

sign electrician's workbook

BASED ON THE 1990 NEC®

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publication

James G. Stallcup

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Introduction

SIGN ELECTRICIAN'S WORKBOOK is designed for use by tradespeople who install, maintain, repair, and inspect electric signs. *SIGN ELECTRICIAN'S WORKBOOK* is based on Article 600 of the 1990 National Electrical Code®. The 1990 NEC must be used with *SIGN ELECTRICIAN'S WORKBOOK*. Copies of the 1990 NEC may be ordered directly from the publisher:

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

Article 600 of the 1990 NEC pertains to the electrical requirements for all types of electric signs. Other Code references are cited and used as necessary for specifying installation and load requirements of electric signs.

SIGN ELECTRICIAN'S WORKBOOK presents information in a concise, descriptive format. Illustrations are used to show portions of the 1990 NEC. Chapters 1–3 of *SIGN ELECTRICIAN'S WORKBOOK* define sections of Article 600. Chapter 4 covers formulas used to calculate the size of conductors and overcurrent protection devices for sign circuits. Examples showing how to solve electrical problems using standard electrical formulas are given in Chapter 4. Guided exercises reinforce the concepts presented. Answers to the guided exercises are listed at the end of the chapter. Chapter 5 covers sizing loads for the electrical requirements of signs. Chapter 6, consisting of five tests, can serve as a comprehensive testing device. The tests contain questions and problems based on material from Chapters 1–5 and articles of the Code. Chapter 7 contains examples and additional sign problems.

Questions and problems require the user to substantiate answers with appropriate Code references. Answers and Code validation to all end-of-chapter questions and problems are given in the *Instructor's Guide*. The appendix contains a quick index and other useful charts, tables, and information designed for easy reference.

The Publisher

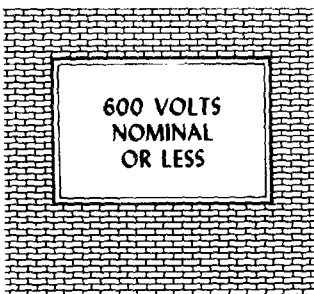
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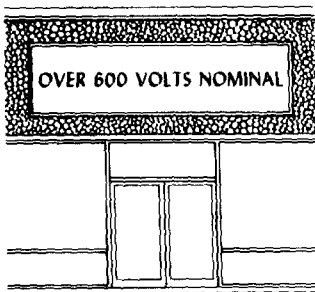
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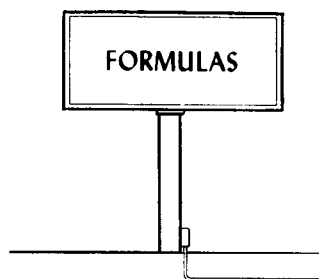


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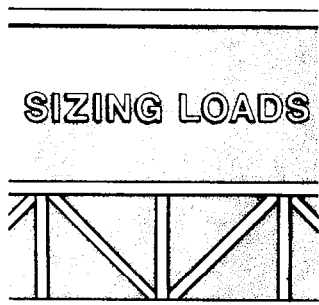


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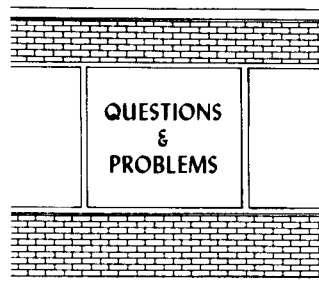
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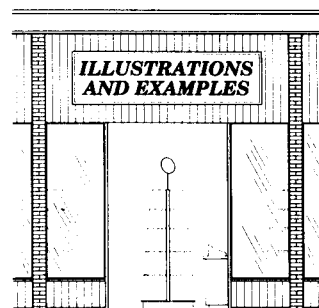
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A two pole sign is used for outdoor advertising. These signs are found along highways and other areas. They are not attached to buildings.



An electric sign is a fixed, stationary, or portable self-contained, electrically illuminated utilization equipment. It has words or symbols designed to convey information or attract attention for advertisement purposes.

Article 600 of the 1990 NEC® pertains to electrical requirements for all types of signs. Basically, there are four types of signs: the pole sign, building sign, channel letter sign, and window sign.

Outline lighting is an arrangement of incandescent lamps or electric-discharge tubing used to outline or call attention to certain features, such as the shape of a building or the decoration of a window. Outline lighting is used in channel letter and window signs. Fluorescent lighting or incandescent lighting is used to illuminate pole signs and building signs.

DISCONNECT REQUIRED 600-2

All signs except portable signs must have a disconnect according to 600-2(a). The disconnecting means may be a switch or circuit breaker. All disconnecting means must be within sight of the sign or outline lighting.

The exception allows a disconnect to not be within sight of a sign if the sign has an automatic controller to turn the sign ON and OFF at specific times of use; however, the disconnect must be within sight of the controller. Additionally, provisions must be supplied to lock open the disconnect. This provides safety from electrical shock while servicing the sign. See Figure 1-1.

