REMOTE MONITORING SPECIALISTS

Technical Note

TN1033 Rev 2

Management of Sealed Lead Acid Batteries in Reliable Small DC Standby Power Supply Systems

SCOPE:

The selection, sizing and choice of Sealed Lead Acid Batteries for use in Omniflex standby systems

DATE	REVISION	COMMENTS
02/04/2000	1	Initial Publication.
20/12/2018	2	Updated footer with correct cross reference as well as logo

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1.1 INTRODUCTION

As more and more remote monitoring is installed on sites ranging from sewerage pump stations and dam level monitors to air-conditioning and environmental monitoring systems, so the need for reliable standby power at 12 or 24Volts to drive conventional instrumentation and other remote monitoring systems has increased.

In the past, this area of standby power equipment has been dominated either by 12Volt systems as used in the access control and security areas, or by computer and general purpose UPS's.

Neither of these classes of equipment are suited to these small remote industrial applications. In such applications parameters such as maximum charge time, minimum standby time, battery life and voltage regulation demand clear specifications to ensure that these installations are fit for purpose. Space and cost are also issues to be addressed during equipment selection.

There is even an inclination by some engineers to simply connect a 24Volt dc battery directly across a 24Volt dc Power Supply to achieve a conveniently simple small standby system.

While specifying and installing such industrial grade systems does not have to be difficult or expensive, there are a number of pitfalls the unwary can easily encounter with the specification and management of small battery standby systems.

This Technical Note introduces the reader to the issues involved and suggests methods to ensure successful equipment selection.

1.2 BATTERY TYPE SELECTION

There are a number of battery types available for standby applications, such as Lead-Acid (sealed and wet cell), NiCad, Lithium-Ion and NiMH. All of these have differing costs and features that suit different applications.

For the type of systems described in this technical note, Sealed Lead Acid (SLA) cells are the dominant source. This is because this technology is proven, readily available from multiple sources, low maintenance, and inexpensive in the typical Ampere-Hour ratings used in these sorts of applications.

This technical note is limited to the use of SLA batteries. These batteries or normally equipped with a safety valve that will open if the pressure inside the battery rises above a pre-set limit. Overcharging or overheating of the battery normally causes this event to occur. When this valve opens, hydrogen can be expelled which will cause an explosive atmosphere to develop that is an extremely dangerous situation. Once this valve has opened, the battery is damaged and needs to be replaced. These types of batteries are also called Valve Regulated Lead Acid (VRLA) Batteries.

There are two types of SLA batteries on the market: Absorbent Glass Mat (AGM) and "Gel-Cell". This refers to the method used to immobilise the electrolyte in the battery. Either of these two types of battery may be used with chargers designed for SLA batteries.

1.3 TEMPERATURE COMPENSATION

A Lead Acid Battery is constructed of a series string of cells. of approx. 2.3 volts each when fully charged. A 12 Volt battery has 6 such cells. It is quit common to put two 12Volt batteries in series for 24Volt applications. This fully charged voltage varies by approximately –3.3mV/°C per cell. This does not sound much but, over 12 cells in a 24Volt application, this amounts to a change of 0.4V over a 10°C temperature swing.

If the float voltage of the charger does not compensate for this change, then it is possible to over-charge the battery at high temperatures and/or under-charge the battery at low temperatures.

Over a normal ambient working range of 15 to 35°C, a fixed voltage charger is considered quite satisfactory, and no temperature compensation is required. The fixed voltage selected for the charger will depend upon the standby time requirement of the battery and how conservative the designer is in his voltage selection.

If the average ambient temperature is likely to be outside of this range, then a temperature compensated float voltage is advisable.

Many chargers are equipped with integral temperature compensation. In industrial applications it is common to mount the batteries away from the charger itself, and the temperature environment of the batteries may be different to that of the charger. This means that the charger will not effectively control the battery voltage to suit the temperature of the batteries.

