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8. Electrical Power Distribution

This chapter covers Section 103.5, which covers energy efficiency requirements for electrical systems. It is addressed primarily to electrical engineers and to enforcement agency personnel responsible for electrical plan checking and inspection.

This chapter is new to the 2013 version of the Nonresidential Compliance Manual. It been developed because the Standards themselves have been restructured to create a new section (Section 130.5) for electrical power system requirements, distinct from lighting control system requirements (Sections 130.1 through 130.4).

In deliberations concerning the 2013 standard, the Commission determined that important emerging issues of circuit metering and disaggregation, plug load (receptacle) controls, demand response systems, and energy management and control systems (EMCS) were cost effective provisions that would either save energy directly, or serve the invaluable purpose of allowing cost effective energy use monitoring for management purposes. In addition, the Standard was changed to make voltage drop limits mandatory that had previously been recommended but not required by the California Electrical Code (Title 24 Part 3).

8.1 Overview

All the requirements in Section 130.5 are mandatory, and therefore are not included in the energy budget for the whole building performance method.

8.1.1 Scope

The requirements for electrical power distribution systems apply to all non-residential buildings. The intention is to save energy and to allow future systems for power use monitoring and control to be added when expected changes in the marketplace occur.

A. New Construction and Major Remodeling

This Section applies to all new structures, and to some additions and alterations to existing structures. . For additions to existing structures, electrical circuits and Energy Management Control Systems (EMCSs) must in general meet the requirements of Section 130.5 if they:

- Serve a lighting system
- Serve an altered space-conditioning system or water heating system
- Serve an addition to an outdoor lighting system

See Section 141.0(a) of the Code for a list of exceptions

For alterations of existing systems, electrical circuits and EMCSs that have been altered must in general meet the requirements of Section 130.5 if:

- Serve lighting, space conditioning or water heating systems
- Are newly installed components of an existing system

B. See Section 8.8 (Additions and Alterations), for a list of exceptions.

B. Existing Construction

This Section does not apply to alterations or renovations in which existing service switchboards or panelboards, existing feeders, and existing motor control centers or panelboards remain in place and are unaltered except for changes to load circuit connections or the number or ampacity of outgoing overcurrent protection devices.

However, Its requirements are invoked when any of the following occur:

- A building is expanded and additional feeder(s), panelboard(s), major load(s), and/or motor control center(s) are added.
- A new service and/or main switchboard or panelboard is installed.
- A building is re-purposed and new panelboards and feeders are installed.

C. Acceptance Testing, Commissioning, and Installation Certificates

The requirements of Section 130.5 are not subject to acceptance testing or commissioning.

8.1.2 Summary of Requirements

The requirements of Section 130.5 are organized as follows:

A. Service Metering

Each electrical service shall have metering that will allow the building Owner to get useful information for managing the use of electrical power. The requirements increase as the size of the service increases. For smaller services, the building owner must be able to manually read the energy use (kWh) meter and to reset the readout to allow for period measurements, without of course affecting revenue measurements. As service size increases, the meter must also allow for demand measurements so that the building owner or operator can gain a better understanding of how and when the building uses electrical power. If the building is equipped with an Energy Management and Control System (EMCS) that provides these measurements, then the manual system is not required.

B. Disaggregation of Electrical Circuits

Above a minimum threshold that varies by load type, electrical power systems must be designed and built such that the total load of specific building load types can be measured. For instance, lighting loads must be able to be measured independently of HVAC loads. The intent is to have a single feeder or breaker with each type of load (such as lighting) on it, such that a meter could be placed on the feeder to report energy use by that load type.

Note that this is a wiring requirement only, and the providing of meters is optional.

C. Voltage Drop

This section makes the National Electrical Code/California Electrical Code suggestion of voltage regulation mandatory, limiting branch circuit voltage drop to 3% at design load and to 2% in feeders at design load.

D. Circuit Controls for 120-Volt Receptacles

This section adds minimum requirements for switching of 120-volt receptacles in non-residential applications. The primary reason is to permit simple control of furniture mounted task lights and other plug loads. There are a number of exceptions and exemptions to this requirement as not all receptacles require control.

E. Demand Response Controls and Equipment

Section 130.1(f) requires nonresidential buildings over 10,000 sf to have a demand responsive lighting system. The provisions of new Section 130.5 (e) require that demand responsive loads be equipped with controls that can receive at least one demand response signal and respond.

F. Energy Management Control System (EMCS)

For buildings employing Energy Management Control Systems, some of the above requirements are modified provided that the EMCS provides them.

8.1.3 Related Documents

There are a number of publications and documents available from the California Energy Commission and others that provide additional guidance on design practice for electrical power distribution. A summary of these is listed below:

1. Doc 1.
2. Doc 2.

8.2 Service Metering

Mandatory Requirement

Projects are required to provide an electric meter that permits the building owner or manager to read the instantaneous power in kilowatts being used by the building, and to be able to reset and measure energy use in kilowatt-hours over a period of his own choosing. If this is possible from the utility company's revenue service meter, then an additional meter does not need to be provided.