There are certain types of switches used to control inductive loads supplied by transformers. When a switch is used to disconnect transformer loads, the switch must have a rating equivalent to the amperage of the load supplied.

General-use switches must have a rating of at least twice the amperage of the transformer. General-use switches are not rated for inductive

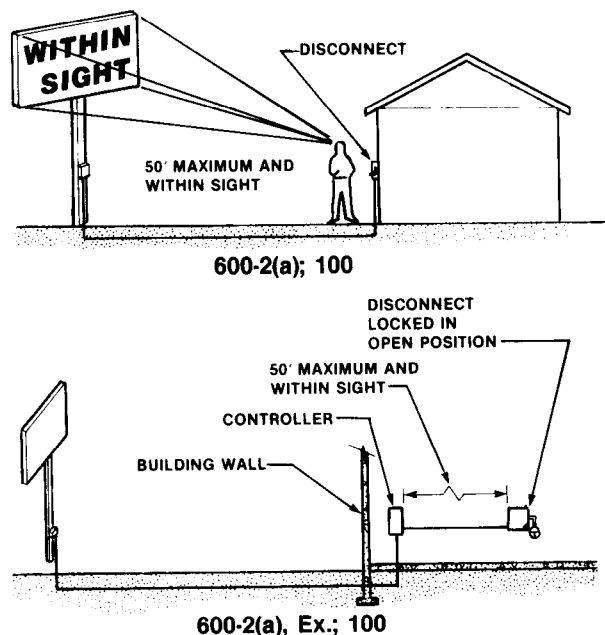


Figure 1-1. Disconnecting means for outdoor signs must comply with 600-2.

loads. For example, a 20-amp general-use switch will carry only 50% of its rating ($20\text{ A} \times 50\% = 10\text{ A}$); thus, it cannot serve a transformer load exceeding 10 amps.

If an AC general-use snap switch is used to disconnect the transformer, the rating of the switch must be equivalent to the output of the transformer. If an AC-DC general-use snap switch is used, the rating of the switch must be twice the output of the transformer. General-use snap switches are not rated for inductive loads.

Flashers used to control transformers must be designed for such use or must have a rating at least twice the output of the transformer. See Figure 1-2.

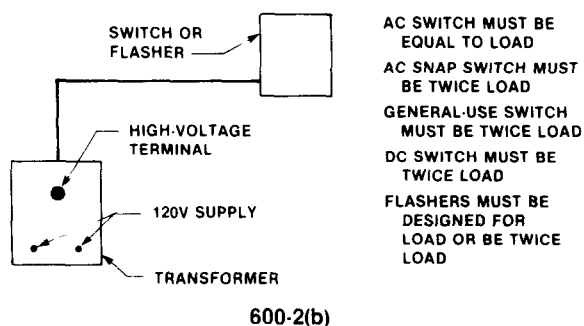


Figure 1-2. Ratings for control switches and flashers for controlling transformers must comply with 600-2(b).

ENCLOSURES AS PULL BOXES 600-3

The type of wiring method used to wire a sign must extend to the transformer. Sign enclosures cannot be used as junction boxes for circuits feeding other loads. See Figure 1-3. Such a hookup could be deenergized, leaving the other load energized.

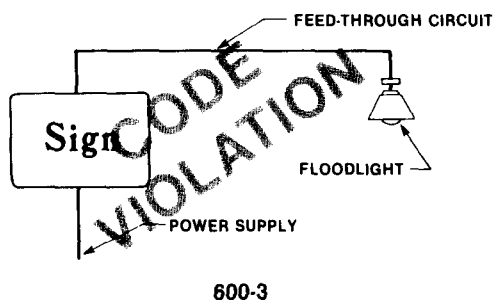


Figure 1-3. Sign enclosures must not be used as junction boxes for circuits feeding other loads. 600-3

LISTING REQUIRED 600-4

Without special permission from the authority having jurisdiction, all electric signs must be listed and installed by the listing on the sign. See Article 100 for the definition of *listing*. For installation by nameplate requirements, refer to 110-3(b). See Figure 1-4.

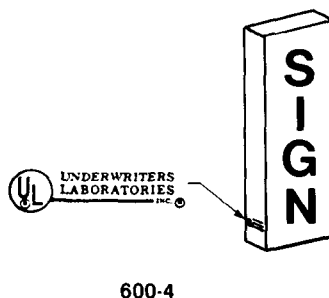


Figure 1-4. Without special permission, signs must be listed and labeled. 600-4

GROUNDING 600-5

Noncurrent-carrying metal parts of signs and metal parts in the sign must be grounded. Items or parts such as troughs and tube terminal boxes may be grounded by an equipment grounding conductor listed in 250-91(b) and sized from Table 250-95 based on the rating of the overcurrent protection device protecting the circuit.

