Exception: Other conductor insulations shall be permitted for the motor starting service.

Part III. Over 1000 Volts, Nominal

470.20 General.

(A) Protected Against Physical Damage. Resistors and reactors shall be protected against physical damage.

(B) Isolated by Enclosure or Elevation. Resistors and reactors shall be isolated by enclosure or elevation to protect personnel from accidental contact with energized parts.

(C) Combustible Materials. Resistors and reactors shall not be installed in close enough proximity to combustible materials to constitute a fire hazard and shall have a clearance of not less than 305 mm (12 in.) from combustible materials.

(D) Clearances. Clearances from resistors and reactors to grounded surfaces shall be adequate for the voltage involved.

(E) Temperature Rise from Induced Circulating Currents. Metallic enclosures of reactors and adjacent metal parts shall be installed so that the temperature rise from induced circulating currents is not hazardous to personnel or does not constitute a fire hazard.

470.21 Grounding. Resistor and reactor cases or enclosures shall be connected to the equipment grounding conductor.

Exception: Resistor or reactor cases or enclosures supported on a structure designed to operate at other than ground potential shall not be connected to the equipment grounding conductor.

470.22 Oil-Filled Reactors. Installation of oil-filled reactors, in addition to the above requirements, shall comply with applicable requirements of Part II and Part III of Article 450.

ARTICLE 480 Stationary Standby Batteries

Δ **480.1 Scope.** This article applies to all installations of stationary standby batteries having a capacity greater than 3.6 MJ (1 kWh).

Informational Note No. 1: See Article 706 for installations that do not meet the definition of stationary standby batteries.

Informational Note No. 2: The following standards are frequently referenced for the installation of stationary batteries:

(1) IEEE 484, *Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*
(2) IEEE 485, *Recommended Practice for Sizing Vented Lead-Acid Storage Batteries for Stationary Applications*
(3) IEEE 1145, *Recommended Practice for Installation and Maintenance of Nickel-Cadmium Batteries for Photovoltaic (PV) Systems*
(4) IEEE 1187, *IEEE Recommended Practice for Installation Design, and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications*
(5) IEEE 1375, *IEEE Guide for the Protection of Stationary Battery Systems*
(6) IEEE 1578, *Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management*
(7) IEEE 1635/ASHRAE 21, *Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications*
(8) UL 1973, *Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications*
(9) UL Subject 2436, *Outline of Investigation for Spill Containment for Stationary Lead Acid Battery Systems*
(10) UL 1989, *Standard for Standby Batteries*
(11) UL Subject 1974, *Standard for Evaluation of Repurposed Batteries*
(12) NFPA 855-2020, *Standard for the Installation of Stationary Energy Storage Systems*

The most common types of storage cells are the lead-acid type, the alkali (nickel-cadmium) type, and the lithium-ion type. A lead-acid cell consists of a positive plate, usually lead peroxide (a semisolid compound) mounted on a framework or grid for support, and a negative plate, made of sponge lead mounted on a grid. Grids generally are made of a lead alloy, such as lead calcium, lead antimony, or lead selenium. The electrolyte is sulfuric acid and distilled water. Lithium-ion batteries, which are used in a variety of consumer electronics products, use a variety of different chemistries. They are increasingly being used in large-scale applications because they have a very high energy density.

Lead-acid cells can be of the vented or sealed (valve-regulated) type. Under normal charging conditions, the vented type will liberate gases — hydrogen at the negative plate and oxygen at the positive plate. The valve-regulated type provides a means to recombine the gases, thus minimizing emissions from the cell.

In the alkali, or nickel-cadmium, battery, the principal active material in the positive plate is nickelous hydroxide; in the negative plate, it is cadmium hydroxide. The electrolyte is potassium hydroxide (an alkali).

In stationary installations, nickel-cadmium cells generally are of the vented type and liberate hydrogen and oxygen during normal charging. Hermetically sealed nickel-cadmium cells are sometimes used, but they require special charging equipment to prevent gas emissions.

Although some of the newer-technology batteries do not ventilate hydrogen under normal operation, they can generate hydrogen during fault conditions.

See also

Article 706 for energy storage systems

480.3 Equipment. Storage batteries and battery management equipment shall be listed. This requirement shall not apply to lead-acid batteries.

