# AVOIDING TROUBLESOME BATTERY INSTALLATIONS

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## Abstract
An excellent way to ensure a user will have a long-lived standby battery system with minimal trouble along the way is to begin with a good installation. Reliability truly begins here. The trouble seems to be that in more than a few cases, installation crews and management personnel alike somehow, on more than an occasion or two, just seem to get it wrong. Whether it is failure to inspect the shipment, someone missing tightening several bolted connections to failing to observe polarity, things can go very badly during installation as well at start-up. Acceptance tests therefore, can become complete disasters as a result.

This paper will present some of the most common mistakes that create a troublesome installation of vented and valve regulated lead acid batteries not only for the installer, but for the end user and maintenance operators long after the installation crew is out of the picture. Installation errors can and do cause trouble for users for years. Suggestions for avoiding these troubles in the first place will be discussed. The author's hope in the end is that project personnel whether management or wrench-turners will give the battery installation the attention it justly deserves, considering its vital role as an emergency power support system.

## Introduction
While there are more topics that can be presented in this paper, in the interest of time, only key items that result in trouble at installation and for the end user will be discussed.

## Applicability
This paper is intended for persons directly involved in the installation and maintenance of lead-acid stationary batteries. Management, technical and field supervisory staff can also benefit from its content.

## Safety
The author would be remiss in not mentioning safety. It must *always* be first on everyone's list of job requirements. Federal, state, and local regulation must be followed to reduce likelihood of accidents on a project. It is also worthwhile to consult the battery manufacturer or the battery manufacturer's installation manual for any recommended safety precautions. Failure to heed safety can be the first in a series of problems on site that lead to a troublesome battery installation.

## Delivery and Inspection
Shipping boxes should be opened, and the contents inspected for possible damage on delivery. Those receiving a battery shipment, frequently destined for installation elsewhere, are not necessarily the same people who will install it. It's often a problem. Cracked and leaking cells, cracked terminal seals, bent terminals, etc., go unnoticed.

This is a shipping matter and there is only so much time to detect and report the problem to the shipping company. It is likely the battery left the factory in good condition, with damage occurring during transport or handling if shipment transfers to other trucks are involved. Double-stacking is a problem on the truck and in the receiving warehouse. This practice causes cracked terminals, post seals, covers, and containers and is easily avoided. The warranty is voided.

## Storage

A battery is a perishable item because of inherent self-discharge. Storage time from delivery to commissioning is generally limited to three to six months in normal ambient temperature and is further dependent on grid alloy. *Normal ambient temperature* is defined by one manufacturer as 60°-85°F. Storage time storage time is halved for each 15°F above 77°F. Applying a freshening charge while a battery is still in storage can be very time consuming and challenging. It's best to schedule delivery so this task will not be required. Going forward through this paper, you should understand that a significant source of answers to your questions regarding installation, as well as maintenance, can be found in the battery manufacturer's manuals; a copy of which is included with every battery system. If it's missing, it can be located on the manufacturer's website.

## Battery Handling

For this paper, it is assumed the battery racks have been installed – and *yes*, anchored to the floor. The task of transporting cells from the staging area to their final installation location can be tricky for some projects. Thank goodness for the invention of the wheel!

While there are numerous methods that can be used to transport cells from point A to point B, a platform lift can perform double duty. It can move the cells to the battery room as well as lift them onto the rack, stand or cabinet. See Figure 1. It must be rated to lift the required weight and to the maximum height; two critical specifications to verify *prior* to installation day. Cells should be secured to the platform, so they don't slide off should a wheel catch on something such as a doorway threshold, errant hardware, etc. Lifts can be manually operated with hydraulics, cable-operated via a hand crank, or have electric hydraulics. It is important for installers to know that the center of gravity changes with lifts the higher the platform is raised and that there can be an increased risk of the lift tipping over, depending on the height of the platform and weight of the battery. Therefore, it is important to make sure that the platform is always in its lowest position before attempting to move the lift with the cell on board.

