EXHIBIT 518.3 A listed power outlet for connection of portable switchboards in an assembly occupancy. *(Courtesy of Union Connector Co., Inc.)*

vary with the amplitude of the applied voltage waveform, without any of the nonlinear switching found in phase-control solid-state dimmers. Because solid-state sine wave dimmers are linear loads, they do not require the neutral to be considered a current-carrying conductor. This characteristic impacts the number of current-carrying conductors in a raceway or cable and the need to apply ampacity adjustment factors.

518.6 Illumination. Illumination shall be provided for all working spaces about fixed service equipment, switchboards, switchgear, panelboards, or motor control centers installed outdoors that serve assembly occupancies. Control by automatic means only shall not be permitted. Additional lighting outlets shall not be required where the workspace is illuminated by an adjacent light source.

In some assembly occupancies, fixed service equipment is installed outdoors. Illumination of indoor service equipment is required by 110.26(D). Section 518.6 requires illumination of outdoor service equipment supplying assembly occupancies.

ARTICLE 520

Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations

Part I. General

520.1 Scope. This article covers all buildings or that part of a building or structure, indoor or outdoor, designed or used for presentation, dramatic, musical, motion picture projection, or similar purposes and to specific audience seating areas within motion picture or television studios.

The special requirements of Article 520 apply only to that part of a building used as a theater or for a similar purpose and do not necessarily apply to the entire building. In a school building, for example, the requirements of Article 520 apply to an auditorium used for dramatic or other performances. The special requirements of this article apply to the stage, auditorium, dressing rooms, and main corridors leading to the auditorium but not to other parts of the building not involved in the use of the auditorium for performances or entertainment. Audience areas of motion picture and television studios, as defined and covered in Article 530, and stage areas of concert and festival venues are also covered by the requirements of Article 520.

520.5 Wiring Methods.

Δ **(A) General.** The fixed wiring method shall be any of the following:

(1) Metal raceways
(2) Nonmetallic raceways encased in at least 50 mm (2 in.) of concrete
(3) Type MI cable, Type MC cable, or Type AC cable containing an insulated equipment grounding conductor sized in accordance with Table 250.122

N **(B) Communications, Signaling Systems, Data Systems, Fire Alarm Systems, and Systems Less Than 120 Volts, Nominal.** Fixed wiring methods for specific installations shall be as follows:

(1) Audio signal processing, amplification, and reproduction equipment — 640.9
(2) Communications systems — Parts I and IV of Article 800, Part IV of Article 805, and Part VI of Article 840
(3) Class 2 and Class 3 remote control and signaling circuits — Part III of Article 725
(4) Class 2 circuits that transmit power, data, or both to a powered device

Informational Note: See ANSI/NEMA C137.3-2017, *American National Standard for Lighting Systems — Minimum Requirements for Installation of Energy Efficient Power over Ethernet (PoE) Lighting Systems*, for information on installation of cables for PoE lighting systems. See Part III of Article 760 for information on fire alarm circuits.

(C) Portable Equipment. The wiring for portable switchboards, stage set lighting, stage effects, and other wiring not fixed as to location shall be permitted with approved flexible cords and cables as provided elsewhere in Article 520. Fastening such cables and cords by uninsulated staples or nailing shall not be permitted.

(D) Nonrated Construction. Nonmetallic-sheathed cable, Type AC cable, electrical nonmetallic tubing, and rigid nonmetallic conduit shall be permitted to be installed in those buildings or portions of buildings that are not required to be of fire-rated construction by the applicable building code.

Because theaters and similar buildings are usually required to be of fire-rated construction as determined by applicable building codes, the fixed wiring methods for power and lighting circuits are limited to those specified in 520.5(A).

See also

518.4 and its commentary for wiring methods where fire-rated construction is required

Section 520.5(B) permits the installation of communications circuits, Class 2 and Class 3 remote-control and signaling circuits, sound-reproduction wiring, and fire alarm circuits using wiring methods, including power-limited circuit cables covered in Article 722 and communications cables covered in Chapter 8. Where portability, flexibility, and adjustments are necessary, suitable cords and cables are permitted. Section 520.5(D) permits Type AC cable as one of the wiring methods in buildings or portions of buildings that are not required to be of fire-rated construction. Under this condition, Type AC cable is not required to contain an insulated equipment grounding conductor (EGC).

520.6 Number of Conductors in Raceway. The number of conductors permitted in any metal conduit, rigid nonmetallic conduit as permitted in this article, or electrical metallic tubing for circuits or for remote-control conductors shall not exceed the percentage fill shown in Table 1 of Chapter 9. Where contained within an auxiliary gutter or a wireway, the sum of the cross-sectional areas of all contained conductors at any cross section shall not exceed 20 percent of the interior cross-sectional area of the auxiliary gutter or wireway. The 30-conductor limitation of 366.22 and 376.22 shall not apply.

520.9 Branch Circuits. A branch circuit of any size supplying one or more receptacles shall be permitted to supply stage set lighting. The voltage rating of the receptacles shall be not less than the circuit voltage. Receptacle ampere ratings and branch-circuit conductor ampacity shall be not less than the branch-circuit overcurrent device ampere rating. Table 210.21(B)(2) and 210.23 shall not apply. The requirements in 210.8(B), other than 210.8(B)(6), shall apply.

The occupancies referenced in Article 520 are excluded from all the general requirements relating to connector rating and branch circuit loading found elsewhere in the *NEC*®, such as in Table 210.21(B)(2). Connectors must be rated sufficiently for the parameters involved, thus permitting connectors with voltage and current ratings higher than the branch-circuit rating to be used. However, per 406.4(F), the same connector cannot be used for a different voltage or current on the same premises.

The stage set lighting and associated equipment, such as stage effects, both fixed and portable, must be as flexible as possible. Connectors often are used for different purposes and are therefore marked on a show-by-show basis to designate the voltage, current, and type of current actually employed. Stage set lighting is usually planned in advance, and the loads on each receptacle are known. Loads are not casually connected as they might be at a typical general-use wall receptacle. Care is taken to ensure that circuits are not overloaded, thereby avoiding unwanted tripping during a performance. Outdoor circuits are often dimmed and are exempt from the GFCI requirement of 210.8(B)(6) because dimmer-rated GFCI devices are not readily available.

520.10 Portable Equipment Used Outdoors. Portable stage and studio lighting equipment and portable power distribution equipment not identified for outdoor use shall be permitted for temporary use outdoors if the equipment is supervised by qualified personnel while energized and barriered from the general public.

Informational Note: See ANSI/ESTA E1.58-2017, *Electrical Safety Standard for Portable Stage and Studio Equipment Used Outdoors*, for information on the use of portable stage and studio lighting equipment outdoors.

Portable indoor stage or studio equipment that is not marked as suitable for wet or damp locations is permitted to be used temporarily in outdoor locations. If rain occurs, this equipment is typically de-energized, and a protective cover is installed before it is re-energized. At the end of the day, the equipment is either de-energized and protected or dismantled and stored.

Part II. Fixed Stage Switchboards

520.21 General. Fixed stage switchboards shall comply with the following:

(1) Fixed stage switchboards shall be listed.
(2) Fixed stage switchboards shall be readily accessible but shall not be required to be located on or adjacent to the stage. Multiple fixed stage switchboards shall be permitted at different locations.
(3) A fixed stage switchboard shall contain overcurrent protective devices for all branch circuits supplied by that switchboard.
(4) A fixed stage switchboard shall be permitted to supply both stage and nonstage equipment.
(5) Fixed stage switchboards shall comply with the marking and working space requirements in 408.18(C) but shall not be required to comply with the load terminal location requirements in 408.18(C)(1), (C)(2), and (C)(3).

