Chapter Four

ARTICLE 400. FLEXIBLE CORDS AND CABLES

400.3. Suitability. This rule requires that any application of flexible cord or cable may require use of "hard usage" cord (such as SJ cord) or "extra hard usage" cord (such as S or SO cord) if the cord is used where it is exposed to abrasion or dragging or repetitive flexing and/or pulling, depending on severity of use. As noted in Table 400.4, cords for portable heaters must be one of those types when used in damp places. Determination of the need for a particular cable on the basis of use severity is subjective. Table 400.4 also indicates the types of portable cable—that is, for data processing and elevator circuits—and conditions under which each type is suitable, as for hazardous or nonhazardous locations. Flexible cord is not a wiring method, which is why it appears in Chap. 4 as equipment, and not in Chap. 3.

400.5. Ampacities for Flexible Cords and Cables. Unlike other current-carrying conductors and cables recognized by the NEC, the permissible value of current permitted for those assemblies listed as "flexible cords and cables" is determined in accordance with this section, instead of the rules given in 310.15. Generally speaking, compliance with these requirements can easily be accomplished by selecting listed cords and cables and using them within their rating.

A three-conductor cord set is permitted by 250.140 to be used with one conductor serving as *both* the neutral conductor *and* the equipment grounding conductor, with the frame of the range or dryer grounded by connection to the neutral, *but* only for an existing branch circuit. It should be noted that the common neutral-grounding conductor does not count as a current-carrying conductor, thereby making the 3-wire cord suitable for use at the higher ampacity shown under column B in Table 400.5A—which is for cord with not more than two wires.

This section now addresses the effects of elevated temperature by specifically incorporating the ampacity correction factors for ambient temperatures other than 30°C that apply to Table 310.16.

example The design load from an Art. 220 load calculation for a floating commercial enterprise moored in a tidal basin on the southeastern coast of Texas is 105 A from a 208Y/120-V system, of which 60 A is continuous and comprised of primarily nonlinear loads. The feeder conductors will be connected directly to the terminals of a 125-A molded-case circuit breaker. The building will be subjected to constant tidal motion of the base water level, in addition to periodic wave effects. The design temperature based on the ASHRAE 2 percent temperature database is 95°F.

Flexible cord solution Section 553.7(B) allows portable power cable rated for extra hard usage, sunlight resistance, and wet locations to be used as a feeder to a floating building.

Conductor calculation The load current is 105 A, but there will be mutual conductor heating because over half the load is nonlinear and will result in harmonic currents flowing on the neutral, per 400.5(B). This will result in a 80 percent factor from Table 400.5, together with a 0.96 percent correction factor based on 90°C conductor rating. Therefore, the minimum size of the cord to address the conditions of use is: 105 A ÷ 0.8 ÷ 0.96 = 137 A. For this, the ampacity can be taken from Table 400.5(B) using the 90°C column. A 2 AWG Type W power cable could be used based on this calculation, ampacity 152 A.

Termination calculation The size of the conductor on the terminals of the circuit breaker must accommodate the continuous portion of the load taken at 125 percent plus the noncontinuous load, or 1.25(60 A) + 45 A = 120 A. The wire size, per 110.14(C)(1)(b), must be referenced to the 75°C column of Table 310.16 and not Table 400.5(B) per 110.14(C)(1). The smallest size copper wire that will allow the overcurrent device to function as intended on this load profile is 1 AWG copper. Since the design constraint is that the cord conductors terminate directly at the circuit breaker, this calculation produces the worst-case, highest conductor size, and therefore this is the correct answer.

400.7. Uses Permitted. Figure 400-1 shows accepted uses for flexible cord. Flexible cord may be used for luminaires under **(A)(2).** Refer to 410.24(A) for limitations on use with electric-discharge luminaires and 410.62(B) and (C) for luminaires that require aiming or adjusting after installation and conditional use with other electric discharge lighting.

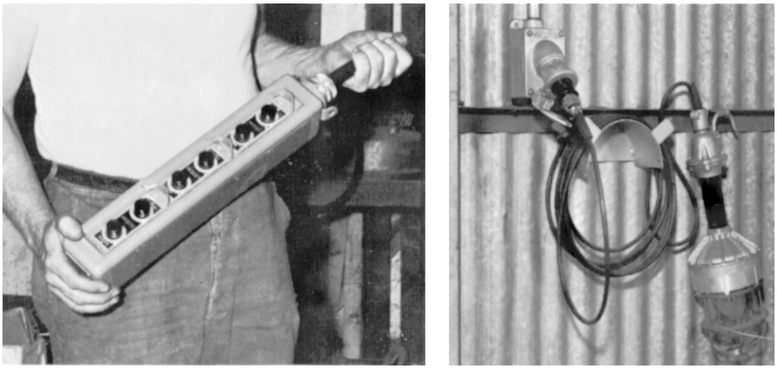


Fig. 400-1. Permitted uses for flexible cable and cord include pendant pushbutton station for crane and hoist controls (left), and connection of portable lamps. (Sec. 400.7.)

Part **(B)** states that *if* flexible cord is used to connect portable lamps or appliances, stationary equipment to facilitate frequent interchange, or fixed or stationary appliances to facilitate removal or disconnection for maintenance or repair, the cord "shall be equipped with an *attachment plug* and shall be energized from a *receptacle outlet.*"

It should be noted that the cords referred to under this section are the cords attached to the appliance and not extension cords supplementing or extending the regular supply cords. The use of an extension cord would represent a conflict with the requirements of the Code in that it would serve as a substitute for a receptacle to be located near the appliance, thereby violating 210.50(B).

Extension cords are intended for temporary use with portable appliances, tools, and similar equipment which are not normally used at one specific location.

But bus-drop cable may be used to feed down to machines in factories. Such cable is UL-listed for that application in accordance with 400.7 and 368.56(B) (Fig. 400-2).

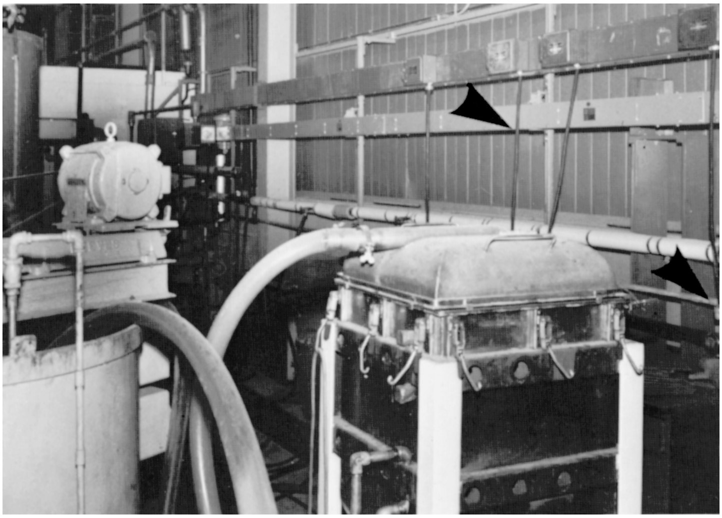


Fig. 400-2. Bus-drop power cables are flexible cables listed by UL for feeding power down from plug-in fusible switches on busway to supply machines. Cables here have connector bodies on their ends for machine cord caps to plug into. (Sec. 400.7.)

