# 1. BRIEF INTRODUCTION

**Sunstar**, a holding company established in 1992, set up as a group companywith its two main shareholders Toyama Electronic Co., Ltd. And Sunstar Electronic Co., Ltd in H K.**Sunstar** has been specialized in Sealed Lead Acid (**SLA**) or Valve Regulated Lead Acid (**VRLA**) batteries with Japanese **AGM** technology since 1995. All of our **SLA** batteries meet the technology requirement stipulated in both **JISC8702** and **IEC60876-2**. We already got the most important international certificates such as ISO9001, UL, CE and VdS.
We have sold **SLA** / **VRLA** batteries with our own brand **Toyama** and offered **OEM** batteries all over the world since we introduced **Y & M** technology (a special technology in battery plates) from Toyama University in Japan.
This manual includes general introduction in technology and product list regarding VRLA batteries to ensure appropriate operation and get the best performance.

# 2. PRODUCT SERIES

## 2.1 General Application (NP series)

- Micro series
  Micro series refers to the battery with capacity from 0.5Ah to 18Ah, rated at 20-hour discharge rate. The series of batteries has 5-year design life and we offer 1-year quality guarantee. We call the series as NP batteries mainly used in security and alarm system, UPS, emergency lightings, etc.
- Medium series
  Medium series refers to the battery with capacity from 24Ah to 250Ah, rated at 10-hour discharge rate. The series of batteries has 8-year design life and we offer 2-year quality guarantee. The series of battery is also called NP batteries mainly used in big UPS, telecommunication system, solar and win energy system, etc.
- Macro series
  Macro series refers to the battery with capacity from 50Ah to 3000Ah with 2V rated voltage and rated at 10-hour discharge rate. The series of batteries has 15-year design life and we offer 3-year quality guarantee. The series of battery is also called NP batteries mainly used in telecommunication system, portable power station and photovoltaic system, etc.

## 2.2 Special Application ($NP^+$ Series)

- High-rate series
  NPH series is a high performance battery, specially designed for application requiring high rate discharge and offers much more improved power densities up to 50% more watts per kilo than general NP type when operated at the 10 minutes discharge rate.
- Deep-cycle series
  NPC series is specifically designed to suit the arduous requirement of cyclic applications allowing increased cycle life (at least double the cyclic life of general NP type).
- Long-life series
  NPL series is designed mainly for UPS and other special applications with 10-year design life.
- Euro-batt series
  NPE series refers to the battery produced based on European Battery Standard in design and technology.
- GEL series
  NPG series refers to the battery produced based on VRLA and Gel Technology. Gel battery has much better performance than general NP battery especially in deep-cycle application.

# 3. DESCRIPTION OF VRLA BATTERIES

## 3.1 Battery Properties

Valve-Regulated Lead Acid battery (VRLA) is an advanced and economic rechargeable battery. It has several properties differing from other types of batteries:

- Maintenance free - As it is valve-regulated, sealed and with acid trapped inside absorbant glass-mat (AGM), it is leak-proof and has no need for refilling.

- High Power-To-Weight Ratio - VRLA batteries can provide much more power in comparison to its weight. For example, 6V and 12V battery capacity range form 0.5AH to 26AH, weight range only from 0.3 to 9.5 kg.
- No Memory Effect - Some batteries, say nickel-cadmium batteries, will become conditioned to provide less power after repetitious short usage/discharge.
- Low Self Discharge - The self-discharge rate for VRLA battery is about 2-3% per month at room temperature compared with 20-30% for other common battery systems.
- Long Service Life - Utilizing thick and massive calcium grids ensure VRLA battery has a long service life.
- High Discharge Rate - Since the internal resistance is very low, the battery can provide high rate of discharge.
- Wide Operating temperature Range - VRLA battery capacity is rated at 20℃ and will operate from -15℃ (5℉) to +50℃ (122℉) when fully charged. Its service life will be more efficient under 15℃ to 25℃.
- Ease of shipment - It is classified as non-dangerous battery and is acceptable to be shipped on passenger and cargo aircraft. VRLA battery meets the requirements to conform to the special provision A67 classifying them as *non-dangerous goods* under **IATA** Dangerous Goods Regulations. 32nd Edition, Un2800.

## 3.2 Battery Applications:

Recently, electronic products are showing remarkable developments. Various communications systems (i.e. VAN, LAN and INS) are quickly advancing to connect portable equipment, OA equipment, and FA equipment. A power generation system with solar cells utilizing solar energy is also being brought into service. **Toyama** VRLA battery is the most suitable lead-acid battery for main and emergency power supply as well as being an energy storage means. Our batteries are designed for ***cycle*** and ***stand-by*** applications. Some specific applications are as bellows:

### 3.2.1 Cycle Use:

- Portable VTR/TV, tape recorders, radios, and etc.
- Power tools, lawn mowers and vacuum cleaners
- Cameras and photographic equipment
- Portable personal computers, word processors, portable terminals and etc.
- Portable measuring equipment
- Portable telephone sets
- Various power toys and recreational equipment
- Lighting equipment

### 3.2.2 Standby Use:

- Communications and electric equipment
- Emergency lighting equipment
- Fire alarms and security systems
- Various telemeter equipment
- Office computers, processors and other office automation equipment
- Robots, control equipment and other factory automation equipment
- UPS power supplies
- Emergency power supplies in power generation plants and substations
- Telecommunications

### 3.2.3 Solar Cell Power Generation:

- Street Garden lighting
- Water pumping stations
- Portable power station
- Photovoltaic system

## 3.3 Battery Construction

The construction of a **Toyama** VRLA battery is shown **Fig 1**. The following is a description of the different parts consisting of our batteries.

