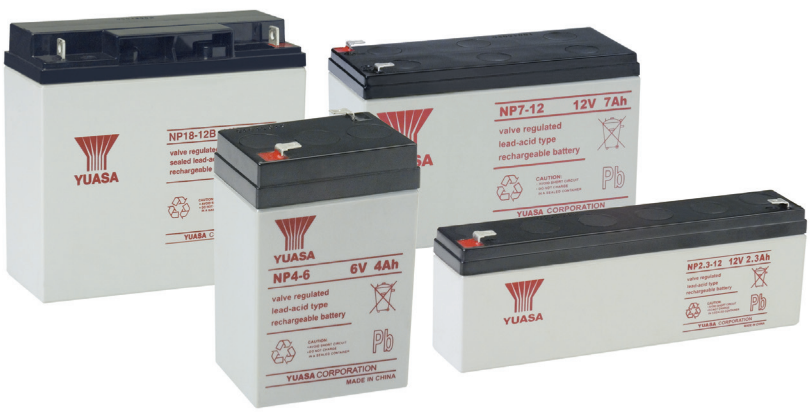
YUASA

Valve Regulated Lead-Acid Rechargable Batteries

NP SERIES

APPLICATION MANUAL



CONTENTS

All of the data in this manual is based on JIS and SBA standards in Japan.
Specification subject to change without prior notice.

Always follow local regulations for design and installation of stationary battery systems, as well as disposal of junk batteries.

1. INTRODUCTION

Yuasa batteries are the trusted choice around the world for standby power in applications where system integrity is paramount. Yuasa's NP series incorporates high energy density, advanced plate technology, efficient performance and long service life to provide complete reliability and peace of mind.

2. APPLICATIONS

A list of some of the more common applications for stand by or principal power is given below:

★ Uninterruptible Power Supplies
★ Telecommunication Systems
★ Communications Equipment
★ Security Systems
★ Alarm Systems
★ Emergency Lighting Systems
★ Television & Video Recorders
★ Electronic Cash Registers
★ Cable Television
★ Solar Powered Systems
★ Control Equipment
★ Vending Machines
★ Microprocessor Based Office Machines
★ Electronic Test Equipment
★ Geophysics Equipment

3. PROHIBITION

★ Medical device
★ Any applications which are expecting fatal damage
★ Usage in an upside down orientation

4. CONSTRUCTION

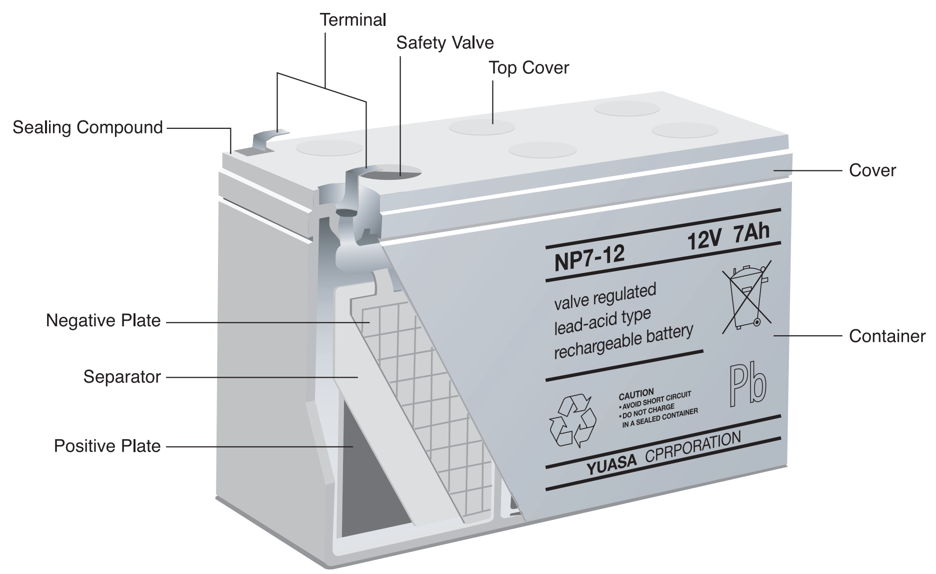
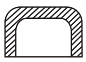


Table 1 Yuasa NP Battery Constructions and Functions

Parts	Material of Construction	Functions
Positive & Negative Plate	• Pasted type Plate in which special lead-calcium alloy grids are pasted with active material.	• Retain sufficient capacity. • Maintain capacity performance for long period of time (long life performance). • Minimise self-discharge.
Separator	• Mat made of glassfibres with excellent heat oxidation resistance.	• Prevents short circuit between positive and negative plates. • Retains electrolyte. • Prevents active material from shedding by pressing plate surfaces.
Electrolyte	• Dilute sulphuric acid in quantity to preclude free electrolyte.	• Causes electro motive reaction in negative and positive active material.
Container & Cover	• ABS synthetic resin.	• Accommodates plate group consisting of positive and negative plates and separators. • Retains sufficient mechanical strength to withstand battery internal pressure.
Safety Valve	• Synthetic rubber with excellent acid resistance and little deterioration by ageing.  • In cap shape. (The right figure is an example)	• Releases gas if cell internal pressure rises abnormally high and keeps low internal pressure. • Prevents ingress of oxygen.
Terminal	• Color of sealing compound: red for positive section and black for negative section.	• Terminal with a large and non welded sectional area enhances high rate discharge characteristics and reliability. • Perfect seal is given at a terminal sealing section.

5. TECHNICAL FEATURES

● Sealed Construction

Yuasa's unique construction and sealing technique ensures that no electrolyte leakage should occur from the terminals or case of any NP battery. This feature provides for safe and efficient operation of NP batteries in any orientation (except upside down). Yuasa NP batteries are classified as "Non-Spillable" and meet all requirements of the International Air Transport Association (I.A.T.A. Dangerous Goods Regulations).

● Electrolyte Suspension System

All Yuasa NP batteries utilize an electrolyte suspension system consisting of a glass fibre separator material. This suspension system helps to achieve maximum service life, by fully retaining the electrolyte and preventing its escape from the separator material. No silica gels or other contaminations are used.

● Gas Recombination

NP batteries incorporate a unique Yuasa design that effectively recombines over 99% of the gas generated during normal usage.

● Low Maintenance Operation

During the life of NP batteries, there is no need to check their specific gravity or add water etc. In fact, there are no provisions for such maintenance functions to be carried out.

● Operation In Any Orientation (Except Upside down)

The combination of sealed construction and Yuasa's electrolyte suspension system permits operation of NP batteries in any orientation without loss of capacity, electrolyte, or service life.

● Low Pressure Venting System

Yuasa NP batteries are equipped with a safe, low pressure venting system, which is designed to release excess gas and reseal automatically in the event of the internal gas pressure rising to an unacceptable level. This low pressure venting system, coupled with the significantly high recombination efficiency, make Yuasa NP battery one of the safest valve regulated lead acid batteries available.

● Heavy Duty Grids

The heavy duty lead calcium alloy grids in NP batteries provide an extra margin of performance and service life in both float and cyclic applications, even in conditions of deep discharge.

● Cyclic Service Life

Depending upon the average depth of discharge, long cyclic life can be expected from NP batteries.

● Float Service Life

The expected service life of NP batteries used in standby applications is typically 3 - 5 years.

● Low Self Discharge-Long Shelf Life

At temperatures of between 20 & 25°C, the self discharge rate of NP batteries per month is approximately 3% of their rated capacity. This low self discharge rate permits storage for up to six months without any significant change in battery performance.

● Operating Temperature Range

Yuasa NP batteries can be used over a broad range of ambient temperatures, allowing considerable flexibility in system design and location.

● High Recovery Capacity

Yuasa NP batteries have excellent charge acceptance and recovery capability, even after deep discharge.

6. CHEMICAL REACTION AND SEALING MECHANISM

The chemical reaction taking place in a lead-acid storage battery is as shown in the following formula:

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

(Lead dioxide)	(Sulphuric acid)	(Spongy lead)	(Lead sulphate)	(Water)	(Lead sulphate)
Positive Active Material	**Electrolyte**	**Negative active Material**	**Positive Active Material**	**Electrolyte**	**Negative active Material**

At discharge, lead dioxide in positive plates and spongy lead in negative plates react with sulphuric acid in the electrolyte and gradually transform into lead sulphate, during which the sulphuric acid concentration decreases.

Conversely, when the battery is charged, the positive and negative active materials which had been turned into lead sulphate gradually revert to lead dioxide and spongy lead respectively, releasing the sulphuric acid absorbed in the active materials, during which the sulphuric acid concentration increases, as shown in Fig. 2

When battery charging approaches its final stage, the charging current is consumed solely for electrolytic decomposition of water in the electrolyte, resulting in generation of oxygen gas from positive plates and hydrogen gas from negative plates. The generated gas will escape from the battery causing a decrease of the electrolyte, thereby requiring occasional water replenishment.

However, Yuasa NP batteries utilize the characteristics of spongy lead, or negative active material, which is very active in moist conditions and reacts very quickly with oxygen, thereby suppressing the decrease of water and eliminating the need for water replenishment.

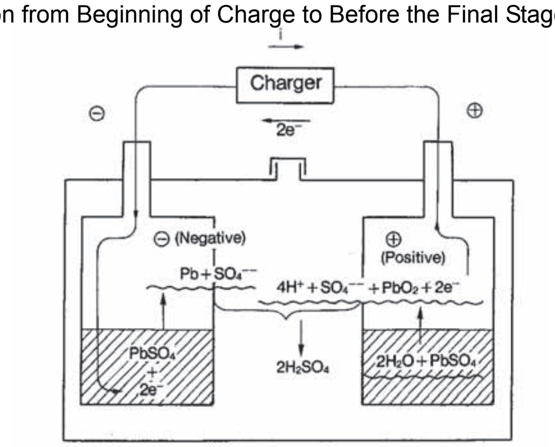
The process of charging from its beginning to the final stage is identical with that of conventional batteries as shown in Fig. 2

On the one hand, after the final stage of charging or under overcharge condition, the charging energy is consumed for electrolytic decomposition of water, and the positive plates generate oxygen gas which reacts with the spongy lead in negative plates and the sulphuric acid in electrolyte, turning a part of negative plates into a discharged condition, thus suppressing the hydrogen gas generation from negative plates.