As energy demands increase, many stationary battery types will be introduced into the electrical infrastructure. Standards exist for stationary batteries to support a practical and reasonable implementation of these technologies within the electrical infrastructure. This requirement does not require listing of battery systems in Article 480 — it only addresses listing of the batteries themselves, other than the lead-acid type, and battery management equipment (such as charge controllers).

480.4 Battery and Cell Terminations.

Δ **(A) Corrosion Prevention.** Where mating dissimilar metals, antioxidant material suitable for the battery connection shall be used where recommended by the battery manufacturer's installation and instruction manual.

(B) Intercell and Intertier Conductors and Connections. The ampacity of field-assembled intercell and intertier connectors and conductors shall be of such cross-sectional area that the temperature rise under maximum load conditions and at maximum ambient temperature shall not exceed the safe operating temperature of the conductor insulation or of the material of the conductor supports.

Informational Note: Conductors sized to prevent a voltage drop exceeding 3 percent of maximum anticipated load, and where the maximum total voltage drop to the furthest point of connection does not exceed 5 percent, may not be appropriate for all battery applications. IEEE 1375-2003, *Guide for the Protection of Stationary Battery Systems,* provides guidance for overcurrent protection and associated cable sizing.

(C) Battery Terminals. Electrical connections to the battery, and the cable(s) between cells on separate levels or racks, shall not put mechanical strain on the battery terminals. Terminal plates shall be used where practicable.

Informational Note: Conductors are commonly pre-formed to eliminate stress on battery terminations. Fine stranded cables may also eliminate the stress on battery terminations. See the manufacturer's instructions for guidance.

(D) Accessibility. The terminals of all cells or multicell units shall be readily accessible for readings, inspections, and cleaning where required by the equipment design. One side of transparent battery containers shall be readily accessible for inspection of the internal components.

480.5 Wiring and Equipment Supplied from Batteries. Wiring and equipment supplied from storage batteries shall be subject to the applicable provisions of this *Code* applying to wiring and equipment operating at the same voltage, unless otherwise permitted by 480.6.

480.6 Overcurrent Protection for Prime Movers. Overcurrent protection shall not be required for conductors from a battery with a voltage of 60 volts dc or less if the battery provides power for starting, ignition, or control of prime movers. Section 300.3 shall not apply to these conductors.

The requirement to use Chapter 3 wiring methods is not applicable to battery-powered single conductors used to perform certain operational functions associated with a prime mover, such as for starting a stationary combustion engine that drives an electric generator. For example, if it is necessary to extend the conductors from the battery to the prime mover starting solenoid at a generator location, battery-powered conductors would not be required to have overcurrent protection and could be run as open, single conductors.

480.7 DC Disconnect Methods.

Δ **(A) Disconnecting Means.** A disconnecting means shall be provided for all ungrounded conductors derived from a stationary standby battery with a voltage over 60 volts dc. A disconnecting means shall be readily accessible and located within sight of the stationary standby battery.

Informational Note: See 240.21(H) for information on the location of the overcurrent device for battery conductors.

Battery systems need maintenance to remain functional. In some cases, such as in 700.3(C), the *NEC*® requires battery system maintenance. For maintenance to be performed safely on a stationary battery system, a readily accessible disconnect means located within sight of the battery system is required. It should be noted that the disconnecting means only isolates the batteries from the equipment and loads being supplied by the battery system. Similar to disconnecting means requirements in Article 690 for photovoltaic electric systems, it is recognized that the batteries, like the photovoltaic modules, cannot be shut down or de-energized. However, having a disconnecting means within sight of the power source minimizes the amount of line-side conductor that remains energized after the disconnecting means is turned off or put into the open position.

See also

240.21(H), which addresses the location of overcurrent protection devices for battery conductors

Δ **(B) Emergency Disconnect.** For one-family and two-family dwellings, a disconnecting means or its remote control for a stationary standby battery shall be located at a readily accessible location outside the building for emergency use. The disconnect shall be labeled as follows:

EMERGENCY DISCONNECT

This requirement applies only to the battery systems covered under the scope of Article 480 that are installed as a primary or standby power source at one- and two-family dwellings. If a battery-type energy storage system (ESS) is installed as a power source for a one- or two-family dwelling, the requirements of Article 706 apply to the installation.

See also

706.15 for the requirements on ESS disconnecting means at one- and two-family dwellings

(C) Disconnection of Series Battery Circuits. Battery circuits exceeding 240 volts dc nominal between conductors or to ground and subject to field servicing shall have provisions to disconnect the series-connected strings into segments not exceeding 240 volts dc nominal for maintenance by qualified persons. Non-load-break bolted or plug-in disconnects shall be permitted.