400.8. Uses Not Permitted. Although 400.7 says that flexible cord may be used for "wiring of luminaires," that must be applied in the context of 400.8(1) that prohibits the use of cord as a substitute for fixed wiring. That rule could be strictly enforced to require all luminaires to be supplied by fixed wiring methods—approved, Code-recognized cables like NM or BX or by a standard raceway method (EMT, rigid, flex, etc.). This sort of narrow reading raises the question, "Is there ever a case where a luminaire could *not* be fed by a fixed wiring method?" Certainly, any luminaire that might be supplied by a cord connection from a junction box to the luminaire could just as easily be fed by conductors in flexible metal conduit or in liquidtight flexible metal conduit—both of which conduit-and-wire connections are considered "fixed wiring" methods. If there are no cases where a luminaire could not be fed by such a fixed wiring connection, then every use of flexible cord to supply a luminaire is "a substitute for fixed wiring." The relationship between 400.7(A)(2), 400.8(1), 410.24(A), 410.62(B), and 410.62(C) must be carefully evaluated to assure ready compliance with Code rules—particularly since cord connection of luminaires has been used so long and so successfully for both indoor and outdoor applications.

The best way to approach wording issues like this in the NEC is to apply an old principle of statutory interpretation that goes back many centuries in the courts: Read both rules that could be viewed as being in conflict, and apply an interpretation that gives the maximum effect to both of the rules. In this case, 400.7 and many other rules in the NEC that provide specific instances where cord connections can be used should be honored; however, any expansion of cord usage beyond that point should be closely questioned under the substitution for fixed wiring methods prohibition. In other words, in those cases where the NEC specifically permits the use of cord, it is presumed not to be a substitute for fixed wiring methods.

Figure 400-3 shows one of a number of twin floodlight units that were installed outdoors for lighting of the facade of a building. The use of cord from a junction box to a stab-in-the-ground twin lampholder assembly does not comply with "(2) wiring of luminaires" in 400.7 because it does not satisfy 410.14 or 410.30(B) or

Fig. 400-3. This use of flexible cord to supply an outdoor lampholder assembly can readily be described as a "substitute for fixed wiring"—which is a prohibited use of cord. Here, the lampholders could have been attached to one or more threaded openings on an outlet box. (Sec. 400.8.)

(C), which regulate use of cord for luminaires, as previously noted under 400.7. And the application does not comply with the other permitted uses in 400.7. Because floodlights could have been installed in lampholders that thread into hubs on a weatherproof box, use of the cord is an evasion of a fixed or permanent connection technique that would totally avoid the potential shock hazard of cord pull-out or breakage. Mounting the floodlights on the box would still allow adjustment. This use of cord is a substitute for fixed wiring and is a violation.

Flexible cord is not permitted to be attached to a building surface **(4)**, unless it is part of a busway branch as covered in 368.56(B). This rule clearly limits the once common practice of running wireway overhead in industrial occupancies, in a manner very similar to busway, and feeding cord drops to machine tools and other equipment. Although permitted by 376.70, the wireway must be carefully located because the cord must drop very nearly straight down to the equipment. Figure 400-4 gives another example of this permission, because the strain relief at the box cover is not a connection to a building surface. A swag out to a strain relief over the equipment is a connection to a building surface, and as such is disallowed for all cord connections, except the busway applications.

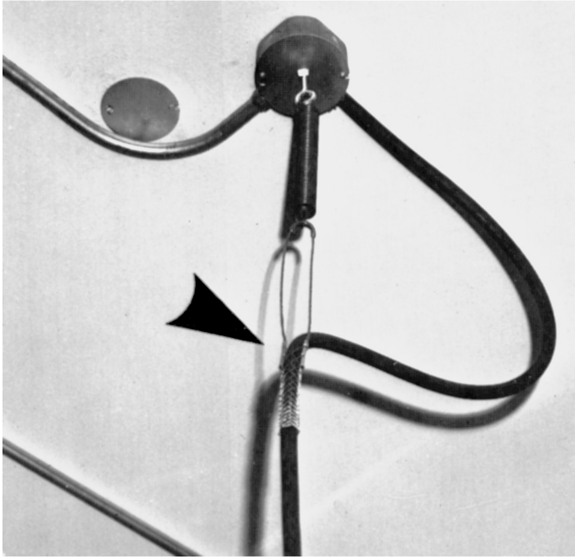
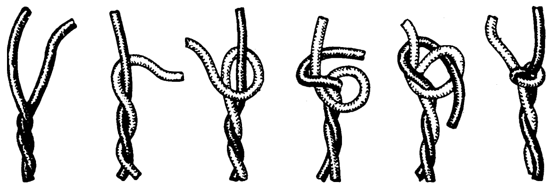


Fig. 400-4. Strain-relief for flexible cord must protect cable jacketing from damage at box connectors and protect wire terminations from pull-out. Spring-loaded come-along support supports cable against weight on bottom end of pendant and also provides up-and-down movement of cable end. (Sec. 400.10.)

Flexible cords and cables may not be installed in raceways, except where the NEC specifically recognizes such uses. Part **(6)** clarifies such use of flexible cords and cables, limiting their use in raceways to applications described or inferred in 400.7 and other Code rules—such as 550.10(G) for sleeving of a mobile home power-supply cord, 551.46(A)(2) on the same technique for recreational vehicles, 645.5(B)(3) for computer-room connecting cables, and 680.23(B) on the flexible cord run in conduit for a wet-niche luminaire—and similar limited applications. One very important allowance occurs in 400.14. The reason for this limitation is that flexible cord ampacities, as expressed in Table 400.5(A) and (B), are evaluated on the ability of the cord to freely radiate its heat.

400.10. Pull at Joints and Terminals. Figure 400-5 shows methods of strain relief for cords. The "Underwriters' knot" has been used for many years and is a good method for taking the strain from the socket terminals where lamp cord is used for the pendant, through the hole in the lampholder or switch device. For reinforced cords and junior hard-service cords, sockets with cord grips such as shown in Fig. 400-4 provide an effective means of relieving the terminals of all strain. Figure 400-4 shows a support technique that comes under "other approved means."



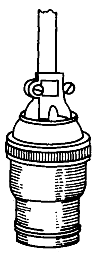


Fig. 400-5. Strain-relief must be provided at cord connections to devices. (Sec. 400.10.)

400.11. In Show Windows and Show Cases. Because of the flammable material nearly always present in show windows, great care should be taken to ensure that only approved types of cords are used and that they are maintained in good condition.