The part of negative plates which had turned to discharged condition through reaction with oxygen gas is then reverted to original spongy lead by subsequent charging. Thus, a negative plate keeps equilibrium between the amount which turns into spongy lead by charging and the amount of spongy lead which turns into lead sulphate through absorbing the gas generated from positive plate, which makes it possible for the battery to be of a sealed type.

The chemical reaction which takes place after the final stage of charging or under overcharge condition is as shown in Fig 3, and the reaction formula is described in the next page.

Fig. 2　Reaction from Beginning of Charge to Before the Final Stage



(1) Reaction at positive plate (oxygen generation)

①$2H_2O \rightarrow \underline{O_2} + 4H^+ + 4e^-$

└> migrates to negative plate surface.

(2) Reaction at negative plate

②(chemical reaction of spongy lead with oxygen)

$2Pb + O_2 \rightarrow 2PbO$

③(chemical reaction of PbO with electroiyte)

$2PbO + 2H_2SO_4 \rightarrow 2PbSO_4 + \underline{2H_2O}$

└> (To reaction - ①)

④(Reduction of $PbSO_4$)

$2PbSO_4 + 4H^+ + 4e^- \rightarrow \underline{2Pb} + \underline{2H_2SO_4}$

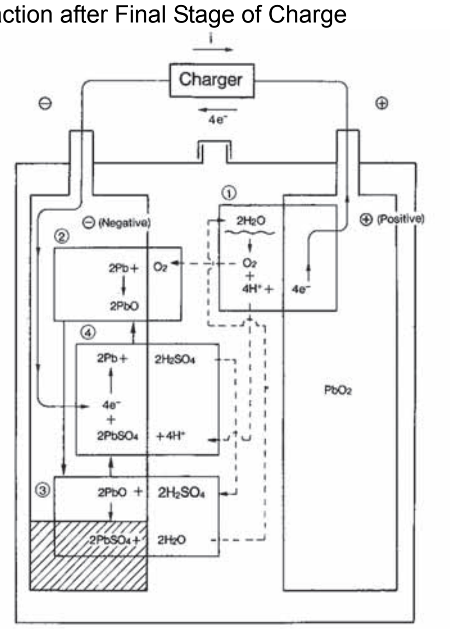
└> (To reaction - ③)

└> (To reaction - ②)

Total reaction at negative plate

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

Fig. 3　Reaction after Final Stage of Charge



As described above, the oxygen gas generated from the positive plates reacts quickly with the active material in charged condition in the negative plates and returns to water causing very little loss thereof, thus making it possible to build the battery in a sealed construction.

7. GENERAL SPECIFICATIONS

Table 2 General Specifications

NP SERIES (FOR GENERAL APPLICATION)

Model	Volts	Rated AH Capacity (20 hr rate)**	Nominal Dimensions (mm)				Weight (kg)	Layout	Terminal
			L	W	H	Total H			
NP1-6*	6	1.0	51	42.5	51	54.5	0.25	5	A
NP1.2-6		1.2	97	25	50	54.5	0.31	1	A
NP2.8-6*		2.8	134	34	59	64	0.57	1	A
NP3-6		3.0	134	34	59	64	0.63	1	A
NP4-6		4.0	70	47	101	105.5	0.87	5	A
NP7-6		7.0	151	34	93	97.5	1.26	1	A
NP10-6		10.0	151	50	93	97.5	1.93	1	A
NP12-6*		12.0	151	50	94	97.5	2.05	1	D
NP0.8-12	12	0.8	96	25	61.5	61.5	0.35	6	H
NP1.2-12		1.2	97	48	54.5	54.5	0.58	3	A
NP2-12		2.0	150	20	89	89	0.70	7	B
NP2.1-12*		2.1	178	34	60	64	0.74	1	A
NP2.3-12		2.3	178	34	60	64	0.95	1	A
NP2.6-12		2.6	134	67	60	64	1.12	3	A
NP4-12		4.0	90	70	102	105.5	1.67	1	A
NPH5-12		5.0†	90	70	97.5	106	2.00	1	D
NP7-12		7.0	151	65	93	97.5	2.65	4	A/D
NP7-12FR¹		7.0	151	65	93	97.5	2.65	4	A
NP12-12		12.0	151	98	93	97.5	4.05	4	D
NP17-12		17.0	181	76	167	167	5.90	2	E
NP18-12B		17.2	181	76	167	167	6.20	2	E
NP24-12B		24.0	175	166	125	125	8.65	2	E
NP26-12*		26.0	175	166	125	125	9.00	2	E
NP38-12		38.0	197	165	170	170	14.20	2	F
NP65-12		65.0	350	166	174	174	23.00	2	G

* Available upon special request. Contact CenturyYuasa for more information.
** Final Voltage: 1.75V/cell, Temperature: 25˚C.
¹ Flame retardant case.
† Rated AH capacity at 10 hr rate. High rate discharge battery. Refer to CenturyYuasa for more information.

Note: Operating temperature range;
- Charging: -15°C(5°F) ～ 45°C(113°F)
- Discharging: -15°C(5°F) ～ 45°C(113°F)
- Storage: -15°C(5°F) ～ 45°C(113°F)

Fig. 4 Layout

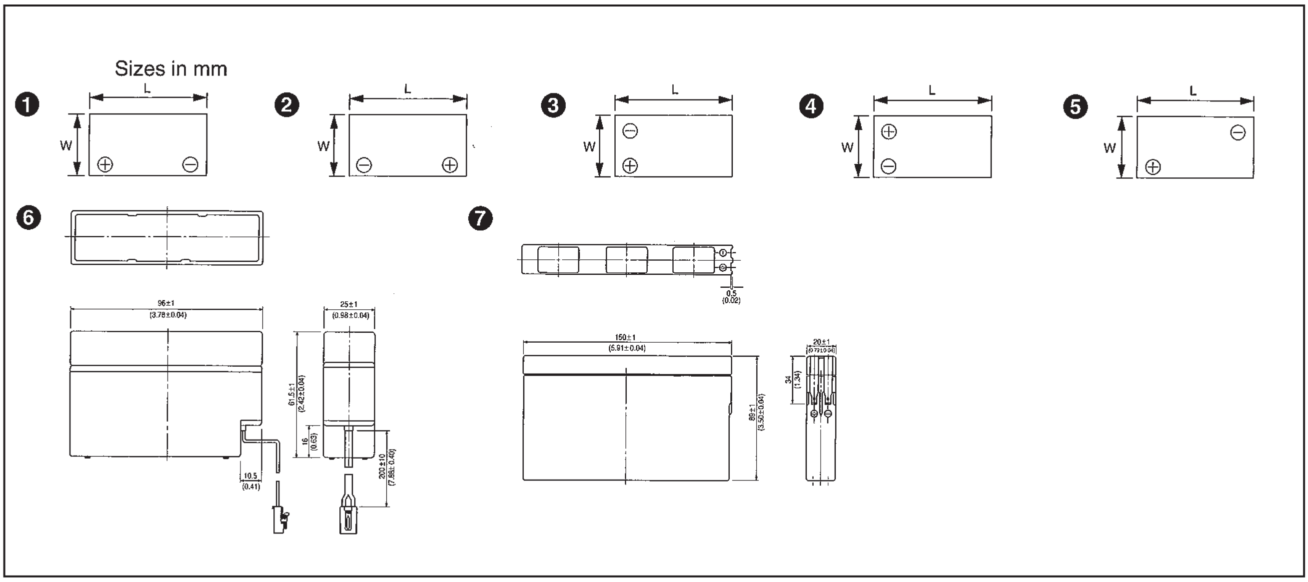
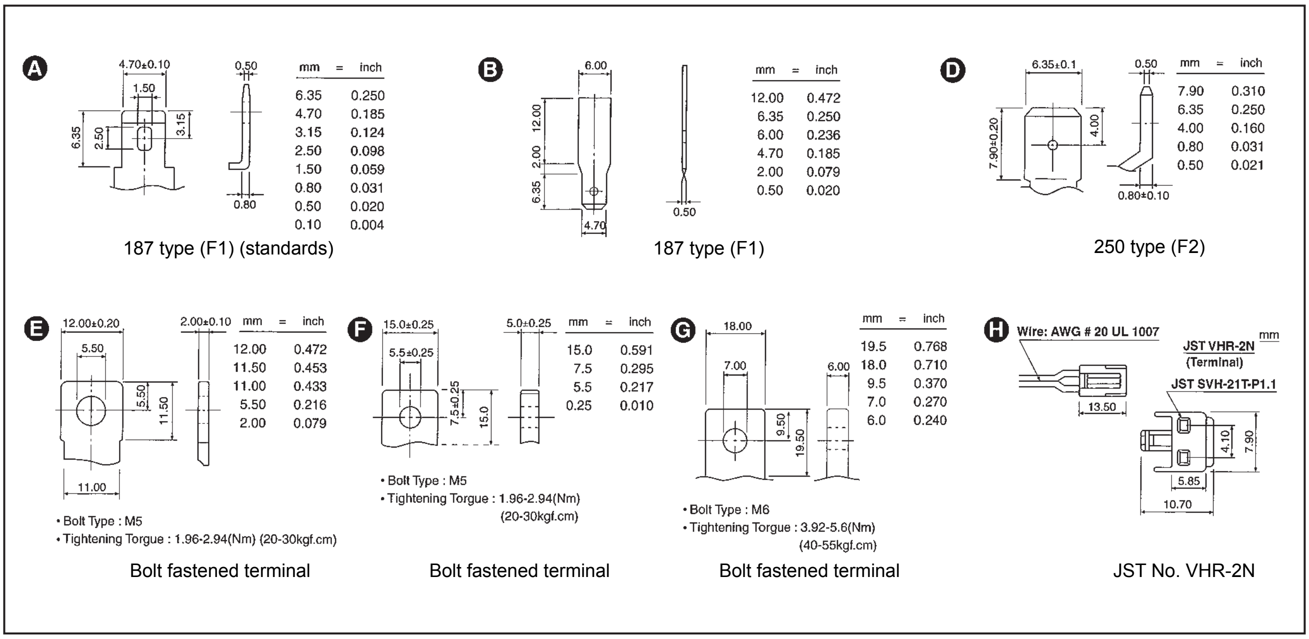


