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NorthStar Battery Installation and Operation Guide

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1 Battery Safety

For full information please read the MSDS (Material Safety Data Sheet). The MSDS document may be downloaded from the Internet at:

http://www.northstarbattery.com/MSD-430-01.pdf

When dealing with VRLA (Valve Regulated Lead Acid Batteries) some additional safety information is required.

1.1 Electrical Safety

The battery terminals are always energized and, if short-circuited, release of harmful electrical energy may occur which can injure personnel or damage equipment. Keep bare conductors away from the battery until the batteries are positioned in their final position where the battery shall be connected using the designated conductors. Keep the protective covers on!

1.2 Large Weight

The batteries are heavy objects. If they are dropped physical damage to persons can occur. A dropped battery may also expose the poisonous and corrosive contents of the battery's interior. Damage from a battery, which has been dropped, may not be visible to the human eye. The interior casing of the battery could be damaged. Never install a battery that has been dropped.

Use proper lifting procedures and the handles for lifting and carrying the batteries.

1.3 Chemical Hazards

The batteries contain concentrated sulfuric acid in water. If any fluid is found outside of the batteries it should be regarded as acid. Please observe that acid that gets on the skin does not feel cool like a stain of water. If there is suspicion of leaked or spilled acid keep a close look at clothes and hands for signs of acid. Normally there is some time before acid comes on the skin and the stinging sets in, by wiping off the acid early and rinsing early damage can be limited.

Should that fluid come in contact with a person, follow the instructions for flushing eyes or skin with water contained in the MSDS and immediately seek medical assistance. Discard clothing that has become contaminated with the battery's sulfuric acid.

Always use protective goggles when handling lead acid batteries!

Always keep a source of water and pieces of cloth or tissue paper at hand!

It is highly preferable to use acid resistant clothing and protective gloves!

Do not smoke or use open flame when handling the batteries!

Do not use garments or other things that generate static electricity!

Batteries will vent hydrogen gas from time to time. This gas, which is flammable, exits the batteries through designated ports. Sources of ignition shall be kept away from these ports.

1.4 Old Batteries

Batteries which have reached their EOL (End of Life) should be removed from the application they are in and disposed of in accordance with federal, state, and local laws concerning the handling of hazardous materials and the environment. EOL is an industry defined term for VRLA batteries which indicates that the battery has only 80% of it's original capacity left. Use of a VRLA battery after it's effective EOL results in an increased rate of grid growth on both the positive plate increasing the internal resistance of the battery. This grid growth can lead to damage of the battery case and to the application within which the battery is placed.

Additionally, it is possible with time that a battery which has passed it's end of life could, but not necessarily will, result in the possibility of thermal runaway. Thermal runaway is the rapid increase of heat within a battery, which can cause the battery case to become soft and distort leading to the possibility of electrolyte leakage.

1.5 Cleaning and Chemicals

Do not use chemical compounds to clean batteries. The chemicals in many commercial cleaning compounds can damage the battery case and cause a leakage of sulfuric acid. If the battery needs to be cleaned, use a moist cloth that has had the moisture wrung out of it.

Do not use chemical insect sprays in areas where VRLA batteries are stored. The chemicals in inspect sprays will damage the battery case and could cause a leakage of sulfuric acid.

Do not move the batteries using the battery terminals. This increases the chance of personal electric shock, but could also damage the positive and negative plates in the

battery leading to internal short circuits, damage of the battery case and the leakage of sulfuric acid.

Always store the batteries in a cool environment. Never store batteries in an environment whose temperature is > +30° C (> +86°F). High temperatures reduce the life of VRLA batteries. For more information see the section on Storage and Handling.

2 Determining Battery Manufacturing Date

It is important to be able to determine the manufacturing date of a battery. Knowing this manufacturing date, and the date when the battery was received, or placed in storage, together can help determine when, or if, a battery will require recharge prior to installing into it's final application.

The manufacturing codes for NorthStar batteries are located in two places on the battery case. Batteries manufactured prior to July 2005 are only marked on the right rear side of the battery case.

1. On the front of the battery (to the left in figure 1).
2. On the right hand side towards the rear of the battery (to the right in figure 1).

Figure 1 Location of manufacturing labels on NSB batteries

Taking the two examples of manufacturing codes above, they can be interpreted as follows:

A08310632031

A = A letter which specifies the battery model.