400.14. Protection from Damage. Flexible cord must be protected from damage where it passes over sharp edges through the use of bushings, etc. The second paragraph recognizes a very common practice on machine tools in industrial occupancies, where cord is used to wire sensors or solenoids on flexible parts or other instances where the flexibility of cord is crucial to orderly equipment function. Cord is permitted for these uses generally, but as soon as the need for flexibility stops, then a wiring method transition must be arranged. This in turn usually means a box with splices inside, the very location where problems crop up most often in electrical systems. The language in the second paragraph allows a raceway to extend from the industrial control panel (Art. 409) (or other point of origin) out to the desired location, with a raceway-to-cord transition fitting at the outer end. This entirely avoids a box needing support plus a set of splices out on the equipment. If mutual conductor heating is an issue, the derating factors apply to all conductors in the raceway, and not cord by cord. The raceway cannot exceed 15 m (50 ft) in length which correlates with rules in NFPA 79, *Electrical Standard for Industrial Machinery.*

400.22. Grounded-Conductor Identification. These are the rules for indentifying the grounded circuit conductor in cord sets, which itemize many methods in addition to white and gray insulation. One of the more important is item (F) which includes a ridge on the outer surface of the cord. This is commonly used for floor and table lamps wired with SPT 2 ("zip cord") wire, and also for pendant applications where the cord weaves through chain links holding a chandelier. It is absolutely essential to know how to recognize and verify proper connections to this wiring, because otherwise Edison-base screw-shells of lampholders will be energized any time the luminaire is lit. This is a hazard during relamping because the screw-shell of the lamp will be hot as soon as it comes in contact with the lampholder, even while someone's finger is touching it.

ARTICLE 402. FIXTURE WIRES

402.5. Allowable Ampacities for Fixture Wires. Note that Table 402.5 gives the ampacity for each size of fixture wire *regardless of the type of insulation used on the wire.* For instance, a 18 AWG fixture wire is rated for 6 A whether it is Type TFN or PF or any other type.

402.7. Number of Conductors in Conduit or Tubing. The maximum number of any size and type of fixture wire permitted in a given size and type of conduit is selected from the same tables as the ones used for determining conduit fill for building wire (THW, THHN, etc.). This must be carefully observed, especially when using fixture wires for Class 1 remote-control, signaling, or power-limited circuits, as permitted and regulated by 725.49 and 725.51.

402.8. Grounded Conductor Identification. This is where the rules in 400.22 become incorporated as rules for identifying fixture wire as well. For example, 400.22(B) allows two fixture wires with yellow braids to be used for a luminaire, with the one finished with a contrasting tracer color, such as red, being the grounded circuit conductor. Many people are fooled by this, and think the red tracer is the hot conductor because its color does not suggest white or gray.

402.10. Uses Permitted. Fixture wires may be used for internal wiring of luminaires and other utilization devices. They may also be used for connecting luminaires to the junction box of the branch circuit—such as by a flex whip to satisfy 410.117(C) (Fig. 402-1).

402.11. Uses Not Permitted. With the exception of their use for remote-control, signaling, or power-limited circuits, fixture wires are not to be used as general-purpose branch-circuit wires. An example of the use permitted by 725.49 would be, say, 18 AWG fixture wires run as remote-control wires in a raceway from a

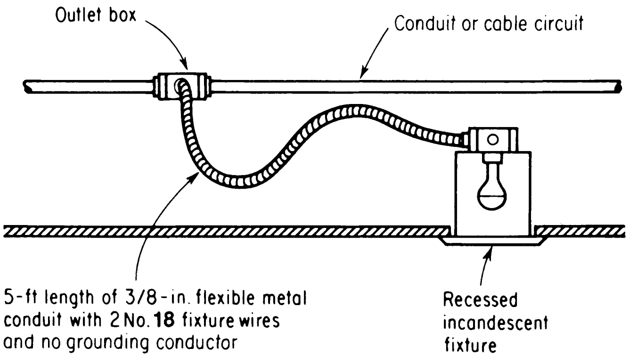


Fig. 402-1. Fixture wires may connect luminaires to branch-circuit wires. (Sec. 402.10.)

motor starter to a remote pushbutton station, where the 6-A rating of the wire is adequate for the operating current of the coil in the starter. Another issue that often comes up is lighting installed for commercial cooking hoods using the special luminaires required by 410.10(C). These luminaires usually have 110°C minimum supply temperature conductor ratings. Since fixture wires of the required temperature rating is quite common, and since branch conductors rated above 90°C are difficult to find on a supply house shelf, and since each luminaire is an outlet on a branch circuit, this section makes it mandatory to order the branch-circuit conductors with the required temperature ratings.

402.12. Overcurrent Protection. This rule refers to 240.5, which covers overcurrent (OC) protection requirements for fixture wire as a separate matter from other building wire and cable, and permits No. 18 and No. 16 fixture wire of any type to be protected by a 15- or 20-A fuse or CB, provided the distance limitations in 240.5(B)(2) are met. That covers use of 18 AWG or 16 AWG in luminaire "whips" on 15- or 20-A branch circuits. Coverage for remote-control, signaling, or power-limited circuits is addressed in 725.43 and as frequently modified for taps in 725.45(C).

ARTICLE 404. SWITCHES

404.1. Scope. Note that all the provisions of this article that cover switches *also* apply to circuit breakers, which are operated exactly as a switch whenever they are manually moved to the ON or OFF position.

404.2. Switch Connections. The rule of part **(A)** is shown in Fig. 404-1. Keeping both the supply and return conductors in the same raceway or cable minimizes inductive heating, as described under 300.20(A). The routing of both the supply and return conductors within the same raceway provides for mutual cancellation of both conductors' magnetic fields and thereby reduces inductive heating, as required under 300.20(A). This is also an issue with multiple 2-conductor (as opposed to a single 3- or 4-conductor) Type NM cable run to steel boxes and entering through separate knockouts for multiple loads on a single circuit (such