Equipment grounding conductors are used to ensure that the metal parts of the equipment have the same potential to ground as the earth. The equipment grounding conductor is used as a path for short-circuit current. This occurs when a hot conductor touches a grounded metal object and creates a short-circuit current. The terms ground, grounded, grounded conductor, grounding conductor, equipment grounding conductor, and grounding electrode conductor are defined in Article 100.

Metal parts of a sign may be bonded together by a #14 AWG conductor. Bonding is the joining together of metal parts to assure electrical continuity and a conductive path for fault current.

Signs which are insulated from ground and not accessible to unauthorized personnel can be ungrounded according to 600-5, Ex. 1.

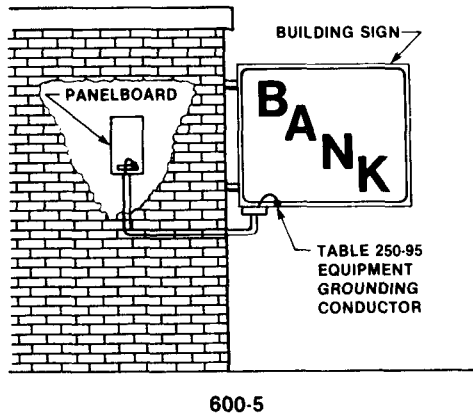


Figure 1-5. Equipment grounding conductors are selected from Table 250-95, based on the size of the overcurrent protection device. 600-5

Selecting Equipment Grounding Conductors Table 250-95

Equipment grounding conductors are selected from Table 250-95 based upon the size of the overcurrent protection device protecting the branch circuit or feeder. For example, to determine the size copper equipment grounding conductor required to ground the metal frame of a sign supplied by a 20-amp circuit, see Table 250-95. A #12 copper conductor is required. See Figure 1-5.

A feeder circuit can be used to feed a panelboard mounted on a pole sign. Branch circuits from the panelboard supply ballasts and other electrical components of the sign. The equipment grounding conductor is routed with the feeder conductors and is selected from Table 250-95. When an equipment grounding conductor is used, the grounded neutral bar of the panelboard must be isolated from the metal enclosure of the panel. See Figure 1-6.

Selecting Grounding Electrode Conductors Table 250-94

Grounding electrode conductors are used to ground the metal enclosure of service equipment. They are also used to ground the circuit and system to the earth. This is accomplished by connecting the grounded neutral bar of the service equipment to the metal pole of the sign, to a driven rod, or to a nearby metal water pipe.

The grounding electrode conductor is selected

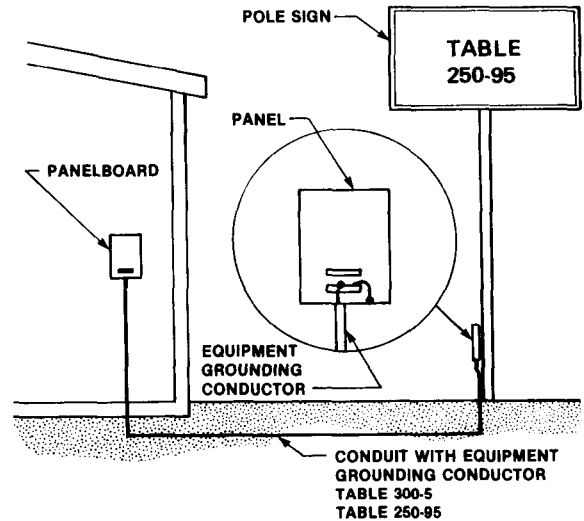


Figure 1-6. Equipment grounding conductors are selected from Table 250-95.

from Table 250-94 based upon the size of service entrance conductors supplying the service equipment. For example, a sign having three #1/0 THWN copper service entrance conductors requires a #6 copper grounding electrode conductor per Table 250-94. See Figure 1-7.

Billboards may be fed by an overhead service or a lateral. The grounding electrode conductor

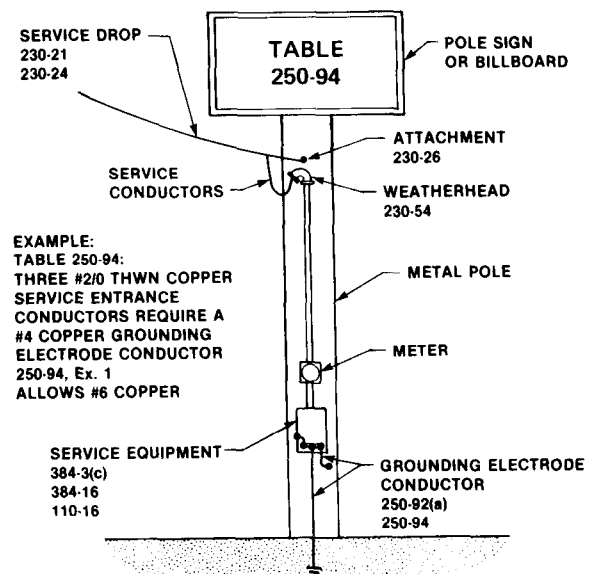
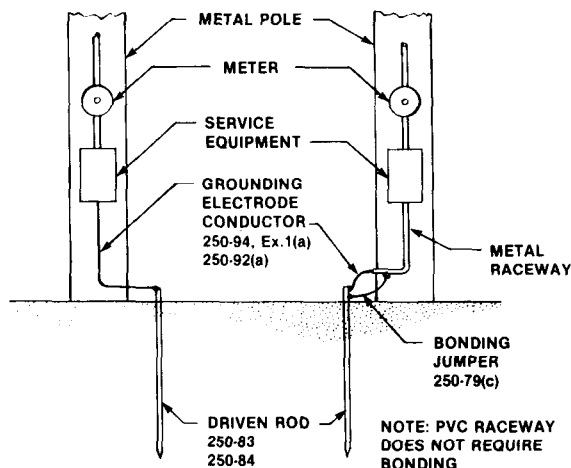


