SECTIONALIZING BATTERIES FOR IMPROVED SERVICEABILITY

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Batteries of more than 250 volts are identified by the National Electrical Code as requiring special installation considerations. There has not been a consistent interpretation of these requirements by inspectors, consultants, electricians or owners. Understanding what the NEC says and doesn't say will help in choosing the best solution for each battery installation.

NATIONAL ELECTRICAL CODE REQUIREMENTS

Requirements for storage batteries are defined in Article 480.

Definition of Battery Voltage

480-2 states that lead-acid battery voltage should be computed at 2 volts per cell and alkali battery voltage is computed at 1.2 volts per cell. Based on this a 250 volt lead acid is 125 cells.

Overcurrent Protection

One change in the 2002 National Electrical Code is a new requirement for overcurrent protection of battery systems.

"480.3 Wiring and Equipment Supplied from Batteries.
Wiring and equipment supplied from storage batteries shall be subject to the requirements of this Code applying to wiring and equipment operating at the same voltage….."

Insulation of Batteries of Over 250 Volts

"480.7 Insulation of Batteries of Over 250 Volts.
The provisions of 480.6 shall apply to storage batteries having the cells connected so as to operate at a nominal voltage exceeding 250 volts, and, in addition, the provisions of this section shall also apply to such batteries. Cells shall be installed in groups having a total nominal voltage of not over 250 volts. Insulation, which can be air, shall be provided between groups and shall have a minimum separation between live battery parts of opposite polarity of 50 mm (2 in.) for battery voltages not exceeding 600 volts."

Since the NEC now requires an overcurrent protective device at the battery sectionalizing the battery with this device can improve safety during battery servicing.
Note that the NEC requirements for overcurrent protection relate to protecting the conductors between the battery and the load not to protecting the battery from damage due to faults. IEEE Std 1375-1998 provides guidance for protecting stationary battery systems.

SECTIONALIZING THE BATTERY

Perhaps the NEC requirements seem clear but in the details hide a number of questions.

"Cells shall be installed in groups having a total nominal voltage of not over 250 volts."

The term group is difficult to define. The code indicates that a group must be limited to 250 volts but when a higher voltage battery is needed groups must somehow be connected together. Therefore a group must be a physical description.

"Insulation, which can be air, shall be provided between groups…."

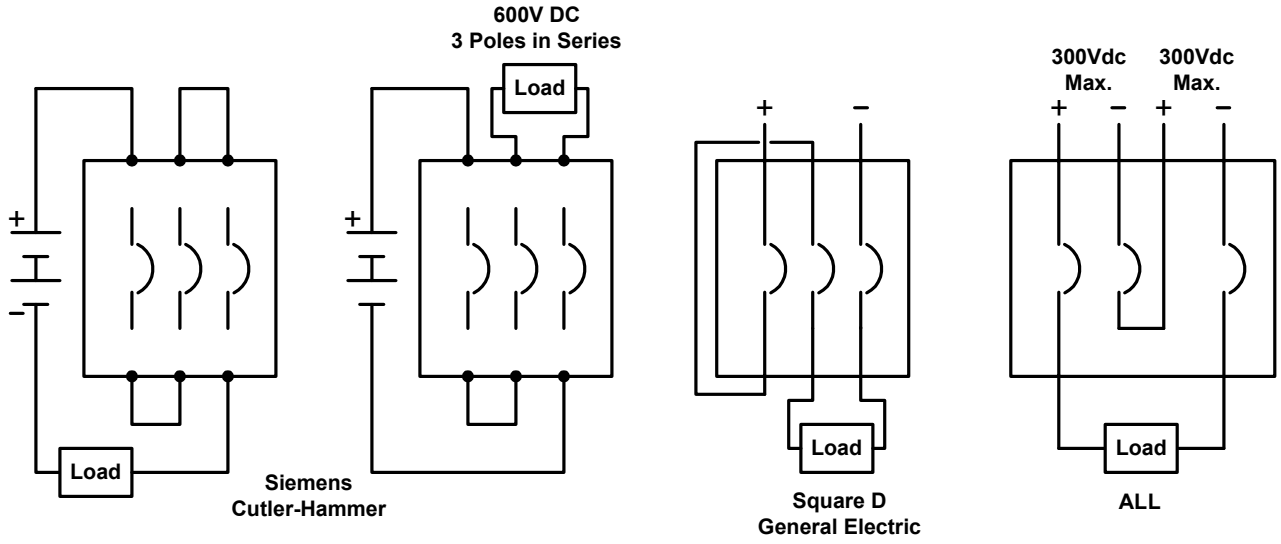
Therefore, two of the interpretations that can be made are:
1. Battery cells in insulated jars inherently meet the grouping requirement as long as terminals are at least two inches from a terminal of opposite polarity.
2. A group is created by interrupting the battery series connection.

