GUIDELINES FOR SUCCESSFUL INSTALLATION OF LARGE LEAD ACID STATIONARY BATTERY SYSTEMS

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ABSTRACT

Stationary battery systems are generally employed in mission critical installations and require special consideration from project conception through final test. Such applications include data processing centers, process control, signaling systems and switch gear, to name but a few. However, installation flaws that go undetected can manifest themselves in a variety of ways long after a battery has been started up, signed off and installation personnel are off site. Post-installation anomalies *can* be avoided. This paper makes recommendations and provides guidelines relating primarily to the handling, installation and bench marking processes for large lead-acid battery systems of the wet and valve regulated varieties. It is hoped that the reader will glean useful information relating to this subject and apply it in a practical manner.

INSPECTION AND STORAGE PRIOR TO INSTALLATION

Inspection

Timely inspection of battery containers and the accessory kit is very important. Cell packaging that exhibits dampness around the bottom of the box is indicative of a cracked cell or loose or missing vent plug. The accessory kit should be checked for quantity and accuracy. The accessory kit contents include, but is not limited to the following;

- Installation & operation manual
- Inter-cell connectors
- Corrosion inhibiting grease
- Flame arrestors & dust covers
- Nut & bolt sets
- Spreader board
- Lifting sling
- Hydrometer
- Thermometer
- Inter-tier/rack cables
- Rack assembly hardware & drawings

Learning of accessory kit shortages halfway through the installation makes it difficult to obtain necessary additional parts in time to complete jobs. Installation drawings are a valuable means of determining the number of parts and identity required. As for damage claims, these are generally handled between the recipient and the shipper. It should be noted here, most shipping companies allow several days to file a claim for damage.

Storage

In the event a battery must be stored for an extended period if time prior to installation, selection of a suitable location should include consideration with two prime concerns in mind. First, the storage temperature should be relatively cool and second, as dry as possible. High storage temperatures cause accelerated internal discharge and cause higher than normal amounts of sulfates to accumulate on plates. Very heavy sulfation can be difficult to remove with normal charging processes once installed.

Lead-Calcium batteries can be safely stored for up to six months from date of shipment at temperatures of 70-80 degrees, F. Lead-Antimony types should be recharged at three month intervals. High humidity storage environments, especially those at condensing levels can contribute to serious accelerated corrosion of terminals. When possible, allow shipping boxes to remain in place to protect the cells and terminals from short circuits.

UNPACKING, STAGING AND TRANSPORT TO INSTALLATION AREA

Unpacking

During the unpacking and examination portion of a battery installation, a full and detailed inspection of containers, covers, seals and terminals should be made. A portion of the packaging materials, such as a skid, box, and packing foam should be saved in case a defective cell needs to be returned to the factory.

Staging

Avoid staging the cells on anything other than a clean, debris-free floor. When possible, leave the cells on the shipping pallets until they are needed in the battery room for installation on the racks. Unfortunately, construction sites are far from a debris-free environment.

Irreparable damage can occur if they are placed on floors where small pieces of mortar, nails and other damaging materials can be caught between the bottom of the container and floor. Due to their weight, a cell inadvertently placed on a nail can present extremely concentrated pressures and easily crack a jar.

Transporting Cells to Installation Area

The ease of getting cells from the staging area to the installation area varies from site to site . There are several concerns installers will be faced with regarding this phase of the project. Failure to thoroughly plan can result in costly mistakes. These include, but are not limited to the following;

- What path will be used from stage point to installation room?
- Does the path contain steps?
- What kind of flooring system with the cells be transported on?
- What type of lift and or transport device is available?
- What type of wheels are employed on this device?
- Does the equipment meet weight specifications?
- Is there a spill kit on site?

