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COURSE 962911

Residential Rehab - Ch 5 Electrical

Review Material

Uscontractorlicense LLC

PO Box 268 / Platteville, Wisconsin 53818 / 608.348.6688 / www.uscontractorlicense.com

Summary Of This Course

RESIDENTIAL REHABILITATION - CHAPTER 5 ELECTRICAL

Approved by the

Wisconsin Department of Safety and Professional Services Safety and Buildings Division
Course Identification Number 962911
Educational Credit Hours: 4 Hours

Course Provider:
USCONTRACTORLICENSE LLC
P.O. Box 268
Platteville, WI 53818-0268
(608) 348-6688

www.uscontractorlicense.com

Chapter 5 of Residential Rehab explains how to inspect and evaluate residential electrical systems to determine whether they are safe, functional, and capable of meeting current and future electrical demands. It begins with an overview of the electrical system, emphasizing the importance of assessing older systems and having qualified electricians perform detailed evaluations. The chapter covers inspection of the service entry, including overhead conductors, electric meters, service entrance conductors, and service capacity. It then discusses the main panelboard, focusing on proper location, grounding, amperage and voltage ratings, overcurrent protection, and recognizing signs of overload or unsafe modifications. The final section examines branch circuits, wiring methods, grounding, GFCI protection, and acceptable wiring types such as NM, UF, AC, MC, and EMT. Special attention is given to older knob-and-tube wiring and aluminum wiring, identifying hazards, deterioration, and proper corrective measures. The chapter concludes by stressing safe installation practices, proper testing procedures, and the importance of functioning smoke detectors for occupant safety.

This Course is approved for the following electrical Registrations/Certifications or Licenses:

UDC Electrical Inspector	4 Hours of Continuing Education	
Commercial Electrical Inspector	4 Hours of Continuing Education	
Registered Electrician	4 Hours of Continuing Education	
Journeyman Electrician	4 Hours of Continuing Education	
Industrial Journeyman Electrician	4 Hours of Continuing Education	
Master Electrician	4 Hours of Continuing Education	
Residential Master Electrician	4 Hours of Continuing Education	
Residential Journeyman Electrician	4 Hours of Continuing Education	

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

Course Outline

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

Chapter 5 Electrical System

5.1 Service Entry

5.2 Main Panelboard (Service Equipment)

5.3 Branch Circuits

Exam

120 questions related to the reference materials are used to test the attendee on their comprehension of the materials. A 70% score will need to be attained in order to pass this course.

Answer Sheet(s)

1 bubble style answer sheets are included. When you are finished with the exam, you may return the answer sheets for grading to:

By Mail: Uscontractorlicense LLC
PO Box 268
Platteville, Wisconsin 53818

By Email: michael@uscontractorlicense.com

By Fax: 608-571-0096

Once we get the answer sheets back, we will graded them, enter your hours into the attendance portal and email or mail you back your certificate of completion(s). You will be responsible for renewing your license with the DSPS at www.license.wi.gov website.

Any questions, please contact us at 608.348.6688

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Electrical System

Electrical systems for small residential buildings are usually simple in concept and layout. Primary components are the service entry, panelboard, and branch circuits. In unaltered buildings built since about 1940, the electrical system is likely to be intact and safe, although it may not provide the capacity required for the planned reuse of the building. Electrical capacity can be easily increased by bringing additional capacity in from the street and adding a larger panelboard between the service entry and the existing panel. Existing circuits can continue to use the existing panel and new circuits can be fed through the new panel.

The electrical systems of small residential buildings built prior to about 1940 may require overhaul or replacement, depending on rehabilitation plans and the condition of the electrical system. Parts of these older systems may function very adequately and they can often be retained if the rehabilitation is not extensive and the load-carrying capacity is adequate.

A thorough and informed assessment of the electrical system will determine the extent to which it can be reused. This assessment should be conducted only by a qualified electrician who is experienced in residential electrical work.

When universal design is a part of a rehabilitation, consult HUD publication *Residential Remodeling and Universal Design* for detailed information about electrical devices.

Assess the capacity of the building's existing electrical service in accordance with Figure 5.1.

The safety standards for the following assessment procedures are generally based on the requirements of the *National Electrical Code*.