Fig. 5 Terminals



187 type (F1) (standards) | 187 type (F1) | 250 type (F2)

Bolt fastened terminal | Bolt fastened terminal | Bolt fastened terminal | JST No. VHR-2N

Table 3 Terminals and Maximum Discharge Current

Terminal Model	Maximum Permissible Current (Amps.)		
	Continuous	Within 1 hour	Within 1 min.
187 type (F1)	16	24	48
250 type (F2)	25	38	75
Lead Wire Type (0.5 mm^2)	7	20	30

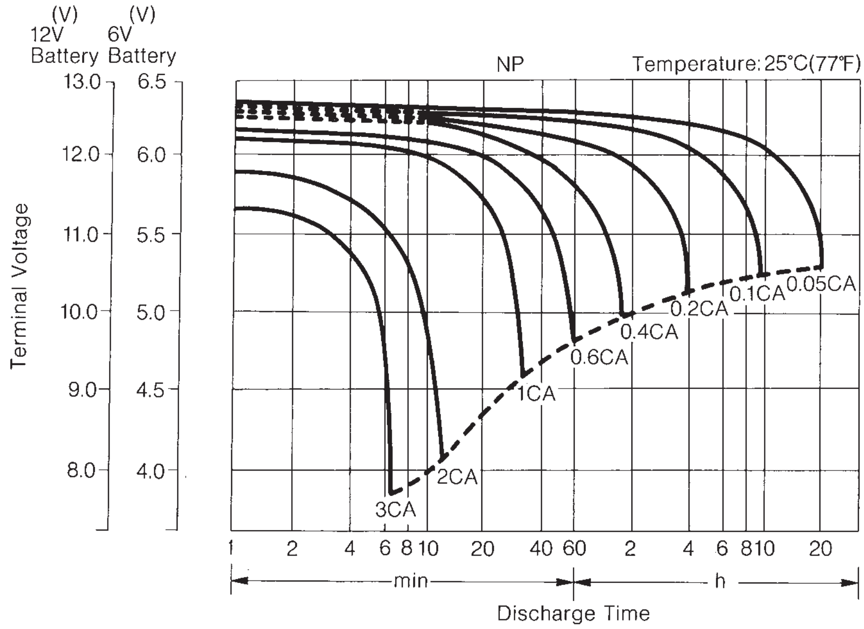
Note:
Electric conductive parts are designed so that the standard NP batteries can discharge continuously up to 3CA. However, when lead wire terminal or faston terminal is used depending on the application, the maximum current is limited to the values shown in Table 3.

8. DISCHARGING

8-1 Discharge Characteristics

Discharge capacity varies depending on discharge current (discharge rate). The smaller the discharge current, the more the discharge capacity is increased. The larger the discharge current, the lower the discharge capacity will be. Therefore, NP batteries use a rated capacity at 20 hour discharged to the final discharge voltage of 1.75 V/cell at 25°C (77°F). Fig 6 shows the constant current discharge characteristics of NP batteries.

Fig. 6 Discharge Characteristic Curves : NP Batteries



Notes;

- "C" is a value of the rated battery capacity expressed in Ah. For example in the case of NP1.2-6, the discharge rate 0.05CA means a discharge at 0.05 X 1.2= 0.06A, or discharge rate 1CA a discharge at 1.2A.

- A battery, will reach the rated capacity in about five cycles of charge and discharge (Defined by JIS C 8702-1 : 2003).

- The dotted line in Fig. 6 indicates the lowest recommended voltage under load, or cut off voltage, for NP batteries at various discharge rates respectively. In general, lead acid batteries are damaged in terms of capacity and service life if discharged below the recommended cut off voltages. It is generally recognized that all lead calcium alloy grid batteries are subject to over discharge damage.

For example, if a lead acid battery were discharged to zero volts, and left standing in either "on" or "off" load conditions for a long period of time, severe sulphation would occur, raising the internal resistance of the battery abnormally high. In such an extreme case, the battery may not accept charge. NP batteries have been designed to withstand some levels of over-discharge. However, whilst this is not the recommended way of operation, Yuasa NP batteries can recover their capacity when recharged correctly. Final discharge voltage is shown in Table 4.

Table 4. Final Discharge Voltage

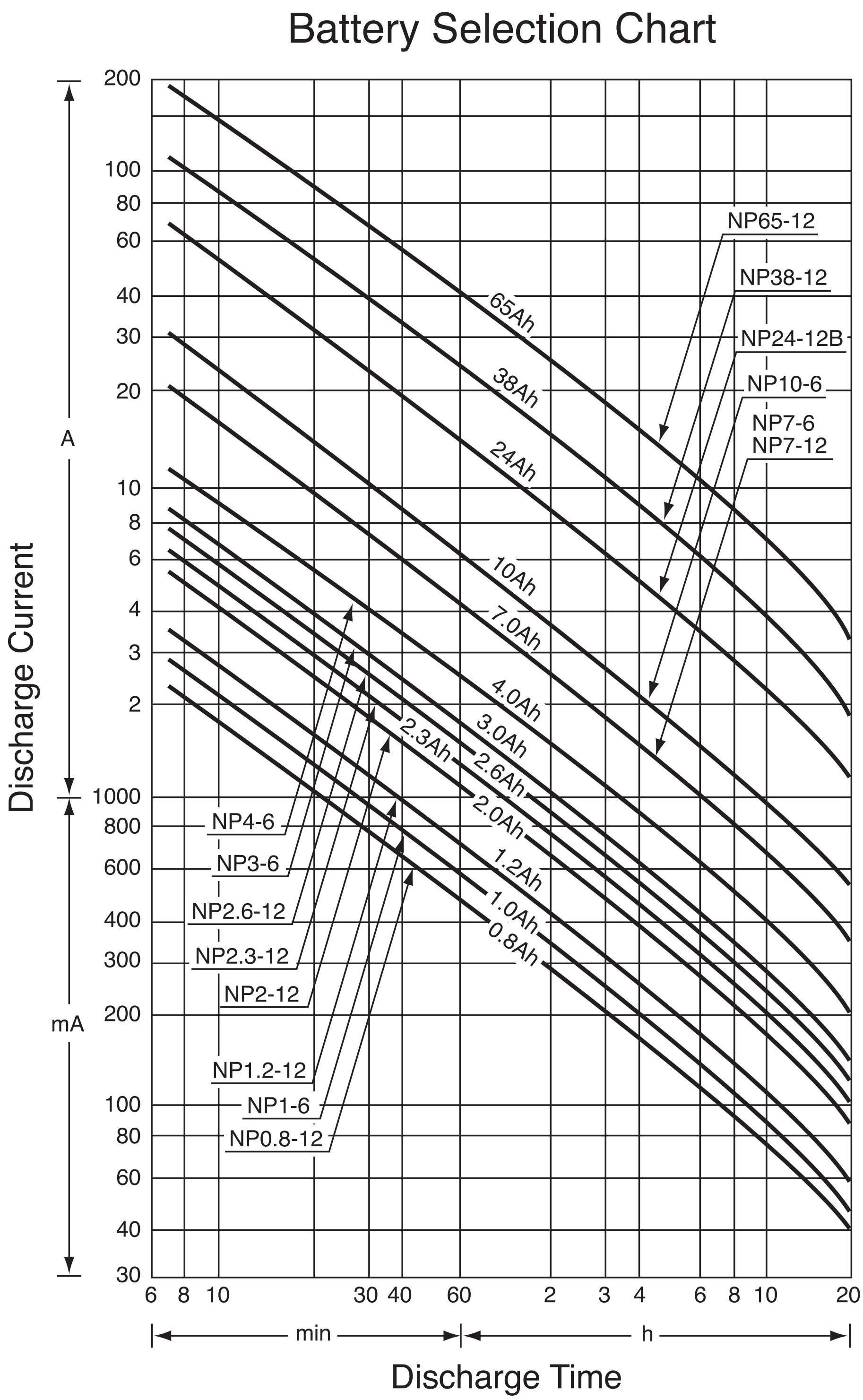
Discharge Current	Final Discharge Voltage (V/Cell)
0.1CA or below, or intermittent discharge	1.75
0.17CA or current dose to it	1.70
0.26CA or current close to it	1.67
0.6CA or current close lo it	1.60
Current in excess of 3CA	1.30
For intermediate values, see Fig. 6 on page 9	see Fig. 6 on page 9

If an NP battery is to be discharged at a rate in excess of 3CA, please seek technical assistance prior to use.

8-2 Battery Capacity Selection

Fig. 8 illustrates relationship between the discharge current and discharge duration of typical models of the NP batteries. These curves can be utilized to select NP batteries suitable for particular load conditions. When a battery is to be selected, consideration should be given to capacity deterioration due to ageing.