The path for cell transport can be direct and trouble free or a long, circuitous one with obstacles along the way. The path should be clear of obstacles to reduce the possibility of a cell upset. If the path includes steps, equipment appropriate for the use should be acquired and used. Protection of floor coverings, including linoleum tiles and carpet should be made. One of the most effective means the author has used is a two part system consisting of plastic sheeting as a base protective layer with one half-inch plywood on top. The plywood can be used when transporting cells over carpeted surfaces. Failure to use a solid buffer between the transport system's wheels and the floor can ruin carpet when traversed repeatedly with four hundred pound cells and thin, hard wheeled carts and trolleys. Carpeting can be quickly ruined. Careful consideration regarding the kind of transportation system to be used should be made well in advance. Because no two jobs will likely be the same, there is no single answer for the type of carrier for the cells. A low center of gravity is a highly desirable feature for this equipment. Regardless of the final selection, the equipment should include the capability for the cell to be secured to it so as not to slide off. Be certain whatever is used is rated for the cells being handled. Finally, commercially available acid spill, containment and clean up kit(s) should be on site during all cell handling operations when wet cells are involved. Two persons should be involved in the safe transport of cells to the installation area.

BATTERY RACKS

Rack Assembly

Battery racks are fabricated steel construction and are well designed to support the load for which they are intended. Most battery manufacturers market rack systems specifically designed for their products. Some fabricate their own in house. Whatever the case, an assembly drawing is usually provided with the racks and provides a parts list as well as assembly instructions. Some provide torque specifications, which should be followed and are usually expressed in foot-pounds. Never loosen load bearing hardware on a loaded rack.

Anchoring Racks to the Floor

Most battery racks provide one or more anchoring holes per frame member to allow racks to be bolted securely to flooring. Racks should be anchored based on the job specification and applicable building codes for the specific type of installation and geographic location. Prior to anchoring, racks should be leveled. Battery manufacturers can provide detailed assembly instructions and can usually found in the installation and operation manual provided with the system.

Loading Cells Onto Racks

Once cells have been transported to the installation area, they will need to be loaded onto the racks. Convention dictates cells be loaded starting on the bottom of any multi-tier rack and centering the first cell on it. Each cell to be set onto the rack is then set alternately to the center cell's left and right. This allows the rack to remain uniformly loaded as weight is added. Loading racks from top to bottom is *not* recommended.

The author has been involved in problem resolution associated with rack support rails that have been treated with greases, oils and other lubricants in order facilitate easier placement of cells onto battery racks. Do not fall into this trap. Battery containers and covers are made of plastics which can react negatively with these substances. It is recommended that before anything is applied to racks, written authorization should be obtained from the battery manufacturer.

CONNECTING CELLS

Contact Surface Preparation

Proper preparation of electrical contact surfaces is a very important phase of a successful installation. Prior to assembly, both the battery terminals and connecting links, also called inter-cell connectors must be properly prepared for final connection to make the series string of cells.

Cell Posts and Inter-Cell Connectors

Cell posts and terminals generally are manufactured in one of two types; 1) All lead and 2) Copper inserted. The distinction is made here because many times, terminals are cleaned with the wrong type of material. Generally, all posts made up of solid lead or lead alloy may be cleaned with a small wire brush or other tool recommended by the manufacturer. However, posts inserted with copper require special attention. The lead plating over the copper insert is generally thin and will be easily removed with the use of a wire brush or similarly abrasive tool. These types of posts are best cleaned with a stiff plastic bristle brush or non-metallic abrasive pad suitable for such tasks. The result of exposing the copper section of the post becomes evident when corrosion begins to form at the critical junction. Electrolyte attacks copper faster than it does lead, hence a system rework will be required sooner than normally necessary.

Inter-cell connectors or "*links*" are copper bus thinly plated with lead. Cleaning these components requires similar care as posts which are copper inserted. The concept here is to remove the thin oxidized layer of lead from these surfaces to minimize corrosion and establish the lowest possible DC resistance. This cleaning process applies to inter-rack and inter-tier cable terminal lugs as well.