5.1
Service Entry

Inspect for the following conditions in the electrical service between the street and the main panelboard:

- **Overhead wires.** Check that overhead wires from the street are no lower than 10 feet above the ground, not in contact with tree branches or other obstacles, and not reachable from nearby windows or other accessible areas. Make sure that the wires are securely attached to the building with insulated anchors, and have drip loops where they enter the weatherhead. Spliced connections at the service entrance should be well wrapped, and bare wires from the street should be replaced by the utility company. Wires should not be located over swimming pools.
- **Electric meter.** Check that the electric meter and its base are weatherproof, and that the meter is functional, has not been tampered with, and is securely fastened. Advise the utility company of any problems with the meter.
- **Seismic vulnerability.** If the building is in a seismic zone, check the electrical service for vulnerability to differential movement between the exterior and interior. Look for flexible connections.
- **Service entrance conductor.** Ensure that the service entrance conductor has no splices and that its insulation is completely intact. If the main panelboard is located inside the building, the conductor's passage through the wall should be sealed against moisture. Where aluminum conductors are used, their terminations at all service equipment should be cleaned with an oxide inhibitor and tightened by an electrician or replaced with equal capacity copper conductors. When it is necessary to replace an overhead service entry, have it replaced with an underground service entry.
- **Type of power available.** Not every jurisdiction provides the same kind of electrical power. Philadelphia, for example, has two-phase electrical power in some locations rather than the more common single-phase. Check with the power company to determine the characteristics of the power available.

5.2 Main Panelboard (Service Equipment)

The main panelboard is the distribution center for electric service within the building and protects the house wiring from overloads. Inspect the panelboard as follows:

- **Condition and location**. Check the overall condition of the panelboard. Water marks or rust on a panel mounted inside the building may indicate water infiltration along the path of the service entrance conductor. Panelboards mounted outdoors should be watertight and tamper proof. Panels mounted indoors should be located as closely as possible to where the service entrance conductor enters the building and should be easily accessible. The panelboard should have a workable and secure cover.
- **Amperage rating**. The amperage rating of the main disconnect should not be higher than the amperage capacity of the service entrance conductor or the panelboard. If the rating is higher (indicating unapproved work has been done), more branch circuits may be connected to it than the service entrance conductor is capable of supplying. This is a serious hazard and should be corrected.
- **Voltage rating.** The voltage rating of the panelboard (as marked on the manufacturer's data plate) should match the voltage of the incoming electrical service.

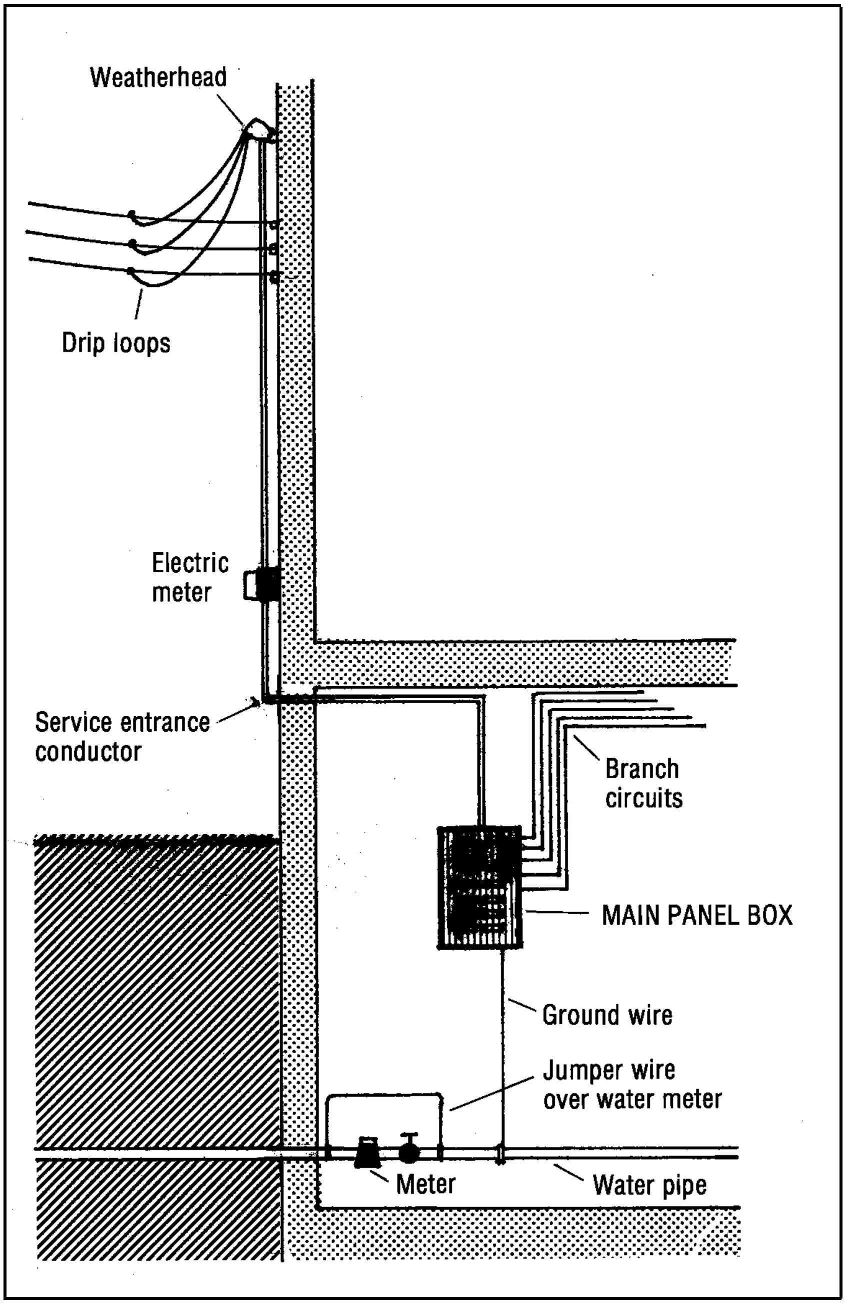
Figure 5.1 Assessing Electrical Service Capacity (Ampacity)