The difficulty with accepting interpretation one is that it really does not require anything other than spacing between terminals where connected to building wiring. The difficulty with accepting interpretation two is it disallows any operating battery of more than 250 volts.

Perhaps the intent of this requirement can be determined by noticing that article 480.6 is for a battery of not greater than 250 volts. What is it about a higher voltage battery that is different than the 250V battery? The answer, I believe, is voltage exposure during installation and off line servicing. Sectionalizing by breaking the battery into lower voltage groups seems to be a reasonable interpretation of this requirement.

Grounded versus Ungrounded Batteries

Most batteries with a voltage greater than 250V are not intentionally grounded at the battery. Note however that any line rectifier charger that is not isolated by a transformer from the grounded AC source is ground referenced and the first ground fault at the battery is an AC ground fault. One of the reasons that batteries require servicing is to prevent a ground fault through jar surface contamination. Every battery should be considered grounded by the person servicing it and expect that ground to be at the point that will result in the greatest hazard.
Another issue with grounded batteries is the proper choice of the overcurrent device. A molded case circuit breaker is commonly used for this purpose. Molded case circuit breakers rated 500VDC are usually marked "Suitable only for use on UPS." These breakers are only listed for use with ungrounded batteries. The UL listing of molded case circuit breakers requires that the breaker be connected as follows.



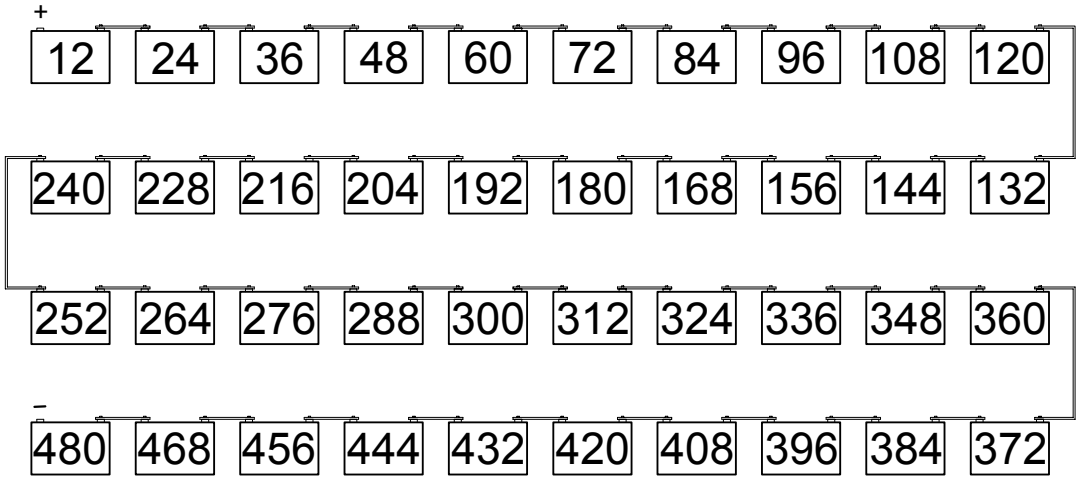
If a grounded battery of over 250VDC is used then a UL listed bolted pressure switch may be used.

EXAMPLES OF SECTIONALIZED BATTERIES

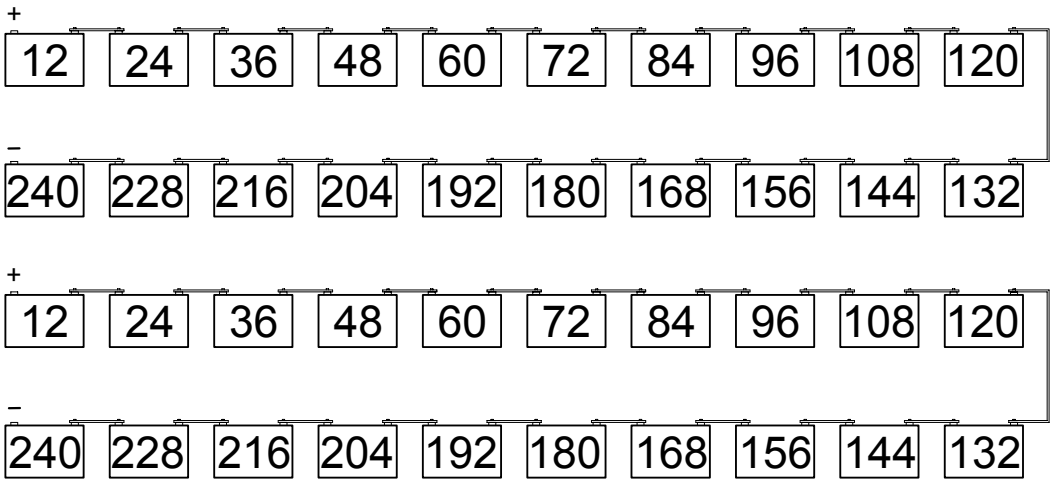
Reducing the voltage hazard with the battery disconnected can be done the following ways.