Application of Corrosion Inhibitors

After connectors and posts have been properly cleaned, it is necessary to coat contact surfaces with a corrosion inhibiting compound. A corrosion inhibiting compound is supplied with battery systems as part of the accessory kit for the system. One of the most common of these is known as "No-Ox Grease". There are several techniques that may be used to apply it. It is usually heated to a liquid state (approximately 160 F.) to facilitate quick, neat and thorough application to cell posts and inter-cell connectors. Caution should be exercised to avoid overheating the grease. This application technique has been employed by the author for a number of years and it has been observed to work well in slowing the corrosion process. Pitfalls include;

- Insufficient application
- Over application
- No application

Insufficient application does not allow for effectiveness that is needed for the compound. When over-applied, the excess simply has no beneficial effects and creates housekeeping problems that include the attraction of dust and dirt to connectors and posts. The absence the grease altogether subjects the connections to premature corrosion and possible failure under dynamic conditions.

Bolting the Connections Together

By far, batteries employed in UPS service use stainless steel nuts, bolts and washers to hold the connectors tight to the posts. UPS battery systems are constructed with one or two holes per post, generally. Some battery manufacturers supply the nut/bolt packs with a split-type locking washer, which should be placed on the nut-side of the nut/bolt assembly between the nut and flat washer.

When applying flat washers, one battery manufacturer instructs the installer to place the rounded edge of their heavy duty flat-cut washers against the inter-cell connector to eliminate edge cutting of the lead plating on the connector. Hardware may be tightened to a snug fit, but not tight, using an insulated ratchet and socket. Always use insulated tools when working with battery connections. Prior to final tightening, the initial torque specification should be checked in the installation manual for the correct value. Be sure to use the initial value and not the re-torque value, as the two differ. Initial torque specification refers to the value of torque needed for a new or disassembled connection about to be re-connected. The re-torque value is used when connections are checked for maintenance purposes, usually once per year. Final tightening of the bolted connections should be accomplished with a calibrated torque wrench graduated in inch-pounds. Use an insulated box or open end wrench in addition to the torque wrench to provide adequate counter torque. This prevents the nut or bolt from slipping, posts from breaking and post seals from being damaged. This very important on small batteries. Failure to use a torque wrench usually results in over tightened connections and damaged terminals. In many case, cells must be replaced.

VERIFYING CONNECTION INTEGRITY

After all connections have been bolted and tightened to specification, the connection integrity of each and every connection in the battery must be checked and verified to be within recommended limits. This is accomplished with an instrument called a micro-ohmmeter. The instrument is capable of measuring very low DC resistance, values of which are typical for bolted battery connections. Measurement of inter-cell, inter-rack, inter-tier and inter-aisle connection resistance is made and recorded as a bench mark for future reference. This data should be provided to the owner of the battery when all measurements have been completed. Battery performance tests should never be conducted without documented proof that connections meet industry or manufacturer specifications.

FLAME ARRESTORS, CABLES GROUPS, FINAL CONNECTIONS, CELL NUMBERING

Flame Arrestors

When a wet cell battery system is shipped from the factory, shipping caps are fitted into the opening of each cell. This is done to prevent electrolyte from spilling during shipment and handling during installation. A component called a flame arrestor replaces the shipping cap when the battery is under actual service conditions, such as float charging. Proper installation is necessary to prevent electrolyte migration from the seal. The key to a good seal is to verify the vent well is dry around its perimeter and the rubber gasket or o-ring is free of contamination and cuts. Flame arrestors are made of a material which can break easily if dropped or incorrectly handled. The arrestors are fitted with dust covers to keep foreign objects from entering cells. Batteries should not be operated without all flame arrestors in place.

Cable Groups

Most battery system accessory kits include flexible cable sets for connecting cells between tiers and racks. Rarely are cables provided to facilitate inter-connection between aisles. These cables are generally provided by the installation contractor. Many times the wire used is not of the flexible welding type, rather, the wire is very rigid and difficult to bend. This can be a problem at termination points, typically end cells. Large diameter wires that have limited flexibility must be correctly pre-bent to prevent stressing of the cell post. Unless this is done, tension on the wire will cause the post to be pulled or pushed, causing post seal damage and possible breakage of the post to strap welds under the cell cover. There should never be any stress on connection points.