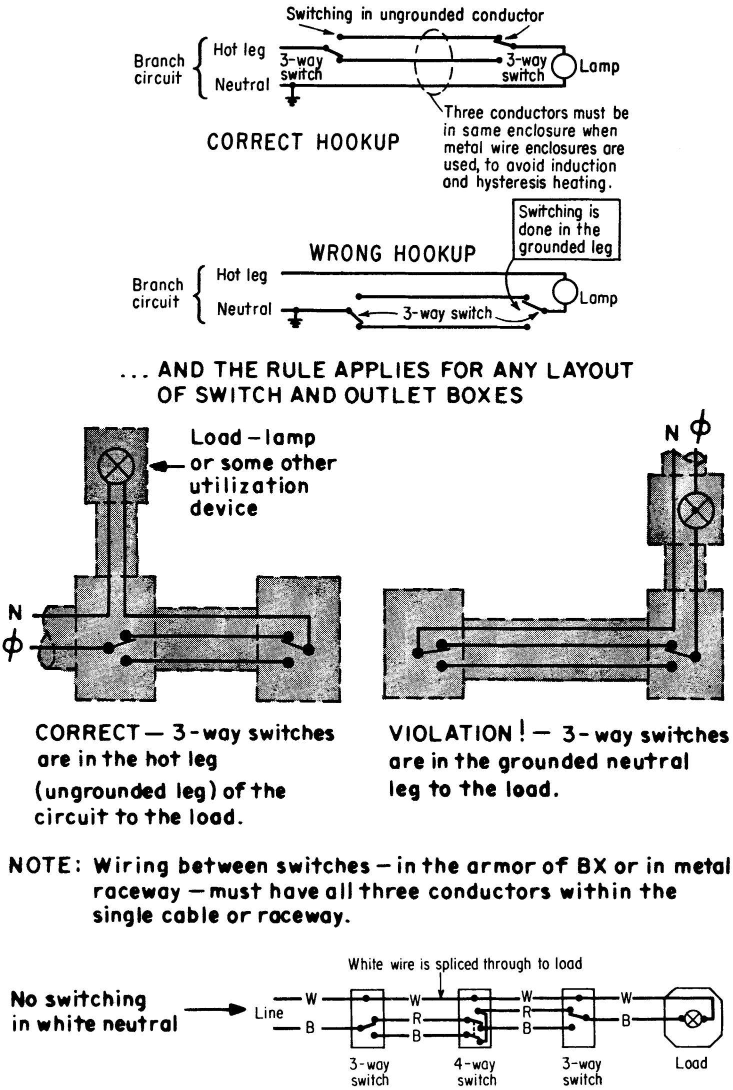


Fig. 404-1. All three-way and four-way switches must be placed in the hot conductor to the load. (Sec. 404.2.)

as a bathroom fan-light unit) or a three-way switch loop run with the travelers in one cable. In either case there will be inductive heating unless both cables enter a single knockout. Fortunately there are numerous cable connectors now listed for two cables that will solve this problem.

The rule of part **(B)** is illustrated in Fig. 404-2. The three-pole switch satisfies the exception. Opening only the grounded wire of a 2-wire circuit would leave all devices that are connected to the circuit alive and at a voltage to ground equal

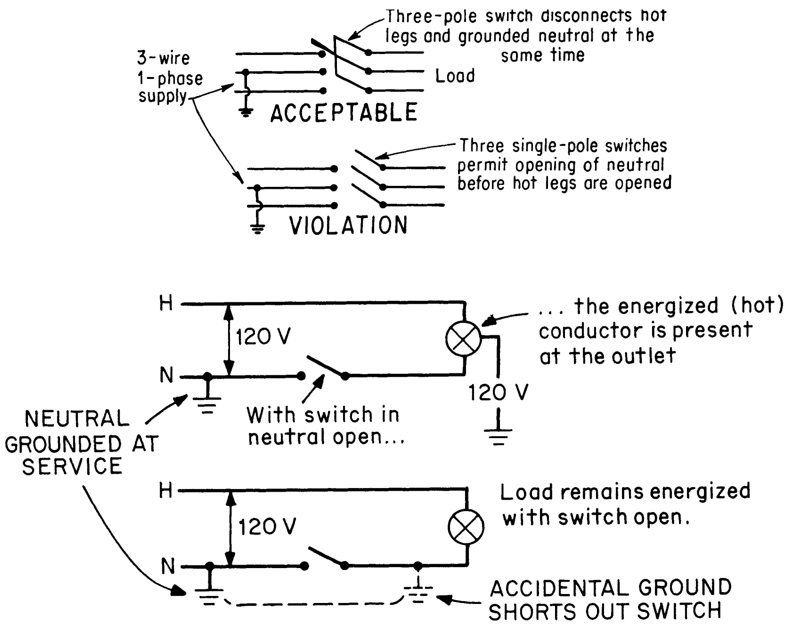


Fig. 404-2. A single-pole switch must not be used in a grounded circuit conductor. (Sec. 404.2.)

to the voltage between wires on the mains. In case of an accidental ground on the grounded wire, the circuit would not be controlled by the single-pole switch.

In Fig. 404-3, the load consists of lamps connected between the neutral and the two outer wires and is not balanced. Opening the neutral while the other wires are connected would cause the voltages to become unbalanced and might burn out all lamps on the more lightly loaded side.

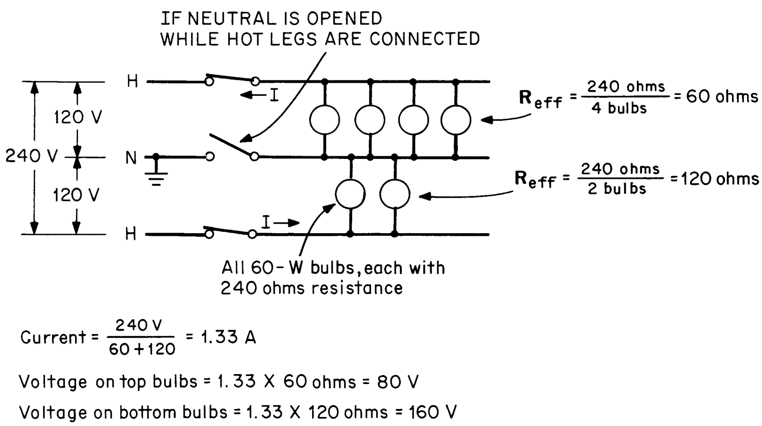


Fig. 404-3. A single-pole switch in neutral can cause damaging load unbalance if opened. (Sec. 404.2.)

Except for 514.11(A), which requires a switch in a grounded neutral for a circuit to a pump at a gas station, the neutral does not need to be switched. But where a grounded neutral or grounded phase leg is switched, it must never be by a single-pole switch or single-pole CB, even if the CBs are provided with handle ties.

A switch may be arranged to open the grounded conductor if the switch simultaneously opens all the other conductors of the circuit.

404.3. Enclosure. Figure 404-4 shows the basic rule of this section and 404.4. This rule also requires adequate wire bending space at terminals and in side gutters of switch enclosures. In this section and in other sections applying to wiring space around other types of equipment, it is a mandatory Code requirement that wire bending space and side gutter wiring space conform to the requirements of Table 312.6(A) for side gutters and to Table 312.6(B) for wire bending space at the line and load terminals, as described under 404.18. Those tables establish the minimum distance from wire terminals to enclosure surface or from the sides of equipment to enclosure side based on the size of conductors being used, as shown in Fig. 404-5.