520.25 Dimmers. Dimmers shall comply with 520.25(A) through (C).

A high-density digital dimmer rack typically contains one dimmer (usually of 20-, 50-, or 100-ampere capacity) for each branch circuit connected to it. The rack is usually supplied by a 3-phase, 4-wire-plus-ground feeder, which is distributed via buses to all dimmers in the rack. Typical dimmer racks contain between 12 and 96 dimmers and can have total power capacities of up to 288 kilowatts. In large theatrical systems, many racks may be bused together. A central control electronics module drives multiple dimmers in the rack. A digital data link can connect the dimmer rack to a remotely located computer control console.

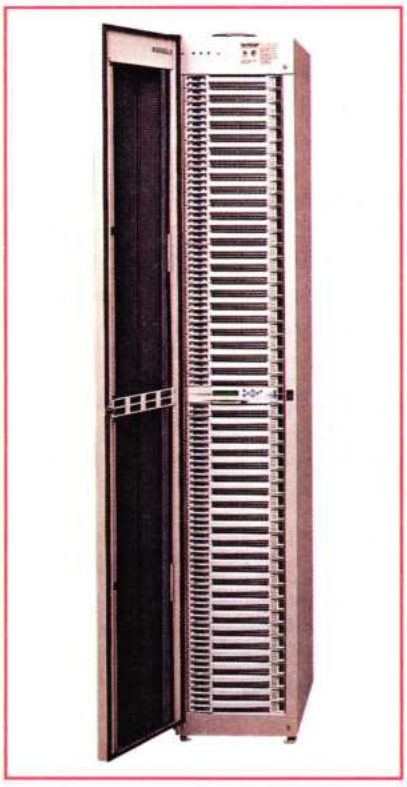

EXHIBIT 520.1 A typical high-density digital SCR dimmer switchboard. *(Courtesy of Electronic Theatre Controls, Inc.)*

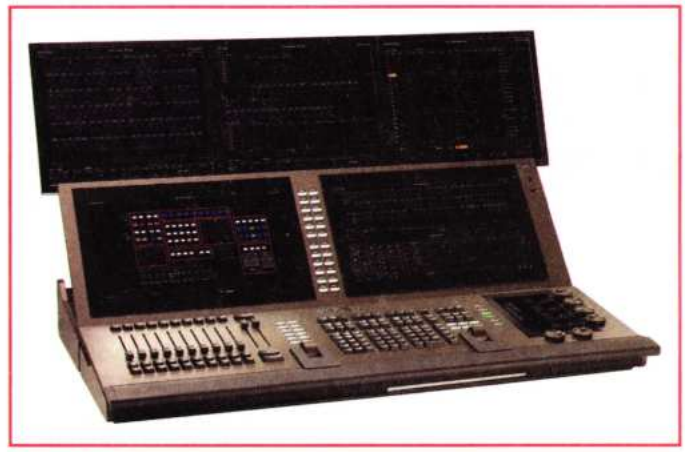

EXHIBIT 520.2 An electronic computer lighting control console for remotely controlling solid-state-type dimmers. (*Courtesy of Electronic Theatre Controls, Inc.*)

Exhibit 520.1 shows a high-density digital silicon-controlled rectifier (SCR) dimmer switchboard. Dimmers for individual circuits are contained in dual plug-in dimmer modules, which also contain circuit breakers for overcurrent protection and filter chokes to minimize acoustic noise from the lamp filaments. The digital control electronics in this exhibit are contained in a plug-in module with front-panel controls for configuration and testing.

(A) Disconnection and Overcurrent Protection. If dimmers are installed in ungrounded conductors, each dimmer shall have overcurrent protection not greater than 125 percent of the dimmer rating and shall be disconnected from all ungrounded conductors where the master or individual switch or circuit breaker supplying such dimmer is in the open position.

(B) Autotransformer-Type Dimmers. The circuit supplying an autotransformer-type dimmer shall not exceed 150 volts between conductors. The grounded conductor shall be common to the input and output circuits.

Informational Note: See 210.9 for circuits derived from autotransformers.

Any desired voltage may be applied to the lamps, from full-line voltage to voltage so low that the lamps provide no illumination, by means of a movable contact tap. This type of dimmer produces very little heat and operates at high efficiency. Its dimming effect, within its maximum rating, is independent of the wattage of the load.

(C) Solid-State-Type Dimmers. The circuit supplying a solid-state dimmer shall not exceed 150 volts between conductors unless the dimmer is listed specifically for higher voltage operation. Where a grounded conductor supplies a dimmer, it shall be common to the input and output circuits. Dimmer chassis shall be connected to the equipment grounding conductor.

Solid-state stage dimmers are often used since stage switchboards are usually remote controlled. The switchboard or dimmer rack normally is located offstage in a dimmer room, where proper climate control can be furnished and noise from the rack cooling fans does not interfere with the performance onstage. Branch circuits usually are connected to the dimmer rack on a dimmer-per-circuit basis. One or more control cables connect the dimmer rack to a remote lighting control console, such as the computer-style one shown in Exhibit 520.2, which can be located onstage or in the auditorium in view of the stage.

520.26 Type of Switchboard. A stage switchboard shall be either one or a combination of the types specified in 520.26(A), (B), (C), and (D).

(A) Manual. Dimmers and switches are operated by handles mechanically linked to the control devices.

(B) Remotely Controlled. Devices are operated electrically from a pilot-type control console or panel. Pilot control panels either shall be part of the switchboard or shall be permitted to be at another location.

(C) Intermediate. A stage switchboard with circuit interconnections is a secondary switchboard (patch panel) or panelboard remote to the primary stage switchboard. It shall contain overcurrent protection. Where the required branch-circuit overcurrent protection is provided in the dimmer panel, it shall be permitted to be omitted from the intermediate switchboard.

The intermediate-stage switchboard located between the dimmer switchboard and the branch circuits is usually called a patch

panel. Its purpose is to break down larger dimmer circuits to smaller branch circuits, to select the branch circuits to be controlled by a dimmer, or both.

(D) Constant Power. A stage switchboard containing only overcurrent protective devices and no control elements.

520.27 Stage Switchboard Feeders.

(A) Type of Feeder. Feeders supplying stage switchboards shall be one of the types in 520.27(A)(1) through (A)(3).

(1) Single Feeder. A single feeder disconnected by a single disconnect device.

(2) Multiple Feeders to Intermediate Stage Switchboard (Patch Panel). Multiple feeders of unlimited quantity shall be permitted, provided that all multiple feeders are part of a single system. Where combined, neutral conductors in a given raceway shall be of sufficient ampacity to carry the maximum unbalanced current supplied by multiple feeder conductors in the same raceway, but they need not be greater than the ampacity of the neutral conductor supplying the primary stage switchboard. Parallel neutral conductors shall comply with 310.10(G).

Stage switchboard feeders are often many dimmer-controlled circuits at 100 amperes or less, single phase, so they can be distributed to different combinations of the same size or smaller branch circuits. This type of installation usually requires a common neutral, and because of the quantity of circuits, many installations require several parallel neutrals running in several raceways. Generally, these parallel neutrals are sized as follows: (1) size the common neutral to the feeder of the primary switchboard, then (2) split the neutral into multiple parallel conductors, one per raceway. In no case are the ungrounded conductors permitted to be installed in one raceway and the common neutral installed in another.