For larger buildings and electrical systems (greater than 250 kVA, which is 700 amps at 120/208 volts three phase and over 1000 amps at 120/240 volts single phase), the meter must also record the historical peak demand in kilowatts.

For much larger systems (greater than 1000 kVA, which is over 2700 amps at 120/208 volts three phase and over 4000 amps at 120/240 volts single phase, the meter must also be able to report the kWh for a fixed rate period.

Table 130.5-A (below) repeats these requirements in table form.

Practical Considerations

Metering of electrical power involves three key components:

- Current transformers (CTs), usually 2 or 3, which are typically in the shape of a doughnut and the power wire being measured goes through the doughnut hole'; and,
- Voltage measurement, phase to phase and/or phase to neutral, with isolation transformers in some instances; and,
- A meter to which the voltage wires and output of the CTs are connected

The simple residential meter has everything in a single box. Most people are familiar with the electromechanical residential and small commercial meter shown in Figure 8-A.

Figure 8-1 A Self Contained Residential or Small Commercial Electromechanical Meter

The electromechanical meter shown above is obsolete. Most new meters are electronic, and over time, most old meters will be replaced with an electronic meter. Meters with electronic data collection, analysis and communications ability are commonly called “smart meters”. Modern “smart” utility meters generally have all of the required features of this mandatory requirement, and more. The question is whether the building owner can access the information. The utility company owns the meter and there is no clear requirement for them to offer access to the data. **If data access is provided, the mandatory requirement is met with the utility meter.**

Figure 8-2 A modern electronic utility revenue meter (*GE*)

It may be desirable add a separate meter so that the building owner can have access to all of the data he needs. Adding a meter includes adding CTs, which will require room in a cabinet separate from the utility company CTs.

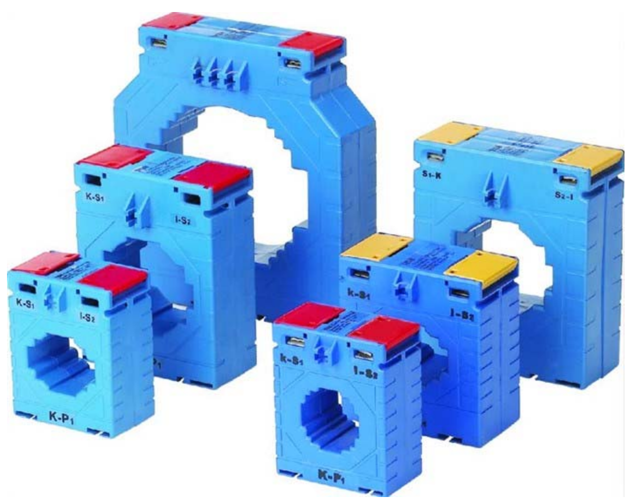


Figure 8-3 Solid Core CTs Various Sizes (*MES*)

Solid core CTs require pulling a de-energized cable through the hole.

Figure 8-4 A Residential Grade Split Core CT(*Efergy*)

A split core CT can be installed on an existing wire without de-energizing. This is a residential and light commercial grade CT with plug connection to a digital energy meter

The accuracy of metering is an issue. In general, “revenue grade” metering requires high accuracy CT’s and metering equipment. Energy-management metering CT’s can be less accurate without affecting their role and purpose.

Figure 8-5 An Electronic Energy Meter with Mandatory Metering and Digital Output Costing Less than $200 (*Akuvim*)

The meter itself can be located remotely from the CT’s, making it easier to read. Most electronic meters have a digital output that permits remote reading using specific hardware and software. Many can be read using a web browser and a password if the meter is connected to the Internet or building Ethernet.

Summary

- A meter that can be read by the building owner or occupant must be provided. This applies to any electrical service and is invoked any time that any section of the Standard applies and a permit is obtained.
- It must allow the building owner or occupant to view instantaneous power (kW) and have a manually resettable cumulative energy measurement (kWh) permitting periodic review of total electric energy use.
- Larger services will require additional capabilities identified in Table 130.5-A.
- Modern electronic utility meters "smart meters" usually meet the requirements as long as the data is accessible to the building owner or occupant.
- The cost of high performance meters is low and metering separate from the utility meter for energy monitoring, energy management, power quality measurement and other features not provided by the utility may be desirable.

TABLE 130.5-A MINIMUM REQUIREMENTS FOR METERING OF ELECTRICAL LOAD

Meter Type	**Services rated 50 kVA or less**	**Services rated more than 50kVA and less than 250 kVA**	**Services rated more than 250 kVA and less than 1000kVA**	**Services rated more than 1000kVA**
Instantaneous (at the time) kW demand	Required	Required	Required	Required
Historical peak demand (kW)	Not required	Not required	Required	Required
Resettable kWh	Required	Required	Required	Required
kWh per rate period	Not required	Not required	Not required	Required

8.3 Disaggregation of Electrical Circuits

Mandatory Requirement

This section of the Standard requires buildings to be wired in a manner that separates loads by types onto independent feeders and risers through the building. This will require separate feeders and panels for lighting, plug and equipment loads, HVAC loads, etc. The requirements are contained in Table 130.5B, reproduced below.

