

and maintenance (those tasks involving operations that can be accomplished by employees and where extensive disassembly of equipment is not required). Routine servicing and maintenance shall be able to be performed without exposing the worker to a risk of electric shock or personal injury.

Informational Note: An example of such routine maintenance is cleaning or replacing an air filter.

ARTICLE

647

Sensitive Electronic Equipment

647.1 Scope. This article covers the installation and wiring of separately derived systems operating at 120 volts line-to-line and 60 volts to ground for sensitive electronic equipment.

This type of supply system is employed as a means to reduce objectionable noise and its adverse effect on the performance of electronic audio and video equipment. Article 647 permits the use of this type of supply system for all commercial and industrial applications where sensitive audio/video or similar electronic equipment is used. Such systems can be used only in areas that are under the close supervision of qualified individuals.

647.3 General. Use of a separately derived 120-volt single-phase 3-wire system with 60 volts on each of two ungrounded conductors to an equipment grounding conductor shall be permitted for the purpose of reducing objectionable noise in sensitive electronic equipment locations, provided the following conditions apply:

- (1) The system is installed only in commercial or industrial occupancies.
- (2) The system's use is restricted to areas under close supervision by qualified personnel.
- (3) All of the requirements in 647.4 through 647.8 are met.

647.4 Wiring Methods.

(A) Panelboards and Overcurrent Protection. Use of standard single-phase panelboards and distribution equipment with a higher voltage rating shall be permitted. The system shall be clearly marked on the face of the panel or on the inside of the panel doors. Common trip two-pole circuit breakers or a combination two-pole fused disconnecting means that are identified for use at the system voltage shall be provided for both ungrounded conductors in all feeders and branch circuits. Branch circuits and feeders shall be provided with a means to simultaneously disconnect all ungrounded conductors.

Circuit breakers and fuses are acceptable means of providing overcurrent protection for technical power circuits. Additionally, all technical power feeder and branch circuits are required to be provided with a disconnecting means that simultaneously opens all ungrounded conductors of the circuit.

(B) Junction Boxes. All junction box covers shall be clearly marked to indicate the distribution panel and the system voltage.

(C) Conductor Identification. All feeders and branch-circuit conductors installed under this section shall be identified as to system at all splices and terminations by color, marking, tagging, or equally effective means. The means of identification shall be posted at each branch-circuit panelboard and at the disconnecting means for the building.

(D) Voltage Drop. The voltage drop on any branch circuit shall not exceed 1.5 percent. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.5 percent.

Unlike electrical distribution systems that supply lighting and appliance branch circuits, the supply systems covered by Article 647 are subject to mandatory voltage-drop requirements. The voltage-drop requirements are needed to ensure the operation of overcurrent devices in order to protect conductors and equipment supplied by these systems. Because the use of standard overcurrent devices and distribution equipment with higher voltage ratings is permitted, the impedance in circuits supplied by these systems under fault conditions is a primary concern.

(1) Fixed Equipment. The voltage drop on branch circuits supplying equipment connected using wiring methods in Chapter 3 shall not exceed 1.5 percent. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.5 percent.

(2) Cord-Connected Equipment. The voltage drop on branch circuits supplying receptacles shall not exceed 1 percent. For the purposes of making this calculation, the load connected to the receptacle outlet shall be considered to be 50 percent of the branch-circuit rating. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.0 percent.

Informational Note: The purpose of this provision is to limit voltage drop to 1.5 percent where portable cords may be used as a means of connecting equipment.

647.5 Three-Phase Systems. Where 3-phase power is supplied, a separately derived 6-phase "wye" system with 60 volts to ground installed under this article shall be configured as three separately derived 120-volt single-phase systems having a combined total of no more than six disconnects.

647.6 Grounding.

(A) General. The transformer secondary center tap of the 60/120-volt, 3-wire system shall be grounded as provided in 250.30.

A technical power system has two ungrounded conductors with 120 volts between them and a grounded reference conductor at 60 volts with respect to the ungrounded conductors.