Figure 1-7. The size of the grounding electrode conductor is based upon the size of the service entrance conductors and is selected from Table 250-94.

is selected by following the same procedure as used with a sign pole. Table 250-94 is used. Refer to Figure 1-7. The grounding electrode conductor can be installed without physical protection if in an area not subject to car or truck travel. Where subjected to physical damage, the grounding electrode conductor must be installed in a protective raceway system. If metal raceway is used, the raceway must be bonded to the grounding electrode conductor or the grounding electrode. See Figure 1-8.



250-83; 250-84; 250-94, Ex. 1(a)

Figure 1-8. Grounding electrode conductors may be connected to a driven rod. 250-94, Ex. 1(a); 250-83; 250-84

BRANCH CIRCUITS 600-6

Branch circuits are used to supply ballasts, transformers, or incandescent lighting to illuminate signs. These circuits are rated at 15, 20, 25, or 30 amps. Branch circuits can be used to supply only one piece of equipment or a number of outlets for lighting and appliances. The branch circuit consists of the conductors between the final overcurrent protection device and the outlets served.

Rating 600-6(a)

Branch circuits feeding transformers, lamps, ballasts, or combinations must be rated at 20 amps or less. Circuits rated above 20 amps cannot be used to supply these loads per 600-6(a).

Branch circuits serving electric-discharge lighting transformers must be rated at 30 amps or less. Electric-discharge lighting includes such loads as fluorescent and neon tube. Branch circuit ratings of 15, 20, 25, or 30 amps may be used to supply these transformers according to 600-6(a). See Figure 1-9.

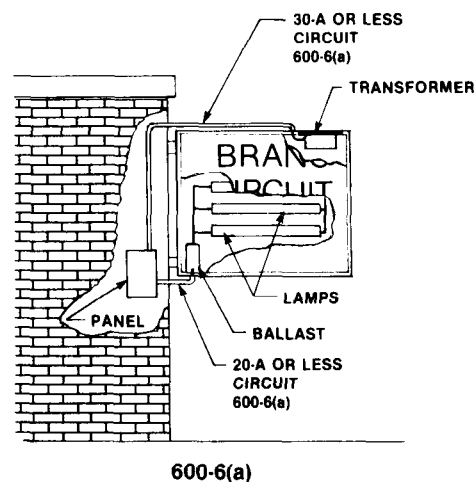


Figure 1-9. Branch circuits may not exceed 30 amps for electric-discharge lighting transformers or 20 amps for combination loads. 600-6(a)

Branch Circuit Required 600-6(b)

Each commercial building with grade level access containing floor footage accessible to pedestrians must have at least one outdoor receptacle to be used for a sign. This circuit must be at least 20 amps and brought to the front of the building. This circuit must not feed other outlets.

Computed Load 600-6(c)

The load calculation for the service or feeder is computed at a minimum of 1,200 volt-amperes. This rating can be higher depending on the load of the sign. Loads for signs are considered to be continuous because they burn for three hours or more. Therefore, a sign load must be increased by 25%. For example, to find the size of the total load of a sign pulling 16 amps, multiply 16 A \times 125% per 220-10(b) to derive 20 A. See 240-6 for the standard ratings of overcurrent protection devices. A 20-amp device is required.

Note: Either multiply the load by 125% or derate the overcurrent protection device by 80%. Either method will produce the same results for continuous load ratings. See 210-22(c), 220-2(a), 220-10(b), and 384-16(c).

A commercial occupancy with grade-level access (ground floor) and provided with an entrance for pedestrians from a sidewalk, parking lot, street, or other means of entrance must have at least one outlet for a sign. The sign circuit must be 20 amps in rating and only 80% used for the load. The service or feeder load must have at least 1,200 volt-amperes applied for selecting the load rating of the conductors. See Figure 1-10.