"Disaggregation" means in this case to break down the total electrical use in the building into groups that permit metering and enable management to determine where energy is being used. For instance, lighting energy use quantities and patterns can be studied and excess use or waste can be targeted for improvements.

In the examples, note that the manner in which disaggregation occurs does not require specific wiring; for instance, a single feeder can provide lighting and plug load power as long as the panelboard has a split bus allowing measurement of one and then the other. However, this can only be used in a smaller building as the all lighting must be able to be measured at one point.

This requirement is for new buildings and for major additions or renovations. It is invoked whenever the service is modified as with a new switchboard, or when sections are added or new feeders pulled. In an existing building that is being altered, this requirement is not invoked as long as the existing service switchboard, existing feeders and existing panelboards remain essentially "as-is".

The requirement is progressive. Disaggregation is not required until the service reaches 50 kVA, which is 60 amps at 277/480 volts three phase, 150 amps at 120/208 volts, three phase and 200 amps at 120/240 volts single phase. For most small buildings or separately metered portions of a building, such as a store in a mall, this requirement will not apply.

Once the service to the building reaches 50 kVA, the requirements are applied to some groups regardless of actual load, and to other groups when the group reaches a threshold value of 25 kVA (100 amps at 240 volts single phase, 70 amps at 120/208 volts three phase, and 30 amps at 277/480 volts three phase).

Note that this requirement does not require any metering. By placing all load of a particular type on one feeder, a portable power measurement and analysis device can be temporarily attached to its feeder, measurements can be made, and then the device can be moved to another feeder.

NOTE: As an alternative, CTs can be added for feeders throughout the building and permanent measurement systems can be installed. In this case disaggregated wiring is not required as long as the metering provisions permit the equivalent disaggregated measurements.

Practical Considerations

These requirements were developed with a reasonably practical eye. In a small building or service, disaggregation is not required at all. The minimum threshold of 50-kVA service means that almost all projects less than 5,000 sf will not be required to comply. Slightly larger projects will be able to comply by using carefully laid-out panelboards. The standard envisions the use of conventional panelboards, motor control centers, through wired panels, and other standard wiring methods. It also envisions a new generation of creative solutions such as split bus panels, with separate bus and breaker sections for lighting and receptacles/equipment. Likewise, clever wiring methods will also emerge, such as connecting all HVAC units to a single feeder from the service, using a combination of through feeds and taps. In other words, with minor changes in how power is distributed in a building, the requirement can be met with little or no added cost.

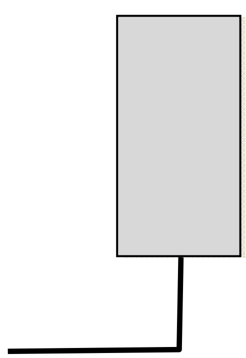
In larger buildings, this mandatory requirement will make separate risers for lighting, receptacles/equipment, and HVAC necessary. Single large loads or groups of loads, such as an elevator machine room, chiller or commercial kitchen, will have a separate feeder and panelboard or motor control center anyway; in many buildings these requirements are already met at least in part.

For buildings with a single large service greater than 50 kVA, such as retail malls, offices and apartment buildings that have submetered distribution to completely demised tenants, the requirements apply as follows:

- Common areas of the building must be disaggregated
- Individual submetered services must be disaggregated if the submetered service is 50 kVA or greater, with the exception of residential units, in which disaggregation is not required.

In remodeled or renovated buildings, the total electrical load is expected to be reduced as Title 24 lighting power requirements, HVAC requirements, insulation and glazing requirements, etc. will necessarily cause the original building to use less energy, and to a certain extent a building can be enlarged without increasing the service or existing feeders and panels. As long as the only changes to the electrical system involve changes to branch breakers and branch circuits, this mandatory requirement is not invoked.

