Automatic Receptacle Control to Meet ASHRAE 90.1-2010 and California Title 24
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Advances in building construction methodology and product technology have allowed for greater energy efficiency in building design than ever before. In the recent past, HVAC and lighting presented the greatest opportunities to reduce power consumption and conserve energy. Designers and manufacturers have been implementing solutions targeting these systems. Office equipment, appliances, and plug-in lighting loads are the next major area for potential reduction of energy use through management and control. Today, much of what is plugged into a convenience receptacle is uncontrolled. Based on data from the Energy Information Administration Commercial Buildings Energy Consumption Survey of 2012, approximately 30% of the energy used in buildings is by loads that are plugged in.

Both ASHRAE 90.10 and California Electric Code (CEC) Title 24 have identified receptacles as an area requiring energy management and have incorporated explicit requirements for automatic control. They target spaces in a building and require that half (50 percent) of the receptacles are controlled by an automatic shutoff device. Most commonly, these are receptacles in personal offices, conference rooms, and cubicle spaces. (Code excerpts shown at the end of the paper)
In this example, 80 percent of the receptacles are required to be controlled; 20 percent are exempt. Further analysis shows that most receptacles are located in the furniture systems or cubicles and conference areas of offices. Receptacles are most often used to control task lighting, followed by computer peripherals and personal devices (e.g., portable electronics, chargers, radios, heaters, fans, etc.). The energy standard requires some receptacles to be controlled. The intent is for the controlled receptacles to provide power when needed by the occupant—that is, when the occupant is present—and minimize wasted energy. Uncontrolled receptacles continuously supply power to equipment, requiring them to be energized at all times. Most computer equipment utilizes a “sleep mode” to optimize energy efficiency. Since the energy consumption on such a mode is very low, it is suitable to keep these devices plugged in to uncontrolled receptacles. Other, more discretionary plug-in items such as fans, heaters, and radios, if used, should be on only when the occupant is in the area, which results in minimum power use.

**Circuit Design: Good, Better, Best**

ASHRAE 90.1 and CEC Title 24 require automatic shutoff control by a time-of-day device, an occupant sensor, or an automated signal from another control or alarm system. It is up to the designer or building engineer to select the most appropriate technique to comply with the standard. Effectiveness and flexibility varies for each of these techniques, as do the types of buildings.
To better understand plug load, it is critical to examine how a particular building is used. Most commercial buildings serve as work locations, which come alive with people and activity throughout the day. Every building has prime use times (for example, 8 a.m. to 5 p.m.), with a reduction at night and then a slight increase if nighttime cleaning is performed. With a 24/7 work environment, it may be common to have variable hours, with people working earlier or later—not to mention weekends, holidays, and occasional exceptions. Many of today’s buildings need to be more responsive to the individual worker and modern work schedule.

A hardwired load controller can be placed in a series with a branch circuit at the breaker panel to control power to the circuits according to preset schedules. Such a controller can be added to the building with minimal changes to the method currently used in circuit design. Either a remotely controllable circuit breaker or remotely controllable relay in a box outside the panel can serve this purpose. Circuits are typically routed conveniently through the building, properly sized to electrical needs and to maximize the number of outlets on a circuit. As a result, however, one circuit may be used for multiple offices and hallways, possibly unrelated to the way they need to be controlled. Office furniture is typically multi-circuited, with at least two circuits per work area, sometimes using isolated ground for computer use. In this instance, using time-based control would facilitate area control but may limit the flexibility of set times.

A sensor-based system, such as is commonly used for keeping lights off in unoccupied areas, can turn-off plug loads when the area is unoccupied. Since one person may be at work late or on a weekend when others are not present, ideally this occupant detection should resolve to a single person, not an entire floor or work group. Typical receptacle circuit design may need to be altered for maximum occupant benefit by limiting it to just a single-person area of use (i.e., only in the office or at the desk where the occupant works). As a result, the power circuit may need to have fewer receptacles, requiring more circuits. For new building construction, more branch circuits can be installed to enable greater control flexibility. For retrofitting existing buildings, wirelessly controlled receptacles can deliver this flexible control.

Open cubicle areas require a different design. As open areas need to be controlled as a group, typically a multiple-circuit control makes sense, similar to a time-based system. It can also be triggered by an overhead sensor, adding flexibility if the worker stays late or comes in on the weekend. Again, individually controlled receptacles, rather than controlled branch circuits, provide maximum flexibility and the best user experience.

**Two Approaches for New Construction Applications**

Controlled branch circuits may offer the use of two circuits for each duplex receptacle, where one receptacle is on one circuit and the other receptacle is on a second circuit (“split wiring”). In this situation, a wired load controller can control one receptacle, while the other receptacle is only controlled by the circuit breaker (i.e., always left on and not controlled). Using split wiring for every duplex receptacle will give the user the ability to plug into either a controlled or non-controlled outlet in the same location. The occupant will have choice of continuous power or a controlled circuit in the same location.

