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