Fig. 8 Battery Selection Chart (NP Batteries)

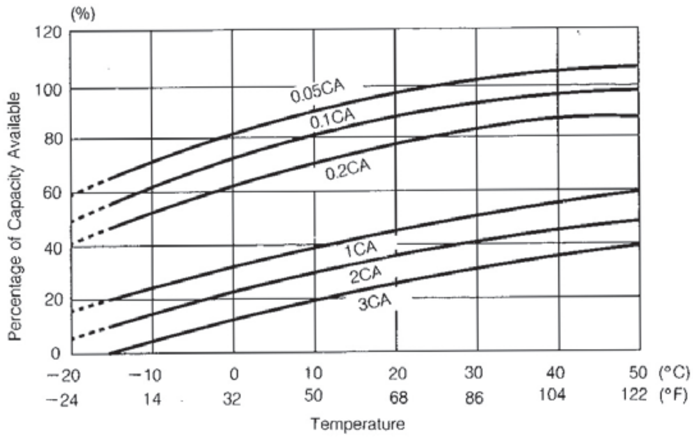


8-3 Temperature Characteristics

At higher temperatures, the discharge capacity (Ah) of a battery increases and conversely at lower temperatures, the discharge capacity (Ah) of a battery decreases.

Fig. 10 shows the effects of different temperatures in relation to battery capacity for NP batteries.

Fig. 10 Temperature Effects in Relation to Battery Capacity (NP Batteries)



9. CHARGING

9-1-1 Charging Method

Correct charging is one of the most important factors to consider when using valve regulated lead acid batteries. Battery performance and service life will be directly dependant on the quality and output characteristics of the charger selected.

The basic charging methods are:

- Constant Voltage Charging
- Constant Current Charging
- Taper Current Charging
- Two Stage Constant Voltage Charging

9-1-2 Constant Voltage Charging

Charging at constant voltage is the most suitable and commonly used method for charging valve regulated lead acid batteries. **Refer to section 9-3 for information on charging voltages.** Fig. 13-18 show the charging characteristics of NP batteries when charged by constant voltage chargers at 2.275 Volts/cell, 2.40 Volts/cell and 2.50 Volts/cell when the initial charging current is controlled at a.1 C Amps and 0.25C Amps.