1.4 CHARGING TIME

While it is true in principle that the battery time to charge is determined by the charge current and the Ampere-Hour rating of the battery, this will only be true over a limited range of charging current. This is because charging the battery is a chemical process, and the chemical changes require a finite amount of time to occur in the battery. Every battery manufacturer quotes a maximum charge current that is normally of the order of 10-20% of the Ampere-Hour capacity of the battery. Exceeding this charging current will not necessarily charge the battery any quicker, but more importantly, the battery could be damaged in the process. When using a single-mode constant-voltage charger it is therefore important to ensure that the current capability of the charger does not exceed this maximum charging rate of the battery. This problem is often encountered when using a conventional power supply as a battery charger. Very few conventional supplies will have a tightly specified maximum current limit, and the current delivery capability of these types of power supplies can quite often reach twice that of the power supply manufacturer’s minimum specification under certain operating conditions.

Using a constant voltage charger set to the recommended float voltage, the battery will not be charged in the optimum time after usage in standby. This is because the battery terminal voltage will reach this float voltage well before the battery reaches its fully charged state. As the battery terminal voltage approaches the float voltage, the charging current will tail off to a smaller and smaller value, and the battery will not reach its fully charged for a significant period of time. These types of chargers are not suited to applications where the time to charge after standby is an important specification of the system.

Many of these limitations are overcome using dual-mode chargers. In a dual-mode charger, the battery is charged in two phases. When the AC power returns after the battery has been supplying the load, and requires recharging, the charger will enter into its “bulk”-mode charging phase. In this mode the battery will be charged with a constant current until the battery reaches its bulk charge voltage. The charger then switches into “float” charge mode, and the voltage is reduced to its “float” voltage, where the battery can remain indefinitely.

The bulk mode charge rate is chosen to ensure that the battery reaches 85-95% charge in the shortest possible time within the constraints of the battery specifications. The remaining 5-15% charge is then topped up more slowly during the float charge cycle.

If it is important in the application that the battery be at design capacity within the ‘bulk’ charge phase, then it is wise to over-rate the battery by up to 15%, and to consider the battery fully charged when it reaches this 85-95% capacity.

1.5 LOW VOLTAGE CUT-OUT

As described above, a battery is a series string of cells. The voltage across one cell will range from about 2.1volts when fully charged and about 1.9Volts when fully discharged.

When charging a battery, only the battery terminal voltage is monitored, and it is assumed that each of the battery cells is the same state of charge at any one time, and therefore that the individual cell voltages are the same across all of the cells in the battery. Because of chemical imbalances in the battery, this is rarely the case in practice. The consequence of this is that the individual cells of the battery will not reach full discharge at the same time. If a battery continues to supply the load after the first cell reaches its state of full discharge (powered by the other cells) then this discharged cell will enter a “deep” discharge state. This results in a reversal of the cell voltage in this cell, which will damage the cell if left too long in this state. It is therefore important for battery life to disconnect the load before the first cell enters this state. Now because the charger is not monitoring the individual cell voltages, this point must be estimated based upon the terminal voltage across the entire battery. This feature of chargers is known as the low-voltage cut-out, and serves to disconnect the battery from the load before the battery is permanently damaged.

1.6 BATTERY SIZE SELECTION

In order to select a battery for the application, follow these simple steps:

1. Calculate the Ampere-hours of standby time required, by multiplying the number of hours of standby required by the average standing load in Amps.

2. To take into account deterioration of battery capacity over the life of the battery (20% over 48 months typical), and residual charge remaining at cut-off (20% remaining) multiply this figure by 1.6 (This figure may vary from application to application)

3. If the battery is required to provide full standby time at temperatures lower than 20°C, then increase this capacity by a further 10% for each 10°C below 20°C.

4. An additional factor of 15% may be added to the battery capacity if the recharge time to required capacity from discharged state is an important factor of the design. (see section on Recharge time).

5. This then gives the minimum Ampere-hour capacity battery required for the application. In general, the larger the battery the better in any given application (size and cost being the compromise).

2. CHOOSING A BATTERY FOR BACKUP

The method for calculating battery backup times and battery sizes, for the batteries used with Omniflex type PSU/Chargers, is as follows:.

2.1 THE 20-HOUR DISCHARGE CURRENT

Back-up times are based on the so-called 20-hour discharge current J20. The product of this current and the time of 20 hours equals the battery capacity. Therefore, if the battery capacity is known, eg 24 Ah, the current can be calculated as follows:

J20 = = 1,2 A

If the discharge current is constant and equals J20, the battery will provide back-up for 20 hours. If the current is even lower, we can assume that the back-up time will increase proportionately, and that a battery of twice the capacity will provide twice the back-up time.