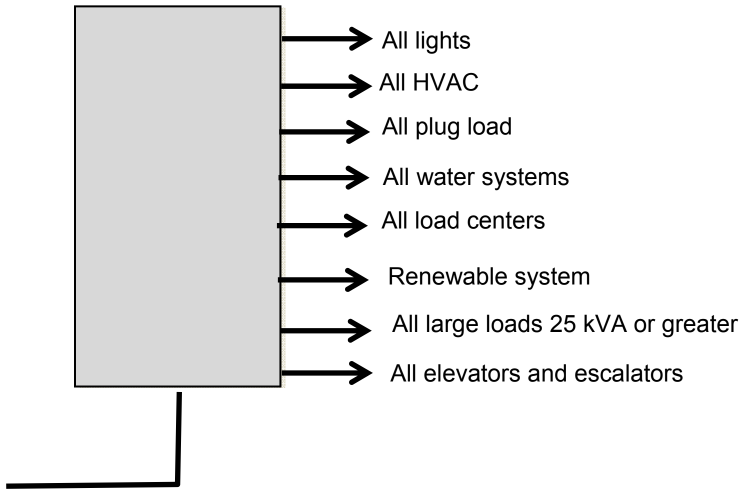
Examples



Example 8.3-A

Single panel with service less than 50 kVA, which is less than 60A@ 277/480v 3□, 135A @ 120/208v 3□, or 200A @ 120/240v 1□

NO REQUIREMENTS FOR DISAGGREGATED WIRING



Example 8.3-B

BASIC REQUIREMENTS FOR DISAGGREGATED WIRING

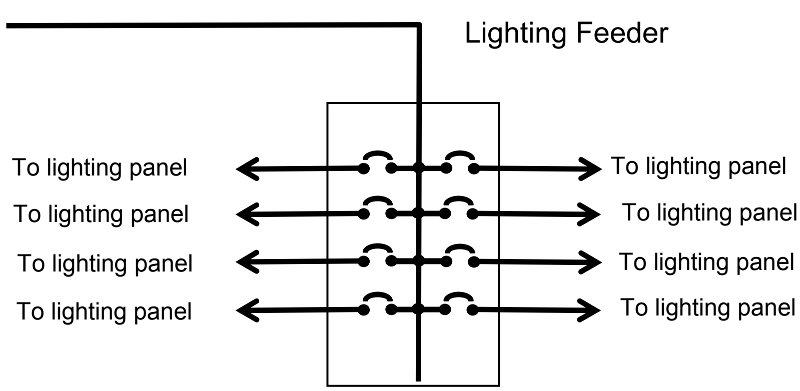
Service panel with service less than 250 kVA, which is less than 300A@ 277/480v 3□, 690A @ 120/208v 3□, or 1000A @ 120/240v 1□

This would be typical of a small school or office building (~25,000 to 50,000 sf), small retail or grocery store (~10,000 to 20,000 sf), etc.

Each feeder serves a breaker panel, load center, or load or load group with its own disconnect and subdistribution.

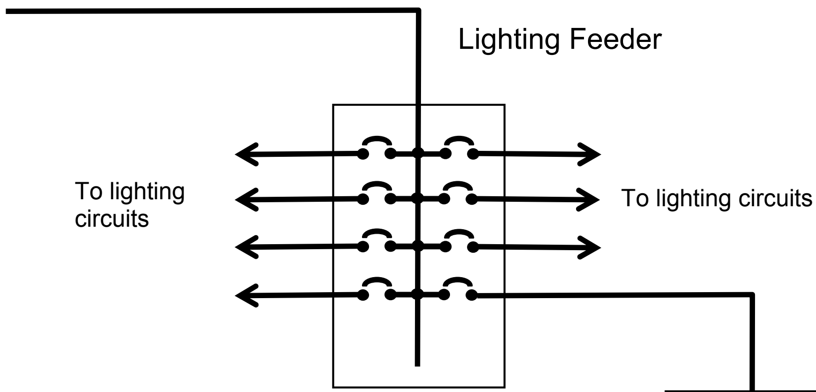
NOTES

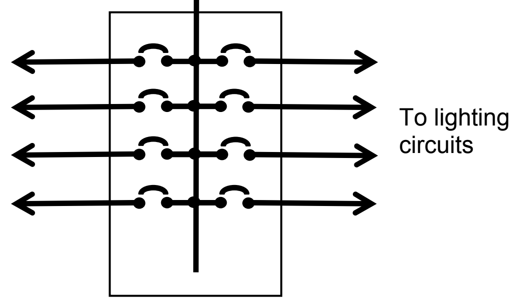
- Large loads smaller than 25 kVA can be connected to load centers or plug load groups
- Load centers can be used to aggregate many small equipment loads such as commercial or industrial equipment, computer server rooms, commercial kitchens, retail refrigeration, etc.
- A single multi-pole breaker can be used to feed all branch circuit loads of one type, such as all lighting loads, in smaller buildings.



Example 8-3C

Using a distribution panel to subfeed branch circuit panelboards. Can be used for lighting, HVAC, plug loads, or any other group of load types.