The remaining digits are interpreted using the format below:

MMDDYYXXXXX

MM = Month
DD = Date
YY = Year
XXXXX = Individual battery serial number

Using the formula and example shown above, the serial number of the left of figure 1 is interpreted as:

A battery manufactured on (083106) August 31, 2006 with individual serial number of (32031) 32031.

The example of a serial number to the right in figure 1, A07130505903 can be interpreted as:

A battery manufactured on (071305) July 13, 2005 with an individual serial number of (05903) 05903.

3 Handling

In addition to safety requirements (see the Safety section) special care should be taken when handling batteries. The following are some do's and don'ts.

3.1 Do

- Always use the handles on the batteries when lifting or carrying them.
- Always have a straight back and lift using your legs when lifting or carrying batteries.
- Always have appropriate safety gear (see safety section) available when handling batteries.
- Always perform an OCV (Open Circuit Voltage) check on a battery PRIOR to installation. The application into which the battery is to be installed may have a

function, which precludes the batteries from being connected to the system if the OCV is too low.

- Always perform a visual inspection of the battery prior to handling. If any damage, or electrolyte leakage is detected during this inspection **DO NOT INSTALL THE BATTERY!**
- Always use the battery packing from new batteries for transporting old batteries for proper disposal. Having the batteries loose during transportation can lead to either an inadvertent discharge of the batteries, or to damage of the batteries and electrolyte leakage.
- Always dispose of batteries in accordance with local and national requirements.
- Always use a mechanical lifting device such as a fork lift when lifting a crate with batteries in it. A crate weighs in excess of 140 kgs (309 lbs).
- Always follow the instructions provided with the batteries when installing them.
- Always use insulated tools when handling batteries. Failure to do so can lead to electric shock and injury to either personnel or equipment.

3.2 Don't

- Never drag a battery along the floor. Doing so could cause damage to the battery case leading to a possible leakage of electrolyte and damage to personnel or equipment.
- Never install a battery into any application that has been dropped. A dropped battery could have damage to either its internal or external casing leading to a possible leakage of electrolyte and damage to equipment.
- Never make the final connection to an application until all batteries in the string have had their interconnections finished. The batteries contain a large amount of stored energy, and can cause damage to personnel or equipment from an energy discharge.
- Never dispose of batteries in unapproved sites. The batteries contain sulfuric acid and compounds of lead that are harmful to nature and can contaminate the environment if not disposed of properly.
- Never drill, or in any other way attempt to breach the battery case. Doing so could lead to a possible leakage of electrolyte and damage to personnel or equipment.
- Never force a battery into equipment. Forcing the battery into equipment can lead to a breach in the battery's internal or external casing causing a possible leakage or electrolyte or electrical short circuit causing with injury to personnel and damage to equipment.

4 Storage

Below is a list of equipment that is recommended to be on hand in the area where batteries are stored.

1. DC volt meter
2. Battery chargers (a normal car battery charger, purchased locally, is sufficient)
3. Mechanical lifting device (such as a fork lift etc)

In addition to the above equipment, proper safety equipment should be on hand whenever batteries are handled. A listing of the proper equipment, clothing, and materials needed to clean any acid spill can be found in the MSDS (Material Safety Data Sheet) located on the Internet at:

http://www.northstarbattery.com/MSD-430-01.pdf

When received a visual check should be made on the batteries. If the batteries show transportation damage, physical damage to the battery case, leaking electrolyte etc., they should not be installed, but a claim should be initiated immediately.

The OCV should also be checked when a battery is received, and just before installation. A low OCV could indicate that a charge may be required. The Performance Calculation Program gives the charging time needed to achieve a SOC (State of Charge) >95% as a function of voltage. The Performance Calculation Program is available by contacting NorthStar Customer Service at +1 (417) 575-8201.