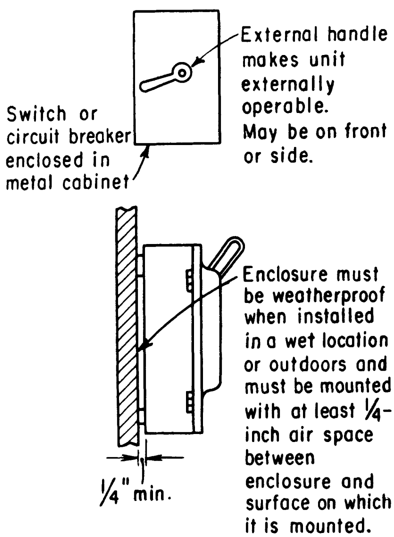


Fig. 404-4. Switch and CB enclosures must be suitable. (Sec. 404.3.)

This whole concern for adequate wiring space in all kinds of equipment enclosures reflects a repeated theme in many Code sections as well as in Art. 110 on general installation methods. One of the most commonly heard complaints from constructors and installers in the field concerns the inadequacy of wiring space at equipment terminals. 404.3 is designed to ensure sufficient space for the necessary conductors run into and through switch enclosures.

404.4. Wet Locations. Refer to Fig. 404.4 and discussion under 312.2. In addition, this rule prohibits switches from being installed in the wet location of a tub or shower space. Although the yoke would be grounded by other rules, the concern is how long the gasket will hold up before water, particularly from a shower, gets behind it and starts rotting out the connections, including the grounding

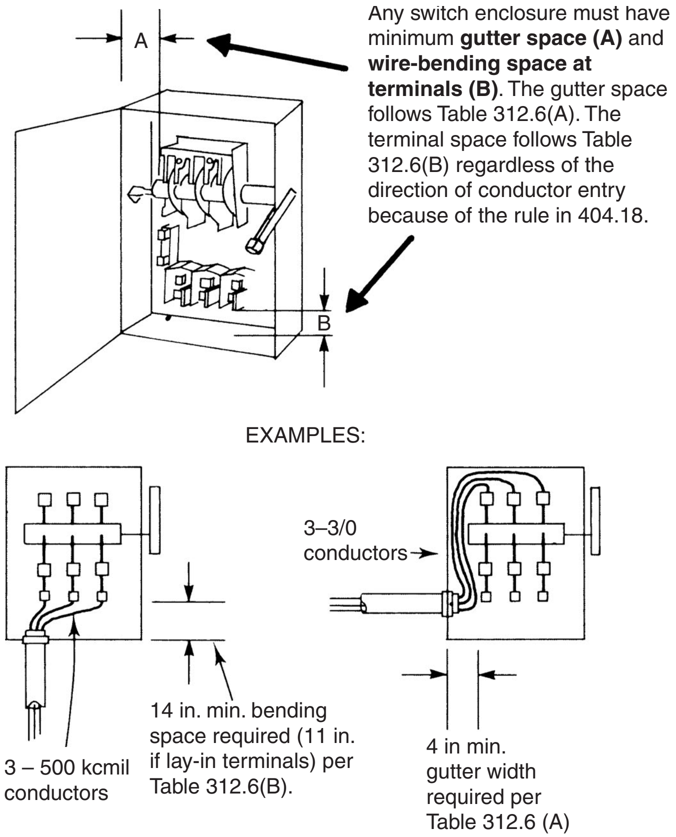


Fig. 404-5. Terminating and gutter space in switch enclosures must be measured. (Sec. 404.3.)

connections. An exception exempts a switch in a "listed tub or shower assembly" under the understanding that some hydromassage tubs or spas may have air or low-voltage switching to control the water or airflow; such controls are carefully controlled by the listing process in terms of potential hazards.

404.5. Time Switches, Flashers, and Similar Devices. Any automatic switching device should be enclosed in a metal box unless it is a part of a switchboard or control panel which is located as required for live-front switchboards. Such devices must not present exposed energized parts, except under very limited conditions where they are accessible only to qualified persons.

404.6. Position and Connection of Knife Switches. The NE Code requires that knife switches be so mounted that gravity will tend to open them rather than close them (Fig. 404-6). But the Code recognizes use of an upside-down or reverse-mounted knife switch where provision is made on the switch to prevent gravity from actually closing the switch contacts. This permission is given in recognition of the much broader use of underground distribution, with the intent of providing a switch with its line terminals fed from the bottom and its load terminals connected at the top (Fig. 404-7). With such a configuration, an upside-down knife switch provides the necessary locations of such terminals, that is, "line" at bottom and "load" at top. However, use of any knife switch in the reverse or upside-down position is contingent upon the switch being approved for such use, which virtually means UL-listed for that application, and also upon the switch being equipped with a locking device that will prevent gravity from closing the switch. The same type of operation is permitted for double-throw knife switches.

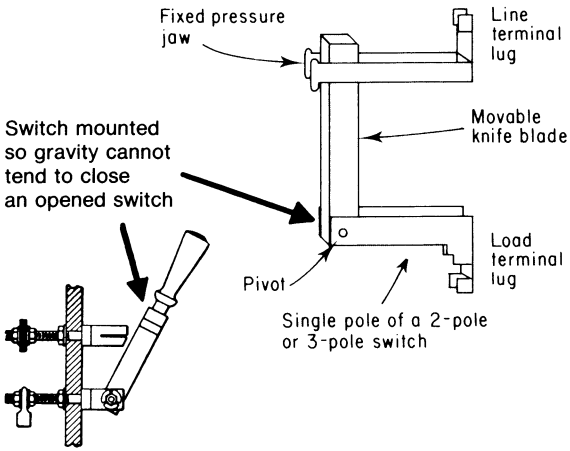


Fig. 404-6. Movable knife blade of a knife switch must be pivoted at its bottom. (Sec. 404.6.)

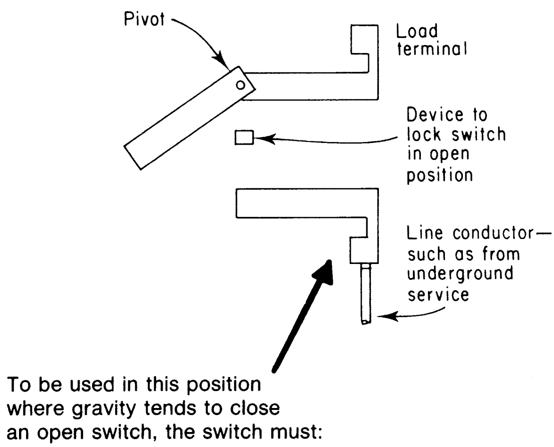


Fig. 404-7. This type of knife-switch operation is permitted. (Sec. 404.6.)

As required by part **(C),** knife-switch blades must be "dead" in the open position, except where a warning sign is used (Fig. 404-8). In a number of electrical system hookups—UPS systems, transformer secondary ties, and emergency generator layouts—electrical backfeed can be set up in such a way as to make the load terminals, blades, and fuses of a switch energized when the switch is in the OFF or open position. Where that might happen, the exception to this section says a permanent sign must be prominently placed at or near the switch to warn of the danger. The sign must read, "Warning—switch may be energized by backfeed."