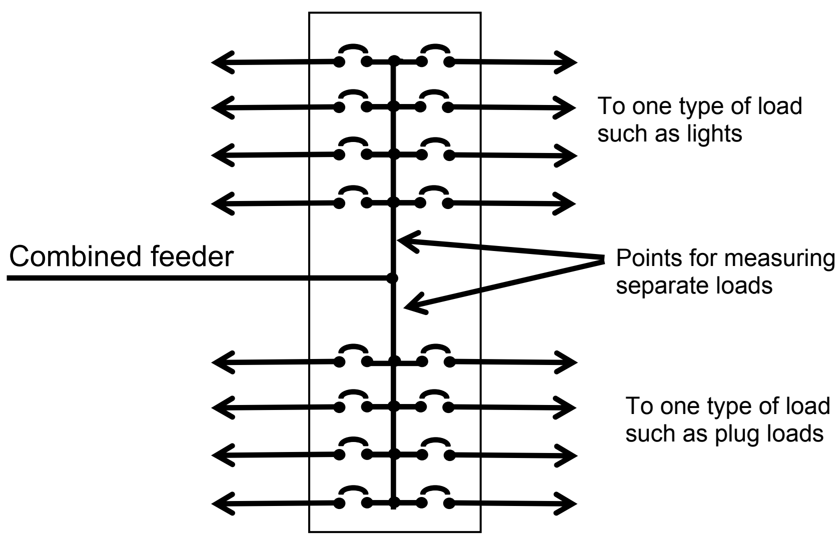


Example 8.3-D

Combined lighting panel with subfeed to other lighting panel(s).

A larger first lighting panel (e.g. 400 amps) could subfeed three 100-amp panels, or 6 60-amp panels, and serve local branch circuits, too.

Can be used for lighting, HVAC, plug loads, or any other group of load types.



Example 8-3E

Using a split bus panel to feed two groups of branch circuits. Can be used for lighting, HVAC, plug loads, or any other group of load types. Limited to use in smaller projects where only one panel is needed for each load type.

TABLE 130.5B Required Disaggregation of Electrical Loads

Load Type	**Services rated 50 kVA or less**	**Services rated more than 50kVA and less than 250 kVA**	**Services rated more than 250 kVA and less than 1000kVA**	**Services rated more than 1000kVA**
Lighting including exit and egress lighting and exterior lighting	Not required	All lighting in aggregate	All lighting disaggregated by floor, type or area	All lighting disaggregated by floor, type or area
HVAC systems and components including chillers, fans, heaters, furnaces, package units, cooling towers, and circulation pumps associated with HVAC	Not required	All HVAC in aggregate	All HVAC in aggregate and each HVAC load rated at least 50 kVA	All HVAC in aggregate and each HVAC load rated at least 50kVA
Domestic and service water system pumps and related systems and components	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Plug load including appliances rated less than 25 kVA	Not required	All plug load in aggregate Groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf	All plug load separated by floor, type or area Groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf	All plug load separated by floor, type or area All groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf
Elevators, escalators, moving walks, and transit systems	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Other **individual** non-HVAC loads or appliances rated 25kVA or greater	Not required	All	Each	Each
Industrial and commercial **load centers** 25 kVA or greater including theatrical lighting installations and commercial kitchens	Not required	All	Each	Each
Renewable power source (net or total)	Each group	Each group	Each group	Each group
Loads associated with renewable power source	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Charging stations for electric vehicles	All loads in aggregate	All loads in aggregate	All loads in aggregate	All loads in aggregate

8.4 Voltage Drop

8.4.1 Mandatory Requirement

This is a new Section. It makes the recommended voltage drop limits from the California Electrical Code (Title 24 Part 3) mandatory. Specifically,

- The voltage drop in feeders is limited to 2% of design load; and
- The voltage drop in branch circuits is limited to 3% of design load.

Emergency power circuits are exempt.

8.4.2 Purpose of this Requirement

Voltage drop represents energy loss as heat in the electrical conductors. The loss is called “I^2R” (I-squared-R) loss, meaning that the loss is directly proportional to the conduction resistance and proportional to the amps **squared**. Because of I^2R loss, it is advantageous to distribute utilization power at the highest practical voltage to reduce current to each load. This basic consideration will continue to promote 277/480-volt systems wherever practical. But with the growth of 120-volt utilization loads, many projects will consider 120/208-volt or 120/240-volt systems to avoid subtransformers and the added costs of having two power systems.

Once the distribution and utilization voltage(s) are determined, feeders and branch circuits are designed. Per code, the wire size or gauge is primarily based on “ampacity”, the number of amps for which the wire is rated in the application[1]. Voltage drop limits may cause increased cable diameter (gauge), particularly for long wire runs.

With rising prices of copper and the heavy demand for it in developing countries, there will be continued pressure to use aluminum alloy and copper clad aluminum for typical projects in the US. Past problems with aluminum branch circuits will discourage aluminum branch wiring, but feeders will use increasing amounts to save both cost and weight. Unfortunately, the resistivity of copper is 10.4 ohms per circular mil per foot as compared to 15% copper-clad aluminum (16.1) and AA-8000 series aluminum alloy (17.0). In practice, larger gauge aluminum and copper clad aluminum conductors will be required to reduce the voltage drop.