The float charging voltage shall be 13.62 V per battery provided that the temperature is a nominal +25°C (+77°F). Ranges of +20°C - +30°C (+68°F - +86°F) are acceptable. For UPS equipment multiply the voltage with the number of blocs. If the temperature varies strongly, please consult the manufacturer's (NorthStar) application manual. The manual can be found on the Internet at:

http://www.northstarbattery.com/SES-544-01.pdf

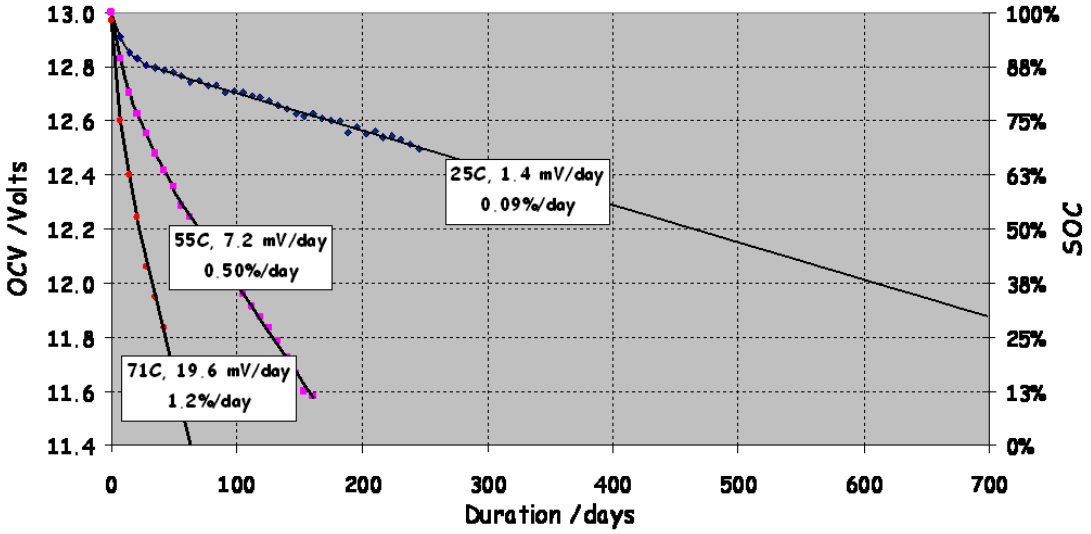
The batteries should be stored in the containers in which they were shipped, but if removed, make sure that the batteries are all evenly spaced, aligned and rest on a flat surface while being stored. It is strongly recommended that the surface the batteries rest on be an acid resistant electrically insulated surface. In some markets, this is a requirement.

Figure 2 Different ways to correctly store batteries

4.1 Storage Life

The storage life of NSB batteries while in storage is 2 years at +25°C (+77°F). The manufacturer's recommendation is that batteries be stored in a cool dry place, away from an ignition source, and properly ventilated. However, many storage facilities are not climate controlled, and due to this, the storage life of a NSB battery may be significantly less than 2 years. This is why it is vital that the OCV of a battery is checked before it is sent to site for installation and if the OCV is found to be low, the battery MUST be recharged before installing. Failure to perform the OCV check, and recharge as necessary, may mean that the battery will not function properly at commissioning.

Graph 1 below shows that the storage life of a battery is reduced as the temperature is increased above +25°C (+77°F).



Graph 1 Open-circuit voltage (OCV) state-of-charge (SOC) of a NSB battery in relation to ambient temperature

5 Installation

Always use the installation instructions provided with the batteries and follow all outlines for safety and handling mentioned earlier in this document.

5.1 Unpacking the Batteries

Make sure the shipment has no transportation damage. If there should be transportation damage the batteries may not be fit for service. Contact the battery distributor in that case.

Make sure all the accessories are present in the delivery. Please observe the cardboard material around the batteries has no bottom! The cardboard should be removed prior to lifting the batteries.

If the batteries cannot be put into place directly in the end application and need to be put on the floor/ground, put some of the cardboard material under them in order to protect the battery from hard surfaces. An alternative material is to use the top of the crate that the batteries were shipped it.

5.2 Checking the Battery Voltage on Arrival

Measure the voltage of the batteries. Depending on the voltage of the batteries the batteries might need a charge with a higher voltage initially. Table 1 gives the charging time needed to achieve above 95% state of charge as a function of voltage.

OCV	Charge
>12,80 V	Overnight charge at float voltage
12,6-12,8 V	3 days of charging
12,3-12,6 V	24 h of charging at 14,4 V
12,1-12,3 V	72 h of charging at 14,4 V

Table 1 Charge times in relation to OCV

5.3 Checking the Voltage Spread

Before connecting the batteries in series the voltage variation must be checked. If the voltage varies more than 0,15 V the batteries should be charged individually before being connected in series.