**Figure 1. Wheeled Lifting Platform**

## Treating Racks

Let's face it, batteries are heavy. And so, we humans try to come up with ever-inventive ways to make life easier. In the end, people invariably tend to become their own worst enemy. Positioning large cells and multicell units on racks requires significant physical effort at times.

Lubricating rack rails for example, while seeming to be a good idea, can have disastrous results to the battery. Rack, stand and modular system supports, and rails are not to be treated with any chemical or lubricant that is not specifically authorized in writing by the battery manufacturer. If you're looking for trouble, this is an excellent place to find it. Talc has been known to be used and may be acceptable. Be prepared to provide brand details. Water will also work. Contact the battery manufacturer.

Container and cover plastics react negatively to petroleum-based compounds, with cracking, crazing, and softening usually resulting. One of these most frequently misused lubricants is wire pulling lube, which is a perfect product for the intended application. It's a direct *misapplication*, however for battery work. The battery warranty will be voided. See Figure 2 for one example of a lubricant that should never be used on rack rails.


**Figure 2. Wire Pulling Lubricant**

## Flame Arrestors

Contrary to what some people think, the use of the supplied flame arrestors is a ***safety requirement*** for vented lead-acid batteries. VLA cells are typically shipped with shipping plugs installed to reduce risk of electrolyte spillage during transportation. These shipping plugs should remain in place until the cells are installed on the battery rack. Once the cells are in place on the battery rack and prior to installing any inter-cell or inter-multi cell connections, the shipping plugs must be removed and replaced with the flame arrestors. VRLA batteries are shipped with them installed at the factory and are not to be removed in the field except under specific circumstances and by qualified service personnel.

### Types

Installation is easy and straightforward, but a couple of things can get installers into a bit trouble if they are installed improperly. First, there are generally two types; the bayonet/tab base and screw-in (see Figures 3 and 4). Both are equipped with a dust cap which is removed to make water additions, and to check electrolyte specific gravity (when/if necessary) in the absence of a sampling tube.


**Figures 3 and 4. Tab/Bayonet (L) and Screw Base Flame Arrestors (R)**

### Installation for Trouble-Free Life

Both types employ a sealing method to prevent the leakage and migration of electrolyte from inside the cell. The tab/bayonet type uses a flat rubber washer while the screw-in type depicted uses an O-ring. The seals must be intact, undamaged, and free of contamination. Likewise, the vent well into which it is installed must be clean and dry. Invariably, there is wetness around the vent well when the shipping cap is removed. Dry mating surfaces are required, or they will leak. Tighten clockwise for both types until snug. Do *not* over-tighten. Broken flame arrestors are to be replaced and not glued or repaired. It is suggested spares be obtained in cases where broken ones are found.

**A battery is not to be placed on charge without flame arrestors installed. To do so is unsafe.**

## Connector Preparation, Assembly and Torque

This part of an installation usually requires considerable time and effort to complete. The idea is to perform the task correctly the first time, thus eliminating the need to perform rework. The latter generally occurs because of incorrect connector and terminal preparation. Reworking a 120-cell battery with four posts per cell, two bolts per post and double intercell connectors will cost an installer considerably in additional project cost and time setbacks.

### Terminal Preparation

Cell/unit terminals are made of lead alloy and may have a copper insert cast into its terminal if the battery is designed for application at high rates of discharge. Care must be taken so as not to expose the copper, because the lead plating can be thin on some batteries. Exposed copper corrodes quickly when electrolyte encounters it. Abrasive pads, such as Scotch-Brite$^{tm}$ are excellent for removing surface oxidation. See Figure 5. This mention is not an endorsement for 3M brands, as many others are available. Highly abrasive pads should be avoided. If the terminal does not contain copper, a fine brass brush (brass is used instead of stainless steel bristles both due to its relative softness and because brass bristles do not create sparks) may be employed. See Figure 6. Use of a wire brush on copper inserted terminals should be avoided as it is too abrasive. In the end, the goal is to remove surface oxidation resulting in a clean, bright appearance.