To determine the capacity (measured in amperes) of the building's existing electrical service at the main panelboard, check the following:

- The ampacity of the service entry conductor, which may be determined by noting the markings (if any) on the conductor cable and finding its rated ampacity in the *National Electrical Code*, Table 310-16, or applicable local code. If the service entry conductor is in conduit, look for markings on the conductor wires as they emerge from the conduit into the panelboard. If all conductors are unmarked, have an electrician evaluate them.
- The ampere rating on the panelboard or service disconnect switch, as listed on the manufacturer's data plate.
- The ampere rating marked on the main circuit breaker or main building fuse(s). This rating should never be higher than the above two ratings; if it is, the system should not be used until it is evaluated by an electrician.

The building's service capacity is the lowest of the above three figures. Once the service ampacity has been determined, compare it to the estimated ampacity the building will require after rehabilitation. If the estimated ampacity exceeds the existing ampacity, the building's electrical service will need upgrading. The method for estimating required ampacity is found in the *National Electrical Code*, Article 220.

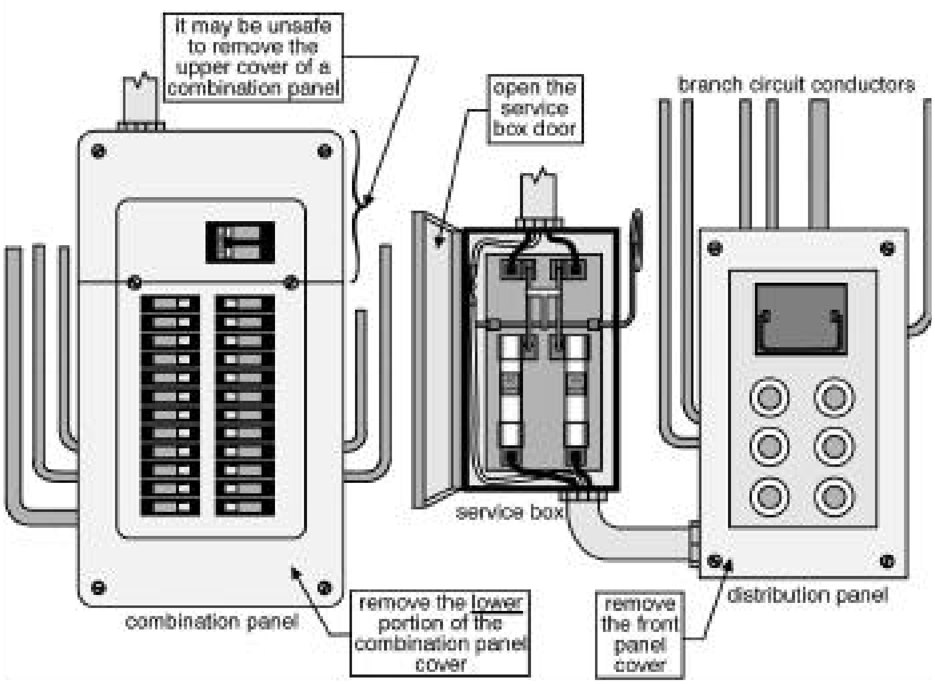
Similarly, the service capacity of each branch circuit can be determined by checking the markings on each branch circuit conductor. If no markings can be found, a plastic wire gauge may be used to measure the wire size (with the power disconnected), although an experienced person can often determine the size by eye. Find the ampere rating of the conductor, either by its markings or wire size, in the *National Electrical Code*, Table 310-16, or applicable local code.