(3) Separate Feeders to Single Primary Stage Switchboard (Dimmer Bank). Installations with separate feeders to a single primary stage switchboard shall have a disconnecting means for each feeder. The primary stage switchboard shall have a permanent and obvious label stating the number and location of disconnecting means. If the disconnecting means are located in more than one distribution switchboard, the primary stage switchboard shall be provided with barriers to correspond with these multiple locations.

Large primary stage switchboards usually consist of several sections, often called dimmer racks, that form a dimmer bank. The dimmer racks can be fed separately or bused together to accept one or more feeder circuits. In older theaters where an intermediate stage switchboard is connected to a primary stage switchboard, a single large feeder usually supplies the primary stage switchboard, because the intermediate stage switchboard patches only the ungrounded conductors and requires a common neutral.

(B) Neutral Conductor. For the purpose of ampacity adjustment, the following shall apply:

(1) The neutral conductor of feeders supplying solid-state, phase-control 3-phase, 4-wire dimming systems shall be considered a current-carrying conductor.
(2) The neutral conductor of feeders supplying solid-state, sine wave 3-phase, 4-wire dimming systems shall not be considered a current-carrying conductor.
(3) The neutral conductor of feeders supplying systems that use or are capable of using both phase-control and sine wave dimmers shall be considered as current-carrying.

The neutral is not always considered a current-carrying conductor with the use of solid-state dimmers. If the sine wave–type dimmer is the only type in use, the neutral of the circuits supplying it need not be considered a current-carrying conductor. However, if phase-control dimmers are used, or if combinations of phase control– and sine wave–type dimmers are connected to the same feeder or branch circuit, the neutral conductor must be considered a current-carrying conductor. The neutral of feeders supplying solid-state, 3-phase, 4-wire dimming systems carries triplen-harmonic currents that are present even under balanced load conditions.

Δ **(C) Supply Capacity.** For the purposes of calculating supply capacity to switchboards, considering the maximum load that the switchboard is intended to control in a given installation shall be permitted if the following apply:

(1) All feeders supplying the switchboard shall be protected by an overcurrent device with a rating not greater than the ampacity of the feeder.
(2) The opening of the overcurrent device shall not affect the proper operation of the egress or emergency lighting systems.

Informational Note: See 220.40 for calculation of stage switchboard feeder loads.

Part III. Fixed Stage Equipment Other Than Switchboards

520.40 Stage Lighting Hoists. Where a stage lighting hoist is listed as a complete assembly and contains an integral cable-handling system and cable to connect a moving wiring device to a fixed junction box for connection to permanent wiring, the extra-hard usage requirement of 520.44(C)(1) shall not apply.

A listed stage lighting hoist, such as the one shown in Exhibit 520.3, is part of the rigging system. It provides an automated system — as opposed to a manual counterweight system — for lifting and supporting heavy integrated lighting equipment over a stage.

520.41 Circuit Loads.

(A) Circuits Rated 20 Amperes or Less. Footlights, border lights, and proscenium sidelights shall be arranged so that no

EXHIBIT 520.3 A stage lighting hoist. *(Courtesy of Electronic Theatre Controls, Inc.)*

branch circuit supplying such equipment carries a load exceeding 20 amperes.

(B) Circuits Rated Greater Than 20 Amperes. Where only heavy-duty lampholders are used, such circuits shall be permitted to comply with Article 210 for circuits supplying heavy-duty lampholders.

In accordance with 210.23(C) and (D), 30-, 40-, or 50-ampere branch circuits are permitted if heavy-duty lampholders, such as medium- or mogul-base Edison screw shell types, are used for fixed lighting.

520.42 Conductor Insulation. Foot, border, proscenium, or portable strip lights and connector strips shall be wired with conductors that have insulation suitable for the temperature at which the conductors are operated, but not less than 125°C (257°F). The ampacity of the 125°C (257°F) conductors shall be that of 60°C (140°F) conductors. All drops from connector strips shall be 90°C (194°F) wire sized to the ampacity of 60°C (140°F) cords and cables with no more than 150 mm (6 in.) of conductor extending into the connector strip. Section 310.15(C)(1) shall not apply.

Informational Note: See Table 310.4(1) for conductor types.

The 125°C minimum temperature rating is due to the heat from the lamps raising the ambient temperature where the wiring is located. Drops from connector strips usually are flexible cord. The derating factor for more than three current-carrying conductors may not be necessary if the conductors are (1) not all energized at one time or are not often energized at full intensity (dimmed) and (2) not energized continuously.

520.43 Footlights.

(A) Metal Trough Construction. Where metal trough construction is employed for footlights, the trough containing the circuit conductors shall be made of sheet metal not lighter than 0.81 mm (0.032 in.) and treated to prevent oxidation. Lampholder terminals shall be kept at least 13 mm (½ in.) from the metal of the trough. The circuit conductors shall be soldered to the lampholder terminals.

(B) Other-Than-Metal Trough Construction. Where the metal trough construction specified in 520.43(A) is not used, footlights shall consist of individual outlets with lampholders wired with rigid metal conduit, intermediate metal conduit, or flexible metal conduit, Type MC cable, or mineral-insulated, metal-sheathed cable. The circuit conductors shall be soldered to the lampholder terminals.

(C) Disappearing Footlights. Disappearing footlights shall be arranged so that the current supply is automatically disconnected when the footlights are replaced in the storage recesses designed for them.

Historically, the footlights described in 520.43(A) and (B) were built in the field. Modern footlights are compartmentalized, factory-wired assemblies for field installation and may be permanently exposed or be of the disappearing type. Disappearing footlights must automatically disconnect the current supply when the footlights are in the closed position, thereby preventing heat entrapment that could cause a fire. Disconnection is accomplished by switches in the terminal compartment.

520.44 Borders, Proscenium Sidelights, Drop Boxes, and Connector Strips.

(A) General. Borders and proscenium sidelights shall be as follows:

(1) Constructed as specified in 520.43
(2) Suitably stayed and supported

(3) Designed so that the flanges of the reflectors or other guards protect the lamps from mechanical damage and from accidental contact with scenery or other combustible material

These types of stage lighting instruments must be suitably supported and protected from mechanical damage. Commonly, lampholders are wired alternately on three or four circuits. A splice box is provided on top of the housing for enclosing connections between the cable supplying the border light and the border light's internal wiring, which consists of wiring from the splice box to the lamp sockets in a trough extending the length of the border.

(B) Connector Strips and Drop Boxes. Connector strips and drop boxes shall be as follows:

(1) Suitably stayed and supported
(2) Listed as stage and studio wiring devices

(C) Cords and Cables for Border Lights, Drop Boxes, and Connector Strips.

(1) General. Cords and cables for supply to border lights, drop boxes, and connector strips shall be listed for extra-hard usage. The cords and cables shall be suitably supported. Such cords and cables shall be employed only where flexible conductors are necessary. Ampacity of the conductors shall be as provided in 400.5.

Border lights typically are supported by steel cables to facilitate height adjustment for cleaning and lamp replacement, and the circuit conductors supplying the border lights are carried to each border light in flexible cable. Each flexible cable usually contains many circuits; however, its overall length is limited by its ability to travel up and down without getting tangled. See Exhibit 520.4.

(2) Cords and Cables Not in Contact with Heat-Producing Equipment. Listed multiconductor extra-hard usage type cords and cables not in direct contact with equipment containing heat-producing elements shall be permitted to have their ampacity determined by Table 520.44(C)(2)(1). Maximum load current in any conductor with an ampacity determined by Table 520.44(C)(2)(1) shall not exceed the values in Table 520.44(C)(2)(1).

Extra-hard-usage cords and cables not in direct contact with heat-producing equipment are permitted to have their ampacity determined by Table 520.44(C)(2)(1) instead of 400.5(A).