[1] The application takes into account how and where the wire or cable is located, such as in free air, in a conduit in a building, directly buried in earth, etc. These affect the cable’s dissipation of the heat and the resulting operating temperature of the cable. Cables subject to a lot of heat are derated by the code.

Figure 8-6 Copper Prices 1986-2011

Source: Wikipedia

8.4.3 Applying Voltage Drop Calculations

Voltage drop losses are cumulative, so that 2% loss in feeders and 3% loss in branch circuits add up to 5% loss relative to the load at the end of the branch circuit. Because electrical loads are not constant, the calculation is based on design load. For feeders, this is the calculated maximum demand load on the circuit per the California Electrical Code but does not include any of the additional ampacity required by the California Electric Code. For branch circuits, the design load is either (a) the branch circuit rating for receptacle loads (usually 16 amps), or (b) the 100% load of a specific load such as motor or fixed equipment.

The calculation is for the total length of the feeder, and for the maximum length of branch circuit to the load. For branch circuits, this calculation can be excessively complicated in many cases. For this reason, any of the following methods can be used to calculate branch circuit voltage drop:

a) A load-by-load, detailed calculation of the voltage drop. This is required for circuits with specific loads such as motors or fixed equipment.
b) For circuits with many loads such as receptacles, determine the approximate centroid of the load. The centroid is defined as the physical center of all possible load locations. For a receptacle or lighting circuit, it is the physical center of the room or all rooms served by the circuit. Determine the voltage drop at that point for the actual load or 75% of the maximum allowable circuit amps, whichever is greater.
c) For circuits as b) but with a common neutral and multiple phase conductors carried as far as a first major junction box, the voltage drop calculated above may be reduced 25% to account for the cancelation of neutral current before the neutral is tapped and single phase circuits begin.

8.4.4 Calculations

While voltage drop calculations can be performed by hand, they are also the output of most modern power design computer programs. In addition there are handy calculators on the Internet[2] and procedures for determining voltage drop are printed in electrician's handbooks[3].

Calculations are relatively straightforward. Multiply the allowed voltage-drop percentage (2% for feeders, 3% for branch circuits) by the nominal system voltage. This is the allowed drop in the feeder or branch circuit. Note to be careful whether calculating voltage drop in a single-phase or three-phase system, as illustrated in the following example.

Example: in a 120/208 volt system, the allowed voltage drop for a single phase 120 volt branch circuit load is (120 *.03) = 3.6 volts. For the feeder in the same 120/208 volt three phase system, the allowed voltage drop is (120*.02) = 2.4 volts, for a cumulative loss of 6 volts (5%).

Next, calculate the actual voltage drop in the circuit. Multiply the resistance times the length of wire in the circuit. Remember, the length of wire is TWICE the distance, as current must flow to the load and back. For three phase circuits, the allowed voltage drop is based on line-to-line volts, not line-to-neutral volts.

Example: In a 120/208 volt system, a single-phase branch circuit runs 100 feet to the centroid of a number of receptacles. Assuming 12 amps (75% of the maximum allowed load) and cooper wire, the voltage drop in the branch circuit will be

With #12 wire @ .00187 ohms/ft, E_{drop} = IR = 12*100*2*.00187 = 4.48 volts

With #10 wire @ .00118 ohms/ft, Edrop = IR = 12*100*2*.00118 = 2.81 volts

With #8 wire @ .000739 ohms/ft, Edrop = IR = 12*100*2*.000739 = 1.76 volts

In this case, the branch circuit should be #10 to the first load or junction box. The remainder of the circuit could probably be wired with #12 gauge provided there are no long runs or single large loads.

Example: a service panel feeds a 120/208 volt three phase panelboard 150 feet away. The design load is 80 amps, three-phase. The panel mains and feeder breaker are rated 100 amps. By code the feeder must be at least #3 AWG copper, but the more common size #2 AWG is used. Does it comply?

For #2 AWG, E = IR = .000513 ohms/ft *150 ft *2* 80 amps =12.3 volts. But the allowed drop is 208 * .02 = 2.4 volts. The answer is no, there will be too much loss in the feeder.

The proper feeder will be at least 400 MCM copper to achieve 2.4 volts or less in voltage drop.

[2] www.electrical-installation.org

[3] Ugly's Electrical References, George Hart and Sammie Hart, Jones and Bartlett, Publishers

8.5 Circuit Controls for 120-Volt Receptacles

8.5.1 Mandatory Requirement

This new section addresses receptacles in offices. Office plug loads are now the largest power density loads in most office buildings. The Standard now requires both controlled and uncontrolled 120-volt receptacles in each private office, open office area, reception lobby, conference room, kitchenette in office spaces, and copy room. The controlled outlets must be clearly different from uncontrolled outlets. The two principal ways to comply include:

1. For each uncontrolled outlet, provide a controlled outlet within 6 feet; or,
2. Use split wired duplex receptacles, with one uncontrolled and one controlled.