Fig. 13 0.1CA-6.825V (13.65V) Constant Voltage Charging

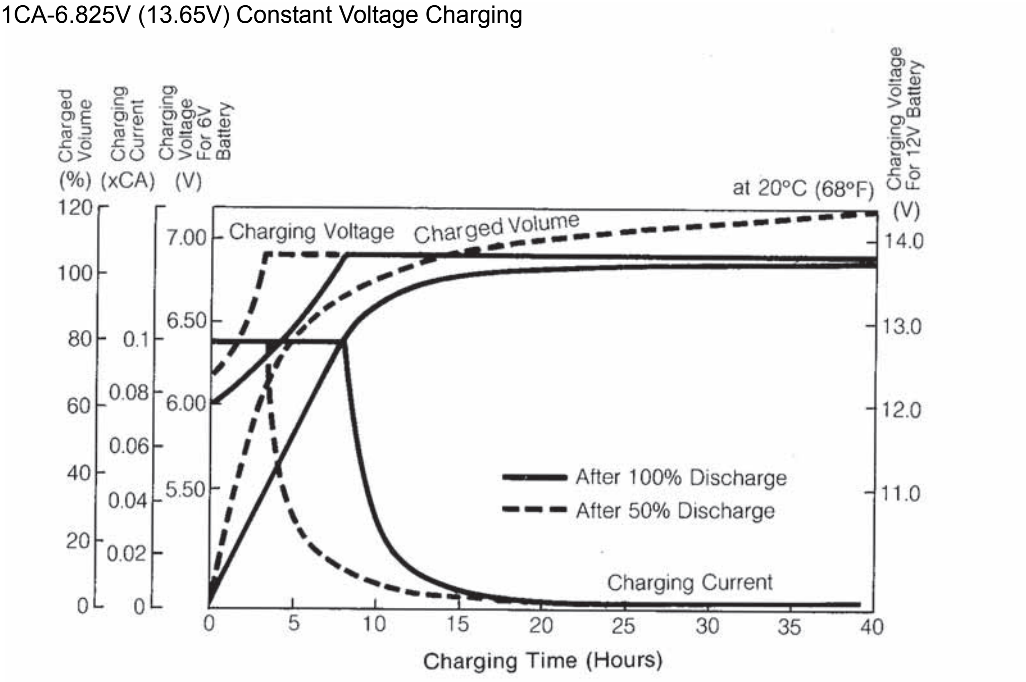


Fig. 14 0.1CA-7.20V (14.4V) Constant Voltage Charging

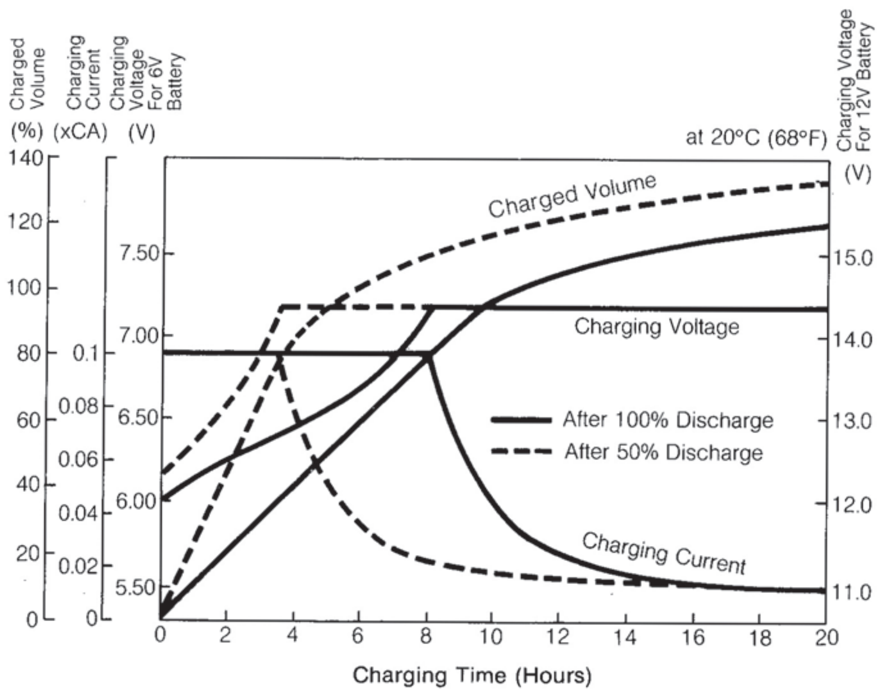


Fig. 15 0.1CA-7.50V (15.0V) Constant Voltage Charging

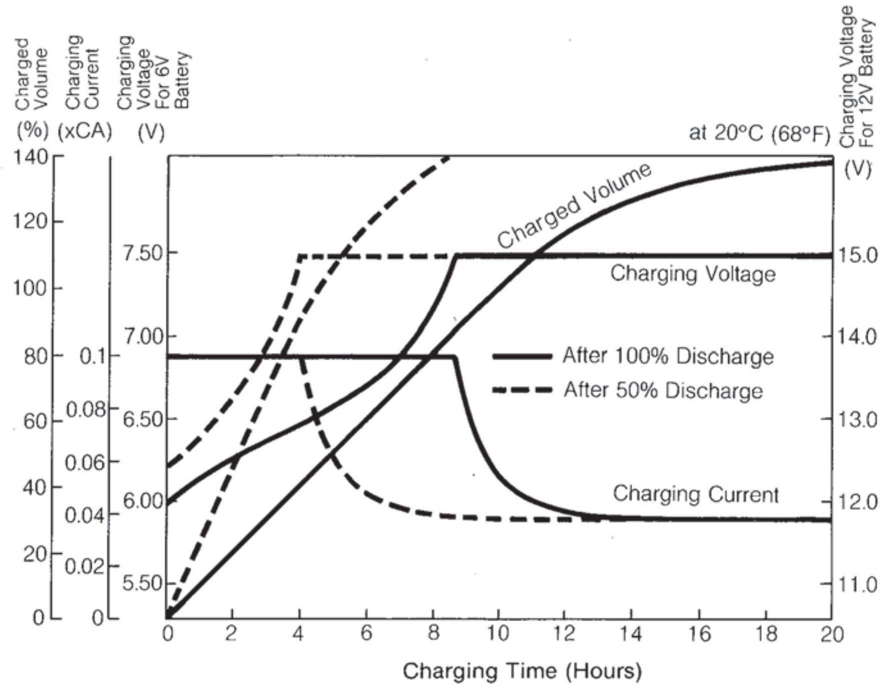


Fig. 16 0.25CA-6.825V (13.65V) Constant Voltage Charging

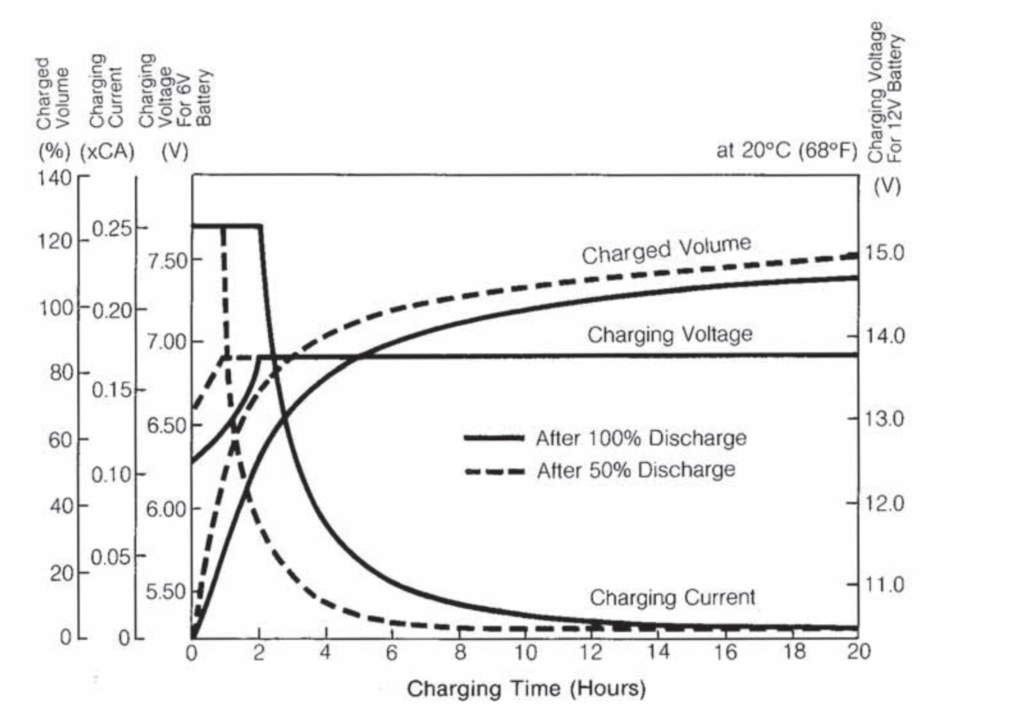


Fig. 17 0.25A-7.20V (14.4V) Constant Voltage Charging

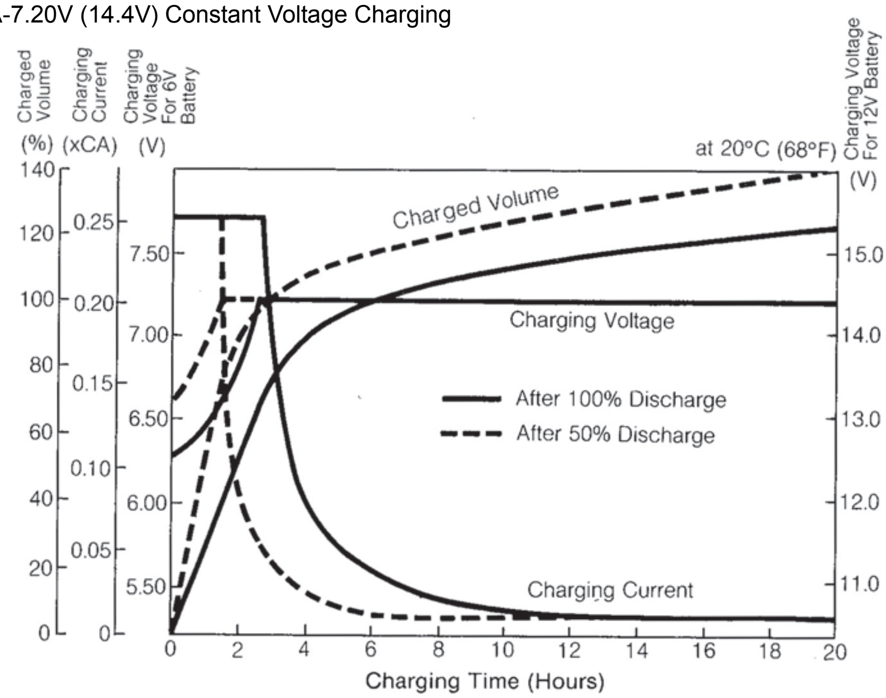


Fig. 18 0.25A-7.50V (15.0V) Constant Voltage Charging

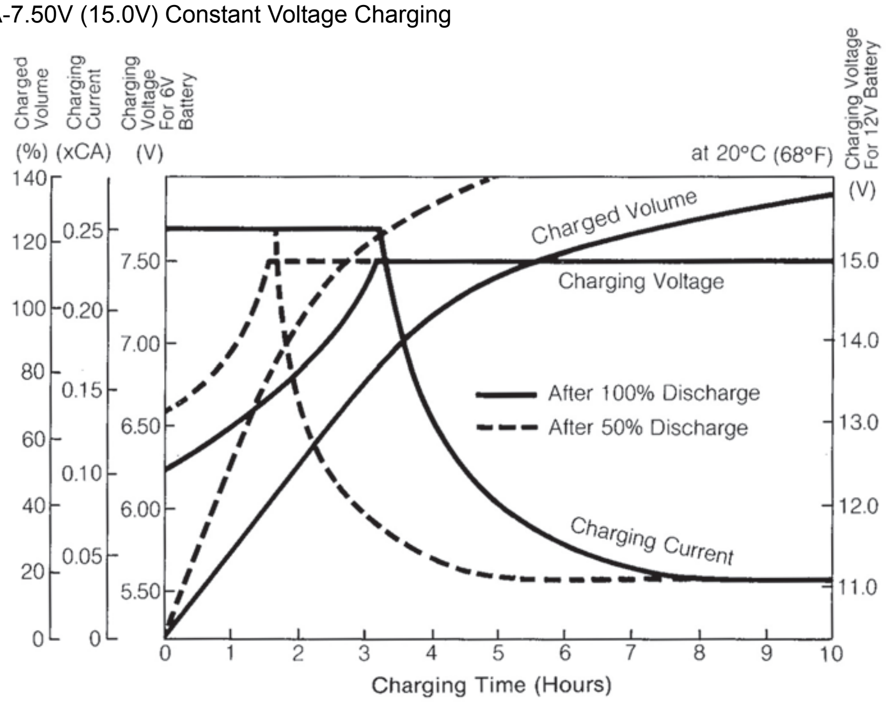
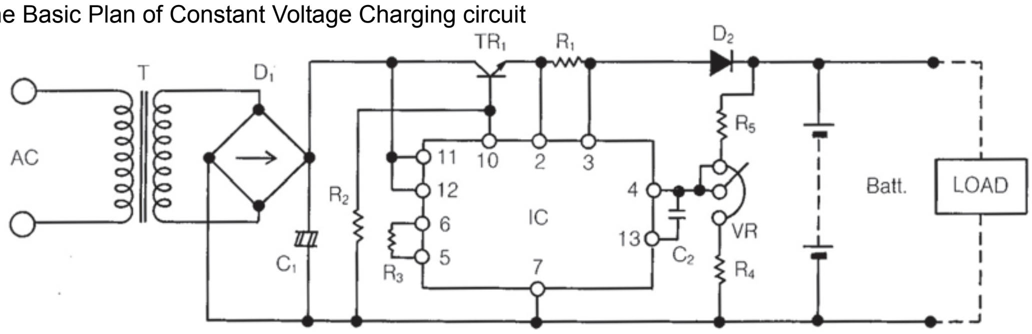


Fig. 19 One Basic Plan of Constant Voltage Charging circuit



Note: Fig. 19 shows one basic plan of a constant voltage charging circuit. In this circuit, the initial charging current is limited by the series resistance R1 .

9-1-3 Constant Current Charging

This charging method is not often utilized for valve regulated lead acid batteries, but is an effective method for charging a number of series connected batteries at the same time, and/or as an equalizing charge to correct variances in capacity between batteries in a series group.

Extreme care is required when charging NP batteries with a constant current. If after the battery has reached a fully charged state, the charge is continued at the same rate, for an extended period of time, severe overcharge may occur, resulting in damage to the battery. Fig. 20 shows one example of constant current charging.

Fig. 20 Constant Current Charging (One Example)

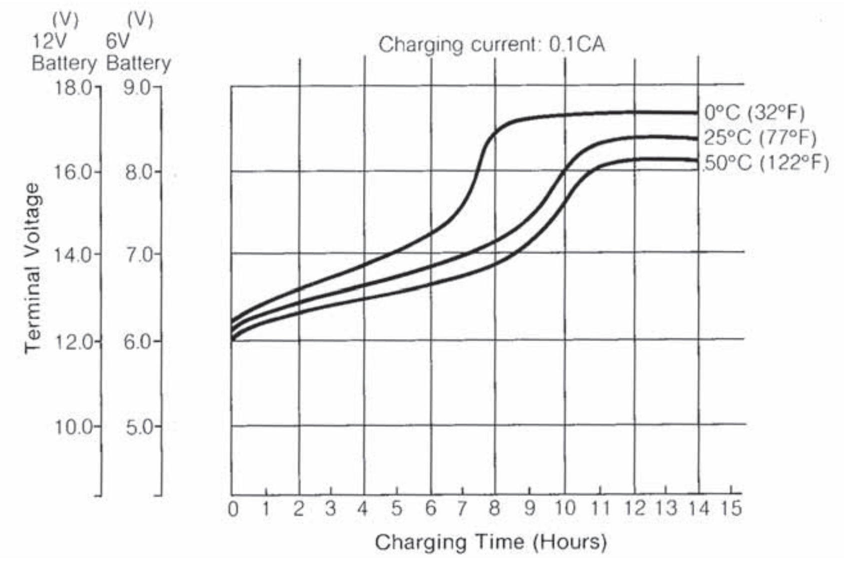
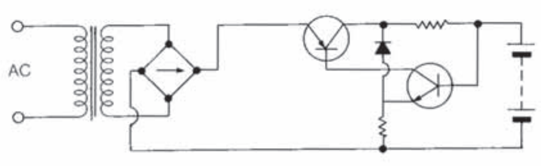


Fig. 21 Constant Current Charging Circuit



9-1-4 Two Stage Constant Voltage Charging

Two stage constant voltage charging should only be be utilised for cycling applications. Fig. 22 illustrates the characteristics of a two stage constant voltage charger. The characteristics shown in Fig. 22 are those of a constant voltage, current limited charger, in the initial charging stage, the current flowing into the battery is limited to a value of 0.25C Amps. The charging voltage across the battery terminals rises, during the charging process, to a value equal to the constant voltage output of the charger, which is set to 2.45 V/cell. Whilst continuing to charge, in stage I (A) at 2.45 V/cell, the current will eventually decrease to point 'Y", where the value of this decreasing current is "sensed" causing the circuit to switch into the second stage (A-B), reducing the charging voltage from 2.45 V/cell to a constant voltage, float/standby, level of 2.275 V/cell. The switch to stage 2, where the constant voltage level of 2.275 V/cell is applied, occurs after the battery has recovered about 80% of its rated capacity. This is one of the most efficient charging methods available as the recharge time is minimized during the initial stage whilst the battery is protected from overcharge by the system switching to stage 2 (float/standby) charge at the switching point 'Y'.