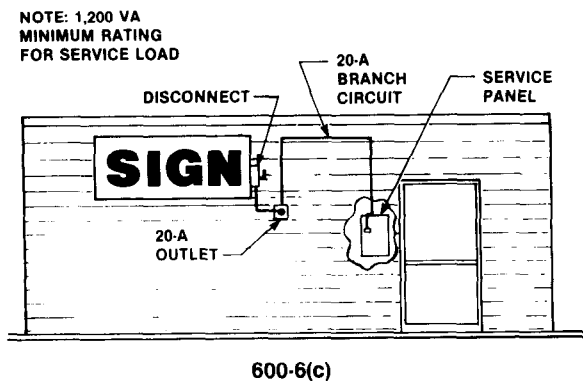


Figure 1-10. A commercial building must have a 20-amp circuit with a minimum rating of 1,200 volt-amperes for the service load on the front of the building.

MARKING 600-7

All signs must be marked by the manufacturer with the maker's name on the sign. The number of lampholders must be indicated when incandescent lamps are used. The full load of amps and input voltage must be indicated in the sign for the installation of electric-discharge lighting per 600-7(a).

Transformers must be marked with the maker's name and give the input rating in amps or volt-amperes, input voltage, and open-circuit output voltage per 600-7(b). See Figure 1-11.

ENCLOSURES 600-8

All conductors except supply leads must be enclosed per 600-8(a). Terminals also must be

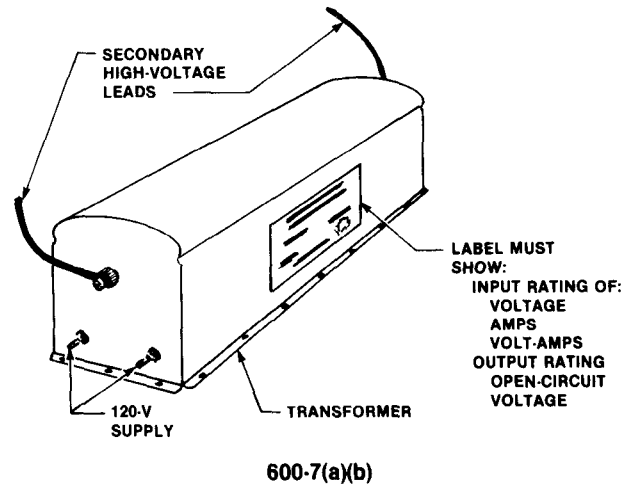


Figure 1-11. Transformers must be marked with the manufacturer's name. 600-7(a)(b)

enclosed. Cutouts and flashers must be enclosed per 600-8(b).

Enclosures must have adequate strength to house all components according to 600-8(c). All signs must be constructed of metal or noncombustible type material. Wood is permitted for external decoration. The wood must be at least 2" from all current-carrying parts per 600-8(d).

Sheet steel used for enclosures must be at least 24 gauge. If corrugated or ribbed, it may be 26 gauge. Signs other than electric-discharge or outline lighting may have enclosures of 28 gauge metal. Sheet copper must be at least 20 ounces in weight when used for signs and outline lighting per 600-8(e). See Figure 1-12.

PORTABLE SIGNS 600-9

A weatherproof grounded type receptacle must be provided with an attachment plug for each letter, fixture, or sign per 600-9. See 210-7 for grounded receptacle requirements.

Cords used to connect letters, symbols, and signs must be provided with an equipment grounding conductor per 600-9(b). These cords must be type S, SJ, SJO, SJT, SJTO, SO, or ST. See 250-59(b) for requirements for grounding conductors. Cords must be at least 10' above grade level per 600-9(c). See Figure 1-13.

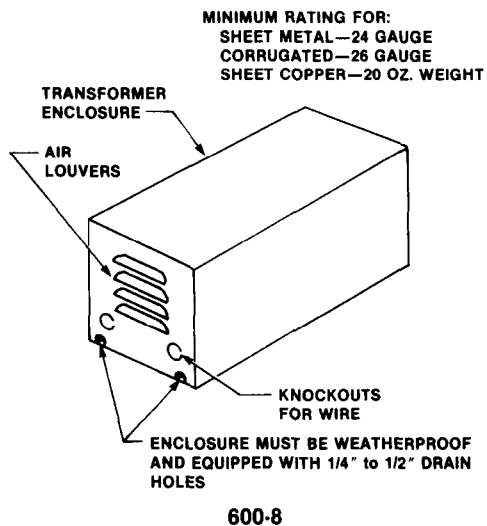


Figure 1-12. Enclosures for transformers must meet standards for thickness per 600-8(e).