Table 520.44(C)(2)(1) is based on a minimum 50-percent diversity factor. It makes allowance for the fact that not all circuits are on at the same time, not all circuits are at full intensity (dimmed), and not all circuits are on for a long period of time. If the load diversity does not follow this pattern, such as border lights that are all left on at full intensity to light the stage for rehearsal, lecture, or classroom purposes, Table 520.44(C)(2)(1) must not be used.

Flexible cords and cables are permitted to be used only where necessary, such as for border lights requiring height adjustment, otherwise Chapter 3 wiring methods are required for fixed connections. These fixed conductors are required to follow the ampacity calculations in Article 310, but the adjustment factors in 310.15(C)(1) do not take into account load diversity. Informational Note No. 1 to 310.15(C)(1) refers to Annex B [see Table B.2(11)] for adjustment factors with at least a 50-percent load diversity. This annex table for Chapter 3 wiring methods correlates with the flexible cord adjustment factors in Table 520.44(C)(2)(1) for a load diversity of 50 percent.

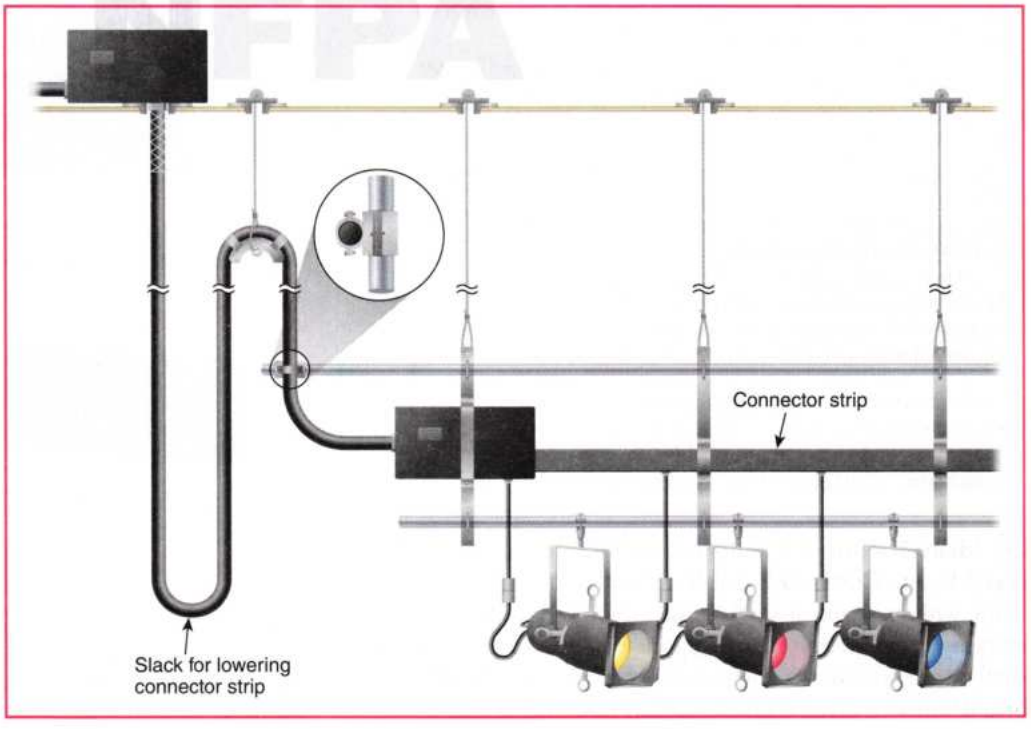

EXHIBIT 520.4 A suspended connector strip with spotlights attached.

Δ ***TABLE 520.44(C)(2)(1)*** *Ampacity of Listed Extra-Hard Usage Cords and Cables with Temperature Ratings of 75°C (167°F) and 90°C (194°F) [Based on Ambient Temperature of 30°C (86°F)]*

Size (AWG)	Temperature Rating of Cords and Cables		Maximum Rating of Overcurrent Device
	75°C (167°F)	90°C (194°F)	
14	24	28	15
12	32	35	20
10	41	47	25
8	57	65	35
6	77	87	45
4	101	114	60
2	133	152	80

Note: Ampacity shown is the ampacity for multiconductor cords and cables where only three copper conductors are current-carrying in accordance with 400.5. If the number of current-carrying conductors in a cord or cable exceeds three and the load diversity is 50 percent or less, the ampacity of each conductor shall be reduced as shown in Table 520.44(C)(2)(2):

N ***TABLE 520.44(C)(2)(2)*** *Ampacity Adjustment Factors for More Than Three Current-Carrying Conductors in a Cord or Cable Where Load Diversity Is 50 Percent or Less*

Number of Conductors	Percent of Ampacity Value in Table 520.44(C)(2)(1)
4–6	80
7–24	70
25–42	60
43 and above	50

Note: Ultimate insulation temperature. In no case shall conductors be associated together in such a way with respect to the kind of circuit, the wiring method used, or the number of conductors such that the temperature limit of the conductors is exceeded.

A neutral conductor that carries only the unbalanced current from other conductors of the same circuit need not be considered as a current-carrying conductor.

In a 3-wire circuit consisting of two-phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, the neutral conductor carries approximately the same current as the line-to-neutral currents of the other conductors and shall be considered to be a current-carrying conductor.

On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, there are harmonic currents in the neutral conductor. Therefore, the neutral conductor shall be considered to be a current-carrying conductor.

Informational Note: For the purposes of Table 520.44(C)(2)(1), load diversity is the percentage of the total current of all simultaneously energized circuits fed by the cable to the sum of the ampacities of all pairs of circuit conductors in that cable.

(3) Identification of Conductors in Multiconductor Extra-Hard-Usage Cords and Cables. Neutral conductors shall be white without stripe or shall be identified by a distinctive white marking at their terminations. Equipment grounding conductors shall be green with or without yellow stripe or shall be identified by a distinctive green marking at their terminations.

520.45 Receptacles. Receptacles for electrical equipment on stages shall be rated in amperes. Conductors supplying receptacles shall be in accordance with Articles 310 and 400.

520.46 Connector Strips, Drop Boxes, Floor Pockets, and Other Outlet Enclosures. Receptacles for the connection of portable stage-lighting equipment shall be pendant or mounted in pockets or enclosures and shall comply with 520.45. Supply cables for connector strips and drop boxes shall be as specified in 520.44(C).

Exhibit 520.4 shows a hanging connector strip with its associated hardware and flexible cable allowing for height adjustment. Exhibits 520.5 and 520.6 illustrate two types of connections for portable stage lighting equipment.

520.47 Backstage Lamps (Bare Bulbs). Lamps (bare bulbs) installed in backstage and ancillary areas where they can come in contact with scenery shall be located and guarded so as to be free from physical damage and shall provide an air space of not less than 50 mm (2 in.) between such lamps and any combustible material.

Exception: Decorative lamps installed in scenery shall not be considered to be backstage lamps for the purpose of this section.