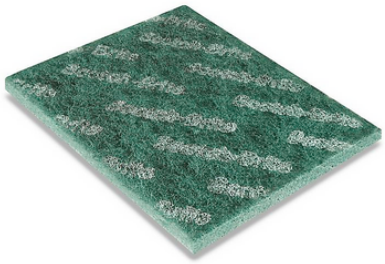

**Figure 5. Scotch-Brite$^{tm}$ Abrasive Pad.**

**Figure 6. Fine Brass Brush.**

## Intercell Connectors and Cables

The means to facilitate connection of cells/units to each another can be termed differently based on where they are used. In identifying these, there are intercell, interunit, intertier, interrack and interaisle connections. They may be lead or tin-plated copper bus, or insulated copper cables with plated crimped lugs. Most tin-plated connectors do not require preparation. See Figure 7. In fact, the instructions may *specifically* warn against performing any pre-assembly cleaning.

However, lead plated connectors as seen in Figure 8 *do* require removal of the surface layer of oxidation as do lead terminals. Again, remove the surface layer of oxidation only. Do not expose the copper. There is more plating on the connector than one may think; about 0.004". Light pressure on the pad is all that's needed to achieve the desired result; a clean, bright finish. Rotating wire and polishing flap brushes on power tools are to be avoided. Excessive force will quickly remove the lead, causing excessive amounts of lead dust to be launched into the air. Only the surface of the inter-cell connector that is in contact with the cell terminal post or assembly needs to be cleaned.

**Figure 7. Tin Plated Copper Intercell Connectors.**

**Figure 8. Lead Plated Copper Intercell Connector.**

## Corrosion Inhibitors

Application of a corrosion inhibitor is typical for stationary battery installations. No-Ox™ grease, as it is commonly known, is supplied in the accessory kit. See Figure 9. Connections must remain free of corrosion and further oxidation after assembly to maintain the lowest possible contact resistance. Therefore, antioxidant (No-Ox™) grease is applied to the previously prepared surfaces of the interconnectors. The only portion of the interconnector that needs to be coated is that surface area which is in direct contact with the cell terminal post, terminal plate, etc. With No-Ox-Id, application can be made either directly from the container or heated, using a hot plate and pan to approximately 160°-180°F. No-Ox-Id-A Special does not require heating. When connector ends are dipped directly into the liquid grease, it makes for a neat, professional looking coating. Here is where the installation can quickly become a troublesome one. More than once, installers have failed to prepare the connectors. To make things worse, corrosion inhibitor was not applied. This requires a rework of all battery connections; a costly and time-consuming mistake. As an aside, nuts, bolts and washers are not generally greased, as the bolt torque specification applies to dry threads. To afford an additional level of corrosion protection, installers should consider a thin application of corrosion inhibitor on nut, bolt, and washers after assembly.


**Figure 9. NO-OX-ID™ "A Special" Grease.**

## Hardware Assembly

Connections are generally assembled using stainless steel nuts, bolts, and washers. Many battery designs require only a bolt and washer that screws directly into a threaded terminal cast with a copper insert. Lead encapsulated brass nuts and brass studs are also employed. In the case of stainless steel, type 316 is frequently used. The type number is stamped on these parts. See Figure 10. One edge of the washer is sharp. *That* edge should face away from the connector, thus allowing the rounded edge to contact the connector hardware. This keeps the washer from cutting into plated parts, exposing copper which is very susceptible to corrosion. Some battery manufacturers supply a lock washer in their nut-bolt assemblies. In such cases, the lock washer is applied on the nut side. Use of galvanized steel hardware should be avoided as it corrodes quickly.


**Figure 10. Type 316 Stainless Steel Washer.**

### Torque

A battery installation cannot be successfully nor safely completed without the use of a calibrated, insulated torque wrench. See Figure 11. Proper torque application of bolted connections is essential. Unqualified installation crews have ruined a new battery by applying excessive torque because they did not know such a tool is required. When terminals become distorted the warranty is invalidated.

