ❑ 1.5 MONTHS at 40°C / 104°F

Before ship the item, GE warehouse management add the Expiring Data on the label:

Expiring Data*
(Month / Year)
… … / 20 … …
(for storage conditions +20°C/68°F)

When customer/warehouse manager receive the item, based on the monthly average temperature condition (if above 20°C), the following table has to be filled:

*** WARNING!**
Maximum storage without charging the batteries for different environment conditions

- ❑ 5 MONTHS at 25°C / 77°F
- ❑ 3 MONTHS at 30°C / 86°F
- ❑ 2 MONTHS at 35°C / 95°F
- ❑ 1.5 MONTHS at 40°C / 104°F

7 BATTERY SHORT CIRCUIT

SHORT CURCUIT CURRENT OF A BATTERY STRING

$$I_{CC} = \frac{V_b}{R_i}$$

$V_b = max. discharging\ voltage\ (100\%\ charged\ battery)$

$R_i = battery\ block\ internal\ resistence\ (depend\ by\ the\ battery\ Ah)$

Average values:

$$I_{CC} = k \times C$$

$k = 20 - 30$

$C = battery\ capacity\ [Ah]$

8 BATTERY GAS EMISSION

VRLA batteries are designed to provide up to 99% recombination under normal charging conditions and, as a result, this required safety awareness about hazardous buildup of hydrogen gas. The volume of gas emitted by the VRLA battery is very small under normal float and equalization charging conditions and special mechanical ventilation would not normally be required. Hydrogen is lighter than air and disperses quickly throughout the surrounding atmosphere. Typically, the gas emission data is for reference only and would not public. Generally, the test result from one of the models can be on behalf of the whole series.

Average gas emission values:

- 0.0025 ml/(hxAhxCell) at float voltage Uflo = 2.275Vpc
- 0.0129 ml/(hxAhxCell) at elevated charge voltage U = 2.40Vpc.

IEC 60896

Based on battery capacity this Standard defines the way to calculate the Ventilation Air Flow and the required openings.

$$Q = v\, q\, s\, n\, I\, C$$

where

Q is the ventilation air flow, in m^3/h;

v is the necessary dilution of hydrogen $(100 - 4)/4 = 24$;

q $= 0{,}45 \times 10^{-3}\ m^3/Ah$ generated hydrogen;

s is the factor of safety;

n is the number of battery cells;

I = 2 A/100 Ah – conventional flooded cell batteries;

I = 1 A/100 Ah – flooded battery cells with low antimony alloy;

I = 0,5 A/100 Ah – flooded battery cells with recombination plugs;

I = 0,2 A/100 Ah – valve regulated lead-acid batteries;

C is the battery nominal capacity in Ah at the 10 h discharge rate.

CALCULATION

VRLA battery Gas Emission

	Data entry values
S =	3
n =	180 cells
I =	0.002 A/Ah
C =	24 Ah

v x q x s = 0.0324 $\frac{m^3}{Ah}$

$$Q = v \times q \times S \times n \times I \times C$$

Q = 0.280 m^3/h

Air speed = 0.1 $\frac{m}{s}$

Natural air flow openings requirements:

$$A \geq \frac{Q}{360}\,[m^2]$$

A = 0.000778 m^2

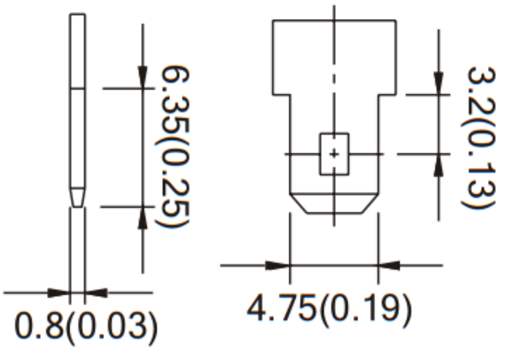
A = 0.07776 dm^2

A = 7.776 cm^2

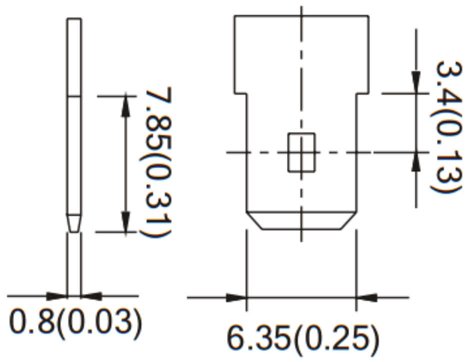
9 STANDARD TERMINALS

Below a description of the commonly used Terminals.

