

(B) Diffraction and Irradiation Types. Diffraction- and irradiation-type equipment or installations not effectively enclosed or not provided with interlocks to prevent access to uninsulated live parts during operation shall be provided with a positive means to indicate when they are energized. The indicator shall be a pilot light, readable meter deflection, or equivalent means.

660.24 Independent Control. Where more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by persons with its live parts.

Part III. Transformers and Capacitors

660.35 General. Transformers and capacitors that are part of an X-ray equipment shall not be required to comply with Articles 450 and 460.

High-ratio step-up transformers that are an integral part of X-ray equipment are not required to comply with Article 450 and are generally used to provide the high voltage necessary for X-ray tubes. Because the fire hazard is lower due to the low primary voltage, X-ray transformers are not required to be installed in fire-resistant vaults.

660.36 Capacitors. Capacitors shall be mounted within enclosures of insulating material or grounded metal.

Part IV. Guarding and Grounding

660.47 General.

(A) High-Voltage Parts. All high-voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Air, oil, gas, or other suitable insulating media shall be used to insulate the high voltage from the grounded enclosure. The connection from the high-voltage equipment to X-ray tubes and other high-voltage components shall be made with high-voltage shielded cables.

(B) Low-Voltage Cables. Low-voltage cables connecting to oil-filled units that are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the oil-resistant type.

Δ 660.48 Grounding. Battery-operated X-ray equipment shall not be required to comply with the grounding requirements of this Code.

According to 90.3, the general requirements of Chapter 2 apply to all electrical installations. Therefore, Part I of Article 250, specifically 250.4(A)(2) and (3), would apply to the grounding of X-ray equipment.

ARTICLE 665

Induction and Dielectric Heating Equipment

Part I. General

665.1 Scope. This article covers the construction and installation of dielectric heating, induction heating, induction melting, and induction welding equipment and accessories for industrial and scientific applications. Medical or dental applications, appliances, or line frequency pipeline and vessel heating are not covered in this article.

Informational Note: See Article 427, Part V, for line frequency induction heating of pipelines and vessels.

To prevent spurious radiation caused by induction and dielectric heating equipment, the Federal Communications Commission (FCC) has established rules that govern the use of this type of industrial heating equipment operating above 10 kilohertz (FCC, 47 CFR 18).

See also

NFPA 86, *Standard for Ovens and Furnaces*, for more information on electric heating systems using an induction heater or a dielectric heater in ovens and furnaces

665.5 Output Circuit. The output circuit shall include all output components external to the converting device, including contactors, switches, busbars, and other conductors. The current flow from the output circuit to ground under operating and ground-fault conditions shall be limited to a value that does not cause 50 volts or more to ground to appear on any accessible part of the heating equipment and its load. The output circuit shall be permitted to be isolated from ground.

If the load (object being heated) accidentally contacts the output coil, a voltage to ground will appear on the load, depending on the various impedances to ground of the coil and the load. If the voltage on the load is limited to less than 50 volts, guarding per 110.27(A) is not required. If the coil is isolated from ground and the load is grounded through an impedance that is low (less than 1 percent) relative to the coil impedance to ground, the voltage of the load to ground will be low no matter where the load contacts the coil.

In induction melting furnaces, an additional reason for isolating the coil from ground is to limit the fault current when a coil does go to ground. Limiting the fault current prevents severe damage to the water-cooled coil, resulting in a water leak and the potential for a water-molten metal explosion. If water is trapped under molten metal, the rapid transfer of heat to the water causes the water to turn almost instantly into steam. The resulting 1600-to-1 expansion of the steam results in the ejection of molten metal from the furnace.