520.48 Curtain Machines. Curtain machines shall be listed.

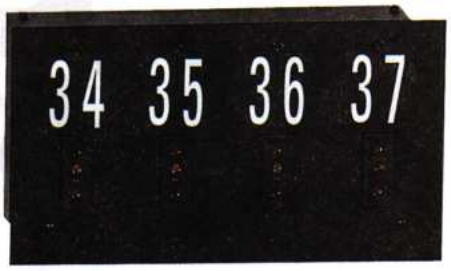

EXHIBIT 520.5 A 4-gang, 4-receptacle pin-plug outlet box designed for flush mounting. *(Courtesy of Electronic Theatre Controls, Inc.)*

EXHIBIT 520.6 A typical three-circuit connector strip designed for wall or pipe mounting. *(Courtesy of Electronic Theatre Controls, Inc.)*

520.49 Smoke Ventilator Control. Where stage smoke ventilators are released by an electrical device, the circuit operating the device shall be normally closed and shall be controlled by at least two externally operable switches, one switch being placed at a readily accessible location on stage and the other where designated by the authority having jurisdiction. The device shall be designed for the full voltage of the circuit to which it is connected, no resistance being inserted. The device shall be enclosed in a metal box having a door that shall remain closed except during service to the equipment.

In addition to the two externally operable switches at different locations, the design of a normally closed circuit ensures that smoke ventilators operate when the circuit opens for any reason, such as a circuit breaker tripping or a fuse blowing.

Part IV. Portable Switchboards on Stage

520.50 Road Show Connection Panel (A Type of Patch Panel). A panel designed to allow for road show connection of portable stage switchboards to fixed lighting outlets by means of permanently installed supplementary circuits. The panel, supplementary circuits, and outlets shall comply with 520.50(A) through (D).

Also known as a road show interconnect or intercept panel, this panel is designed to connect the load side of a portable switchboard to the fixed building branch circuits and associated outlets. It may also provide for the fixed branch circuits to be connected to a fixed switchboard when the portable switchboard is not installed.

(A) Load Circuits. Circuits shall originate from grounding-type polarized inlets of current and voltage rating that match the fixed-load receptacle.

The required grounding-type polarized inlets may be flush or pendant. The fixed-load receptacle is where the portable switchboard connects to the house circuits to control the theater lights.

(B) Circuit Transfer. Circuits that are transferred between fixed and portable switchboards shall have all circuit conductors transferred simultaneously.

(C) Overcurrent Protection. The supply devices of these supplementary circuits shall be protected by branch-circuit overcurrent protective devices. Each supplementary circuit, within the road show connection panel and theater, shall be protected by branch-circuit overcurrent protective devices installed within the road show connection panel.

Because inlets feeding permanent circuits are cord-and-plug-connected to a portable switchboard, there is no guarantee that the branch circuit overcurrent protective devices (OCPDs) in the switchboard will be rated correctly for the ampacity of the permanent circuit conductors fed by the panel. That is why supplemental overcurrent protection is provided for every inlet in a road show connection panel.

(D) Enclosure. Panel construction shall be in accordance with Article 408.

520.51 Supply. Portable switchboards shall be supplied only from power outlets of sufficient voltage and ampere rating. Such power outlets shall include only externally operable, enclosed fused switches or circuit breakers mounted on stage or at the permanent switchboard in locations readily accessible from the stage floor. Provisions for connection of an equipment grounding conductor shall be provided. For the purposes of ampacity adjustment, the requirements of 520.27(B) shall apply.

Power outlets, known in the entertainment industry as company switches or bull switches, are the point in the wiring system where portable feeder cables connect to the fixed building wiring. They can be as simple as an overcurrent-protected multipole receptacle designed to accept the supply cable described in 520.54(K), Exception, or they can be multiple sets of parallel single-conductor feeder cables. These single-conductor feeder cables, as described in 520.54(C), can be terminated via single-pole separable connectors, as described in 520.53(C), or directly to busbars, fused disconnect switches, or circuit breakers with wire connectors (lugs).

520.52 Overcurrent Protection for Branch Circuits. Portable switchboards shall contain overcurrent protection for branch circuits. The requirements of 210.23 shall not apply.

520.53 Construction. Portable stage switchboards shall be listed and shall comply with 520.53(A) through (E). The load

EXHIBIT 520.7 A large, portable SCR dimmer switchboard (rolling rack). *(Courtesy of Electronic Theatre Controls, Inc.)*

terminal location requirements in 408.18(C)(1), (C)(2), and (C)(3) shall not apply to portable stage switchboards.

Exhibit 520.7 illustrates a portable switchboard known as a rolling rack.

(A) Pilot Light. A pilot light shall be provided for each ungrounded conductor feeding the switchboard. The pilot light(s) shall be connected to the incoming feeder so that operation of the main overcurrent protective device or master switch shall not affect the operation of the pilot light(s).

This requirement applies to switchboards with or without a main disconnect provided on the switchboard. The pilot light serves as a warning at the switchboard to indicate the presence of power, whether or not there is a main disconnect in the portable switchboard, and before an integral main disconnect is activated.

(B) Neutral Terminal. In portable switchboard equipment designed for use with 3-phase, 4-wire with ground supply, the current rating of the supply neutral terminal, and the ampacity of its associated busbar or wiring, or both, shall have an ampacity equal to at least twice the ampacity of the largest ungrounded supply terminal.

Exception: Where portable switchboard equipment is specifically constructed and identified to be internally converted in the field, in an approved manner, from use with a balanced 3-phase, 4-wire with ground supply to a balanced single-phase, 3-wire with ground supply, the supply neutral terminal and its associated busbar, wiring, or both, shall have an ampacity equal to at least that of the largest ungrounded single-phase supply terminal.

If a 3-phase, 4-wire portable switchboard is brought into a space that has only single-phase, 3-wire service, the switchboard most likely will be connected with one leg feeding two phases and the other leg feeding the third phase of the switchboard. This type of connection increases the current flowing through the neutral, so the neutral terminal and busbar must be rated for double size to allow for that possibility. The exception to 520.53(B) provides for a neutral sized for the single-phase feed where a switchboard contains devices that can divide the B-phase load equally between the A-phase and C-phase buses for single-phase operation.

Δ **(C) Single-Pole Separable Connectors.** Single-pole separable connectors shall comply with 406.13. Sections 400.14, 406.7, and 406.8 shall not apply to listed single-pole separable connectors and single-conductor cable assemblies utilizing listed single-pole separable connectors. Where paralleled sets of current-carrying, single-pole separable connectors are provided as input devices, they shall be prominently labeled with a warning indicating the presence of internal parallel connections.

A listed, special type of connection device suitable for connecting single-conductor feeder cables must be of the locking type to reduce the likelihood of its separating while under load. The connectors must be used in sets because they are only single-pole types. The connector sets must be arranged to reduce the likelihood that connections are made in the incorrect order, in accordance with one of the following methods:

1. The supply disconnect cannot be energized until all conductor connectors are connected. This includes equipment grounding conductors (EGCs), grounded conductors (if used), and ungrounded conductors.
2. The connectors are precluded from being connected in any order other than the proper one (first make/last break of the grounding conductor and connect next-to-first and disconnect next-to-last for the grounded conductor).
3. The individual connectors, free of any special electromechanical intervention, are marked with instructions to the user regarding proper connection.

Single-pole separable connectors are quick-connect feeder splicing and terminating devices, not attachment plugs or receptacles. They are designed to be sized, terminated, and inspected by a qualified person before being energized and are to be guarded from accidental disconnection before being de-energized.

See also

Article 100 for the definition of *single-pole separable connector*

406.13 for the general requirements covering the use of single-pole separable connectors

(D) Supply Feed-Through. Where a portable stage switchboard contains a feed-through outlet of the same rating as its supply inlet, the feed-through outlet shall not require overcurrent protection in the switchboard.

(E) Interior Conductors. All conductors other than busbars within the switchboard enclosure shall be stranded.

520.54 Supply Conductors.

(A) General. The supply to a portable stage switchboard shall be by means of listed extra-hard usage cords or cables. The supply cords or cables shall terminate within the switchboard enclosure in an externally operable fused master switch or circuit breaker or in an identified connector assembly. The supply cords or cable (and connector assembly) shall have current ratings not less than the total load connected to the switchboard and shall be protected by overcurrent devices.