For open office areas, separate controlled and uncontrolled circuits must be provided to the workstations. If workstations are not installed at the time of occupancy, then when installed they must be equipped with non-residential power strips having motion controls built into the workstation, or alternatively, use the controlled and uncontrolled circuits already built in to the building system.

The controlled outlets must be automatically switched off in the same manner as required for general lighting, as described in Section 130.1(c.). The most common means will be a local motion sensor that can be connected to control both general lighting and outlets and using the occupancy (not vacancy) control method. Another common method will be to employ time of day controls with manual override switches.

Note that plug strips with motion sensors CANNOT be used to meet this requirement. The intent is to have built-in, hardwired power controls. Wireless motion sensors can be used, but the actual power switch must be hardwired.

The requirement for controlled receptacles in all of these spaces allows plug loads to be turned off for energy savings, and perhaps, for demand response. These particular space types were singled out because they commonly employ portable lighting and other loads that can be automatically controlled to save energy.

There are important exceptions not requiring a controlled outlet including:

- Clock outlets.
- Outlets for copiers, printers and other IT equipment (with the exception of personal computers) in copy rooms.
- Outlets for refrigerators and water dispensary devices in kitchenettes.

8.5.2 Practical Considerations

In general, the most cost effective approach will be:

Private Offices, Conference Rooms, and other Spaces with Periodic Occupancy

A common motion sensor can control general lighting and receptacles (Figure 8-7). If needed because of different voltages, an auxiliary relay can be connected to the sensor. Likewise, with an auxiliary relay, the lighting system could be operated in the vacancy mode, and the controlled receptacles in the occupancy mode, thus permitting lights to be off while receptacles are on.

Lobbies, Break Rooms, and other Spaces with Frequent Occupancy During Business Hours

Time of day controls, with either a motion sensor or switch override, can switch the controlled receptacles. Programmable relay panels or controllable breakers can be used, or for less complex projects, a combination of motion sensors and programmable time switches can accomplish the same task. Note that if motion sensing is used, controls need to be room-by-room or space-by-space, but if time of day controls with manual override are used, whole circuits can be controlled together.

Open Office Areas

Open office areas can be designed to either provide controls by the building system (Figure 8-8), or controls integrated into the furniture systems. If the building provides controls, the most reliable system will most likely employ relays or controllable breakers, with manual override switches for zones within a open office space. A system using motion sensors might also be considered if sensors can be added as needed to address partitioning of the workstations thus ensuring proper operation. Systems contained within workstation systems are an acceptable alternative provided that they are hardwired as part of the workstation wiring system.

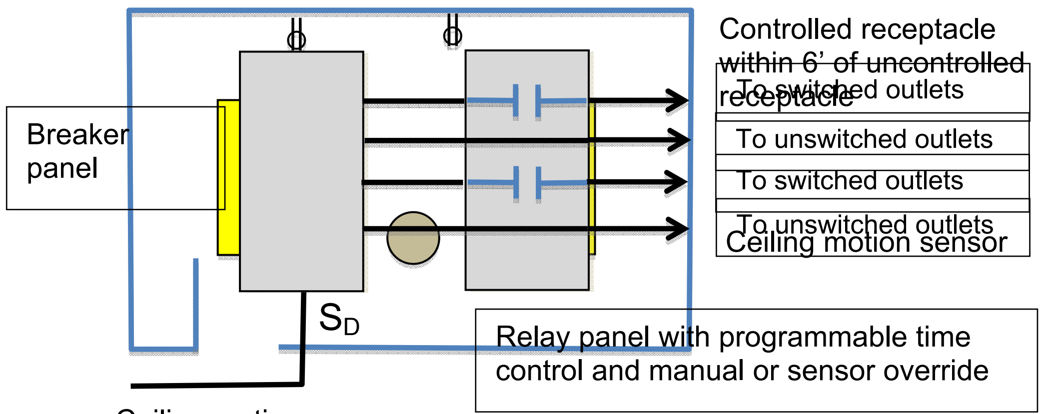
Networked Control Systems and Building Automation Systems

Most advanced lighting and energy control systems can be easily designed to accommodate outlet controls.

Certain office appliances, e.g. computers and fax machines, need to be powered all the time to provide uninterrupted services. These would be connected to the uncontrolled receptacles. Other appliances, e.g. task lamps, personal fans and heaters, monitors, do not need to be powered without the presence of occupants. They are considered as controllable plug loads and would be plugged into the controlled receptacles for automatic shutoff controls. A hardwired control system provides the capability and convenience for automatic plug controls. Ultimately, it depends on building occupants to determine the appliances to be controlled.

In open office areas, it is better to implement occupancy sensor control at each workstation (cubicle) to maximize the opportunities of shutoff controls. System furniture (cubicle) is usually equipped with more than one internal electrical circuit and some of these circuits can be dedicated for controllable plug loads. Electric circuit connectors for system furniture are modularized and, therefore, split between controlled and uncontrolled circuits has to be made at a junction box. If external occupancy sensor switches are used, they all need to be wired to the corresponding junction box and the overall system wiring is complicated. In addition, off-the-shelf occupancy sensors are designed to be mounted on walls, not onto system furniture. For the above reasons, office furniture with embedded occupancy sensor controls are the ideal choice for occupancy sensor controls in open office areas.

