Proper Commissioning Procedures for Lead-Acid Batteries

Rick Tressler
Senior Training Engineer
Alber
Pompano Beach, FL 33064

Abstract
After the last bolt has been tightened on a new battery installation and its assembly deemed complete, the next part of the process is the proper commissioning of the system. The responsible party should be identified at some point in the installation phase; however, this does not always occur. In many cases, the battery system is simply placed on float charge at an arbitrary voltage. Pre-commissioning measurements and checks are not always made. When it *is* performed, steps can be omitted or, commissioning is performed incorrectly. The result can be myriad problems for the life of the battery. New system commissioning must be carried out properly and documented for the record. This paper will explore typical commissioning procedures for both, vented lead-acid (VLA) and valve regulated lead-acid (VRLA) batteries. The author will offer suggestions as well.

Introduction
Throughout my nearly thirty years in the stationary battery industry, I have been told of and witnessed many interesting things relating to the perceived proper installation, operation, maintenance, testing and commissioning of stationary batteries. Many are simply wrong. The commissioning charge process and its associated procedures are intended to make the battery ready for service, including acceptance (discharge) testing. Multiple names for this activity such as boost charge, initial charge, equalize charge and even start-up charge, are used interchangeably which can cause confusion. It is the author's intent to discuss through text and illustration that there is no single commissioning procedure and voltage potential, and that battery manufacturer instructions need to be followed in order to achieve the desired result; make the battery ready for service.

Purpose of the Commissioning Charge
While a battery is stored after manufacture, it loses some of its charge. The rate of self discharge is a function of grid alloy and storage temperature. Basically, for all lead-acid batteries, the rate of self discharge increases with storage temperature. The total charge lost is a function of the time in storage at a given temperature. The primary purpose of the commissioning charge is to make sure a new battery is fully charged before it is placed into operational service. Noteworthy is the fact that if an acceptance (capacity) test is to be performed, it is vital the battery is up to the task. An improperly charged battery will not deliver rated capacity.

The All Important Installation Operation and Maintenance Manual (IOM)
The IOM frequently seems to grow legs and walk off the installation site, never to be seen again. Newsflash! Copies of this document can be downloaded from the manufacturer's website to practically most web-enabled devices such as a PC, smart phone or tablet. No excuses. When it comes time to perform the commissioning charge, no one seems to know where the IOM documents are. Worse, it's also a time when guessing at just how to charge a battery begins. Things can go from good to bad quickly in some instances. Why? Despite the fact that there are just two types of lead-acid batteries, that is, vented lead-acid (VLA) and valve regulated lead-acid (VRLA), the manufacturers are numerous.

Grid alloys, specific gravity ratings, and charge/self-discharge characteristics, thus result in differing procedures. With relatively new alloys in VRLA for example, gone are the days of using rules of thumb to commission a battery. In some cases, failure to comply with the IOM can and has resulted in the ruination of a perfectly good battery! There will be more on the actual procedures later in the paper. The bottom line is this; you or the person commissioning the battery needs the IOM.

Readiness for Initial Charge

Prior to carrying out initial charge procedures, key checks and measurements should be completed. These provide important as-installed information and conditions before the battery is given its initial charge. This is the first time site-specific parametric data is collected, documented and reviewed for a new battery. Benchmark readings are excellent to have on hand in the event problems arise before, during or after the initial charge has been completed. Remember, maintenance records are required for warranty claims.

Pre-charge checks and measurements include, but may not be limited to:

- Verification all bolted connections are tight
- Connection resistances (when measurable) are within IEEE recommended practices[1, 2]
- Proper polarity of cells in-circuit has been verified (no cells installed backwards)
- Verify open circuit voltage (OCV) of all cells is acceptable
- Electrolyte specific gravity has been measured and recorded (VLA only)
- Electrolyte levels
    - No levels above the high line
    - Add approved water only if plates/straps are exposed and only to the low line
    - Final level adjustments to be made per battery manufacturer instructions
- Internal ohmic measurements have been made and are acceptable
    - Strongly recommended for all VRLA batteries
    - Slowly becoming a requirement of VLA users as a means of confirming internal damage to cells has not occurred

When I worked in the field installing battery systems, it was standard procedure to collect this information, create a report and forward it to the appropriate party.