Typical electrical service entry and main panelboard for a single family residence. This type of grounding applies only if the water pipe is metal. If the water pipe is plastic, a separate driven ground rod is required.

Test: The actual voltage rating of the incoming electrical service can be checked with a voltmeter. This test should be performed by an electrician. Usually three service conductors indicates 120/240 volt current, and two conductors indicates 120 volt current.

- **Grounding.** Verify that the panelboard is properly grounded. Its grounding conductor should run to an exterior grounding electrode or be clamped to the metal water service inlet pipe between the exterior wall and the water meter. If it is attached on the house side of the meter, the meter should be jumpered to ensure proper electrical continuity to the earth. Make sure that the ground conductor is securely and properly clamped to the pipe—often it is not, and occasionally it is disconnected altogether. Ensure also that the grounding conductor is not attached to a natural gas pipe, to an inactive pipe that may be cut off on the exterior side of the wall, or to a pipe that is connected to a plastic water service entry line. If the grounding conductor is attached to an exterior grounding electrode driven into the earth, verify that the electrode is installed in accordance with local code. Many older buildings will have the ground connected to the cold water pipe. If this is the case and the building needs to conform to the current code, an alternate ground is required.



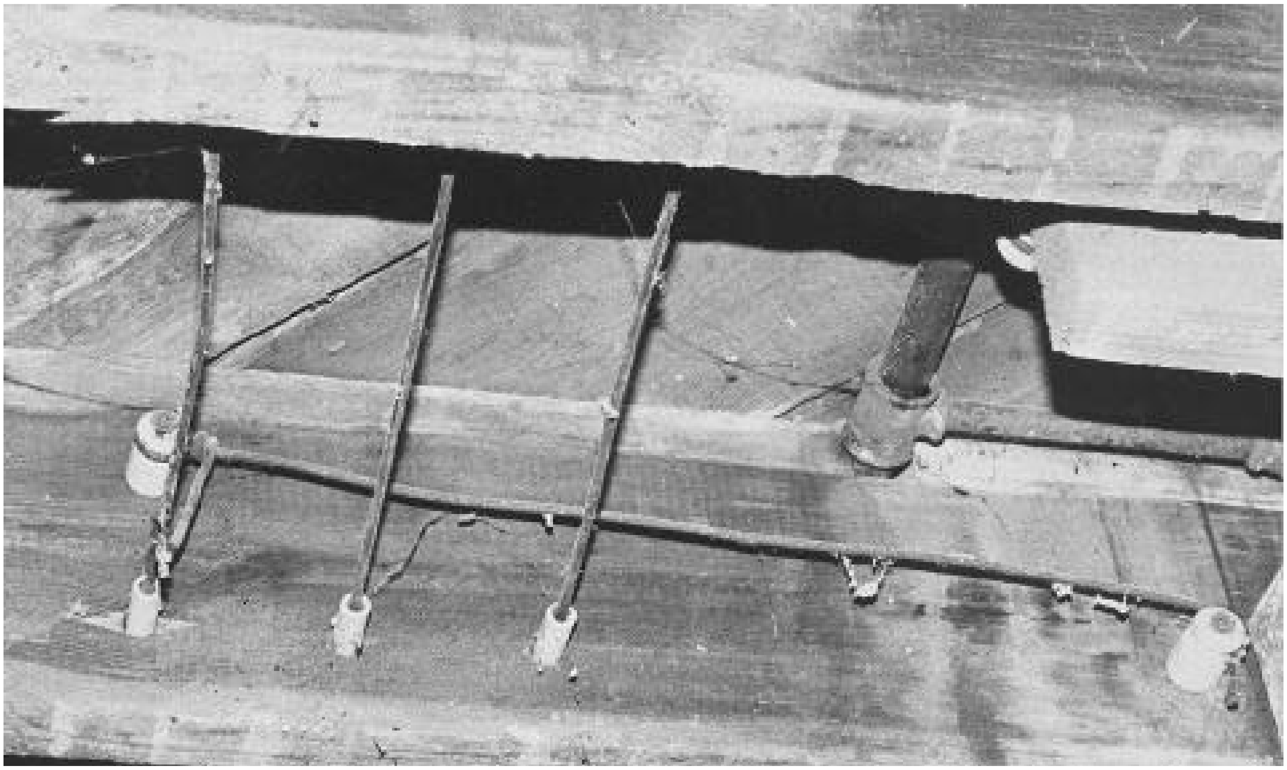
Typical service equipment

Test: An electrical ground (resistance-to-ground) test may be used to determine whether the electrical system is well grounded to the earth. The test requires the use of an ohmmeter and should be performed by an electrician.

- **Overcurrent protection.** Check the rating of the fuse or circuit breaker for each branch circuit. The amperage of the fuse or circuit breaker should not exceed the capacity of the wiring in the branch circuit it protects. Most household circuits use #14 copper wire, which should have 15 amp protection. There may be one or more circuits with #12 copper wire, which should have 20 amp protection. Large appliances, such as electric water heaters and central air conditioners, may require 30 amp service, which is normally supplied by #10 copper wire. If there is an electric range, it would require a 40 or 50 amp service with #6 copper wire. Central air conditioning equipment will have an overcurrent protection requirement on the nameplate. Aluminum wire must be one size larger than copper wire in each case (e.g., #14 to #12), but it should not be used for 15 and 20 amp circuits. See Figure 5.1 for determining wire size.