Figure 8-7 Office or Conference Room Basic Controls



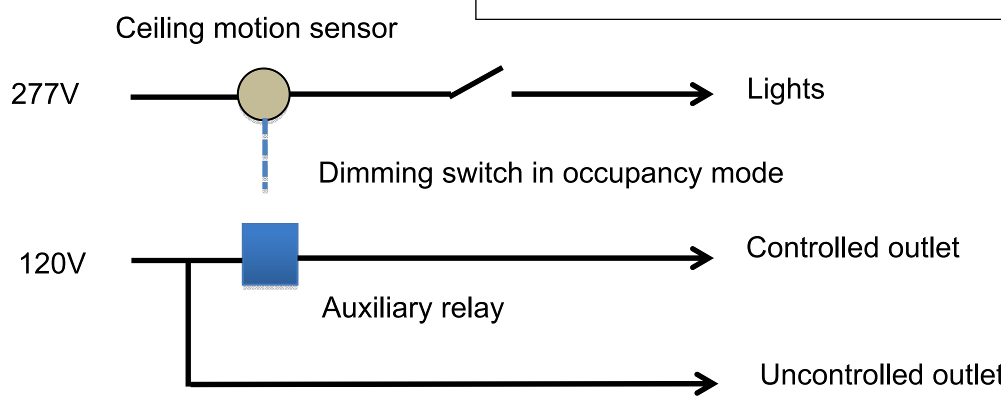


Figure 8-8 Wiring for Open Office Area

8.6 Demand Response

8.6.1 Mandatory Provisions

This section requires that, in any building or sign having mandatory provisions for demand response (DR), controls and equipment for DR shall be capable of receiving and automatically responding to at least one standards-based messaging protocol that enables demand response after receiving a demand response signal.

Mandatory demand response is required for lighting in buildings over 10,000 square feet (Section 130.1(f)) and for electronic message centers over 15 kW (Section 130.3(a.) 3.), including remodeled and renovated buildings whenever Section 130.1 compliance is required.

8.6.2 Application Notes

Note that this requirement only makes the building DR ready. It does not require buildings to be demand responsive. The decision to employ demand response is up to the building owner or manager, the utility company, and/or a governing authority.

Demand response is defined as short term changes in electric energy use in response to a signal sent from the local power utility, independent system operator (ISO), or designated curtailment service provider. The signal may be to indicate changes in electricity costs or to reduce load when the grid reliability is threatened with black outs.

Demand response is becoming increasingly important as it permits the temporary reduction of electric load on the grid when extreme weather or other conditions cause high electric energy use. It is also seen as a means to control electricity costs as future prices are expected to change constantly as a function of overall system demand.

Because mandatory demand response is relatively new, standards and systems are still being developed and evolving. For this reason, Section 130.5 (f.) does not specify a particular protocol or system, but rather, lets it be specified by the utility company or other authority.

8.7 Energy Management Control System (EMCS)

EMCSs are a common approach to building control because they allow building operators to monitor and adapt energy systems, to troubleshoot problems, to schedule routine maintenance, and to perform a host of other useful functions. The Standards allow EMCSs to be used to provide lighting controls functionality for demand response, as long as the EMCS meets the mandatory requirements described below.

8.7.1 Mandatory Requirements

An energy management control system can be used to comply with one of more of the following mandatory requirements:

- Lighting controls included in Section 110.9 for automatic control devices and systems, especially clock time and astronomic time functions and integrated functions using occupancy and vacancy sensing.
- Lighting controls included in Sections 130.0 through 130.4, especially if functioning as an integrated control system
- In lieu of disaggregated wiring requirements under Section 130.5 if built-in metering provides the same capability as intended
- In lieu of a demand response system under Section 130.5 if it can be connected to a demand response signal and permit demand response control

Note that when an EMCS is used to comply with the lighting control requirements of 130.1, it must be certified according to 130.4(b)2:

> *Certification that when an Energy Management Control System is installed to function as a lighting control required by Part 6, it functionally meets all applicable requirements for each application for which it is installed, in accordance with Sections 110.9, 130.0 through 130.5, 140.6 through 150.0, and 150.2; and complies with Reference Nonresidential Appendix NA7.7.2.*

Also, when an EMCS is used to earn lighting Power Adjustment Factors (PAFs), it must be certified according to 130.4(b)6:

> *Certification that lighting controls installed to earn a lighting Power Adjustment Factor (PAF) comply with Section 140.6(a)2; and comply with Reference Nonresidential Appendix NA7.7.6.*

8.8 Additions and Alterations

TO BE DEVELOPED