To summarize, a battery must be verified ready to receive its initial charge *before* the actual charge commences. If something does not meet the manufacturer's requirements for readiness, deficiencies must be corrected first.

Set to Float and Forget

A new battery should not be simply placed on float and considered ready for service unless the manufacturer instructions say so. Some do actually allow this, but the battery must be placed on float within a specified period of time after receipt. This won't apply if the battery has been sitting on open circuit for longer than specified by the manufacturer. Some battery chargers may not be able to fully float the battery after considerable time in storage. Additionally, during the time the battery is coming up to charge on float, the load will not likely be fully protected. Check your IOM for specific guidance.

Seventy Two Hours at 2.33 VPC Right?

Battery folklore frequently relates to, among other things, the all-important commissioning charge procedure. Throughout my time in the standby battery business, it has been widely rumored that the industry default procedure to commission any battery consists of applying 2.33 volts per cell (VPC) for a period of 72 hours. In such a case, a 60 cell substation battery would receive a 139.8 volt charge for that time, the 24 cell telecom battery gets 55.92 volts and a UPS battery system consisting of 240 cells is charged at just over 559 volts. Under some circumstances, this charge potential may work. However, the time is another matter entirely. Continuing, once complete, the charger is adjusted to a universal float voltage for the cell count (more folklore) and the initial charge is complete. At this point, folklore further tells us the battery is not only fully charged, it is also immediately ready for an acceptance test. This is not true. After the commissioning charge is complete, a VLA battery is to be placed on float for no less than 72 hours prior to an acceptance test.[3]

Once it has been determined a battery is ready to receive its initial charge, the manufacturer IOM must be consulted for the procedure. This is generally found in the commissioning or initial charge heading portion of the document. The IOM usually indicates the required charge voltage(s) and time(s), at a minimum. This is frequently illustrated in tabular format, accompanied by instructional text. See Figure 1. This is as an example of the initial charge voltages and times for VLA cells employing Antimony or Calcium grids at different rated specific gravities. There are additional considerations which accompany the charge voltage/time tables.

Figure 1. Initial Charge Table for ABC VLA Cells

MINIMUM HOURS OF CHARGE AFTER CURRENT STABILIZATION					
Alloy	**Antimony**		**Calcium**		
Sp. Gr.	1.215	1.250	1.215	1.250	1.300
V.P.C.					
2.27	140	210	-	-	-
2.30	100	150	-	-	-
2.33	70	110	140	-	-
2.36	50	78	100	160	-
2.39	35	56	70	110	-
2.42	25	-	50	80	125
2.45	24	-	40	55	85
2.50	22	-	36	50	60
2.60	-	-	30	44	50
2.70	-	-	24	36	44

The battery manufacturer IOM indicates the following must also be considered or followed:

- Charge current must be stabilized for 24 hours before using the selected time in the table
- The charge voltage must not exceed the rating of the connected load equipment
- The tabular data applies to cell temperatures between 60° and 90° F (16° and 32°C)
- Charge times increase significantly at cell temperatures below 60°F (32°C)

The author adds the following noteworthy considerations:

- Double-check you are reading the correct specific gravity values as there is more than one specified
- The user must be certain of the number of cells in the battery to determine the charger setting
- Charge VPC must be multiplied by the number of cells in the battery to determine charger setting

Commissioning instructions, while similar to one another, are rarely identical. The instructions for the XYZ cells in Figure 2 differ from those for the ABC cells in Figure 1. For example, compare the charge time after current stabilization for 1.250 gravity calcium cells charging at 2.36 VPC. The XYZ cells are charged for 235 hours compared to 160 hours for the ABC cells.

Figure 2. Initial Charge Table for XYZ VLA Calcium Cells

	Lead-Calcium Types		
Cell Volts	Time-Hrs. 1.215 sp. gr.	Time-Hrs. 1.250 sp. gr.	Time-Hrs. 1.300 sp. gr.
2.24	444	—	—
2.27	333	—	—
2.30	210	—	—
2.33	148	333	—
2.36	100	235	400
2.39	67	160	267
2.42	48	108	182
2.45	38	73	125
2.48	36	55	83
2.50	32	44	60

In Figure 2, the battery manufacturer states that the following must also be considered or followed:

- The times given are minimums. Additional time may be required if storage time is excessive.
- Applicability of the charge times commence at the point of stabilization of charging current
- Stabilization is defined as a 3 hour period where charge current exhibits no further reduction
- Continue charging until the lowest cell voltage ceases to rise
- Time periods given apply to cell temperatures 70°F (21°C) to 90°F (32°C)
- For temperatures 55°F (13°C) to 69°F (20.5°C) double the number of hours
- For temperatures 40°F (4°C) to 54°F (12°C) quadruple the number of hours

Commissioning Lead-Selenium Vented Batteries

The following is an example of the commissioning procedure for one manufacturer of vented lead-selenium cells, wet and charged, covering the OGi and OPzS types. Such cell types are produced by a number of manufacturers. Be sure to read and follow the instructions supplied for the particular battery being used. The text that follows is paraphrased.

For OGi and OPzS cells, maximum time in storage is 12 weeks (8 weeks if above 35°C (95°F). At that time, the batteries must be charged at 2.23 VPC. No further action is required regarding charging. Once the batteries have been on float for 24 hours, approved water should be added to bring the electrolyte level to the high level line. Specific gravity is nominally rated at 1.240 with an expected range of 1.230 to 1.250, corrected for temperature.

For batteries stored for periods longer than specified in the manual special commissioning instructions need to be followed with attention to the specific manufacturer, even though all share the same cell type designation. As a point of reference, maximum storage time for a VLA Calcium cell is 6 months. It is typically 3 months for VLA Antimony and Selenium cells. VRLA batteries generally have a maximum storage period of 6 months. Storage temperature with respect to these times, for most cells, is fairly broad; approximately 51°F (11°C) to 77°F (25°C).

Thermal Runaway and VLA Batteries

Readers should keep in mind that any battery can experience thermal runaway under certain conditions; VLA batteries included. For that reason, it is suggested to monitor electrolyte temperature during commissioning. Know the current limit values for the specific battery you are working with. As it accepts the charge, battery voltage continues to rise and current will decrease. Check the manufacturer charge current limit specification. This value varies, but it is typically 5 amperes (A) per 100 ampere hours (AH) of the nominal 8 hour capacity. For a 1000 AH battery, that's 50 amperes. Current limiting may be required to avoid overheating and excessive gassing.

Commissioning VRLA Batteries

Some VRLA batteries do not require a commissioning charge if they have been installed and are ready to be placed in service shortly after receipt. This may also be the case for some VLA batteries. The maximum time is frequently specified by the battery manufacturer. However, after significant time off charge, a more involved approach may be prescribed.

Excessive current draw during initial charging, should it occur, may need to be controlled to the battery manufacturer's maximum value through the use of the current limit setting in the charger. Consult the IOM to determine if there is a maximum value specified. The concern is premature cell dryout, thermal runaway and premature failure. Thermal runaway is to be avoided.

When comparing Figure 3 to Figures 1 and 2, it is clear that this VRLA battery requires a different approach to commissioning. Generally, commissioning charge times for VRLA cells are less than for VLA types.

Figure 3. Initial Charge Table for JKL Large Format (20 yr) VRLA Cells

Cell Type	Average String Float Voltage 77°F (25°C)	Average String Freshening Voltage	Freshening / Equalization Charging Time
	VPC	VPC	Hours
Cell Type A	2.25 to 2.30	2.35 +/- 0.02	12 – 16
Cell Type B	2.17 to 2.22	2.29 +/- 0.02	12 – 16

Summary

While commissioning a battery may appear to be elementary to some, it is very important that it is performed properly. There is no universal commissioning procedure. Read, understand and follow all battery manufacturer instructions. The installation, operation and maintenance manual, so thoughtfully authored, provides the majority of what the user needs to know to get the job done unless special circumstances exist. Proper commissioning is even more important if an acceptance test follows. A battery may not pass a test if correct charging and time on float prior are not followed. VRLA batteries do not generally require as much time for a commissioning charge as VLA and the voltages used are generally lower than for VLA cells. Thermal runaway may occur if a VRLA battery is given a commissioning charge that is conducted for longer than indicated even if the charge voltage is within limits. When questions arise, contact should be initiated with the manufacturer for technical support and guidance.

References

1. IEEE 484-2002, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications, Section 6.2.2 l)
2. IEEE 1187-2002, IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications 6.2.2 l)
3. IEEE 450-2010, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, Section 7.2 a)