When this charging method is used, the output valves will be as follows:

Initial Charging Current··························· 025C Amps (max.)
Charging Voltage: -
    1st Stage···················· 2.45V/cell (2.40 to 2.50 V/cell, max)
    2nd Stage·················· 2.275V/cell (2.25 to 2.30 V/cell, max)
Switching Current From
    1st Stage to 2nd Stage ··········0.05C Amps (0.04C to 0.08C Ams)

Note: This charging method cannot be used in applications where the load and the battery are connected in parallel.

Fig. 22 Charging Characteristics of a Two Stage Constant Voltage Charger

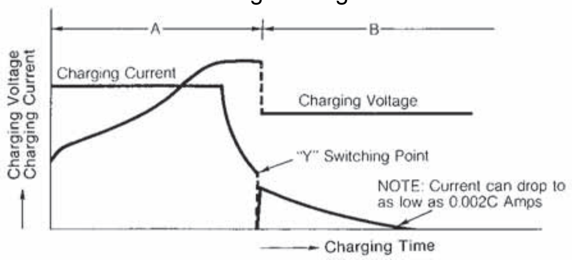
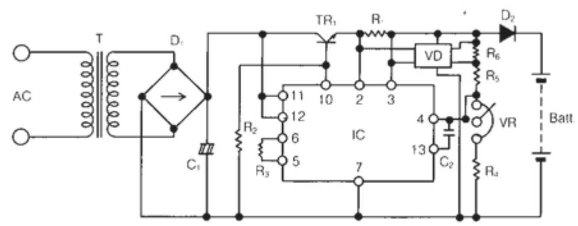


Fig. 23 Basic Plan of a Two Stage Constant Voltage Current Limited Charging Circuit



9-2 Solar Powered Chargers

A battery is an indispensable component of any solar powered system designed for on-demand energy use. NP batteries can be charged by the solar array using diode regulated circuitry as shown in Fig. 24.

In designing a solar powered system, consideration should be given to the fact that in addition to normal periods of darkness, weather conditions may be such that solar energy is limited, or virtually unavailable for long periods of time. In extreme cases, a system may have to operate for 10 to 20 days with little or no power available for charging. Therefore, when selecting the correct battery for a solar application, the capacity should be determined based upon maximum load conditions for the maximum period of time the system may be expected to be without adequate solar input.

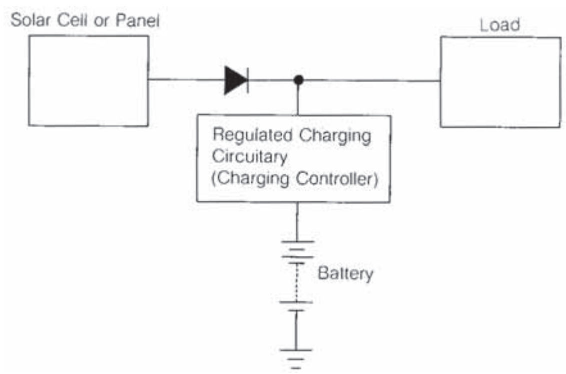
In many instances the battery capacity will be 10 to 50 times greater than the maximum output of the solar panels. Under these circumstances, the maximum output of the solar array should be dedicated to charging the battery with no load sharing or intervening control devices of any kind.

Naturally, in cases where the output of the solar array exceeds the capacity of the battery, and weather conditions are such that the potential for overcharging the battery exists, appropriate regulated charging circuitry between the solar panels and the battery is recommended.

Remote sites and other outdoor applications are where most solar powered systems are normally found. When designing a solar powered system for this class of application, a great deal of consideration must be given to environmental conditions. For example, enclosures which may be used to house batteries and other equipment may be subject to extremely high internal temperatures when exposed to direct sunlight. Under such conditions, insulating the enclosure and/or treating the surface of the enclosure with a highly reflective, heat resistive material is highly recommended.

In general, when designing a solar powered system, seek technical assistance from a qualified person.

Fig. 24 Block Diagram of
a Solar Powered Charging System



9-3 Charging Voltage

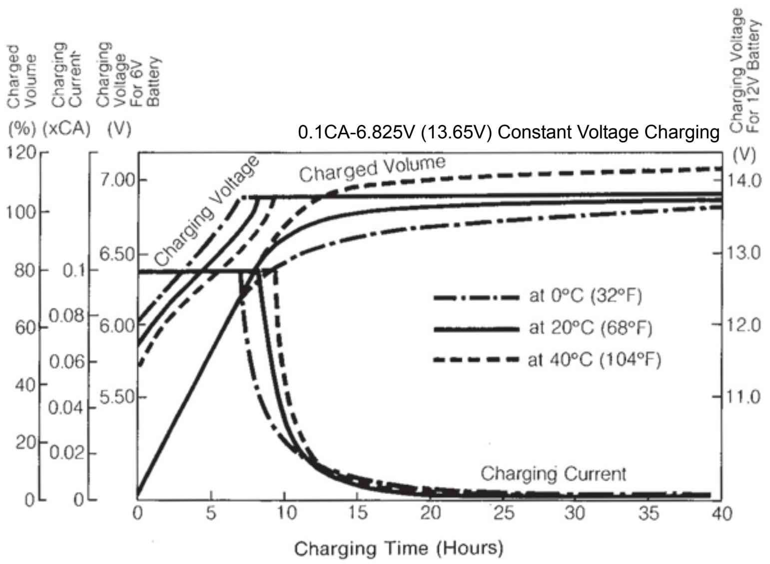
The charging voltage should be chosen according to the type of service in which the battery will be used. Generally, the following voltages are used:

For float (standby) use··········2.275volts per cell

For cyclic use.················2.40 to 2.50 volts per cell

In a constant voltage charging system, a large amount of current will flow during the initial stage of charging but will decrease as the charging progresses. When charging at 2.30 V/cell, the current at the final stage of charging will drop typically to a value of between 0.0005C Amps and 0.004C Amps. The charged volume in ampere hours, shown on the vertical axis of Fig 13-18 (pages 13-15), indicate the ratio of charged ampere hours to the previously discharged ampere hours. When a battery has been charged up to the level of 100% of the discharged ampere hours, the electrical energy stored and available for discharge will be 90% or more, of the energy applied during charging. Charging voltage should be regulated in relation to the ambient temperature. When the temperature is higher, the charging voltage should be lower and conversely when the temperature is lower, the charging voltage should be higher. For specific recommendations, please refer to the section on Temperature Compensation on page 21. Similarly, charged volume (measured in ampere hours) realised over a given time will vary in direct relation to the ambient temperature: the higher the ambient temperature, the higher the charged volume in a given period of time and the lower the ambient temperature, the lower the charged volume in the same given period of time. Fig 25 shows the relationship between charged volume and temperature.

Fig. 25 Charging Characteristics at Different Temperatures



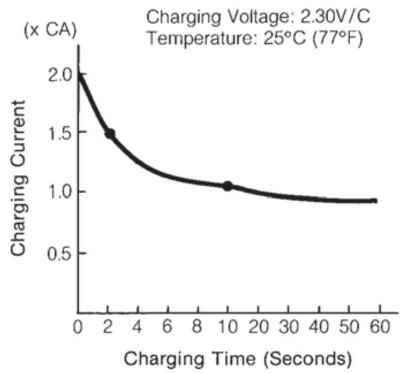
9-4 Initial Charge Current Limit

A discharged battery will accept a high charging current at the initial stage of charging. High charging current can cause abnormal internal heating which may damage the battery. Therefore, when applying a suitable voltage to recharge a battery that is being used in a cycling application it is necessary to limit the charging current to a value of 0.25C Amps.

However, in float/standby use, Yuasa NP batteries are designed so that even if the available charging current is higher than the recommended limit, they will not accept more than 2C Amps and the charging current will fall to a relatively small value in a very brief period of time. Normally, therefore, in the majority of float/standby applications no current limit is required. Fig. 26 shows current acceptance in NP batteries charged at a constant voltage of 2.30 V / cell without current limit.

When designing a charger, it is recommended that suitable circuitry is employed to prevent damage to the charger caused by short circuiting the charger output or connecting it in reverse polarity to the battery. The use of current limiting and heat sensing circuits fitted within the charger are normally sufficient for the purpose.

Fig.26 Constant Voltage Charging Characteristics with No Current limit

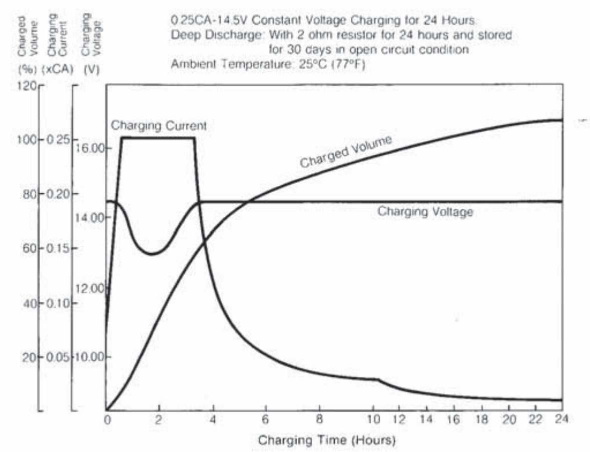


Note: Applicable to batteries up to 7AH capacity. Consult CenturyYuasa if battery capacity exceeds 7AH.