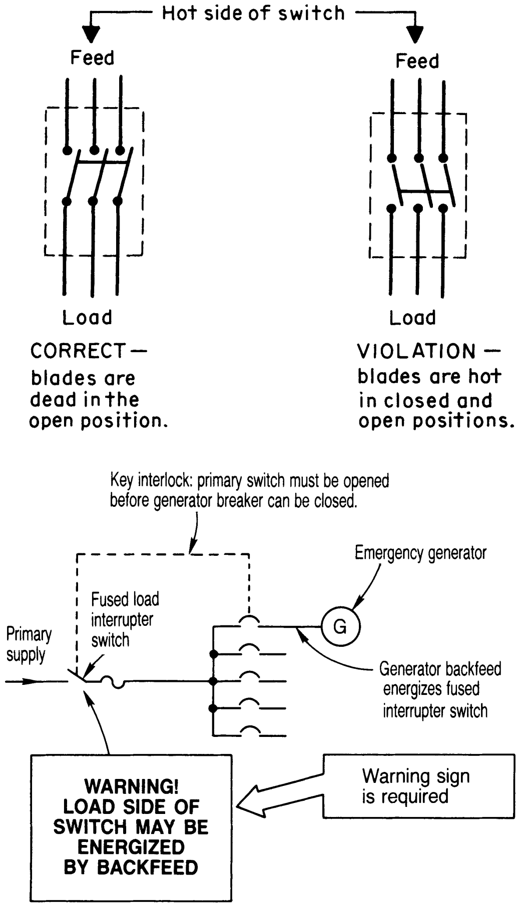


Fig. 404-8. Supply conductors must connect to "LINE" terminals of switch, but backfeed is permitted if carefully marked. (Sec. 404.6.)

This potential hazard has long been recognized for high-voltage systems (over 600 V), and 490.21(E) covers the matter. This rule that the load side of the switch be de-energized when the switch is open applies the same concept to systems operating up to 600 V.

404.7. Indicating. Switches and circuit breakers in individual enclosures must be marked to clearly show ON and OFF positions, and vertically operated switches and CBs must be ON when in the up position. This is basically a repetition of the rule that has been in 240.81 for circuit breakers used in switchboards and panelboards. Exception No. 2 covers busway switches that have a center-pivoting switch, so with one side pulled down the switch is ON and with the other side down the switch is OFF. This makes the switch easy to work from the floor with a hook stick. The positions must be clearly marked so the status of the switch will be visible from the usual operating location.

404.8. Accessibility and Grouping. The rule of part **(A)** of this section presents certain requirements regarding the *accessibility* (as defined in Art. 100 for equipment) generally required for disconnects and OC devices. This rule, along with the exceptions, is shown in Fig. 404-9. Exception No. 1 cross-references with 368.17(C). Exception No. 2 correlates with 240.24(A)(4), and Exception No. 3 makes the hook stick principle apply generally to other isolating switches.

Part **(B)** of this section applies where 277-V switches, mounted in a common box (such as two- or three-ganged), control 277-V loads, with the voltage between *adjacent* switches in the common box being 480 V. Anyone changing one of the switches without disconnecting the circuit at the panel could contact 480 V, as shown in Fig. 404-10. The rule of this section requires permanent barriers between adjacent switches located in the same box where the voltage between such switches exceeds 300 V. This rule applies anytime adjacent devices operate over 300 V between them, whether or not the terminals are exposed or use pigtail connections. Of course, the hookup shown would be acceptable if a separate single-gang box and plate are used for each switch, or a common wire from only one phase (A, B, or C) supplies all the three switches in the three-gang box.

This rule has been broadened to include snap switches mounted with other devices, such as receptacles. Although the actual voltage between a 277-V snap switch and a 125-V receptacle is not necessarily over 300 V (depending on which phases of the two systems are involved and the amount of phase shift between them), the intent is to classify this as impermissible without the grounded barrier between the devices. This rule has been reinforced by similar language appearing in 406.4(G), and means that the old practice of putting a snap switch for a 277-V lighting system together with a 125-V general purpose receptacle as the only opening in small rooms with specialized equipment is no longer possible the way it used to be done. However, square outlet boxes with 2-gang plaster rings are generally manufactured with notches and drillings that easily accommodate these barriers, and nonmetallic box manufacturers now have similar products available.

Part **(C)** covers multipole snap switches, and is new in the 2008 NEC. The intention is to compel a change in a particular guide card rule regarding snap switches. Specifically, if you wanted to use a two-pole snap switch to control two oil burners, one for heat and one for hot water, why not get a 277-V 2-pole snap switch? Even if the two circuits came from different buses, the total line-to-line voltage would still be less than that of the switch. What has stood in the way of this application has been the following statement in the UL guide card requirements: "Multi-pole, general-use snap switches have not been investigated for more than single-circuit operation unless marked '2-circuit' or '3-circuit.'" Since

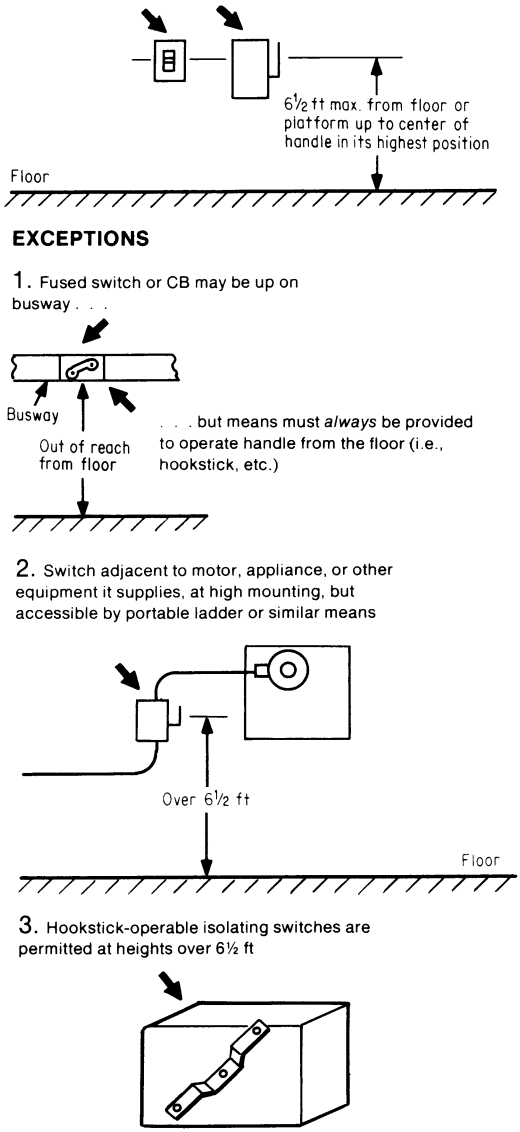


Fig. 404-9. All switches and circuit breakers used as switches must be capable of being operated by a person from a readily accessible place. (Sec. 404.8.) Note that the maximum height dimension has been slightly changed to 2.0 m (6 ft 7 in.) from 6½ ft.