  Make sure that no circuit has a fuse or circuit breaker with a higher ampere rating than its wiring is designed to carry. Air conditioners and other equipment with motors may have circuit breakers up to 175 percent ampacity of the conductor rating to allow for starting current. Look near the panelboard for an inordinate number of new or blown fuses, or breakers taped in the "on" position. Be suspicious of 20 or 25 amp fuses on household lighting circuits. These are signs of frequent overloads and inadequate electrical service. Other indications of overloading are the odor of burned insulation, evidence of melted insulation, discolored copper contact points in the fuse holders, and warm fuses or circuit breakers.

Test: Flip all circuit breakers on and off manually to make sure they are in good operating condition. A commercially available circuit breaker and resistance tester, which can simulate an overload condition, can be used to test each breaker. Such a test should be performed by an electrician. Note



This knob and tube wiring is in good condition except for a piece of broken insulation (top of photograph).

that this test is not recommended for computers, VCRs, clocks, and many similar devices.

Many older residential buildings have more than one panelboard or fused devices. Check that all supplementary overcurrent devices are located in metal boxes and that they are not in the vicinity of easily ignitable materials. All panelboards must have covers. It should be possible to turn off all electrical power to a dwelling from a single location.

5.3 Branch Circuits

The oldest types of residential wiring systems are seldom encountered today. They include open wires on metal cleats, wiring laid directly in plaster, and wiring in wooden molding. These systems proved quite hazardous. The oldest wiring system that may still be acceptable, and one still found fairly often in houses built before 1930, is “knob and tube.” This system utilizes porcelain insulators (knobs) for running wires through unobstructed spaces, and porcelain tubes for running wires through building components such as studs and joists. Note whether knob and tube wiring splices are mechanically twisted, soldered, and taped, as required. Knob and tube wiring should be replaced during rehabilitation; but if it is properly installed, needs no modification, has adequate capacity, is properly grounded, has no failed insulation, and is otherwise in good condition, it can be an acceptable wiring system and is still legal in many localities. Check with local building code officials. Also check the terms and conditions of the home insurance policy in force to see if knob and tube wiring is excluded. The greatest problem with such wiring is its insulation, which turns dry and brittle with age and often falls off on contact, leaving the wire exposed.

The armored cable and junction box are in good condition and can be reused, even if the lighting fixture is relocated.

Insulation that can be seen to have failed also will likely have failed where wiring is concealed. If any failed insulation is observed, the knob and tube wiring should be replaced.