9-5 Recovery Charge After Deep Discharge

When a battery has been subjected to deep discharge (commonly referred to as a over discharge), the amount of electrical energy which has been discharged can be 1.5 to 2.0 times greater than the rated capacity of the battery. Consequently, a battery which has been over discharged requires a longer charging period than normal. Please note from Fig. 27 that as a result of increased internal resistance, the charging current accepted by an over discharged NP battery during the initial stage of charging will be quite small, but will increase rapidly over approximately the first 30 minutes until the internal resistance has been overcome, then normal, full recovery charging characteristics resume.

Fig.27 Charging Characteristics of NP7-12 After Deep Discharge



Because of this initial small charge current, in an over discharged battery, as described above, unless due consideration is given to this fact then if the charging regime uses current monitoring for determining either the state of charge and/or for signaling that the switching point has been reached for reducing the voltage to a float/standby value (as is the normal case in a multi-stage charger), the charger could be 'tricked' into entering further stages before completing earlier ones. In other words the charger may give a false "full charge" indication, or may initiate charge at the float voltage figure, instead of at a higher voltage level.

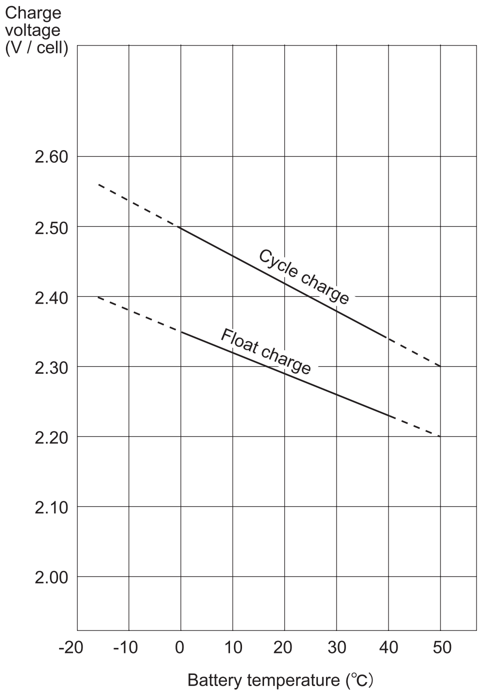
Note: Batteries left in an over discharged state for extended periods of time may not be able to be recharged.

9-6 Temperature Compensation

As temperature rises, electrochemical activity in a battery increases and conversely decreases as temperature falls. Therefore, as the temperature rises, the charging voltage should be reduced to prevent overcharge and increased, as the temperature falls, to avoid undercharge. In general, in order to attain optimum service life, the use of a temperature compensated charger is recommended. The recommended compensation factor for NP batteries is -3 mV/°C/Cell (for floating/standby) and -4 mV/°C/Cell (cyclic use). The standard centre point for temperature compensation is 25°C. Fig 28 shows the relationship between temperatures and charging voltages in both cyclic and float/standby applications.

In practice where there are short term temperature fluctuations between 5°C and 40°C temperature compensation is not absolutely essential. However, it is desirable to set the voltage at a value shown in Fig. 28 which as closely as possible, corresponds to the average ambient temperature of the battery during its service life. When designing a charger equipped with temperature compensation, the temperature sensor must sense only the temperature of the battery. Therefore, consideration should be given to thermally isolating the battery and temperature sensor from other heat generating components in the system.

Fig. 28 Relationship Between Charging Voltage and Temperature

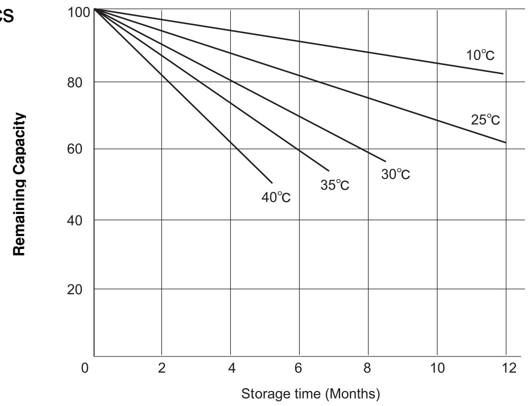


10. STORAGE

10-1 Self Discharge

The self discharge rate of NP batteries is approximately 3% per month when stored at an ambient temperature of 25°C. The self discharge rate will vary as a function of ambient storage temperature. Fig. 29 shows the relationship between storage times at various temperatures and the remaining capacity.

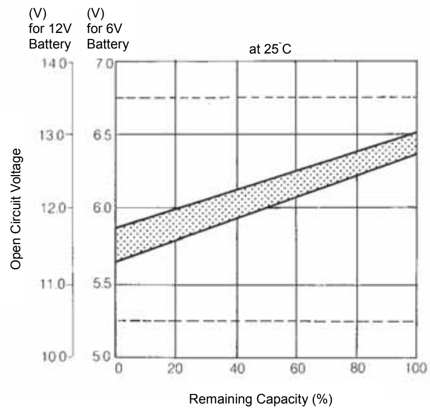
Fig. 29 Self Discharge Characteristics



10-2 Open Circuit Voltage vs Remaining Capacity

The approximate depth of discharge, or remaining capacity, in a Yuasa NP battery can be empirically determined by referring to Fig 30.

Fig. 30 Open Circuit Voltage vs Remaining Capacity



10-3 Shelf Life

In general, when lead acid batteries of any type 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 5 shows the normal storage time or shelf life at various ambient temperatures.

Brief excursions i.e., 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 NP batteries should be stored in dry, cool conditions.

Table 5. Shelf Life at Various Temperatures

Temperature	Shelf Life
Under 25°C	6 months
Under 30°C	4 months
Under 35°C	3 months
Under 40°C	2 months
Over 40°C	Do not store the batteries

10-4 Top-Up Charging

Since any battery loses capacity through self discharge, it is recommended that, prior to putting the battery into service, a process called "top-up charging" be applied to any battery which has been stored for a long period of time. Excluding conditions in which storage temperatures have been abnormally high, top-up charging is recommended within the following parameters:

Battery Age	Top-Up 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 2.40 V/cell
Within 12 months after manufacture	8 to 10 hours at constant current of 0.1 C Amps or 20 to 24 hours at constant voltage of 2.40 V/cell

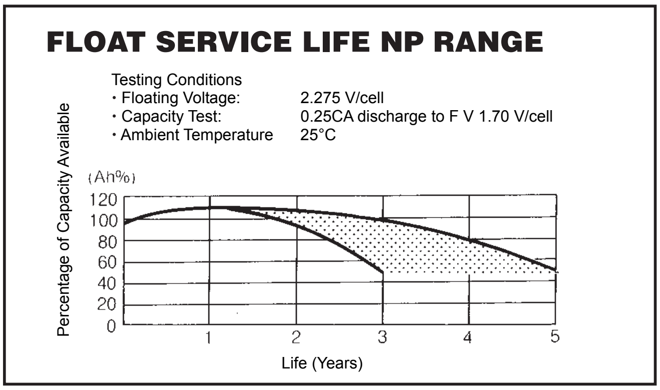
In order to successfully top-up charge a battery stored for more than 12 months, the open circuit voltage must be checked to ensure that it is higher than 2.0 V/cell. Therefore ALWAYS check the open circuit voltage FIRST. If the open circuit voltage of the battery is 2.0 V/cell or lower, please seek technical assistance prior to attempting a "Top-Up Charge".

11. LIFE CHARACTERISTICS

11-1 Floating (Trickle Charge) Life

Yuasa NP batteries have a floating charge life of 3 to 5 years (25°C). Some may end their life in 3 years but most will have a floating life of 5 years. Fig 31 is an example of testing where the battery was discharged once every three months. The floating life is affected by the number of discharges during operation, depth of discharge, floating charge temperature, and voltage.

Fig. 31



The life of NP batteries varies depending on use conditions. Attention is required to applied voltage, voltage accuracy, and ambient temperature.

Under normal float charge (2.275 V/cell), the gas absorption mechanism described earlier absorbs the gases generated in a battery, and returns it to water, and therefore, the battery will not lose its capacity because of electrolyte depletion during the design life. The battery's life ends because plate grids become slowly corroded. Since this corrosion is accelerated by elevated temperatures, high temperatures shorten life.

Also, because larger charger currents accelerate corrosion, the battery must be given floating charge at an adequate voltage. Fig 32 shows the relationship between floating charge voltage and battery life.

Fig. 32 Relationship between Float Charge Voltage and Battery Life

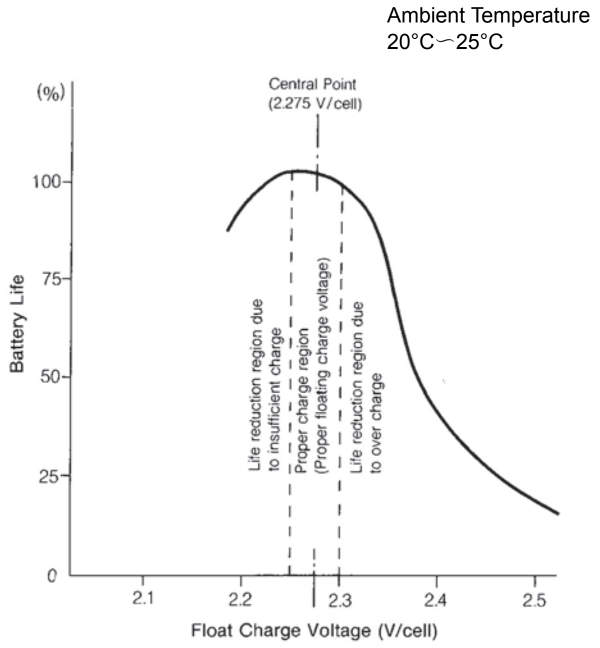


Fig. 33 Relationship between Temperature and Life in Floating Operation

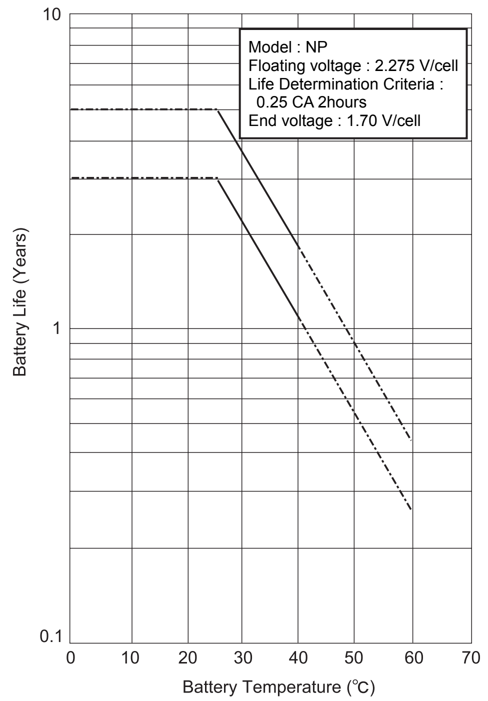


Fig 33 shows relationship between temperature and life in floating operation.