no such switches have been in production with that marking, any such use would be a violation of this limitation, which would be citable under 110.3(B). The 2008 NEC change trumps this limitation by allowing it by right, provided the line-to-line voltage doesn't exceed the snap switch rating. If it does exceed the

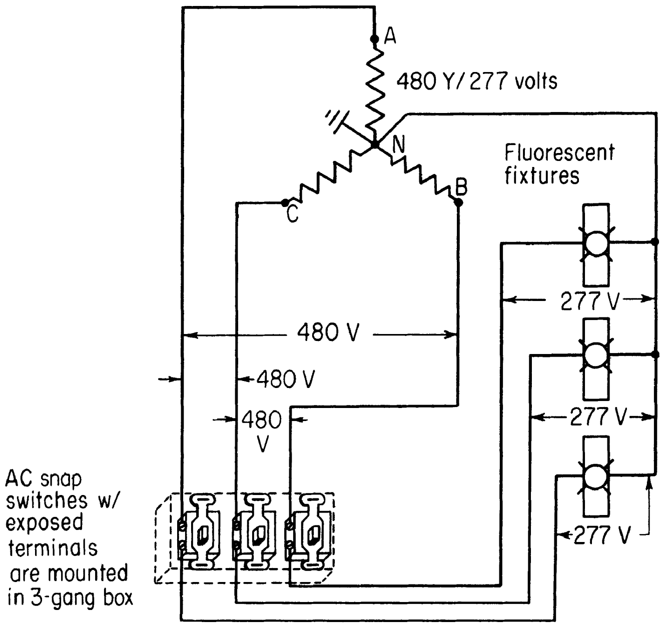


Fig. 404-10. This is a violation if barriers are not used between switches in the box. (Sec. 404.8.)

rating, then the limitation continues in force. Note that this permission must be correlated with 210.7(B), which still will require a common disconnecting means at the panel. The substantiation for this change reads as follows:

> The device industry still shows no inclination to mark two-pole switches "2-circuit," and thereby allow their use on two circuits with a total voltage spread within the switch rating. Representatives generally declare their willingness to act promptly if there were market demand. Unfortunately, the submitter strongly suspects the lack of demand is a result of lack of knowledge, and not any lack of applications. In other words, installers are routinely installing these switches and inspectors are accepting them for want of any observable hazard. A routinely available 277-volt rated two-pole snap switch used to control two 120-volt circuits within the ampere rating of the switch to control related equipment, such as two oil burners, is a completely reasonable application. It can be frustrated, usually only on paper, by the UL Guide Card restriction. If this proposal is accepted, UL will have to revisit the Guide Card information, and the problem will disappear. Note that under the terms of this proposal, as soon as the potential line-to-line voltage exceeded that of the switch, the enhanced marking provisions would still apply.

404.9. Provisions for General Use Snap Switches. The first sentence of this section [Part **(A)**] requires that faceplates be installed to cover the wall opening completely to ensure that the box behind the faceplate is properly covered and to prevent any openings that could afford penetration to energized parts.

Part **(B)** requires that metal faceplates be grounded, even if they are installed in the future. This is done by writing the rule to require that snap switches, including dimmer and similar control switches, be connected to an equipment grounding conductor, and that in the process the snap switch provide a means to connect the faceplate to the grounding conductor, "whether or not a metal faceplate is installed." Although "what if" code writing is generally a poor practice, in this case it is necessary because unqualified persons change faceplates all the time without benefit of permits and inspections. This way, whenever a metal faceplate is installed, it will be safely grounded in the process.

There are two methods of accomplishing this objective. The first is to use an actual bonding jumper between an equipment grounding terminal on the device yoke and the equipment grounding system for the box. The second is to rely on a conductive connection between the device yoke and a metal box or metal cover that is connected to an equipment grounding conductor for the supply circuit, or to a nonmetallic box with an integral equipment grounding conductor. Put simply, this could be two 6-32 screws from yoke to metal device box, or from the yoke to a raised cover.

At this point, many ask how this compares with 250.146, where receptacles are only permitted to rely on the 6-32 screws when the box is surface mounted, or in a raised cover with crushed corners and locking means for the cover screws, or where a special yoke modification holds the 6-32 screw securely. The answer is simple: this wording is more lenient, and very intentionally so. A receptacle is a portal to a quasi-branch-circuit extension whenever it supplies a cord-and-plug connected load. This is not the case for a snap switch, which only has to protect itself. The panel is not aware of any credible loss experience that would support revisiting the quality of this connection.

Figure 404-11 shows the basic operation of the exception to this part of the section. Note that the recessed metal box is not grounded and that is not acceptable by 314.4; however, the NEC is not retroactive and at one time this was

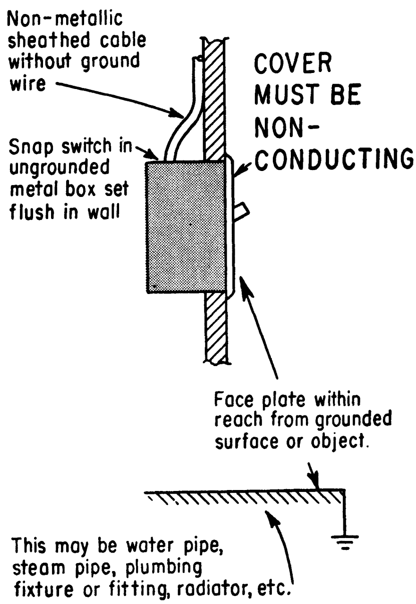


Fig. 404-11. Nonmetallic faceplate eliminates shock hazard. (Sec. 404.9.)

acceptable because the box is not exposed to contact, and this exception is for replacement duty only. Note also that, as an alternative, and in correlation with 410.42(B) Exception No. 2 for ungrounded luminaires with exposed conductive parts, if the switch circuit has GFCI protection arranged ahead of the switch, it can have a metal faceplate.

404.10. Mounting of Snap Switches. The purpose of paragraph **(B)** is to prevent "loose switches" where openings around *recessed* boxes provide no means of seating the switch mounting yoke against the box "ears" properly. It also permits the maximum projection of switch handles through the installed switch plate. The cooperation of other crafts, such as drywall installers, will be required to satisfy this rule.

404.11. Circuit Breakers as Switches. Molded-case CBs are intended to be mounted on a vertical surface in an upright position or on their side. Use in any other position requires evaluation for such use. ON and OFF legends on CBs and switches are not intended to be mounted upside down. This general permission does not specifically state that any CB used as a switch must be listed for such use and be marked "SWD," which indicates only that the CB has been evaluated for a particular type of switching duty during product testing for listing, namely, fluorescent lighting banks. [See 240.83(D).]

