# EAGLE EYE TECHNICAL NOTE

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| **Title** | **Considerations for Lead-Acid Batteries in Electrical Substations** |
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## Revision History

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**Introduction.**

**What is an electrical substation?**
It is that part of the electrical generation, transmission and distribution grid, that contains equipment that transforms line voltage from high to low and vice versa. The locations can also contain other elements such as protection and communications equipment. All of these critical elements are backed up by batteries. It is estimated that there are over 55,000 substations in the U.S., most of which are unmanned. Since batteries play an essential role, many factors regarding the battery need to be taken into consideration. This Technical Note is merely a low-level overview. More specific details can be found in many of the subject matter Technical Notes available from Eagle Eye Power Solutions.

**Note.** The term battery may refer to a single battery unit, a battery, string, or a battery system/plant.
A battery unit is a single battery block containing one or more battery cells.
A battery string is one or more battery units connected in series to increase battery voltage.
A battery plant is one or more battery strings connected in series/parallel to increase battery capacity.

**Some important things to consider are:**

- Charging.
- Temperature.
- Location.
- Installation.
- Spill Containment.
- Maintenance.
- Redundancy.
- Safety.
- Ventilation.
- Recycling.
- Ancillary Equipment.

**Charging.**
A battery is only as good as the way it is charged. If the charging voltage is too high, it will shorten the life of the battery. If it's too low, the battery will never reach full charge. The correct charge voltage is basically determined by two things: 1. the specific gravity of the electrolyte and 2. temperature. Manufacturer's instructions will give the recommended float/equalize voltage at a specific temperature usually 77°F (25°C). However, if the ambient or battery temperature is above or below this norm, then the charge voltage should be adjusted to compensate for the difference. See below.

**Temperature.**
Batteries are very sensitive to heat and should be treated accordingly. As mentioned above, the charging voltage should be changed in order to maintain the correct charging current to the battery. This is called temperature compensated charging and involves adjusting the charger output voltage to facilitate this. This can be achieved automatically by using chargers with temperature compensating features where the adjustment is made in reaction to a temperature probe(s) placed at the battery. If a temperature probe is

placed on the battery, it should be on the most negative terminal. The placement of the battery is also important, see below.

**Location.**
Whether in a building or in a cabinet/shelter, care should be taken to locate the battery where it has adequate ventilation and not near a direct heat or cooling source. Restricted air flow that hinders natural convection cooling can be a problem, especially in confined spaces such as cabinets. Try to not have the battery in direct sunlight.

**Installation.**
The batteries should be installed in accordance with IEEE Std. 484 for VLA[1] and 1187[2] for VRLA. The battery model numbers, date codes, batch numbers, installation date, and other pertinent information should be clearly visible or available on site. The cell/unit numbers should be displayed and increment from the most positive terminal to the most negative terminal. Adequate space should be provided around the battery to facilitate maintenance. It is also good practice to arrange the battery configuration so that the positive and negative takeoff terminals are as far away from each other as possible. This could avoid accidental shorting.

**Spill containment.**
Is electrolyte spill containment required? Well, the answer is, like many battery questions, "it depends". Some electrical utilities may be exempt. However, since dilute sulfuric acid is corrosive and can damage the racking and flooring, it is advisable to provide whole battery spill containment. This should be installed in accordance with IEEE Std. 1578[3].

**Maintenance.**
NERC[4] requires that batteries and their charging systems be maintained with PRC-005, Protection Systems, Automatic Reclosing, and Sudden Pressure Relaying Maintenance. This document dictates the maintenance requirements based on a timeframe. Certain actions can be eliminated if a permanent monitor is connected. Since most substations are unmanned, this is usually recommended. IEEE Std. 450[5], and IEEE Std. 1188[6] are more demanding maintenance documents and should be considered.

**Redundancy.**
NERC TPL-001-5 is also a requirement. This is the Transmission System, Planning Performance Requirements. Without getting into details, this was promulgated in order to harden the backup power system and avoid a single point of failure. It discusses the redundancy of key elements such as the battery and chargers.

**Safety.**
This is a key consideration when working on or around a battery backup system. One thing that must be remembered is that a battery cannot be switched off, it is always energized, even if disconnected from the charger. NFPA -70E[7] considers a voltage above 100 Vdc is a dangerous working voltage. Consequently, most substation batteries being 125Vdc nominal, should be treated accordingly with the appropriate PPE being worn and if possible, the battery should be segmented into sections of under 100 Vdc when working on the battery. Insulated tools should also be used.

**Ventilation.**
All lead-acid batteries can ventilate oxygen and hydrogen. This is a normal occurrence for VLA batteries and can also occur with VRLA batteries if overcharged. Hydrogen gas is combustible if it reaches a certain concentration in a confined air space. To combat this, several agencies have created a high concentration limit of 4% or less, the most stringent being 1%. Since hydrogen is the lightest element, it can easily escape through very small openings. If hydrogen detection is required, then apply the lowest concentration of 1%. A hydrogen detector should be used and placed at the highest point of the battery location. The detector, which may need to be regularly calibrated, should be coupled with an extraction fan that can be activated by a signal from the detector. For detailed information, see IEEE Std. 1635[8]

**Recycling.**
All lead-acid batteries can easily be recycled. Indeed, they are probably the country's most recycled product with the materials having a recycling rate of 99%. If a battery has to be changed out, then it is relatively easy - either through the installation company or an independent contractor. It is important that whoever removes the battery for recycling also provides a written document declaring the transfer of ownership to indemnify the company from legal action.

**Ancillary Equipment.**
Every batter location should have an eyewash station. This can either be portable or fixed. Also, it may be a good practice to have warning signs such as "No Smoking" or "Power Off Button." Nonconductive floor matting around the battery can act as a personnel isolation means when working on the battery.

**References.**

1. IEEE 484. Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.
2. IEEE 1187. Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications.
3. IEEE Std 1578. Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management.
4. NERC. North American Electrical Reliability Corporation.
5. IEEE Std. 450. Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
6. IEEE Std. 1188. Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid Batteries for Stationary Applications.
7. NFPA 70E. Standard for Electrical Safety in the Workplace.
8. IEEE/ASHRAE 1635 Guide to the Ventilation and Thermal Management of Batteries for Stationary Applications.

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