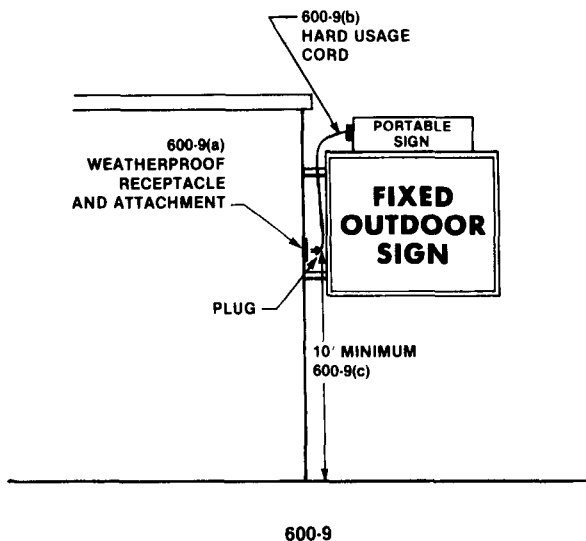


Figure 1-13. Hard usage cord may be used to connect outdoor portable signs. 600-9

CLEARANCES 600-10

Vertical and horizontal enclosures for signs and outline lighting systems must comply with vertical and horizontal clearances for conductors per 600-10(a). See 225-19. Signs and outline lighting systems must maintain these minimum

600-10 225-19 MINIMUM VERTICAL AND HORIZONTAL CLEARANCES

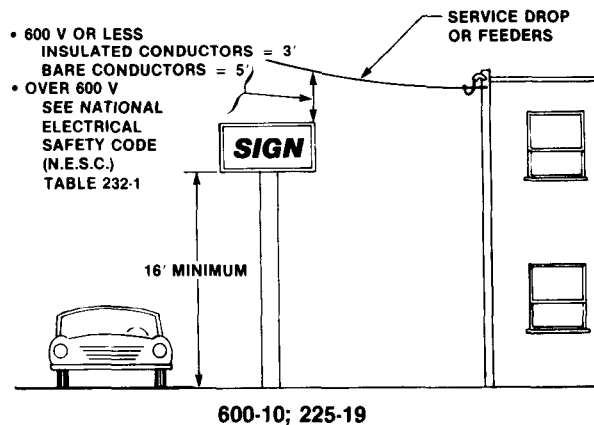


Figure 1-14. Signs must have a 16' clearance above areas with vehicular traffic. Clearance from insulated conductors is 3' minimum, and clearance from base conductors is 5' minimum, vertically and horizontally. 600-10; 225-19

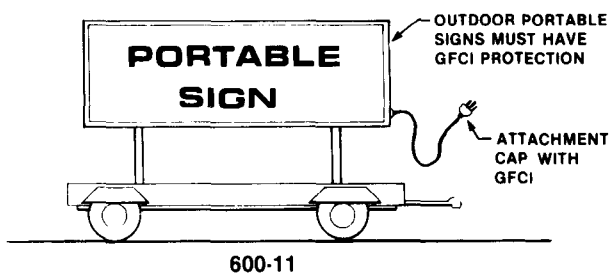


Figure 1-15. Outdoor portable signs must be GFCI protected. 600-11

clearances to avoid shorting open conductors that are run overhead in close proximity. Where signs are above areas accessible to vehicles, the bottom of the enclosure housing the sign parts must be at least 16' above finished grade per 600-10(b). The exception does allow reduction of this clearance when the sign is properly protected. See Figure 1-14.

Portable outdoor signs, including mobile signs, readily accessible must be provided with ground-fault protection for personnel. The ground-fault circuit-interrupter (GFCI) must be mounted on the sign. A GFCI provides protection for people by tripping open the circuit at four or five milliamps. A GFCI on the sign will not provide protection for faults on the line side feeding the GFCI. The sign and supply cord can be protected by a GFCI designed into the attachment cap. See Figure 1-15.

Chapter 1 - Questions

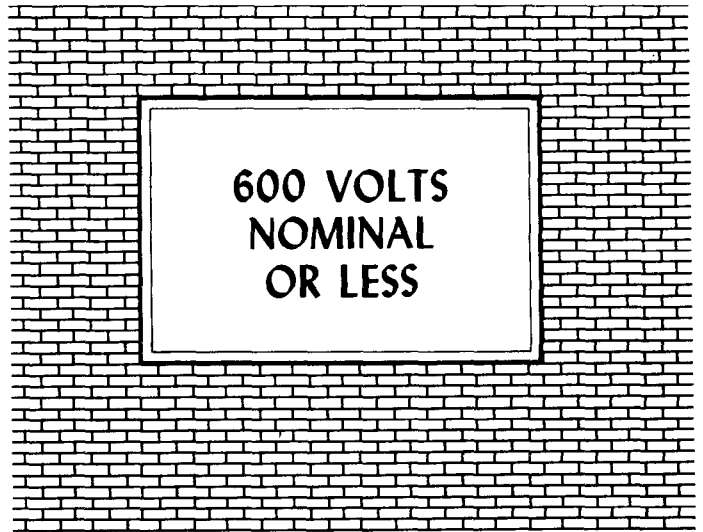
CODE REFERENCE	ANSWER	
_____	T F	1. A disconnecting means is required within sight and must be located not more than 50' from all outdoor signs.
_____	T F	2. A general-use switch must be three times the rating of the load served.
_____	_____	3. Without special permission from the inspector, all electric signs must be installed by the _____ on the sign.
_____	_____	4. Circuits supplying loads other than sign loads must not feed _____. A. through the sign enclosures B. through the supply conduit C. both A and B D. neither A nor B
_____	_____	5. A _____-amp branch circuit must be brought to the front of each commercial store building to serve a sign.
_____	_____	6. A system or circuit conductor that is intentionally grounded is a _____. A. bonded conductor B. grounding electrode conductor C. grounded conductor D. equipment grounding conductor
_____	_____	7. Branch circuits supplying electric-discharge lighting transformers must be rated at _____ amps or less.
_____	T F	8. Transformer enclosures must be provided with $\frac{1}{4}$ " to $\frac{1}{2}$ " drain holes.
_____	_____	9. Sheet metal used for transformer enclosures must be at least _____ gauge. A. 20 B. 22 C. 24 D. 30
_____	T F	10. Portable outdoor signs must be provided with a GFCI in the attachment cap of the supply cord.
_____	_____	11. Signs located above areas accessible to vehicles must have a clearance of at least _____' from the finished grade.
_____	_____	12. Cords used to connect portable letters must be located at least _____' above grade. A. 8 B. 10 C. 12 D. 15
_____	T F	13. Flashers must be enclosed in metal boxes.
_____	_____	14. Wood used for external decoration must be at least _____" clear of current-carrying parts.
_____	T F	15. Transformers are not required to have the open-circuit output voltage marked on their nameplates.