404.12. Grounding of Enclosures. This section calls for the metallic enclosures and metal switch boxes used to house switches and circuit breakers to be connected to an equipment grounding conductor. 250.110 requires *all* exposed metal parts (including enclosures) of fixed equipment to be grounded under any of the conditions described. And any switch or CB enclosure must be grounded, either by an equipment grounding conductor run with the circuit conductors, or by a metallic conduit or a metal-sheathed cable with listed fittings. In addition, provisions must be made when nonmetallic enclosures are used with metallic raceways and cables to ensure grounding continuity between all interconnected raceways, cables, and any equipment within the enclosure.

404.13. Knife Switches. UL data on ratings and application correspond to the Code data (Fig. 404-12).

404.14. Rating and Use of Snap Switches. The usual snap switch is covered in **(A)**, which is the snap switch rated for ac only. These switches will control inductive and resistive loads up to the switch rating; motor loads up to 80 percent of the switch rating, and tungsten filament lamp loads up to the switch rating on a 120-V circuit.

The ac and dc snap switch will control dc loads, although that is seldom a concern on today's branch circuits and these switches are comparatively unusual. Because they have a dc rating, which is a more difficult switch function because there is no current zero, they are built differently and have a much louder "click" when actuated. Some people actually specified them for their children's bedrooms because they wanted to hear if their kids turned the lights back on after bedtime. They will handle the full rating of the switch for resistive loads, the full rating for tungsten filament lamp loads (but only if "T" rated) and inductive loads up to 50 percent of the switch rating.

Part **(C)** covers the special devices with an enhanced design on their terminal screws rated for direct aluminum terminations, known by the mandatory labeling

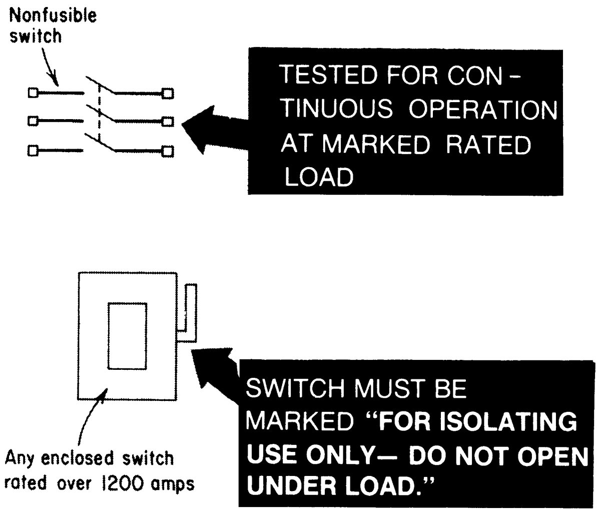


Fig. 404-12. UL data must be correlated to the Code rules. (Sec. 404.13.)

"CO/ALR." For snap switches rated 20 A or less, these are the only permissible switches unless the aluminum wires are pigtailed to copper for the final device terminations.

Part **(D)** covers the 347-V snap switches primarily used in the Canadian market. Instead of using 480Y/277-V systems, they more commonly use 600Y/347-V systems, and these switches are engineered accordingly. They will handle most applicable inductive and resistive loads up to the switch rating; however, any limitations imposed as part of a listing process must be observed. They must not be rated less than 15 A, and they must be physically configured so that flush applications in device boxes will not be readily interchangeable with switches identified for 120/240, or 208Y/120, or 480Y/277-V systems.

Part **(E)** prohibits the use of dimmer switches to control receptacles; they are only permitted to control fixed incandescent lighting, unless specifically listed otherwise.

404.15. Marking. Part **(B)** of this section requires any switch with a marked "OFF" position to completely disconnect all ungrounded conductors to the load. This is comparable to the rule for electric heating thermostats with "OFF" positions, as covered in 424.24(A). The reason for this was incidents where electronic switches, such as occupancy sensors, were installed on circuits with no grounded conductor present, and the switch leaked a small amount of current through the load in order for its electronics to work. Workers in the room replacing ballasts assumed that since the lights were out, there was no voltage at the luminaires. The amount of current is regulated by the product standards and is not a shock hazard, but it was enough to startle the workers to the point of falling off the ladder. Now these switches must use some other indication, such as "standby." Be aware that a switch with some marking other than "OFF" very likely will pass voltage to the luminaires even when they appear to be off. A good example is the lit-handle snap switches that have the toggle handle illuminated with the load off (pilot-handle switches, lit with the load on, use a grounded circuit conductor connection and are OK). These devices also pass current through the load in the off position, and for that reason the normally off position of the toggle no longer reads "OFF."

404.18. Wire Bending Space. At terminals of individually enclosed switches and circuit breakers, the spacing from lugs to the opposite wall *must* be at least equal to that of Table 312.6(B) for the given size and number of conductors per lug. The larger spacing of that table, rather than the smaller spacing of Table 312.6(A), must be used regardless of how conductors enter or leave the enclosure—on the sides or opposite terminals.

Figure 404-13 shows the rule on wire bending space in switch or CB enclosures.

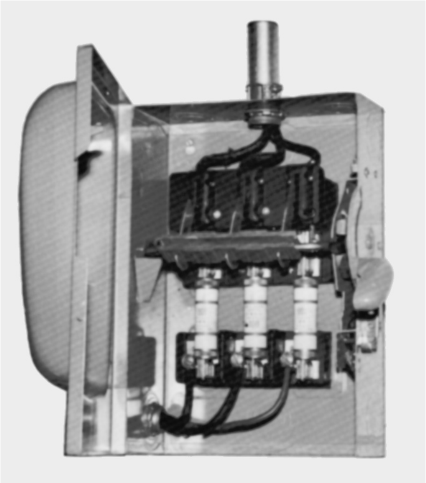


Fig. 404-13. Top wire-bending space contains offset (S) bends and must have dimensions from Table 312.6(B). Bottom wiring space has single (L) bends—but must conform to Table 312.6(B), not Table 312.6(A). That varies from 312.6(B)(4), which permits terminal space from Table 312.6(A) when wires go out the side of the enclosure.

ARTICLE 406. RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

406.1. Scope. Previously part of Art. 410 in the 1999 NEC, this article gives a number of requirements for the proper use of receptacles, cord connectors, and attachment plugs.

406.2 Rating and Type. In part **(A),** the Code makes a general statement regarding any receptacle that is used. *All* receptacles must be listed by a third-party testing agency, such as Underwriters Laboratories, for the specific application. This wording effectively prohibits the use of any receptacle that is not listed, as well as the use of listed receptacles that are not specifically listed for that use. The only way to ensure compliance with this requirement is to read and understand the product literature supplied with the receptacle. Then one can evaluate the acceptability of any receptacle for any application, based on the listing of the receptacle in question.

Part **(B)** requires that receptacles be rated no less than 15 A at either 125 or 250 V. This establishes the minimum acceptable ampere rating for receptacles recognized by the Code for general wiring, in any occupancy.