Alternatively the batteries may be matched in each string so that all the batteries with voltage spread less than 0,15V.

5.4 Putting the Batteries in Place

Make sure the batteries are all evenly spaced, aligned and rest on a flat surface. It is strongly recommended that the surface the batteries rest on shall be an acid resistant electrically insulated surface. (On some markets this is a requirement).

5.5 Connecting the Batteries

The batteries shall be connected into series using the cable and connectors designed for the particular layout of your delivery. We refer to the particular layout of the system. Please observe the risk for arcing and high currents when connecting the battery string to the system. Preferably the last connection should be made at distance from the battery string. If the system comprises a battery circuit breaker or any other means of disconnection this shall be in an off condition when connecting the battery to the system. A torque wrench must be used for tightening the bolts on the battery. The covers shall be put back after all connections have been completed. Please observe that when heavy cables are use these need to be supported in order not to stress the battery terminals.

5.6 Putting the Battery Into Service

Depending on the voltage of the batteries at the time of installation charge at elevated voltage may be needed. Please consult the table above.

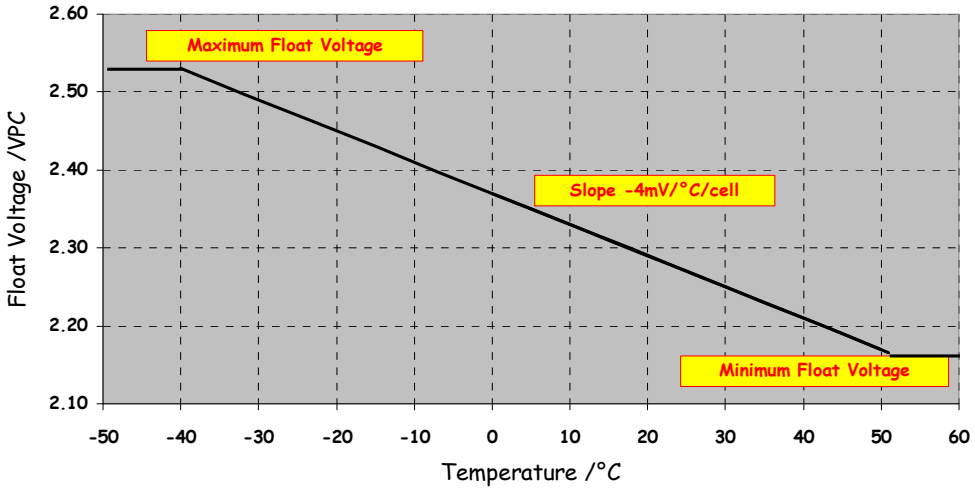
5.7 Charging Voltage

The float charging voltage shall be 13,62 V per battery provided that the temperature will be close to 25°C (20-30°C). For other temperature please refer to our table below. If temperature varies strongly please consult our application manual. For UPS equipment multiply the voltage with the number of blocs.

T °C	U(float) V	24 V	48 V
20	13,74	27,5	55,0
25	13,62	27,2	54,5
30	13,50	27,0	54,0
35	13,38	26,8	53,5

Table 2 OCV limits in relation to temperature

The graph below shows the float voltage per cell. Depending upon the string configuration, the voltages below should be multiplied by 6, 12 or 24.