As with the supply end described in 520.51, the termination connection required in 520.54(A) could be as simple as a permanently terminated multiconductor supply cord or multipole connector assembly (inlet) or as complex as a set of parallel single-conductor feeder cables. These cables can be field-connected to an assembly of single-pole connectors (inlet) or directly connected, with wire connectors, to busbars or a fused switch or breaker.

Road shows are permitted to size the feeder to the actual connected load rather than sizing it based on the overcurrent protection rating. Section 220.40 provides the requirements for sizing the feeder or service. Sections 520.54(D) and (E) provide rules under which conductors are permitted to be reduced in size.

(B) Conductor Sizing. The power supply conductors for portable stage switchboards utilizing solid-state phase control dimmers shall be sized considering the neutral conductor as a current-carrying conductor for ampacity adjustment purposes. The power supply conductors for portable stage switchboards utilizing only solid-state sine wave dimmers shall be sized considering the neutral conductor as a non–current carrying conductor for ampacity adjustment purposes.

(C) Single-Conductor Cables. Single-conductor portable supply cable sets shall be not smaller than 2 AWG conductors. The equipment grounding conductor shall not be smaller than 6 AWG conductor. Single-conductor grounded neutral cables for a supply shall be sized in accordance with 520.54(J). Where single conductors are paralleled for increased ampacity, the paralleled conductors shall be of the same length and size. Single-conductor supply cables shall be grouped together but not bundled. The equipment grounding conductor shall be permitted to be of a different type if it meets the other requirements of this section, and it shall be permitted to be reduced in size in accordance with 250.122. Grounded (neutral) and equipment grounding conductors shall be identified in accordance with 200.6, 250.119, and 310.6. Grounded conductors shall be permitted to be identified by marking at least the first 150 mm (6 in.) from both ends of each length of conductor with white or gray. Equipment grounding conductors shall be permitted to be identified by marking at least the first 150 mm (6 in.) from both ends of each length of conductor with green or green with yellow stripes. Where more than one nominal voltage exists within the same premises, each ungrounded conductor shall be identified by system.

(D) Supply Conductors Not Over 3 m (10 ft) Long. Where supply conductors do not exceed 3 m (10 ft) in length between supply and switchboard or supply and a subsequent overcurrent device, the supply conductors shall be permitted to be reduced in size where all of the following conditions are met:

(1) The ampacity of the supply conductors shall be at least one-quarter of the current rating of the supply overcurrent protective device.
(2) The supply conductors shall terminate in a single overcurrent protective device that will limit the load to the ampacity of the supply conductors. This single overcurrent device shall be permitted to supply additional overcurrent devices on its load side.
(3) The supply conductors shall not penetrate walls, floors, or ceilings or be run through doors or traffic areas. The supply conductors shall be protected from physical damage.
(4) The supply conductors shall be suitably terminated in an approved manner.
(5) Conductors shall be continuous without splices or connectors.
(6) Conductors shall not be bundled.
(7) Conductors shall be supported above the floor in an approved manner.

(E) Supply Conductors Not Over 6 m (20 ft) Long. Where supply conductors do not exceed 6 m (20 ft) in length between supply and switchboard or supply and a subsequent overcurrent protection device, the supply conductors shall be permitted to be reduced in size where all of the following conditions are met:

(1) The ampacity of the supply conductors shall be at least one-half of the current rating of the supply overcurrent protective device.
(2) The supply conductors shall terminate in a single overcurrent protective device that limits the load to the ampacity of the supply conductors. This single overcurrent device shall be permitted to supply additional overcurrent devices on its load side.
(3) The supply conductors shall not penetrate walls, floors, or ceilings or be run through doors or traffic areas. The supply conductors shall be adequately protected from physical damage.
(4) The supply conductors shall be suitably terminated in an approved manner.
(5) The supply conductors shall be supported in an approved manner at least 2.1 m (7 ft) above the floor except at terminations.
(6) The supply conductors shall not be bundled.
(7) Tap conductors shall be in unbroken lengths.

Similar to the requirements for feeder taps in 240.21(B), 520.54(D) and (E) permit supply conductors for portable switchboards to be sized according to their overcurrent protection, not by the total connected load. Loads of 144 kilovolt-amperes and greater are not uncommon, even on portable switchboard equipment. Installations in the field include lighting for theatrical-type productions with large numbers of stage lighting fixtures. However, only a fraction of the many fixtures installed are used at any one time.

These rules are intended to allow one or more switchboards with smaller feeders to be connected to larger supplies (company switches). If the requirements cannot be met, properly sized fixed or portable OCPDs must be provided for each of the smaller switchboards.

Column D of Table 400.5(A)(2) can be used if the conductors are not bundled. If the conductors are bundled, column F and all applicable derating factors apply. Some devices used in the theater to terminate single-conductor cables are rated for use at 90°C. However, if single-conductor cables are terminated directly to a circuit breaker or fused switch, the temperature limitations of the terminations might be lower than 90°C.

(F) Supply Conductors Not Reduced in Size. Supply conductors not reduced in size under 520.54(D) or (E) shall be permitted to pass through holes in walls specifically designed for the purpose. If penetration is through the fire-resistant–rated wall, it shall be in accordance with 300.21.

(G) Protection of Supply Conductors and Connectors. All supply conductors and connectors shall be protected against

physical damage by an approved means. This protection shall not be required to be raceways.

(H) Number of Supply Interconnections. Where connectors are used in a supply conductor, there shall be a maximum number of three interconnections (mated connector pairs) where the total length from supply to switchboard does not exceed 30 m (100 ft). In cases where the total length from supply to switchboard exceeds 30 m (100 ft), one additional interconnection shall be permitted for each additional 30 m (100 ft) of supply conductor.

Excessive numbers of interconnections could jeopardize the mechanical and electrical integrity of the supply conductors.

(I) Single-Pole Separable Connectors. Where single-pole portable cable connectors are used, they shall be listed and of the locking type. Sections 406.7 and 406.8 shall not apply to listed single-pole separable connectors and single-conductor cable assemblies utilizing listed single-pole separable connectors.

(J) Supply Neutral Conductor. Supply neutral conductors shall comply with 520.54(J)(1) and (J)(2).

(1) Marking. Grounded neutral conductors shall be permitted to be identified by marking at least the first 150 mm (6 in.) from both ends of each length of conductor with white or gray.

(2) Conductor Sizing. Where single-conductor feeder cables not installed in raceways are used on multiphase circuits feeding portable stage switchboards containing solid-state phase-control dimmers, the grounded neutral conductor shall have an ampacity of at least 130 percent of the ungrounded circuit conductors feeding the portable stage switchboard. Where such feeders are supplying only solid-state sine wave dimmers, the grounded neutral conductor shall have an ampacity of at least 100 percent of the ungrounded circuit conductors feeding the portable stage switchboard.

Three-phase, 4-wire switchboards that contain solid-state phase-control dimming devices must, when connected to a 3-phase, 4-wire supply, be connected to that supply with a multiconductor cable sized by counting the neutral as a current-carrying conductor or with a set of single-conductor cables where the neutral is sized at 130 percent of the ungrounded conductors.

Solid-state sine-wave dimmers are linear devices that do not add nonlinear loads to the neutral conductor. Where feeders supply solid-state sine-wave dimmers, the neutral conductor is sized by considering it a non–current-carrying conductor. However, it must have an ampacity of at least 100 percent of the ampacity of the phase conductors.