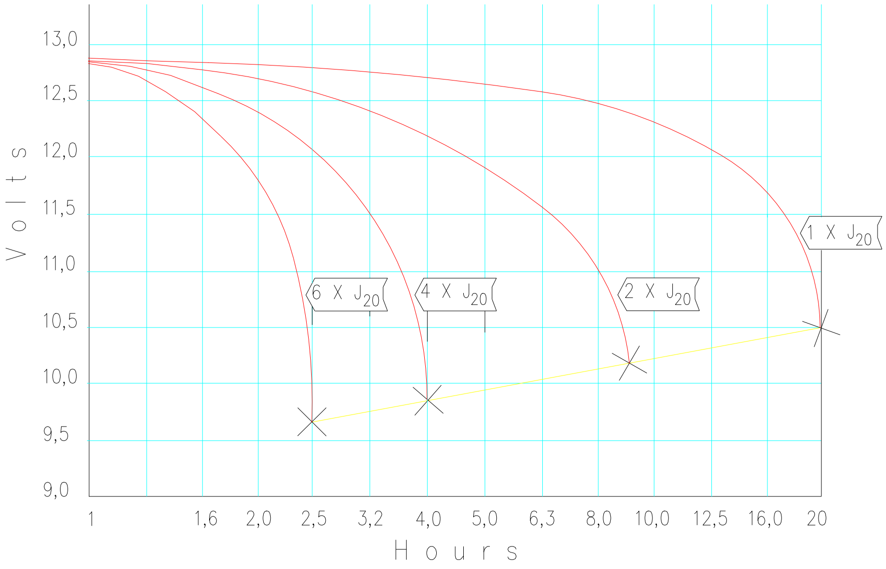
However, this relationship is not linear for currents greater than J20. For larger load currents the battery needs to be allowed to discharge to a lower terminal voltage, and the back-up times are shorter than expected. The graph in Figure - is a typical example of the recommendations available from battery manufacturers in this case a 12V battery.

The graph shows that if the current is four times higher than J20, the battery should be allowed to work down to about 9,8 V, and the back-up time would be only four hours, instead of the expected five hours.

Normally the PSU must provide particular voltage levels to power the associated equipment, and therefore have a fixed terminal voltage to which the battery can be allowed to discharge. When the battery is discharged to this voltage, the battery should be galvanically disconnected from the load until the primary power source is restored to protect the battery.

The important conclusion is that if the battery size is reduced to a point when the base draws an average current greater than J20, the backup time must be evaluated using the battery manufacturer's graph similar to that in Figure 1, as described in the following example.

Figure 1 : Battery manufacturers graph of Backup time at various current consumption.



3. EVALUATING BACKUP TIME AND BATTERY SIZE

The following example illustrates the evaluation of backup times from the graph in Figure 1-, when the average current is greater than J20:

If for example the power consumption from the PSU is 38 W and the battery disconnect voltage is required to be 11,3 V.

Under the battery backup condition, the load will be working from a fully charged battery. For the greater part of the of the backup period, the voltage across the output terminals will be 12,6 V. The current drawn by the load will be:

Inom = @ 3 A

Because of its small size, it would be convenient to use a 12 Ah backup battery. For this battery, J20 is calculated as follows:

J20 = = 0,6 A

The nominal current is 5 times higher than the J20 current, as below:

Inom = 3 A = 5 x 0,6 A = 5 x J20

From the graph in Figure 1, it can be established that at the load current which is 5 times greater than J20, the battery will reach 11,3 V after about 3 hours. Conversely, if 4 hours backup time is needed, the nominal current should equal 3 times J20, to ensure a safety margin. This requires a J20 of 1 A and a 20 Ah battery.

4. CONCLUSION

There are a number of factors to be considered when designing a battery backed dc power supply system. Ignoring any one of them can lead to a system that will either not meet specification or will cause premature battery failure.

It is therefore important to choose a power supply/battery charger combination that meets the needs of the system. If this is done, there is no reason why such systems cannot give years of useful life without needing to be high in cost, space or weight.