Graph 2 Float voltage per cell

6 Operation

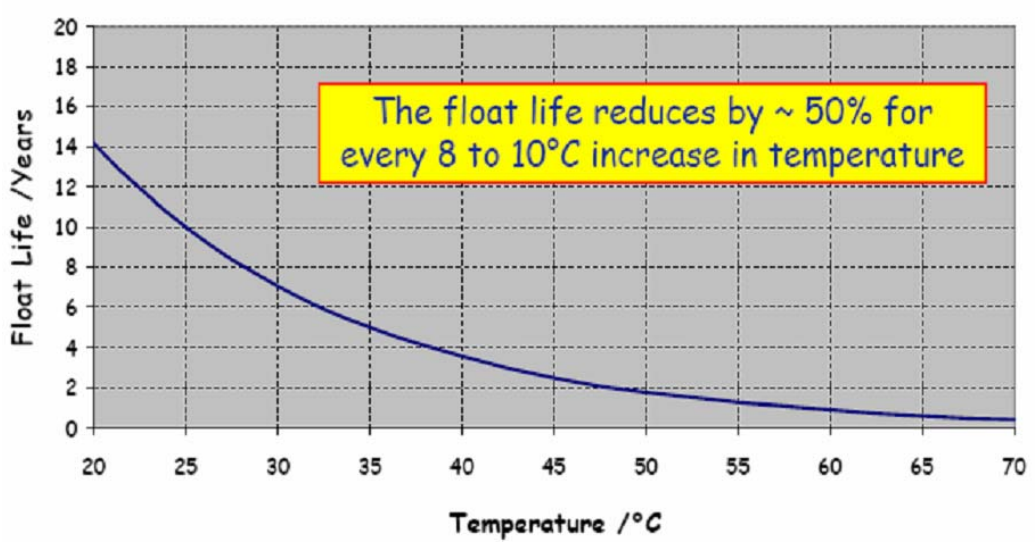
This section describes how several parameters affect the float life of Valve Regulated Lead Acid (VRLA) batteries. Batteries once charged, have a constant chemical reaction occurring regardless of whether they are installed or not. In storage, depending upon temperature, it may be necessary to check the OCV of batteries every 3 months. In an application, as a minimum, the OCV should be checked annually, but certain applications may require more frequent maintenance.

Use the information below to estimate battery float life. The practical life of a battery is strongly influenced by the operating conditions for the specific installation. The main factors are:

- Temperature (both of the battery itself, and it's operating environment)
- Number and depth of discharges

6.1 Effects of Temperature on Float Life

High battery and/or battery environment temperatures are one of the main causes of battery aging. An additional factor, no less influential, is the number and depth of discharges.



Graph 3 Effect on battery life by temperature

A good rule of thumb on the relation of temperature to float life is that for every approximately 10°C (18°F) increase in temperature reduces the float life by 50%. This is illustrated in the top graph above.

The end of life for any VRLA battery is industry defined as the battery having reached 80% of its rated capacity. After a VRLA battery reaches 80% or its rated capacity, the capacity loss increases dramatically. Additionally, the resistance between the positive and negative grids within the battery increases. This creates more heat and could lead to thermal runaway. Also, the subsequent grid growth on the positive plate increases pressure on the case. The main point to remember about a VRLA battery's EOL is:

NEVER OPERATE A VRLA BATTERY PAST IT'S EOL!!!!!!!!!!!!

6.2 Effects of Cycling on Float Life

The cycling effects on float life of a battery are dependent upon two discharge factors. These factors are:

1. DOD (Depth of Discharge)
2. The number of discharge cycles

The two graphs below illustrate these points.