CODE REFERENCE	ANSWER	
_____	_____	16. A 20-amp branch circuit can only be loaded to _____ % of its rating.
_____	_____	17. A commercial building with grade level access to pedestrians must have _____ volt-amps added to the service load calculation. A. 1,200 B. 1,500 C. 1,800 D. 2,400
_____	T F	18. A 20-amp branch circuit can feed combination loads, such as ballasts, lamps, and transformers.
_____	_____	19. A 100-amp branch circuit protected by a 100-amp overcurrent protection device requires a # _____ copper equipment grounding conductor.
_____	_____	20. Equipment grounding conductors must be _____. A. black B. white C. green D. red
_____	T F	21. A disconnecting means capable of being locked in the open position and located by the controller cannot serve as the disconnect for a sign.
_____	_____	22. The disconnect required for an outdoor pole sign is required to _____ all ungrounded conductors.
_____	_____	23. A 90-amp circuit breaker can be used for the protection of a # _____ THW copper conductor. A. 4 B. 3 C. 2 D. 1
_____	_____	24. Enclosures built of sheet copper must be at least _____ ounces.
_____	T F	25. Type SJTO cords can be used to connect portable letters installed outdoors.
_____	T F	26. A sign mounted on a pole can be located 60' from its disconnecting means.
_____	_____	27. A neutral conductor must be either white or _____ in color.
_____	T F	28. The wiring method used to supply a sign must be terminated in a sign or transformer enclosure.
_____	_____	29. Sign enclosures must not be used as pull boxes for _____ feeding loads other than the sign load.
_____	T F	30. Isolated noncurrent-carrying metal parts of outline lighting can be bonded with a #14 copper conductor.
_____	_____	31. All metal noncurrent-carrying parts of signs must be grounded with an equipment grounding conductor per Article _____.

CODE REFERENCE	ANSWER	
_____	_____	32. Equipment grounding conductors are selected from Table _____ based upon the size of the overcurrent protection device protecting the branch circuit.
_____	_____	33. Grounding electrode conductors are selected from Table _____ based upon the size of the service entrance conductors.
_____	T F	34. Branch circuits supplying a sign are not required to be color coded according to the 1990 NEC.
_____	_____	35. An outdoor sign supplied by a 20-amp circuit can be loaded to _____ amps for continuous duty.

2

A building sign is located on the outside of a building. Building signs have fluorescent or incandescent lighting.



The requirements and procedures for installing wiring methods operating at 600 volts or less are listed in Section 600-21. The installer must meet these provisions when determining the wiring methods to connect and supply signs. The majority of electric signs in use operate at 600 volts or less. Operating voltages of ballasts and transformers are normally rated over 600 volts.

INSTALLATION OF CONDUCTORS 600-21

Conductors supplying signs must be installed in a wiring method which will protect the conductors from physical damage and diggings. Conductors within the sign must be installed in a wiring method which will provide protection from abrasion and other physical damage.

Wiring Method 600-21(a)

Any one of the following wiring methods may be used to connect wiring systems to signs or out-line lighting:

- (1) Rigid metal conduit
- (2) EMT
- (3) Type MC cable
- (4) Metal troughing
- (5) Rigid nonmetallic conduit
- (6) Type MI (mineral-insulated) cable
- (7) Liquidtight flexible metal conduit
- (8) Flexible metal conduit
- (9) Intermediate metal conduit

Burial depths for wiring methods are determined by the type of raceway used. Table 300-5 lists the minimum burial depth for each type of raceway (with exceptions for specific conditions of use). For example, the minimum burial depth of rigid metal conduit is 6" from finished grade to the top of the conduit. Exceptions to Table 300-5 will allow burial depths of conduit to vary according to the type of installation. For example, when running conduit beneath a street, a minimum burial depth of 24" is required. These wiring methods are permitted at 600 volts or less. See Figure 2-1.