Bolt torque is specified by the manufacturer in inch-pounds (in-lbs) and/or Newton-meters (N-m). It may be specified as a single value or a range. When a nut-bolt assembly is employed, an insulated box or open-end wrench must be used in addition to the torque wrench. Torque is generally applied to the nut-side of the assembly unless otherwise instructed by the battery manufacturer. Others may not specify which side is to be used and the decisions is left to the installer. That said, the author was trained to always torque the nut unless instructions indicated otherwise.

**Figure 11. Insulated Torque Wrench with Removable Sleeve and Sockets.**

## Battery System Numbering

Systems can be installed in a variety of ways, such as open racks, modular stands, and cabinets. Rack and stand installations generally facilitate easy application of cell/unit number labels. Cabinet type systems can be numbered; however, this is not always done. Generally, systems other than the cabinet enclosure type will include a numbering kit in the accessory package.

The industry convention is to apply a number to each cell or unit where a single voltage measurement would be made during maintenance. The numbering sequence begins with #1 at the battery main (+) terminal. Cell numbers are applied to each cell or unit following the series circuit from cell/unit #1, ending with the last cell/unit's main (-) terminal. See Figures 12 and 13.


**Figure 12. Properly Numbered 24 Cell Battery.**


**Figure 13. Properly Numbered 4 Unit, 48V Battery Using 12V Multicell Units.**

## Placement

Surfaces must be clean and dry for proper adhesion and long life. Numbers should be placed such that they can be easily viewed. Avoid placement where the cell element requires specific visual inspection, such as the sediment space and weld straps on vented lead-acid systems. Cell numbers are generally placed on the container, at the mid-point between the top and bottom of the container.

## Connection Integrity

Measuring and documenting interconnection integrity by means of resistance measurement is an essential part of the installation process and cannot be over-emphasized. That said, the task is not always performed. Not all battery terminal designs accommodate test leads, so the measurement may not be possible. In those cases, it is even more important that no connection is missed with the torque wrench. Loose connections under load, at a minimum, can overheat, with the worst case resulting in a battery fire. Unless otherwise arranged, it is the installer's responsibility to perform this work, along with other items too numerous to cover in this paper.

The point of this section is to make the reader aware that the installer should be providing this and other post-installation readings, including cell/unit open circuit voltage and possibly specific gravity (for VLA only). They are considered *as-installed readings*, prior to commencement of a commissioning charge.

## Post-Installation Cleaning

Whenever possible, a battery should be cleaned prior to being placed into service. It is best performed prior to the commissioning charge, while the battery is disconnected from the charging system. This does not always happen and unfortunately, the battery doesn't get proper attention later in its service life.

Cleaning is accomplished with durable non-woven disposable wipes, water, and when needed to neutralize spilled electrolyte, baking soda. As for how much baking soda, the standard mix ratio is 1 pound to 1 gallon of water. As for other cleaners, there aren't any other than ammonia-based solutions (which, unlike baking soda mixes, do not produce much aerosol while neutralizing). As was discussed in the *Treating Racks* section of this paper, you'll be on your own if unapproved chemicals are applied to a battery and damage occurs.

## Summary

This paper covers but a few of many installation related topics. If individual installation tasks are not properly performed, there can be trouble not only at installation, but for maintenance crews long after the installers are gone. In most cases, a troublesome battery installation can be avoided by reading installation instructions and asking questions when clarification is needed. Experienced, seasoned battery installers are certainly a plus. To coin the phrase, an ounce of prevention is truly worth a pound of cure.

## Suggested Additional Reading, Reference, and Recommended Practices

The below documents and others on the Battcon paper archive page may be useful in assisting project managers, technicians, electricians, and other personnel involved in battery installation. Visit the page at http://battcon.com/conference-archive-form.htm.

## IEEE Standards, Guides and Recommended Practices

IEEE documents contain valuable information on installation of stationary batteries. In addition, information can be found regarding selection and sizing. All IEEE Standards are copyrighted. As such, they are available only for purchase. More information about the IEEE, the PES and its mission regarding standards development in the energy storage industry, including stationary batteries, can be found at the IEEE PES Energy Storage and Stationary Battery Committee website at website at http://sites.ieee.org/pes-essb/.