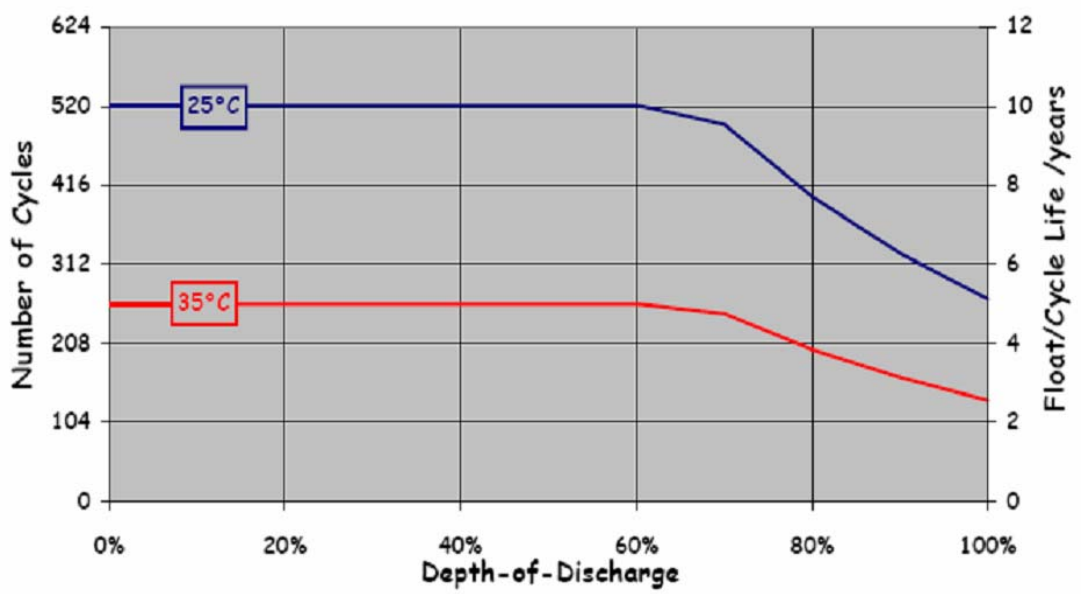


Figure 3 Effect on number of cycles by temperature and DOD

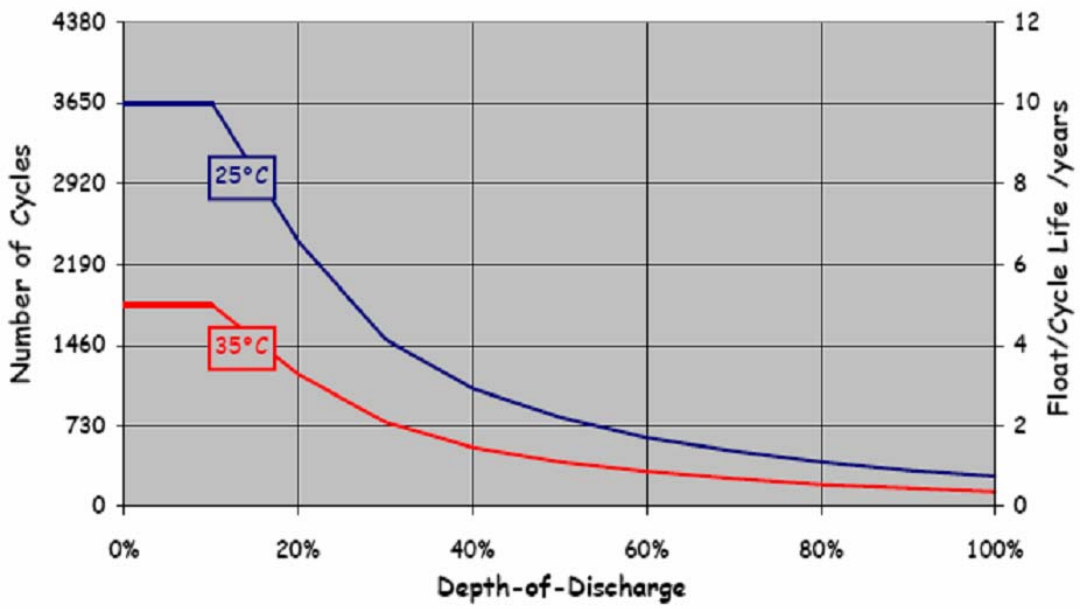


Figure 4 Effect on number of cycles by temperature and DOD

The top graph above shows that the effect cycling has on the float life starts at a DOD value greater than 60%. The graph also shows that the estimated battery float life is about 4 years, compared with 5 years at 35°C (95°F) for batteries with no cycling effects, that is a DOD of less than 60%.

The graph below it shows that the float life is influenced by the cycling effects at a much lower DOD value of 10% due to the 7 times higher cycle rate. The estimated battery float life is about 2 years, compared with 5 years at 35°C (95°F) for batteries with no cycling effects, that is a DOD of less than 10%.

7 Testing

NorthStar Battery LLC endorses the use of the Midtronics Celltron-Ultra meter as a state-of-health tool for their range of batteries. A conductance manual detailing the principals behind conductance testing, the full rage of NSB conductance values, what the limitations are and how to use the device in a correct manner can be downloaded from the Internet at:

http://www.northstarbattery.com/Conductance_Manual.pdf

8 Abbreviations

°C	Degrees Celsius
DC	Direct Current
EOL	End of Life (of a battery)
Etc	Et Cetera
°F	Degrees Fahrenheit
Kgs	Kilograms
Lbs	Pounds
MSDS	Material Safety Data Sheet
NSB	NorthStar Battery
OCV	Open Circuit Voltage
SOC	State of Charge (of a battery)
V	Volt
VRLA	Valve Regulated Lead Acid (Battery)