## 3.3.1. Plates (Electrodes)

Plate construction is the key to produce a good battery. Recognizing this, **Sunstar** utilizes the latest technology and equipment to cast grids from a lead-calcium alloy free of antimony, The small amount of calcium and tin in the grid alloy imparts strength to the plate and guarantees durability even in extensive cycle service. Lead oxide paste is added to the grid to form the electrically active material. In the charged state, the negative plate paste is pure lead and that of the positive lead oxide. Both of these are in a porous or spongy form to optimize surface area and thereby maximize capacity.

## 3.3.2. Separators

The separator is made of woven glass fiber cloth with high heat and oxidation resistance. The material further offers superior electrolyte absorption and retaining ability, as well as excellent ion conductivity.

## 3.3.3. Electrolyte

Immobilized dilute sulfuric acid: $H_2SO_4$.

## 3.3.4. Container

Case material is ABS, a high-impact proof plastic resin, styrene, or a polypropylene-polyethylene polymer with resistance to chemicals and flammability. For 2V, 4V, 6V, 8V and 12V batteries, standard container are manufactured from ABS plastic resin (UL94HB). It is optional to use Flame Retardant ABS plastic resin (UL94V0). Each cell has 2V in voltage and 4V battery has 2 cells, 6V battery has 3 cells, 8V battery has 4 cells and 12V battery has 6 cells.

## 3.3.5. Terminals

Depending on the battery model, the terminals may be Fasten type, bolt-and-nut type, pressure-contact type, cable-and-connector type or other special types. Some are threaded-insertion type or bolt-and-nut type.

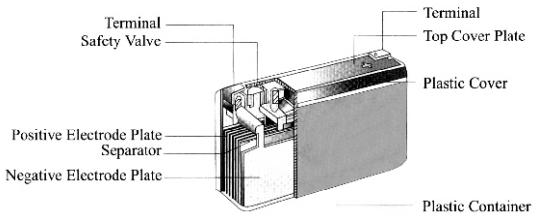
## 3.3.6. Relief Valve

In case of excessive gas pressure build-up inside the battery (usually caused by abnormal charging) the relief valve will open and relieve the pressure. The one-way valve not only ensures that no air gets into the battery where the oxygen would react with the plates causing internal discharge, but also represents an important safety device in the event of excessive overcharge. Vent release pressure is between 2-6 PSI and the seal ring material is neoprene rubber.

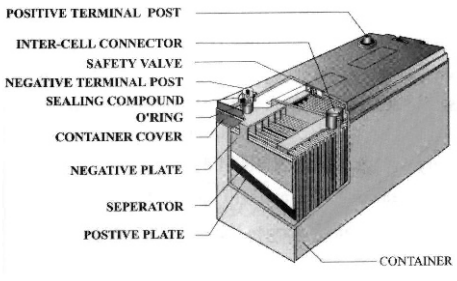
## 3.3.7. Case Sealing

The case sealing is tongue and groove with polyrethane, epoxy, or heat seal. The ABS plastic cover and container are sealed by a special epoxy made in Japan and is acid resistant.

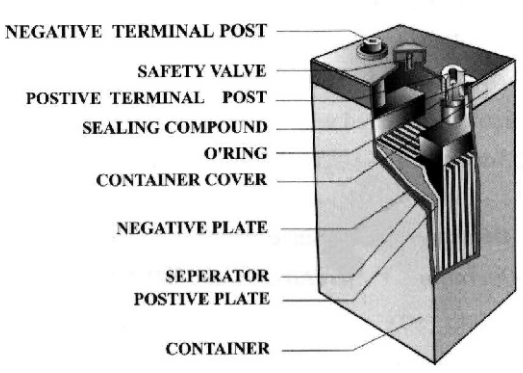
**Fig 1. Construction of Toyama VRLA battery**




**Micro series**




**Medium series**




**Macro series**

## 3.4 Sealing Principle

### 3.4.1 The charge/discharge reaction of the battery can be expressed as following

The battery is designed so that the negative plate does not have to be fully charged even when the positive plate is fully charged. Furthermore, no $H_2$ gas is generated from the negative plate although $O_2$ gas is being generated from the over charged positive plate. $O_2$ generated from the positive plate then reacts with the charged sponge lead (Pb) of the negative plate and turns into lead monoxide (PbO). The lead monoxide, in turn, reacts with sulfuric acid ($H_2SO_4$) in the electrolyte to turn into lead sulfate ($PbSO_4$), allowing the negative plate to discharge. In other words, $O_2$ from the positive plate is absorbed by the negative plate without being expelled to the outside. Since the negative plate develops discharging with the help of $O_2$, there always exists a portion free from discharging. As a result, the negative plate never generates $H_2$. This completely prevents the loss of water.