(D) Remote Actuation. Where a disconnecting means, located in accordance with 480.7(A), is provided with remote controls to activate the disconnecting means and the controls for the disconnecting means are not located within sight of the stationary standby battery, the disconnecting means shall be capable of being locked in the open position, in accordance with 110.25, and the location of the controls shall be field marked on the disconnecting means.

(E) Busway. Where a dc busway system is installed, the disconnecting means shall be permitted to be incorporated into the busway.

(F) Notification. The disconnecting means shall be legibly marked in the field. A label with the marking shall be placed in a conspicuous location near the battery if a disconnecting means is not provided. The marking shall be of sufficient durability to withstand the environment involved and shall include the following:

(1) Nominal battery voltage
(2) Available fault current derived from the stationary standby battery

Informational Note No. 1: Battery equipment suppliers can provide information about available fault current on specific battery models.

(3) An arc flash label in accordance with acceptable industry practice

Informational Note No. 2: See NFPA *70E*-2021, *Standard for Electrical Safety in the Workplace*, for assistance in determining the severity of potential exposure, planning safe work practices, arc flash labeling, and selecting personal protective equipment.

(4) Date the calculation was performed

Exception: List items (2), (3), and (4) shall not apply to one- and two-family dwellings.

(G) Identification of Power Sources. Stationary standby batteries shall be indicated by 480.7(G)(1) and (G)(2).

Δ **(1) Facilities with Utility Services and Stationary Standby Batteries.** Plaques or directories shall be installed in accordance with 705.10.

Exception: This requirement does not apply where a disconnect in 480.7(A) is not required.

(2) Facilities with Stand-Alone Systems. A permanent plaque or directory shall be installed in accordance with 710.10.

480.8 Insulation of Batteries. Batteries constructed of an electrically conductive container shall have insulating support if a voltage is present between the container and ground.

480.9 Battery Support Systems. For battery chemistries with corrosive electrolyte, the structure that supports the battery shall be resistant to deteriorating action by the electrolyte. Metallic structures shall be provided with nonconducting support members for the cells, or shall be constructed with a continuous insulating material. Paint alone shall not be considered as an insulating material.

480.10 Battery Locations. Battery locations shall conform to 480.10(A) through (G).

Batteries should be located in clean, dry rooms and be arranged to provide sufficient work space for inspection and maintenance. The voltage of the battery system, rather than the voltage of the individual batteries or cells, is to be used in determining the work space requirements in 110.26 for systems rated 1000 volts and less and 110.34 for systems rated over 1000 volts. Adequate ventilation is necessary to prevent an accumulation of an explosive mixture of the gases from batteries that generate hydrogen.

The fumes given off by some storage batteries are very corrosive; therefore, wiring and its insulation must be of a type that withstands corrosion, as required by 110.11 and 310.10(F). Special precautions are necessary to ensure that all metalwork (such as metal raceways and metal racks) is designed or treated to be corrosion resistant. The battery racks shown in Exhibit 480.1 are coated with a nonmetallic outer covering as required by 480.9. The covering insulates and provides protection against the corrosive action of fumes from batteries being charged and any

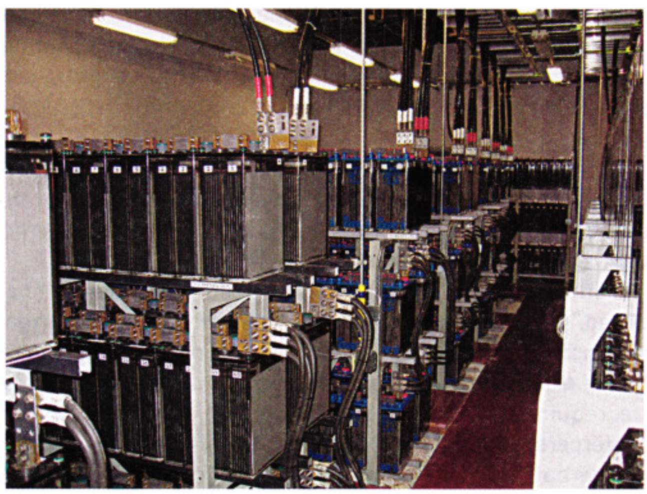

EXHIBIT 480.1 A battery room with batteries installed on corrosion-resistant racks. *(Courtesy of the International Association of Electrical Inspectors)*

electrolyte that might escape from the cells. Manufacturers sometimes suggest that aluminum or plastic conduit be used to withstand corrosive battery fumes or, if steel conduit is used, that it be zinc coated and corrosion protected with a coating of an asphaltum-type (asphalt-based) paint.