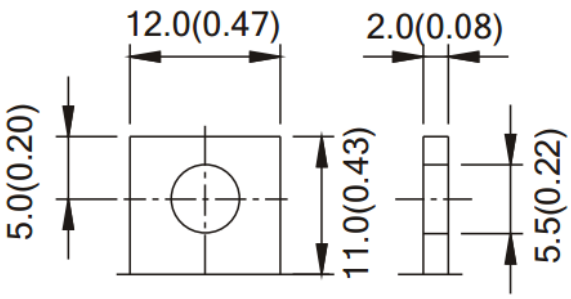
TERMINAL T1



TERMINAL T2

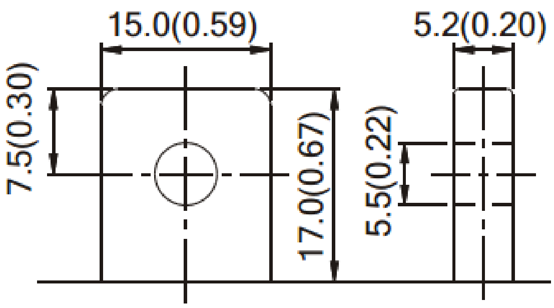


TERMINAL B1



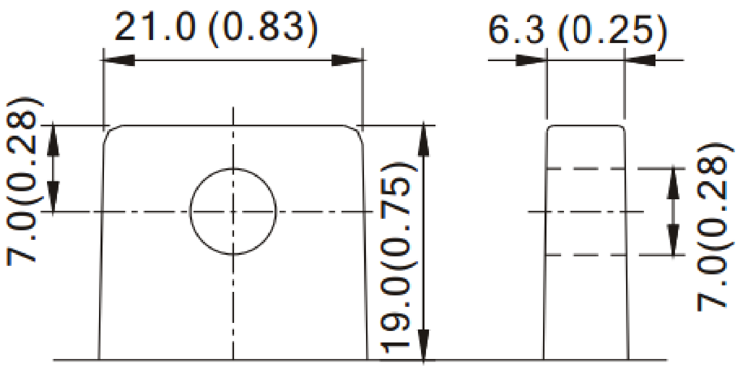
[M5 BOLT & NUT]

TERMINAL B2



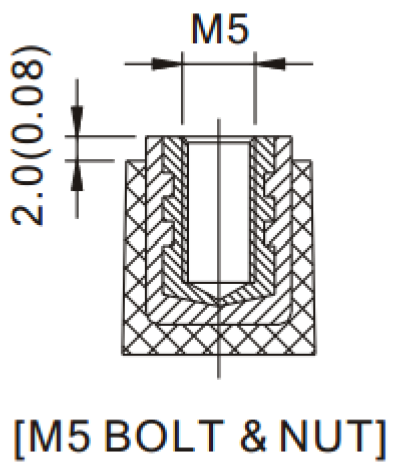
[M5 BOLT & NUT]

TERMINAL B5

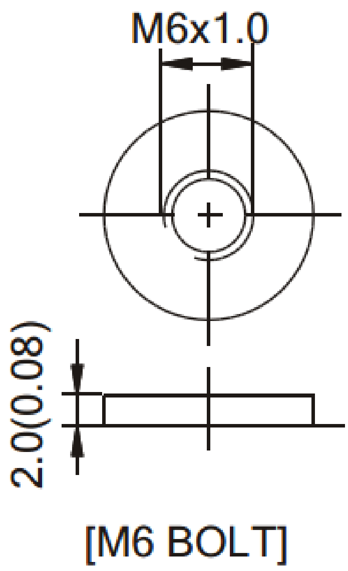


[M6 BOLT & NUT]

TERMINAL I1



TERMINAL I2



Terminal Hardware Initial Torque: B5/I2(5.5Nm±5%)

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

TERMINAL, BOLT AND NUTS MATERIAL

Terminal Type	Material
T1	Brass materials with coating(Pb+ Sn)
T2	
B0	
B1	
BE	
B2	Pb-Sb alloy
B3	
B4	
B5	
B6	
B7	
B8	
B9	
I1	Brass materials with coating (Ag)
I2	
I3	

bolt and nuts	Material
BN31(M5*10)	Steel materials with coating(Pb+ Sn)
BN32(M5*15)	
BN33(M6*20)	
BN34(M8*25)	
BNI1(M5*12)	
BNI2(M6*15)	
BNI2S(M6*12)	
BNI3(M8*20)	
BNI3B(M8*18)	
BNI4(M10*25)	