Final Connections

At some point during the installation of the battery final connections must be made. The author has observed a number of methods used to accomplish this in a safe manner. Before final connections are made, for a 180 cell battery, for example, a safety ground check is recommended. This is accomplished by measuring for DC potential from battery system positive (cell 1) to ground, then from battery system negative (cell 180) to ground. No voltage should be measured from these two points to ground. If voltage is observed, locate its source, identify and correct it before making the final connection.

Cell Numbering

Battery manufacturers provide a cell numbering kit as a standard accessory. The kits consist of numbers printed on pressure sensitive plastic or paper for application to the cells. Their use greatly reduces confusion and speeds the process of identifying cells during maintenance inspections. The numbering convention basically states that cell number one (1) be identified as the most positive (+) in the string with respect to the main terminals. Cell numbers should then be placed on each in the series sequence following battery system wiring through to the end cell, which is the most negative (-) in the string.

Battery cells are configured in one of several packaging methods. Single two volt jars as well as two, three and four cell "monoblocs" make up these packaging styles. This helps to reduce footprint requirements and reduces labor required to set cells onto racks. The author has observed a number of errors regarding cell numbering techniques with multi-cell jar systems. Keeping in mind that multi-cell jars contain more than one cell, a number should be placed on each cell as opposed to each jar. It is fairly common to see a 180 cell, 4 cell monbloc system numbered from 1-45, contrary to accepted numbering convention. Rather, each *cell* should have its own number applied.

CLEANING BATTERIES

Upon completion of the installation, a cleanup of the system prior to placement into final service is recommended. This generally includes removal of dust accumulation on cell covers, racks and jars. Caution must be exercised when cleaning with regard to the cleaning agents. Battery manufacturers do not usually recommend the use of anything other than a clear water and baking soda solution to clean cells. Use of cleaners containing soaps, abrasive cleansers, ammonia, chlorine, degreasers, etc. can ruin plastic jar and covers. To a greater extent, damage can result in cracked and crazed jars, which could cause bleeding of electrolyte through the jar walls.

SUMMARY

Installing stationary batteries is a specialized form of electrical work. Persons involved in such work should be properly trained and aware of the unique nature of storage batteries. Manufacturer installation and operating manuals should be thoroughly reviewed and maintained at the installation site for ready reference. When questions arise, contact the battery manufacturer or the authorized local sales and service operation for assistance. Batteries are electrochemical-chemical devices and as such should be treated with great respect and care at all times. Failure to heed safety warnings and precautions can and has resulted in serious equipment damage and personnel injury.

THINK SAFETY - WORK SAFELY - STAY ALIVE

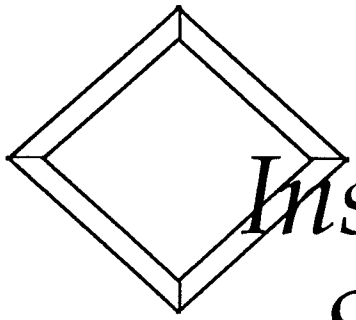
Bibliography

IEEE Standard 484-1996, "*IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*"

IEEE Standard 450-1995, *"IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications"*

IEEE Standard 1187-1996, *"IEEE Recommended Practice for Installation Design and Installation of Valve Regulated Lead-Acid Batteries for Stationary Applications"*

IEEE Standard 1188-1996, *"IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve Regulated Lead-Acid Batteries for Stationary Applications"*



Guidelines for Successful Installation of Large Lead-Acid Stationary Battery Systems

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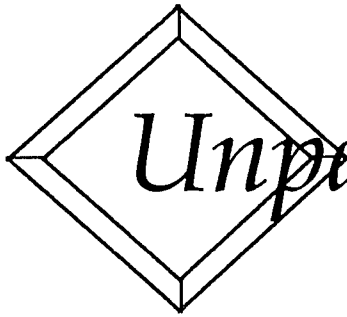
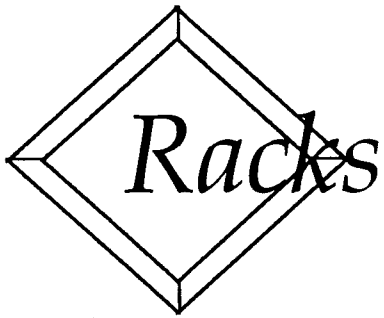
Receipt, Inspection and Storage