Other approved wire types include:

- **NM** (non-metallic) cable, often called by the trade name "Romex," a plastic covered-cable for use in dry locations (older NM cable may be cloth covered).
- **NMC,** similar to NM but rated for damp locations.
- **UF** (underground feeder), a plastic-covered waterproof cable for use underground.
- **AC** (armored cable), also called BX, a flexible metal-covered cable.
- **MC** (metal-clad cable), a flexible metal-covered cable with a green insulated ground conductor.
- **EMT** (electrical metallic tubing), also called "thinwall," a metal conduit through which the wires are run in areas where maximum protection is required.

Check branch circuits for the following:

- **Marking.** The function of each branch circuit should be clearly and legibly marked at its disconnect, fuse, circuit breaker, or on the directory on the panelboard.
- **Connected loads.** Trace branch circuit conductors to determine that their connected load does not exceed their rating (e.g., a 30 amp clothes dryer connected to a 20 amp circuit). Generally speaking, each dwelling unit should have two to four 15 amp circuits for lighting and convenience outlets; two 20 amp circuits for appliances in the kitchen, dining, and laundry areas; and separate circuits of appropriate ampacity for large appliances such as dryers, ranges, disposals, dishwashers, and water heaters. See Section 3.4 for additional kitchen electrical service information. Check the size and length of all branch circuit wiring against the requirements of the local electrical code. Buildings built before 1980 may be considered to have an inadequate number of circuits because present day codes require a separate laundry circuit and a separate circuit for the bathroom receptacle. For air conditioning units, many local codes will allow one wire size smaller than called for in the disconnect.

  Test: A voltmeter may be used to measure voltage drop due to excessive branch circuit length, poor wiring connections, or undersized wire. Measurements must be made under a connected load. This test should be performed by an electrician.
- **Grounding.** It is best that all circuits be grounded to the panelboard, but this was not required by the *National*

Electrical Code prior to 1965. Do not assume that circuits in metal cable are grounded without testing each outlet. Also, do not assume that three-prong plug convenience outlets are connected to ground. Remove each one to observe the presence of a connected ground wire. Check to see whether GFI (ground fault interruption) type receptacles have been installed in laundries, kitchens, and bathrooms, and test their operation. These types of receptacles were not required before 1990, but are easily installed as replacements.

Test: Commercially available circuit analyzers can be used for checking the following circuit conditions: open ground, open hot, open neutral, hot/ground reversed, hot/neutral reversed. Operation of these analyzers varies by manufacturer.

- **Condition and safety.** Check that all wire types and equipment are installed properly in accordance with good practice. Check the conductors' exposure to possible damage or abrasion. Look for proper fastening, clearance, and frayed or damaged insulation. Make certain that all wire splices are made in work boxes and that all boxes for splices and switches have cover plates. Check all exterior receptacles to make sure they are of the waterproof type.

  Test: A megohm test may be used for detecting deteriorated insulation. It requires a Megger tester and operates at high voltage. With the electrical service disconnected, branch circuits should read at least one megohm to ground. If lights or appliances are connected to the circuit, readings should be at least 500,000 ohms. This test should be performed by an electrician. A visual inspection of insulation on accessible circuits will usually determine whether additional tests should be performed by an electrician.

  Look for unprotected wire runs through ducts and other inappropriate areas. Inspect for evidence of "handyman tampering" (e.g., unconventional splices), and if found in one location, expect it to be more widespread. Check for surface-mounted lamp cord extension wiring. It is dangerous and must be removed. It is best to remove all unused wiring or wiring that will be abandoned during rehabilitation work to avoid future confusion or misuse.

- **Aluminum wire.** Aluminum wire was used in residential buildings primarily during the 1960s and early 1970s. Inspect with local code requirements in mind. Be sure that aluminum wire is attached only to approved devices (marked "CO-ALR" or "ICU-AL") or to approved connectors. Problems with aluminum wiring occur at connections, so feel all cover plates for heat, smell for a distinctive odor in the vicinity of outlets and switches, and look for sparks and arcing in switches or outlets and for flickering lights. Also check for the presence of an oxide inhibitor on all aluminum wire connections. All such conditions should be corrected. Aluminum wire should not be used on 15 and 20 amp circuits. Whenever possible, aluminum wire and its devices should be replaced with copper wire and devices appropriate for copper. If aluminum wiring is not replaced, it must be frequently inspected and maintained.

- **Smoke Detectors.** Check to see if buildings have functioning smoke detectors. Detectors should be wired to a power source, and also should contain a battery. Most likely, buildings built before 1970 will not have detectors, but they should be added.