(K) Qualified Persons. The routing of portable supply conductors, the making and breaking of supply connectors and other supply connections, and the energization and de-energization of supply services shall be performed by qualified persons, and portable switchboards shall be so marked, indicating this requirement in a permanent and conspicuous manner.

Exception: A portable switchboard shall be permitted to be connected to a permanently installed supply receptacle by other than qualified persons provided that the supply receptacle is protected for its current rating by an overcurrent device of not greater than 150 amperes, and where the receptacle, interconnection, and switchboard comply with all of the following:

(1) They employ listed multipole connectors for every supply interconnection.
(2) They prevent access to all supply connections by the general public.
(3) They employ listed extra-hard usage multiconductor cords or cables with an ampacity not less than the load and not less than the ampere rating of the connectors.

This requirement divides the acceptable practices and requirements for professional and professional-grade educational venues (qualified) from those for amateur or amateur-grade educational venues (other than qualified). The requirements allow for such things as single-conductor feeder systems, feeders sized for the current-connected load, tap rules, and so forth, and require the services of a qualified person. The exception provides for a conventional feeder system suitable for use by an untrained person.

Part V. Portable Stage Equipment Other Than Switchboards

520.61 Arc Lamps. Arc lamps, including enclosed arc lamps and associated ballasts, shall be listed. Interconnecting cord sets and interconnecting cords and cables shall be extra-hard usage type and listed.

520.62 Portable Power Distribution Units. Portable power distribution units shall comply with the requirements of 520.62(A) and (B).

N **(A) Listing.** Portable power distribution units shall be listed.

(B) Single-Conductor Feeder Systems. Portable power distribution equipment fed by single-conductor feeder systems shall comply with the requirements of 520.53(C) and (D) and 520.54.

520.63 Bracket Fixture Wiring.

(A) Bracket Wiring. Brackets for use on scenery shall be wired internally, and the fixture stem shall be carried through to the back of the scenery where a bushing shall be placed on the end of the stem. Externally wired brackets or other fixtures shall be permitted where wired with cords designed for hard usage that extend through scenery and without joint or splice in canopy of fixture back and terminate in an approved-type stage connector located, where practical, within 450 mm (18 in.) of the fixture.

(B) Mounting. Fixtures shall be securely fastened in place.

520.64 Portable Strips. Portable strips shall be constructed in accordance with the requirements for border lights and proscenium sidelights in 520.44(A). The supply cable shall be protected by bushings where it passes through metal and shall be arranged so that tension on the cable will not be transmitted to the connections.

Informational Note No. 1: See 520.42 for wiring of portable strips.

Informational Note No. 2: See 520.68(A)(4) for insulation types required on single conductors.

520.65 Festoons. Joints in festoon wiring shall be staggered. Where such lampholders have terminals of a type that puncture the insulation and make contact with the conductors, they shall be attached only to conductors of the stranded type. Lamps enclosed in lanterns or similar devices of combustible material shall be equipped with guards.

Staggering joints in festoon wiring ensures that connections are not opposite one another. Joints that are not staggered could cause sparking due to improper insulation or unraveling of insulation, which, in turn, could ignite lanterns or other combustible material enclosing lamps. Where lampholders have terminals that puncture the conductor insulation to make contact with the conductors, stranded conductors must be used.

See also

Article 100 for the definition of *festoon lighting*

520.66 Special Effects. Electrical devices used for simulating lightning, waterfalls, and the like shall be constructed and located so that flames, sparks, or hot particles cannot come in contact with combustible material.

520.67 Multipole Branch-Circuit Cable Connectors. Multipole branch-circuit cable connectors, male and female, for flexible conductors shall be constructed so that tension on the cord or cable is not transmitted to the connections. The female half shall be attached to the load end of the power supply cord or cable. The connector shall be rated in amperes and designed so that differently rated devices cannot be connected together; however, a 20-ampere T-slot receptacle shall be permitted to accept a 15-ampere attachment plug of the same voltage rating. Alternating-current multipole connectors shall be polarized and comply with 406.7 and 406.10.

Informational Note: See 400.14 for pull at terminals.

520.68 Conductors for Portables.

(A) Conductor Type.

(1) General. Flexible conductors, including cable extensions, used to supply portable stage equipment shall be listed extra-hard usage cords or cables.

(2) Protected Applications. Listed, hard usage (junior hard service) cord or cable shall be permitted where all of the following conditions are met:

(1) The cord or cable is protected from physical damage by attachment over its entire length to a pipe, tower, truss, scaffold, or other substantial support structure, or installed in a location that inherently prevents physical damage to the cord.
(2) The cord or cable is connected to a branch circuit protected by an overcurrent protective device rated at not over 20 amperes.
(3) The cord or cable does not exceed 30 m (100 ft) in length.

(3) Stand Lamps. Listed, hard usage cord shall be permitted to supply stand lamps where the cord is not subject to physical damage and is protected by an overcurrent device rated at not over 20 amperes.

One of the most common stand lamps is a ghostlight, as shown in Exhibit 520.8. Ghostlights typically are placed on a stage outside of performance and rehearsal times to keep the theater from being in total darkness.

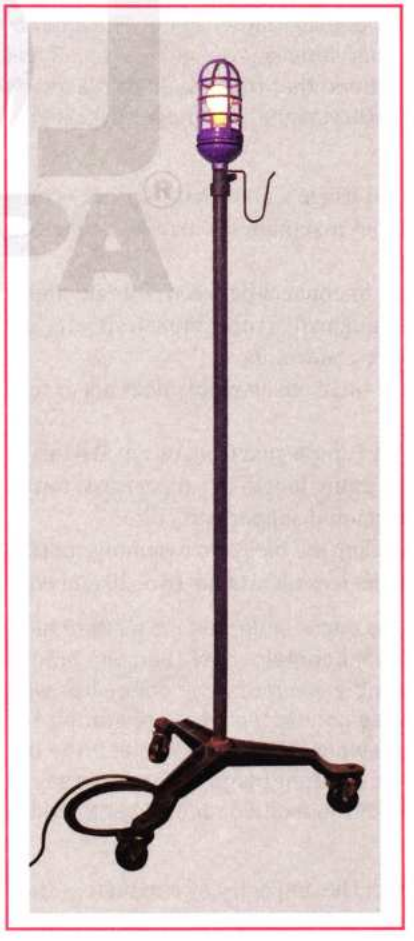

EXHIBIT 520.8 A stand lamp known as a ghostlight. *(Courtesy of Behind the Scenes Foundation)*

(4) Luminaire Supply Cords. Listed hard usage supply cords shall be permitted to supply luminaires if all of the following conditions are met:

(1) The supply cord is not longer than 2.0 m (6.6 ft).
(2) The supply cord is attached at one end to the luminaire or a luminaire-specific listed connector that mates with a panel-mounted inlet on the body of the luminaire.
(3) The supply cord is protected by an overcurrent protective device of not more than 20 amperes.
(4) The luminaire is listed.
(5) The supply cord is not subject to physical damage.

(5) High-Temperature Applications. A special assembly of conductors in sleeving not longer than 1.0 m (3.3 ft) shall be permitted to be employed in lieu of flexible cord if the individual wires are stranded and rated not less than 125°C (257°F) and the outer sleeve is glass fiber with a wall thickness of at least 0.635 mm (0.025 in.).

Portable stage equipment requiring flexible supply conductors with a higher temperature rating where one end is permanently attached to the equipment shall be permitted to employ alternate conductors as determined by a qualified testing laboratory and recognized test standards.