11-2 Failure Mode at End of Battery Life

The failure mode when the battery ends its life (life ending mode) includes:

- Capacity decrease ········ Electrolyte decrease and reduced adhesion of active material
- Internal short circuit
- Damage to container or lid

  (Internal short circuit and Damage to container or lid) — Corrosion and growth of plate grids
- Terminal corrosion
- Reduced open circuit voltage

A key point to using an NP battery more efficiently is to provide temperature compensation to the set voltage. The associated effect is an extended battery life. Use the temperature gradient stated in section 9-6 for temperature compensation.

Such temperature compensation enables proper charging at various temperatures. The advantage is that the final charge current will not get excessive even if a temperature rise occurs.
Therefore, the final charge current is suppressed sufficiently low to avoid the phenomenon of "thermal runaway" where the temperature in a grouped battery becomes excessively high, even if the temperature exceeds 35°C in cycle use, or 40°C in floating use. To avoid a "thermal runaway", it is best to reduce the floating voltage when temperature rise is detected in a grouped battery. Alternatively, discontinue charging till temperature has returned to normal.

12. DESIGN/APPLICATION TIPS TO ENSURE MAXIMUM SERVICE

Yuasa NP batteries are highly efficient maintenance free electrochemical systems designed to provide years of trouble free electrical energy. The performance and service life of these batteries can be maximised by observing the following guidelines:

1. Heat kills batteries. Avoid placing batteries in close proximity to heat sources of any kind. The longest service life will be attained where the battery temperature does not exceed 20°C (also see notes 4 & 9 below). When calculating the correct float voltage setting, whether or not temperature compensation is required, full consideration must be given to the temperature of the battery and room ambient. For the purpose of the calculation, consider the temperature of a battery on float to be 1°C above the ambient temperature. Also, if the battery is used in an enclosure, the temperature gradient of the enclosure itself must be included in the calculation i.e. the operating temperature of the battery is given by: -Room temperature + enclosure temperature + 1°C.

2. Install the batteries on the lowest step of a device to prevent temperature rise. In the case of integrating NP batteries into equipment, arrange the batteries and the ventilation holes in the housing container so that the temperature difference among the batteries is suppressed to below 3°C. Keep the batteries from contacting device walls, or with each other.

3. Since a battery may generate ignitable gases, do not install close to any equipment that can produce electrical discharges in the form of sparks.

4. When the battery is operated in a confined space, adequate ventilation should be provided.

5. The battery case is manufactured from high impact ABS plastic resin. It should not be placed in an atmosphere of, or in contact with organic solvents or adhesive materials.

6. Correct terminals should be used on battery connecting wires. Soldering is not recommended but if unavoidable please refer to us for further guidance.

7. Avoid operating at temperatures outside the range -15 to + 50°C for float/standby applications +5 to +35°C for cyclic use is recommended.

8. When there is a possibility of the battery being subjected to heavy vibration or mechanical shock it should be fastened securely and the use of shock absorbent material is advisable.

9. When connecting the batteries, free air space must be provided between each battery. The recommended minimum space between batteries is 5mm to 10mm. In all installations due consideration must be given to adequate ventilation for the purposes of cooling.

10. When the batteries are to be assembled in series to provide more than 100V, proper handling and safety procedures must be observed to prevent accidental electric shock. (See note #16 next page)

11. If two or more battery groups are to be used connected in parallel, they must be connected to the load through lengths of wires, cables or busbars that have the same loop line resistance as each other. This makes sure that each parallel bank of batteries presents the same impedance to the load as any other of the parallel banks thereby ensuring correct equalisation of the source to allow for maximum energy transfer to the load.

12. To obtain maximum life, the ripple current flowing in the battery, from any source, should not exceed 0.1 C Amps R.M.S.

13. When cleaning the battery case, ALWAYS use a water soaked wet or dampened cloth. NEVER use oils, organic solvents such as as petrol, paint thinners etc. DO NOT even use a cloth that is impregnated or has been in contact with any of these or similar substances.

14. Do not attempt to dismantle the battery. If accidental skin/eye contact is made with the electrolyte, wash or bathe the affected area/part straight away with liberal amounts of clean fresh water and seek IMMEDIATE medical attention.

15. DO NOT INCINERATE batteries as they are liable to rupture if placed into a fire. Batteries that have reached the end of their service life can be returned to us for safe disposal.

16. Touching electrically conductive parts might result in an electric shock. Be sure to wear rubber gloves before inspection or maintenance work.

17. The use of mixed batteries with different capacities, that may have been subjected to different uses, be of different ages and are of different manufacturers is liable to cause damage to the battery itself and/or the associated equipment. If this is unavoidable please seek technical assistance beforehand.

18. To obtain maximum life batteries should never be stored in a discharged state.

19. In order to obtain maximum working life, when the batteries are used in an UPS system, the following is advised: -
    (a) Where the D.C. input exceeds 60 volts each battery should be insulated from the battery stand by using suitable plastic material. Refer to CenturyYuasa for more information.
    (b) In high voltage systems the resistance between battery and stand should always be greater than I Megohm. An appropriate alarm circuit could be incorporated to monitor any current flow.

20. Daily check and service: If during periodical checks of the NP batteries abnormally in performance, or such damages as cracks and deformation of the container and lid or electrolyte leakage is detected, replace the battery.

13. GLOSSARY

1. Ampere (A) ········· The unit for measuring the flow of electric current.

2. Ampere hour (Ah) ········· The current in (A: Amperes) multiplied by time in (h hours). Used to indicate the capacity of a battery.

3. Capacity (C) ········· Ampere hours that can be discharged from a battery.

4. Cell ········· The minimum unit of which a battery is composed, consisting of positive and negative plates, separators, electrolyte, etc. In valve regulated lead acid batteries, the nominal voltage is 2 volts per cell.

5. Charging (Charge) ········· The process of storing electrical energy in a battery in a chemical form.

6. Cyclic Service ········· The use of a battery with alternate repetition of charging and discharging.

7. Cycle Service Life ········· The total number of cycles expected at a given depth of discharge.

8. Deep Discharge ········· (a) Discharge of a battery until 100% of the capacity is exhausted (b) Discharge of a battery until the voltage under load drops below the specified final discharge voltage (over discharge).

9. Depth of Discharge ········· The ratio of discharge capacity vs the rated capacity of a battery.

10. Discharging (Discharge) ····· The process of drawing stored energy out of a battery in the form of electrical power.

11. Energy Density ········· The ratio of energy that can be discharged from a battery to the volume of that battery measured in Watt Hours (WH) per cubic inch or litre.

12. Float Service ········· Method of use in which the battery and the load are connected in parallel to a float charger (or rectifier) so the constant voltage is applied to the battery continuously, maintaining the battery in a fully charged state and to supply power to the load from the battery without interruption or load variation.

13. Gas Recombination ········· The process by which oxygen gas generated from the positive plates during the final stage of charging is absorbed into the negative plates, reducing the potential at the negative plates, so suppressing the generation of hydrogen.

14. Impedance ········· The ratio of voltage variation vs. current variation in alternating (a.c.) supply.

15. Internal Resistance ········· The term given to the resistance inside a battery, consisting of the sum of resistance of the electrolyte, the positive and negative plates & separators, etc.

16. Life Expectancy ········· Expected service life of a battery expressed in total cycles or time in float service in relation to a specified application.

17. Nominal Capacity ········· The nominal value of rated capacity. (Nominal capacity: 20 hour rate for NP batteries.)

18. Nominal Voltage ········· The nominal value of rated voltage. In lead acid batteries, nominal voltage is 2 volts per cell.

19. Open circuit Voltage ………… The voltage of a battery which is isolated electrically from any external circuit, i.e.the voltage is measured in a no load condition.

20. Parallel Connection ………… Connection of a group of batteries by interconnecting all terminals of the same polarity, thereby increasing the capacity of the battery group but not increasing voltage.

21. Recovery Charge ……………… The process of charging a discharged battery to restore its capacity in preparation for subsequent discharge.

22. Self Discharge …………………… Loss of capacity without external current drain.

23. Series Connection …………… Connection of a group of batteries by sequentially interconnecting the terminals of opposite polarity thereby increasing the voltage of the battery group but not increasing capacity.

24. Shallow Discharge …………… Discharge of a battery in which discharge is less than 50% depth of discharge. (D.O.D.)

25. Shelf Life ……………………………… The maximum period of time a battery can be stored under specified conditions, without needing supplementary charging.

26. Standby Service ………………… General term for an application in which the battery is maintained in a fully charged condition by trickle or float charging. Synonymous with Float Service.

27. Trickle Charge …………………… Continuous charging by means of a small current designed to compensate for self discharge in a battery which is isolated from any load. For valve regulated lead acid batteries, constant voltage charging is common.

28. Valve regulated cell ……………… A secondary cell which is closed under normal conditions but which has an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cell cannot normally receive addition to the electrolyte (Ref: AS4029.2).

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