- Cells
  - Damage?
  - Leaking?
- Accessory Kit
  - All Parts Accounted For?
- Cool, Dry, Out of The Way



Unpacking, Staging & Transport

- Detailed Inspection of Cells
- Leave on Pallets Until Ready
  - If Not, Floor Must Be Free of Debris
- Path Clear of Obstructions?
- Use the Right Cart For The Job
- Secure Cells During Transport
- Keep Spill Kits Close at Hand



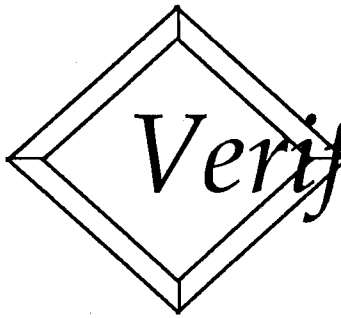
- Refer to Supplied Drawings
- Use Torque Specifications When Instructed
- Anchor Racks Per Battery Manufacturer and Building Codes
- Load Cells Starting at Center Rail of Bottom Tier

Racks - Lubricants

- Get Written Authorization From Battery Manufacturer for Approved List
- Some Compounds *Will* Destroy Jar/Cover Plastics

Making Cell Connections

- Contact Surface Preparation is Critical
  Copper or Solid Lead Posts?
  - Use The Correct Cleaning Tools
- Clean Posts and Connectors Properly
  - No Wire Wheels on Drills, Please...
- Coat With Compound Supplied
- Tighten to Initial Torque Specification
  - Use an Inch/Pound Torque Wrench



Verifying Connection Integrity

- Critical For Verifying Connection Are the Best They Can Be
- Micro-Ohmmeter Use is Standard of The Industry
- IEEE 450-1995 Provides Details

Flame Arrestors

- Install *After* All Connections Are Tight
- Seal Surfaces Must be Clean and Dry
- Break Easily if Mishandled
- Don't Throw Dust Caps Away
- Must be in Place When Battery is Charging

Cable Groups

- Use Caution and Care When Terminating Heavy Wiring to Terminal Plates
  - Avoid Stressing Posts
- Pre-Bend Wire Before Terminating

Final Connection

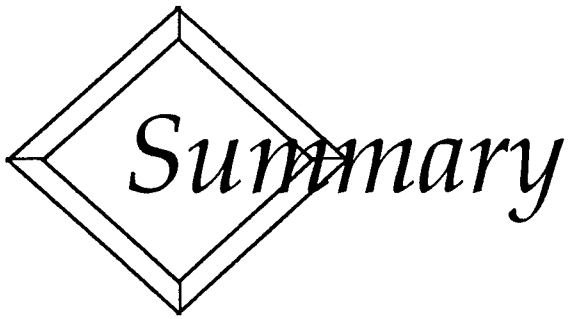
- Make a Safety Check Before Terminating the Final Connections
  - + To Ground = 0 Volts
  - - To Ground = 0 Volts
- If Voltage is Detected, Identify the Source and Correct
-

Cell Numbering Convention

- Number Each *Cell*
- Start at Battery Positive
- Follow Series Circuit Through to Negative
- Place Numbers Where Cell Inspection Will Not be Obscured

Cleaning Batteries

- Clean Off-Line
- Gloves, Goggles, Apron
- Baking Soda & Water Solution *Only*
- No Cleaners, Soaps, Ammonia, Chlorine
- Cracks, Crazing & Leaking May Result
- Voids Warranty



Summary

- Stationary Batteries are Specialized Equipment
- Personnel Must Be Properly Trained
- Observe All Safety Rules
- Use The Installation Manuals
- Questions?
  - Call The Battery Manufacturer