Stage equipment, such as stage lighting fixtures, often operate at elevated temperatures. High-temperature (150°C to 250°C), extra-hard-usage cords are not generally available. The alternative use of conductors in a glass fiber sleeve is limited to 3.3 feet in length to reduce the likelihood that they would be placed on the floor or other area where they might be damaged by traffic or moving scenery.

(6) Breakouts. Listed, hard usage (junior hard service) cords shall be permitted in breakout assemblies where all of the following conditions are met:

(1) The cords are utilized to connect between a single multipole connector containing two or more branch circuits and multiple 2-pole, 3-wire connectors.
(2) The longest cord in the breakout assembly does not exceed 6.0 m (20 ft).
(3) The breakout assembly is protected from physical damage by attachment over its entire length to a pipe, truss, tower, scaffold, or other substantial support structure.
(4) All branch circuits feeding the breakout assembly are protected by overcurrent devices rated at not over 20 amperes.

These requirements apply to multiconductor cable assemblies with multipole connectors that contain more than one branch circuit. The breakout assembly is a multipole connector with several pendant receptacles connected to it, separating the multiple branch circuits into individual branch circuits. The use of a similar arrangement of pendant plugs to form a break-in assembly on the other end of the multiconductor cable is also possible.

(B) Conductor Ampacity. The ampacity of conductors shall be as given in 400.5, except multiconductor, listed, extra-hard usage portable cords that are not in direct contact with equipment containing heat-producing elements shall be permitted to have their ampacity determined by Table 520.44(C)(2)(1). Maximum load current in any conductor with an ampacity determined by Table 520.44(C)(2)(1) shall not exceed the values in Table 520.44(C)(2)(1). Where the ampacity adjustment factors of Table 520.44(C)(2)(2) are applied for more than three current-carrying conductors in a portable cord, the load diversity shall be 50 percent or less.

Exception: Where alternate conductors are allowed in 520.68(A)(5), their ampacity shall be as given in the appropriate table in this Code for the types of conductors employed.

Listed portable, multiconductor cable is permitted to be sized in accordance with Table 520.44(C)(2)(1) and Table 520.44(C)(2)(2), similar to the method used for border light cable. A cable, used in lieu of a connector strip, directly above heat-producing equipment should be spaced sufficiently above that equipment to avoid the elevated temperatures or should be sized in accordance with 400.5.

(C) Overcurrent Protection. Overcurrent protection of conductors for portables shall comply with 240.5.

N **(D) Special-Purpose Multicircuit Cable Systems.** Special-purpose multicircuit cable systems shall comply with the following requirements:

(1) Branch circuits shall be rated at not more than 20 amperes and not more than 150 volts to ground.
(2) Trunk cable types shall be extra-hard usage (hard service) or hard usage (junior hard service).
(3) The ampacity of trunk cables shall be determined in accordance with Table 520.44(C)(2)(1).
(4) Trunk cables, breakout assemblies, and multicircuit enclosures shall be listed.
(5) Section 406.4(F) shall not apply to multicircuit, multipole plugs or receptacles that are part of a special-purpose multicircuit cable system.
(6) All multicircuit, multipole connectors shall be clearly marked with the voltage of the branch circuits serviced by the connector.
(7) Installation and operation shall be performed by qualified persons.

520.69 Adapters. Adapters, two-fers, and other single- and multiple-circuit outlet devices shall comply with 520.69(A), (B), and (C).

(A) No Reduction in Current Rating. Each receptacle and its corresponding cable shall have the same current and voltage rating as the plug supplying it. It shall not be utilized in a stage circuit with a greater current rating.

(B) Connectors. All connectors shall be wired in accordance with 520.67.

Plugs and receptacles must be of the same rating even though available adapters allow connector bodies to be connected to a plug of a larger rating. For example, a 12 AWG conductor with an ampacity of 20 amperes could be connected to a 100-ampere circuit via an adapter. An overload could result in a fire because the circuit breaker or fuse would not provide adequate protection.

(C) Conductor Type. Conductors for adapters and two-fers shall be listed extra-hard usage or listed hard usage (junior hard service) cord. Hard usage (junior hard service) cord shall be restricted in overall length to 2.0 m (6.6 ft).

Part VI. Dressing Rooms, Dressing Areas, and Makeup Areas.

520.71 Pendant Lampholders. Pendant lampholders shall not be installed in dressing or makeup rooms.

520.72 Lamp Guards. All exposed lamps in dressing or makeup areas including rooms where they are less than 2.5 m (8 ft) from the floor shall be equipped with open-end guards riveted to the outlet box cover or otherwise sealed or locked in place. Recessed lamps shall not be required to be equipped with guards.

Lamps in dressing rooms are required to be provided with suitable open-end guards that permit relamping and that are not easily removed. Guards make it difficult to circumvent their purpose of preventing contact between the lamps and flammable materials.

520.73 Switches Required. All luminaires, lampholders, and any receptacles adjacent to the mirror(s) and above the dressing or makeup counter(s) installed in dressing or makeup rooms shall be controlled by wall switches installed in the dressing or makeup room(s). Other outlets installed in the dressing or makeup rooms shall not be required to be switched.

520.74 Pilot Lights Required. Each switch required in 520.73 shall be provided with a pilot light located outside of and adjacent to the door of the room being controlled to indicate when the circuit is energized. Each pilot light shall be permanently identified indicating a description of the circuit controlled. Pilot lights shall be neon, LED, or other extended-life lamp. Pilot lights shall be recessed or provided with a mechanical guard.

Part VII. Equipment Grounding Conductor

520.81 Equipment Grounding Conductor. All metal raceways and metal-sheathed cables shall be connected to an equipment grounding conductor. The metal frames and enclosures of all equipment, including border lights and portable luminaires, shall be connected to an equipment grounding conductor.

ARTICLE 522

Control Systems for Permanent Amusement Attractions

Part I. General

522.1 Scope. This article covers the installation of control circuit power sources and control circuit conductors for electrical equipment, including associated control wiring in or on all structures, that are an integral part of a permanent amusement attraction.

Article 522 provides requirements for permanent amusement attractions and theme parks. Article 525 applies to temporary attractions, such as carnivals, circuses, and fairs, where most of the attractions consist of portable modules that are moved from place to place. In contrast, theme parks are permanent facilities that have entertainment features fixed in place so that they are not readily portable. In the United States, approximately 475 amusement and theme parks operate a wide variety of permanent entertainment features.

Article 522 addresses the unique applications and installations utilized in the theme park and amusement industry and covers the wiring requirements for the control circuit power source and control circuit conductors, allowing for installation methods that are not recognized in the requirements of Articles 724 and 725. The control voltage used is a maximum of 150 volts ac to ground or 300 volts dc to ground.

522.5 Voltage Limitations. Control voltage shall be a maximum of 150 volts, nominal, ac to ground or 300 volts dc to ground.

522.7 Maintenance. The conditions of maintenance and supervision shall ensure that only qualified persons service the permanent amusement attraction.

Part II. Control Circuits

522.10 Power Sources for Control Circuits.

(A) Power-Limited Control Circuits. Power-limited control circuits shall be supplied from a source that has a rated output of not more than 30 volts and 1000 volt-amperes.

(1) Control Transformers. Transformers used to supply power-limited control circuits shall comply with the applicable sections within Parts I and II of Article 450.

(2) Other Power-Limited Control Power Sources. Power-limited control power sources, other than transformers, shall be protected by overcurrent devices rated at not more than 167 percent of the volt-ampere rating of the source divided by the rated voltage. The fusible overcurrent devices shall not be interchangeable with fusible overcurrent devices of higher ratings. The overcurrent device shall be permitted to be an integral part of the power source.