Insulation and Size 600-21(b)

Table 310-13 lists the types of insulation used to protect conductors based upon the condition of use. The Type Letter on the insulation of the conductor indicates the temperature rating of the insulation and the location or locations where the conductor may be installed. For example, THWN, which is a moisture and heat-resistant thermoplastic insulation, may be used in wet or dry locations where the maximum

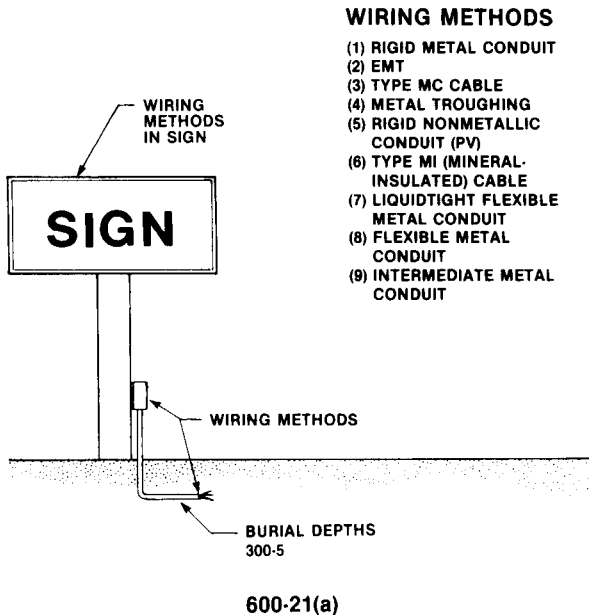


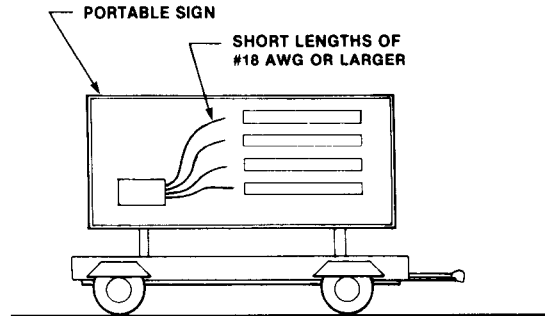
Figure 2-1. Wiring methods connecting signs of 600 volts or less must be permitted for use by the NEC.

operating temperature does not exceed 75°C (167°F).

All conductors of the general-use type which are used to supply and connect signs must be #14 AWG or larger, depending upon the load served. For example, a #14 conductor can serve a 12-amp sign load and a #12 conductor is required for a 16-amp sign load.

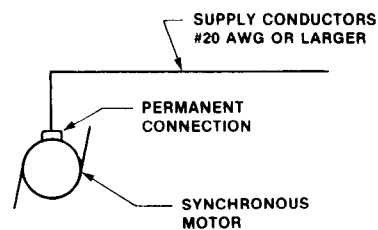
Note: Overcurrent protection devices for branch circuits that supply sign loads cannot be loaded to more than 80% of the device rating. Section 600-21(b), Ex. 1 permits #18 AWG or larger conductors to be used in short lengths for portable signs to connect components, such as lampholders, electric-discharge ballasts, and flashers. See Figure 2-2. Table 402-3 lists fixture wires.

Conductors used to connect electric-discharge lampholders for portable signs are limited to 8' in length according to 600-21(b), Ex. 1(c). Exception 1(d) requires only one supply conductor for control of multiple incandescent lamps whose load does not exceed 250 volt-amps. Section 600-21(b), Ex. 2 allows the use of #20 AWG or larger conductors to be permanently attached in short leads for connecting synchronous motors. See Figure 2-3.



600-21(b), Ex. 1

Figure 2-2. Short lengths of #18 AWG or larger conductors may be used in portable signs.



600-21(b), Ex. 2

Figure 2-3. Short leads of #20 AWG or larger conductors may be permanently connected to synchronous motors.

Exposed to Weather 600-21(c)

Metal-clad wiring methods exposed to weather must be the leaded type or other approved types, such as TW, THW, THWN, RHW, and XHHW.

Note: All of these insulation types contain a "W." The "W" indicates weatherproof insulation.

Conductors in conduit, EMT, or other metal raceways are not required to be the leaded type. However, they must have weatherproof type insulation as listed in Table 310-13. See 600-21(c), Ex. The raceway must be raintight and installed to drain the accumulated water from the sign enclosure or raceway system. See Figure 2-4.

Number of Conductors in Raceway 600-21(d)

Any number of conductors can be installed in conduit or raceway as long as the fill percent-