See also

300.6 for more on protection against corrosion and deterioration

Overcharging heats a battery and causes gassing and loss of water. A battery should not be allowed to reach temperatures over 110°F, because heat causes a shedding of active materials from the plates, which will eventually form a sediment buildup in the bottom of the case and short circuit the plates and the cell. Because mixtures of oxygen and hydrogen are highly explosive, flame or sparks should never be allowed near a cell, especially if the filler cap is removed.

(A) Ventilation. Provisions appropriate to the battery technology shall be made for sufficient diffusion and ventilation of gases from the battery, if present, to prevent the accumulation of an explosive mixture.

Informational Note No. 1: See NFPA 1-2021, *Fire Code*, Chapter 52, for ventilation considerations for specific battery chemistries.

Informational Note No. 2: Some battery technologies do not require ventilation.

Informational Note No. 3: See IEEE Std 1635-2012/ASHRAE Guideline 21-2012, *Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications*, for additional information on the ventilation of stationary battery systems.

Ventilation is necessary to prevent classification of a battery location as a hazardous (classified) location, in accordance with Article 500.

Mechanical ventilation is not mandated. Hydrogen disperses rapidly and requires little air movement to prevent accumulation. Unrestricted natural air movement in the vicinity of the battery, together with normal air changes for occupied spaces or heat removal, normally is sufficient. If the space is confined, mechanical ventilation might be required in the vicinity of the battery.

Hydrogen is lighter than air and tends to concentrate at ceiling level, so some form of ventilation should be provided at the upper portion of the structure. Ventilation can be a fan, a roof ridge vent, or a louvered area.

Although valve-regulated batteries often are referred to as "sealed," they actually emit very small quantities of hydrogen gas under normal operation and are capable of liberating large quantities of explosive gases if overcharged. These batteries, therefore, require the same amount of ventilation as their vented counterparts. Of the primary types of battery chemistries used in storage battery systems and energy storage systems, only lithium-ion and sodium-nickel chloride batteries do not require ventilation under normal or abnormal charging conditions.

(B) Live Parts. Guarding of live parts shall comply with 110.27.

(C) Spaces About Stationary Standby Batteries. Spaces about stationary standby batteries shall comply with 110.26 and 110.34. Working space shall be measured from the edge of the battery cabinet, racks, or trays.

For battery racks, there shall be a minimum clearance of 25 mm (1 in.) between a cell container and any wall or structure on the side not requiring access for maintenance. Battery stands shall be permitted to contact adjacent walls or structures, provided that the battery shelf has a free air space for not less than 90 percent of its length.

Informational Note: Additional space is often needed to accommodate battery hoisting equipment, tray removal, or spill containment.

(D) Top Terminal Batteries. Where top terminal batteries are installed on tiered racks or on shelves of battery cabinets, working space in accordance with the battery manufacturer's instructions shall be provided between the highest point on a cell and the row, shelf, or ceiling above that point.

Informational Note: See IEEE 1187-2013, *IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications*, for guidance for top clearance of valve-regulated lead-acid batteries, which are commonly used in battery cabinets.

(E) Egress. Personnel doors intended for entrance to, and egress from, rooms designated as battery rooms shall open at least 90 degrees in the direction of egress and shall be equipped with listed panic or listed fire exit hardware.

(F) Piping in Battery Rooms. Gas piping shall not be permitted in dedicated battery rooms.

Δ **(G) Illumination.** Illumination shall be provided for working spaces containing stationary standby batteries. The lighting outlets shall not be controlled by automatic means only. Additional lighting outlets shall not be required where the work space is illuminated by an adjacent light source. The location of luminaires shall not result in the following:

(1) Expose personnel to energized battery components while performing maintenance on the luminaires in the battery space
(2) Create a hazard to the battery upon failure of the luminaire

480.11 Vents.

(A) Vented Cells. Each vented cell shall be equipped with a flame arrester.

Informational Note: A flame arrester prevents destruction of the cell due to ignition of gases within the cell by an external spark or flame.

(B) Sealed Cells. Where the battery is constructed such that an excessive accumulation of pressure could occur within the cell during operation, a pressure-release vent shall be provided.