480 volt 240 cell lead-acid battery consisting of forty 6 cell jars

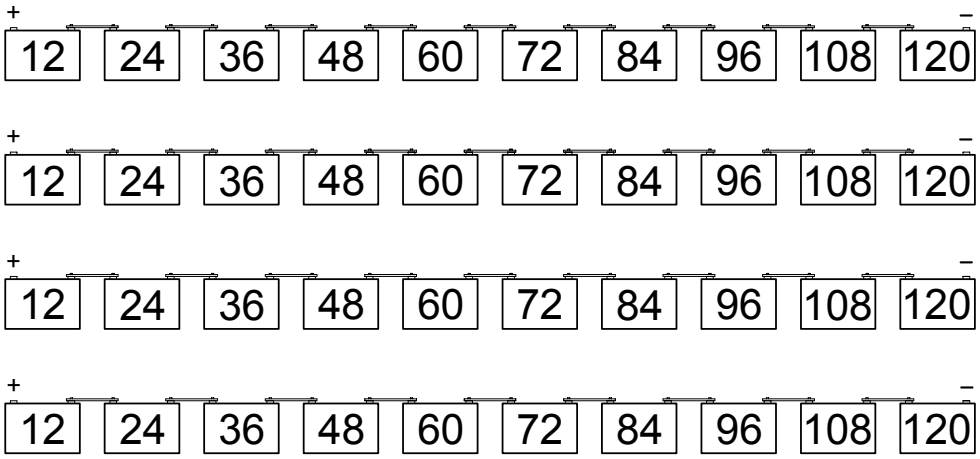
Article 480.7 requires that the positive connection terminal and the negative connection terminal must be at least 2 inches apart.



If during servicing we interrupt the connection between jars twenty and twenty-one then the voltage is halved.



If we also interrupt the connections between jars ten and eleven and thirty and thirty-one then the voltage is halved again.

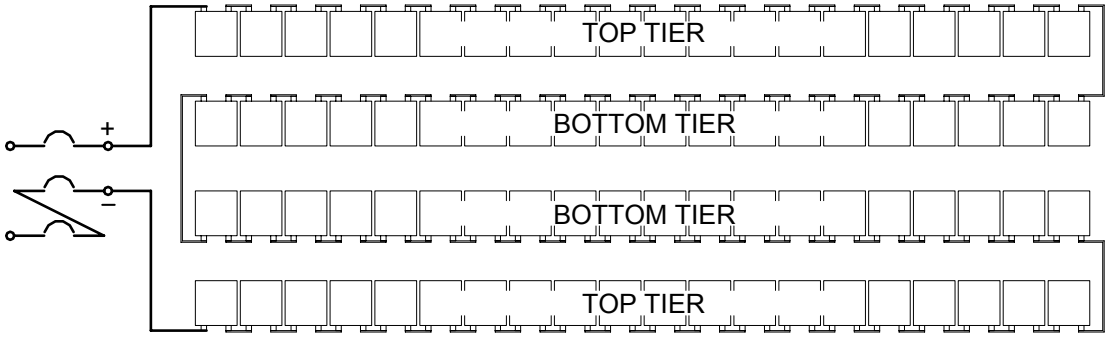


USING THE OVERCURRENT DEVICE TO SECTIONALIZE A BATTERY

Use of a three pole overcurrent device is a convenient way to sectionalize the battery into two groups. The battery can be split into smaller groups by interrupting the series connection at additional points.