(B) Equipment Grounding Conductors Required. Permanently wired utilization equipment and receptacles shall be grounded by means of an equipment grounding conductor run with the circuit conductors and connected to an equipment

grounding bus prominently marked “Technical Equipment Ground” in the branch-circuit panelboard. The equipment grounding bus shall be connected to the grounded conductor on the line side of disconnecting means supplied by the separately derived system. The equipment grounding conductor shall not be smaller than that specified in Table 250.122 and run with the feeder conductors. The technical equipment grounding bus shall not be required to be bonded to the panelboard enclosure. Other equipment grounding methods authorized elsewhere in this *Code* shall be permitted where the impedance of the equipment grounding return path does not exceed the impedance of equipment grounding conductors sized and installed in accordance with this article.

Informational Note No. 1: See 250.122 for equipment grounding conductor sizing requirements where circuit conductors are adjusted in size to compensate for voltage drop.

Informational Note No. 2: These requirements limit the impedance of the ground fault return path where only 60 volts apply to a fault condition instead of the usual 120 volts.

647.7 Receptacles.

Δ (A) **General.** Where receptacles are used as a means of connecting equipment, the following conditions shall be met:

- (1) All 15- and 20-ampere receptacles shall be GFCI protected.
- (2) All receptacle outlet strips, adapters, receptacle covers, and faceplates shall be marked with the following words or equivalent:

WARNING — TECHNICAL POWER

Do not connect to lighting equipment.

For electronic equipment use only.

60/120 V, 1Φac

GFCI protected

The warning sign(s) or label(s) shall comply with 110.21(B).

- (3) A 125-volt, single-phase, 15- or 20-ampere-rated receptacle having one of its current-carrying poles connected to a grounded circuit conductor shall be located within 1.8 m (6 ft) of all permanently installed 15- or 20-ampere-rated 60/120-volt technical power-system receptacles.
- (4) All 125-volt receptacles used for 60/120-volt technical power shall have a unique configuration and be identified for use with this class of system.

Exception: Receptacles and attachment plugs rated 125-volt, single-phase, 15- or 20-amperes, and that are identified for use with grounded circuit conductors, shall be permitted in machine rooms, control rooms, equipment rooms, equipment racks, and other similar locations that are restricted to use by qualified personnel.

(B) **Isolated Ground Receptacles.** Isolated ground receptacles shall be permitted as described in 250.146(D); however, the branch-circuit equipment grounding conductor shall be terminated as required in 647.6(B).

647.8 Lighting Equipment. Lighting equipment installed under this article for the purpose of reducing electrical noise originating from lighting equipment shall meet the conditions of 647.8(A) through (C).

(A) **Disconnecting Means.** All luminaires connected to separately derived systems operating at 60 volts to ground, and associated control equipment if provided, shall have a disconnecting means that simultaneously opens all ungrounded conductors. The disconnecting means shall be located within sight of the luminaire or be lockable open in accordance with 110.25.

(B) **Luminaires.** All luminaires shall be permanently installed and listed for connection to a separately derived system at 120 volts line-to-line and 60 volts to ground.

(C) **Screw Shell.** Luminaires installed under this section shall not have an exposed lamp screw shell.

ARTICLE

650

Pipe Organs

650.1 Scope. This article covers those electrical circuits and parts of electrically operated pipe organs that are employed for the control of the keyboards and of the pipe organ sounding apparatus, typically organ pipes.

Informational Note: The typical pipe organ is a very large musical instrument that is built as part of a building or structure.

Δ **650.3 Other Articles.** Installations of circuits and equipment shall comply with 650.3(A) and (B) as applicable. Wherever the requirements of other articles in Chapters 1 through 7 of this *Code* and Article 650 differ, the requirements of Article 650 shall apply.

(A) **Electronic Organ Equipment.** Installations of digital/analog-sampled sound production technology and associated audio signal processing, amplification, reproduction equipment, and wiring installed as part of a pipe organ shall be in accordance with Article 640.

Some pipe organ installations incorporate digital/analog-sampled sound technology. The requirements in Article 640 are necessary for electronic sound production, amplification, signal processing, and other sound reproduction circuits and equipment installed as part of a pipe organ.

(B) **Optical Fiber Cable.** Installations of optical fiber cables shall be in accordance with Parts I and V of Article 770.

650.4 Source of Energy. DC power shall be supplied by a listed dc power supply with a maximum output of 30 volts.

Informational Note: Class 1 power-limited power supplies are often utilized in pipe organ applications.