Choosing to run two circuits and control every other receptacle is another technique. The requirement is that a non-controlled receptacle be within 6 feet of a controlled receptacle.
In either case, concern for user convenience needs to be considered to make sure there are enough outlets to meet the plug-in needs of the occupant. Location is key.

**Receptacle Markings**

NEC has chosen the symbol 🌘 to indicate an automatically controlled receptacle. As non-controlled receptacles never had an identifier, none is required. Both ASHRAE and the CEC require receptacles to have a permanent marking. The installer may choose to add a permanent marking during construction. There are pre-marked receptacles available from several manufacturers that comply with permanent marking requirements.

![Automatic Receptacle Control](image)

The overall intent of the energy code and requirement is to minimize wasted energy and maximize efficiency. The directive is to control plug loads through the management of selected outlets. How this is done is left up to the property owner. It is impossible to say whether minimum compliance or a totally integrated building management system is appropriate without understanding the building and its use. Correct sizing in the design is paramount to proper automatic receptacle control.

**Code Excerpts**

**ASHRAE 90.1-2010 and 2013**

8.4.2 Automatic Receptacle Control

The following shall be automatically controlled:

a) At least 50% of all 125 volt, 15 and 20 ampere receptacles in all private offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, classrooms, and individual workstations

b) At least 25% of branch circuit feeders installed for modular furniture not shown on the construction documents

This control shall function on

a) a scheduled basis using a time-of-day operated control device that turns receptacles off at specific programmed times—an independent program schedule shall be provided for controlled areas of no more than 5000 ft² and not more than one floor (the occupant shall be able to manually override the control device for up to two hours);
b) an occupant sensor that shall turn receptacles off within 20 minutes of all occupants leaving a space; or

c) an automated signal from another control or alarm system that shall turn receptacles off within 20 minutes after determining that the area is unoccupied.

All controlled receptacles shall be permanently marked to visually differentiate them from uncontrolled receptacles and are to be uniformly distributed throughout the space.

Plug-in devices shall not be used to comply with section 8.4.2.

**Exceptions:** Receptacles for the following shall not require an automatic control device:

a) Receptacles specifically designated for equipment requiring continuous operation (24 hours/day, 365 days/year)

b) Spaces where an automatic control would endanger the safety or security of the room or building occupant(s)

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**California Electric Code (CEC) Title 24 Section 130.5**

**(d) Circuit Controls for 120-Volt Receptacles.**

In all buildings, both controlled and uncontrolled 120 volt receptacles shall be provided in each private office, open office area, reception lobby, conference room, kitchenette in office spaces, and copy room. Additionally, hotel/motel guest rooms shall comply with Item 5. Controlled receptacles shall meet the following requirements, as applicable:

1. Electric circuits serving controlled receptacles shall be equipped with automatic shut-OFF controls following the requirements prescribed in Section 130.1(c)(1 through 5); and

2. At least one controlled receptacle shall be installed within 6 feet from each uncontrolled receptacle or a splitwired duplex receptacle with one controlled and one uncontrolled receptacle shall be installed; and

3. Controlled receptacles shall have a permanent marking to differentiate them from uncontrolled receptacles; and

4. For open office areas, controlled circuits shall be provided and marked to support installation and configuration of office furniture with receptacles that comply with Section 130.5(d) 1, 2, and 3; and

5. For hotel and motel guest rooms at least one-half of the 120-volt receptacles in each guest room shall be controlled receptacles that comply with Section 130.5(d)1, 2, and 3. Electric circuits serving controlled receptacles shall have captive card key controls, occupancy sensing controls, or automatic controls such that, no longer than 30 minutes after the guest room has been vacated, power is switched off.

6. Plug-in strips and other plug-in devices that incorporate an occupant sensor shall not be used to comply with this requirement.

**EXCEPTION 1 to Section 130.5(d):** In open office areas, controlled circuit receptacles are not required if, at time of final permit, workstations are installed, and each workstation is equipped with an occupant sensing control that is permanently mounted in each workstation, and which controls a hardwired, nonresidential-rated power strip. Plug-in strips and other plug-in devices that incorporate an occupant sensor shall not be used for this exception.

**EXCEPTION 2 to Section 130.5(d):** Receptacles that are only for the following purposes:
i. Receptacles specifically for refrigerators and water dispensers in kitchenettes.

ii. Receptacles located a minimum of six feet above the floor that are specifically for clocks.

iii. Receptacles for network copiers, fax machines, A/V and data equipment other than personal computers in copy rooms.

iv. Receptacles on circuits rated more than 20 amperes.

National Electrical Code® Article 406

(E) Controlled Receptacle Marking. All nonlocking-type, 125-volt, 15- and 20-ampere receptacles that are controlled by an automatic control device, or that incorporate control features that remove power from the outlet for the purpose of energy management or building automation, shall be marked with the symbol shown in Figure 406.3(E) and located on the controlled receptacle outlet where visible after installation.

Figure 406.3(E) Controlled Receptacle Marking Symbol.

Exception: The marking is not required for receptacles controlled by a wall switch that provide the required room lighting outlets as permitted by 210.70.

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