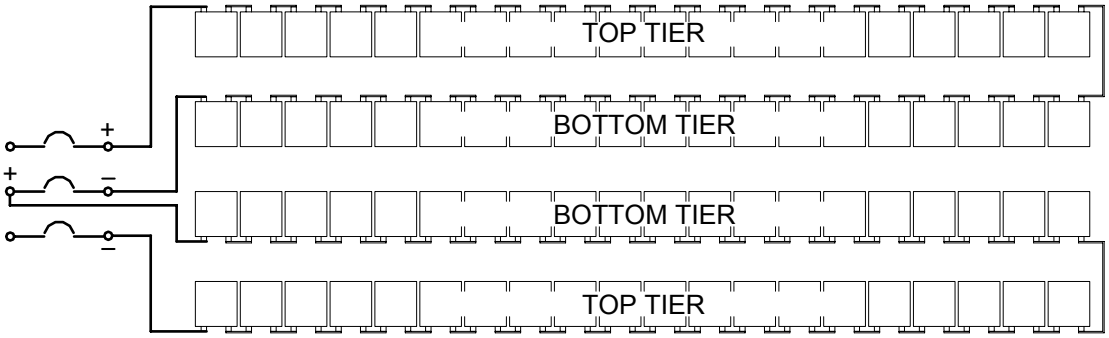
Current Usual Practice without Sectionalizing the Battery

The battery in this example is not sectionalized but is acceptable in most jurisdictions.



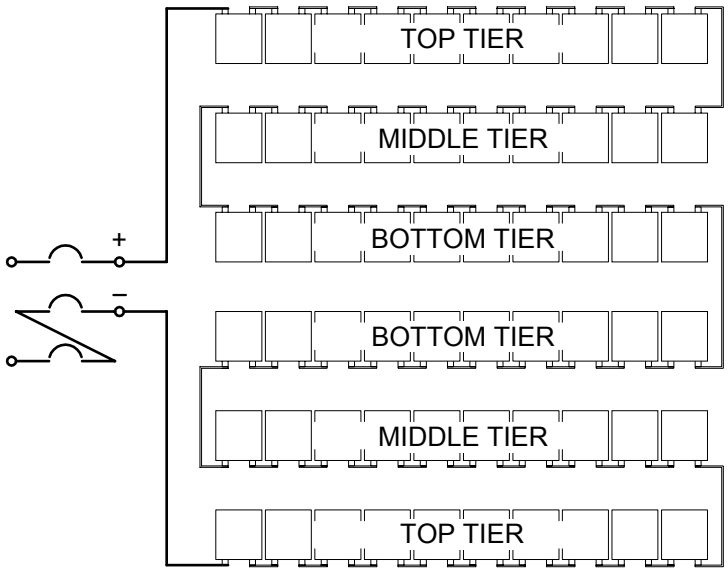
Sectionalizing the Battery by Using a Three Pole Device

With this arrangement when the battery overcurrent device is installed at the end of back to back two tier racks little additional cabling is required.



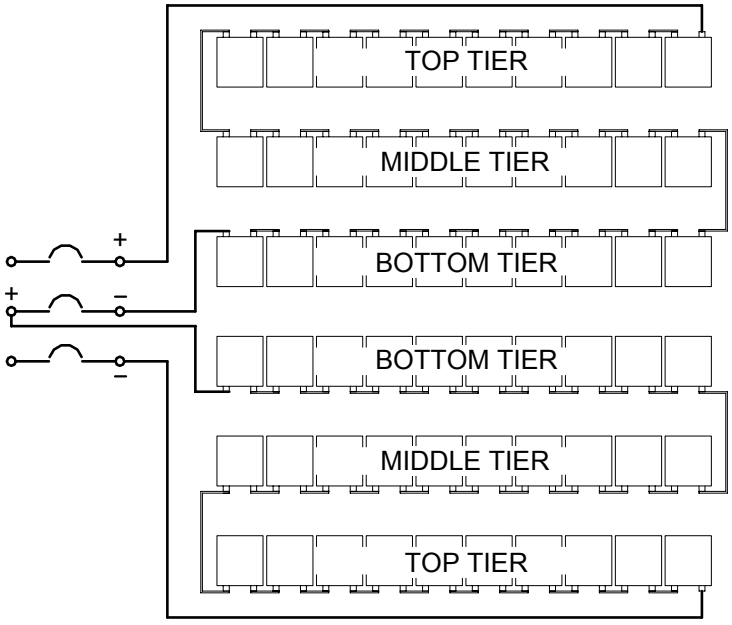
Current Usual Practice for Three Tier Rack Installation without Sectionalizing the Battery

The battery in this example of a three tier arrangement that is not sectionalized.