Overcharging causes electrolysis of the water content of the electrolyte, which generates $O_2$ gas at the positive plate and $H_2$ gas at the negative plate. These gasses are then discharged to the outside.

### 3.4.2 Electrochemical process

**(A) Chemical reaction formula during charge and discharge:**

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

| (Lead Dioxide) Positive Active Material | (Sulfuric Acid) Electrolyte | (Lead) Negative Active Material | | (Lead Sulfate) Positive Active Material | (Water) Elcctrolyte | (Lead Sulfate) Negative Active Material |
|---|---|---|---|---|---|---|

In this reaction, charge and discharge are reversed with high effiency. Electrical energy used during discharge will be regained by recharging.

**(B) In the final stage of charging or undercharge:**

**Oxygen gas generation-** Oxygen generates at the positive plate:

Reaction(1)

$$2H_2O \underset{}{\overset{}{\rightleftharpoons}} O_2 + 4H + 4e^-$$

| (Water) | (Oxygen) | (Hydrogen ions) | (Electrons) |
|---|---|---|---|

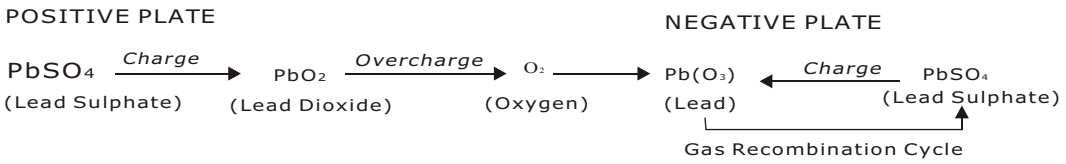
**Oxygen gas absorption-** Oxygen generated from the positive plate converts to the surface of the negative plate, and absorption takes place:

Reaction(2)

$$2Pb + O_2 + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O$$

| (Lead) | (Oxygen) | (Sulfuric Acid) | (Lead Sulphate) | (Water) |
|---|---|---|---|---|

The above reactions of generation and absorption can be expressed as followings:




Since oxygen gas generated in the stage of charging is absorbed by the negative plate, there is no increase in internal pressure.

**(C) Overcharge or abnormal charge:** However, when a battery is overcharged or when charging is conducted at less than the specific temperature, the amount of oxygen gas generated by reaction (1) cannot be fully-absobed by reaction (2). So the internal pressure increases and the safety valves activate. The gas including hydrogen generated ( along with oxygen) at the negative plate during exccesive overcharge will be released..

Reaction(3)

NEGATIVE PLATE

$2H^+$ (Hydrogen ions) $2e^-$ (Electrons) $\longrightarrow$ $H_2$ (Hydrogen)

It should be noted that when the safety valves functiin, electrolyte is consumed and its performance deteriorates. To prevent or reduce this, it is important that charging should be conducted under recommended conditions without overcharging.

# 4. CHARGING CHARACTERISTICS

## 4.1 Charging methods

Choose the appropriate charging method according to the applications and conditions of Toyama VRLA battery to get full performance from the battery. Methods available are: *semi-constant current charging method*, *constant current charging method*, *constant voltage charging method*, and *two-step constant voltage method*. The semi-constant current method and constant voltage method are generally used for batteries with cycle servicing. The constant voltage charging method is generally used for standby servicing (trickle or float). Also, the semi-constant current charging method is used for supplementary charging of the battery with extended storage period. Recently the two-step constant voltage charging method is being used for rapid charging of VRLA battery. Please refer to **Table 1** for an explanation of the charging methods and their features.

**Table 1**

| Charging method | Cycle service | Standby ( tricide or float) | Supplementary charge |
|---|---|---|---|
| **Semi-constant current charging (simplified charging)** | • Charging is possible within a relatively short period<br>• Overcharge is easy because it is difficult to control the charging current<br>• Low cost | Not applicable | • Charging possible within a relatively short period<br>• Suitable for charging batteries connected in series. Control of the time is necessary to prevent overcharging<br>• See **Fig 15** |
| **Constant current charging** | • Charging is possible within a relatively short period<br>• Protective circuit required to prevent overcharge<br>• High cost | Not applicable | • Charging to meet discharge quantity is possible by controlling the time<br>• See **Fig 16** |
| **Constant voltage charging (constant-current constant-voltage)** | • Proper charge method<br>• In general, charging requires a lot of time<br>• Rapid charging is possible by changing set voltage and current.<br>• Overcharge countermeasure necessary for the final stage of charge.<br>• Normal cost | • Proper charge method<br>• Inaccurate charge voltage may cause overcharge or undercharge<br>• Relatively long time necessary for recovery after deep discharge<br>• Normal cost | • Charging of batteries connected in series is possible for batteries discharged under a given condition<br>• Normal cost<br>• See **Fig 17** |
| **Two-step constant voltage charge** | • Reasonable rapid charging<br>• High cost | • Charging for recovery is possible within arelatively short period even after deep discharge<br>• High cost | |