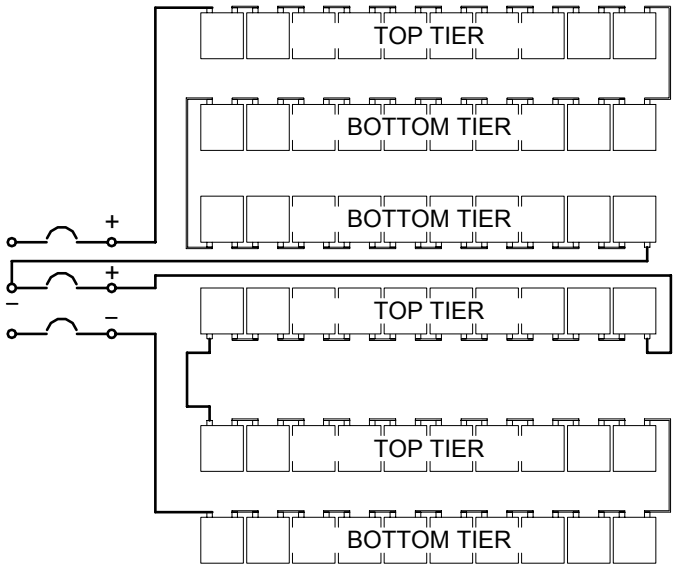
Sectionalizing the Battery on Three Tier Racks by Using a Three Pole Device

With this arrangement when the battery overcurrent device is installed at the end of back to back three tier racks significant additional cabling is required.



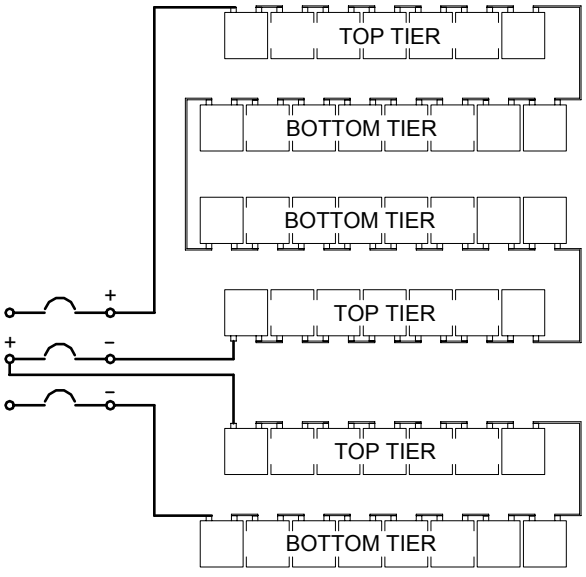
Sectionalizing the Battery on Three Two Tier Racks by Using a Three Pole Device

With this arrangement when the battery overcurrent device is installed at the end of back to back two tier racks with a third two tier rack across the aisle.



Sectionalizing a Lower voltage Battery on Three Two Tier Racks by Using a Three Pole Device

In this case a 360 volt battery is sectionalized for 240 volts and 120 volts.



SELECTING AN OVERCURRENT DEVICE FOR SECTIONALIZING A BATTERY

Proper selection of an overcurrent device must deal with voltage rating, current rating, system time constant and trip characteristics. The NEC deals with the minimum requirements for sizing conductors and overcurrent devices to protect the conductors but not for protecting the battery. IEEE Std 1375 deals with more of the system level issues associated with the DC power system.

Overcurrent Device Voltage Rating

The requirements for a listing of overcurrent device voltage rating are defined in UL standard 489 for molded case circuit breakers, standard 98 for 400 – 1200A switches and standard 977 for 800 – 4000A switches.

Circuit breakers are designed and labeled either for general DC operation or as "Suitable only for use on UPS". Molded case circuit breakers for 500VDC will probably be labeled for UPS use which means ungrounded applications.

Circuit Current Rating

NEC Article 215.3 requires that feeder circuits be sized for 125% of the continuous load plus 100% of the non-continuous (less than 3 hours) load. It is commonly accepted that circuit sizing for battery discharge of less than 3 hours is based on the non-continuous requirements. UPS unit maximum battery discharge current should be the value used to pick the minimum size cable and overcurrent device trip rating.

Trip Characteristics

Don't expect to protect the battery unless trip curves for circuit breakers and/or fuses are compared with the battery short circuit characteristics. Battery system characteristics are not as widely understood as AC system characteristics so this capability needs to be developed if battery damage becomes an issue.

TRICKS FOR SECTIONALIZING A BATTERY

Making it Easier

There are some tricks that make sectionalizing easier

1. Use an even number of racks.
2. Layout battery on a per tier basis and pick building cable connection points to minimize raceway and cable interference problems.
3. Minimize cabling to minimize voltage drop.
4. Overcurrent device must not have more than twenty five feet between overcurrent device (except center pole) and battery terminals.
5. Building cables will connect to jars on the bottom tier. Use longer racks or offset batteries to have room for cable connection.
6. Plan ahead and review battery drawings.

WARNING

Never trust a disconnect unless you can see that the contacts are open. Check it first!