ELECTRICAL HANDBOOK FOR REMODELERS

BY REX CAULDWELL

Few things are as depressing as sweating through a hard job and realizing that you've underestimated expenses and will either just break even or lose money. Because most remodeling contractors are not electricians, this is an area where it's easy to bid wrong. Having technical knowledge of electrical is essential for an accurate job estimate. In this article I'll look at some common problem areas where I've seen contractors underbid.

If the remodel requires any electrical add-ons, you should first look at the main service panel. Identify any existing problems within the panel and determine how much room is available for additional circuits. These panels will either be fuse boxes, circuit breakers, or a combination.

PROTECT YOURSELF WITH KNOWLEDGE OF THIS COMPLEX TRADE

Fuse Boxes

If the main service panel is an old 60-amp fuse box, additional circuits probably should not be wired into it. Although you may be adding a few receptacle outlets to an existing circuit, it's possible the additional load will be enough to overload the timeworn fuse box and cause a fire. Even if the fuse panel is 100 amps or more, it should be scrutinized thoroughly before any additional loads are added. Look for the following:

- Is there room for more circuits? Look for empty screws adjacent to the glass fuses. If there aren't enough empty circuits, an expensive service upgrade may be required. If there are empty screws, check the voltage on the screw terminals to verify that full voltage is present for the new circuits. Old fuse boxes are famous for loose, corroded connections, which only allow partial voltage to be available. This may be why there isn't a circuit presently using that connection.
- Are there two or more wires (circuits) under one screw and using one fuse? This situation normally occurs when a circuit is added to a panel that is already completely full, or when a circuit within the panel fails and a working circuit is doubled up to compensate. This is never allowed by code.
- Is the fuse amperage already exceeding the circuit maximum? For example, suppose a 30-amp glass fuse (colored green) is installed into a circuit wired with 12-gauge wire. The fuse won't open until 30 amps is exceeded, but the wiring starts overheating and burning at 20 amps. This commonly happens when circuits are overloaded and homeowners keep increasing the fuse size until the fuse finally holds. Watch out for this situation; it's a fire waiting to happen.
- Are there any hot spots on the fuse box that have melted and then solidified, or any discoloration due to overheating? Pull the main cartridge fuses out and the check the main prongs and the fuse itself for discoloration due to overheating. The plastic on the old fuse panels doesn't hold up well to heat. The most common problem in fuse panels next to oversizing fuses is meltdown.

Replacement is the best option. If budget permits, it's a good idea to recommend replacement of all older fuse panels with new circuit breaker panels. If you don't do this, you must assure yourself (1) that the fuse panel isn't already overloaded, (2) that it's in satisfactory condition for additional loads, and (3) that there is room for the additional circuits required for the remodel. Note any problems before work begins and add in the necessary extra money on the contract. Otherwise you may have to absorb the extra cost of correcting them after the work begins. Whatever you do, don't ignore problems with the panel or you may end up in court.

Circuit Breaker Panels

Circuit breaker panels must also be carefully checked. You cannot tell if a service panel is full by observing the cover. There might be several blank knock-outs on the cover, but inside no empty slots for the breakers. Remove the cover to see if there is room for additional breakers. Also, look for damage to the hot buss. For example, either lightning or arcing in the box (from loose circuit breakers) can burn and deform the buss, making it physically impossible to pop in a new breaker.

Expensive breakers. Make note of the brand of service panel. Some manufacturers have gone out of business, which makes their breakers hard to find and very expensive. If you need a considerable number of these hard-to-find breakers, it could be less expensive to change out the panel to one that has readily available breakers.

Load Calculation

Once you have verified that the new circuits can be inserted into the panel, you must determine that the additional loads of these new circuits won't exceed the maximum load allowed for the service panel, main breaker, and service entrance wire. Just because there are physical openings for additional breakers doesn't mean the code allows them to be added.

Sometimes it is obvious that additional loads can be added. For example, a 200-amp box may have only one or two low-amperage double-pole breakers with a few 15 or 20 single-pole breakers. However, many times it is not so obvious. A 200-amp panel may hold up to a maximum of 40

This three-prong outlet looks like it's on a grounded circuit, but using a simple plug-in analyzer the author found there was no ground wire present.

circuits and have only 10 in it. Yet these 10 circuits could be pulling all the current the main breaker can hold.

To be absolutely certain, a house load calculation must be done. Page 761 of the 1990 National Electrical Code (NEC) or page 1103 of the NEC Handbook describes in detail how to do this. See also Sections 220-31, 220-30, and 220-35 of the NEC. Do not shy away from doing the load calculation. As a contractor you should know how to do it. If it seems overwhelming, hire a competent licensed electrician.

If the main panel has no main breaker, have a certified electrician verify the size of the service entrance wire and current rating of the service panel itself (the current rating for the panel will be indicated on a sticker inside the panel). Base the load maximum on that current figure (the lesser of the two if they differ).

Tying Into Existing Circuits

If you are adding only square footage without any fixed loads, and you intend to tie into an existing branch circuit, you must consider three items:

- First, what is the condition of the old wiring? Is it old knob-and-tube wiring, installed in the 1920s? Or ungrounded wiring, installed during the post-war building boom? In any case, if the existing wiring is ungrounded, the new wiring should run all the way back to the main panel to obtain a ground. Use a plug-in analyzer on a receptacle of the circuit that you are tapping into to verify that the existing wiring on that circuit is wired properly. Also, verify that the service has a service ground other than the house metal pipes. If none exists or the ground rod or ground connection is corroded beyond repair, a new house grounding system will need to be installed.
- Second, verify that the wire you are tapping into is of the proper gauge. If your renovation requires a 20-amp circuit, physically check the old wiring to make sure it is not 14 gauge (15-amp wire).
- Third, the load of the house increases by the additional square footage multiplied by 3 watts per square foot (NEC Section 220-3d). The increased house load must not exceed the house service load. Loads for additional circuits without any structural add-ons are also covered in the same section.

The bottom line here is not to tie into the existing house wiring unless you verify its gauge, that you are not placing too many receptacle outlets on one branch circuit, and that the existing wiring is in good condition and grounded. Be sure to add the new loads to the house load calculation to verify that the current is still under the amount allowed by the main service.

Service Main Panels Used as Subpanels

In the midst of renovation, it is not uncommon to change the existing service panel to a subpanel as a new and larger main service is installed. This situation is considerably more expensive than most contractors are led to believe.

You normally cannot use the existing three-wire service entrance cable as the feed to the old panel. The feed from the new service entrance panel to the old main (now a subpanel) must be a four-conductor (or three-conductor with metal raceway) feeder (hot, hot, neutral, ground). The ground wire connecting the old panel to earth ground (ground rods, structural steel, etc.) as well as any ground wire to metallic plumbing pipes, must be disconnected from the old panel and run to the new one. In addition, as a newly created subpanel, it must have the neutrals (white wires) separated from both the equipment grounding wires (the bare wires coming into the box within the NM wire) and the box (the panel itself). All of these problems can translate into a significant cost.

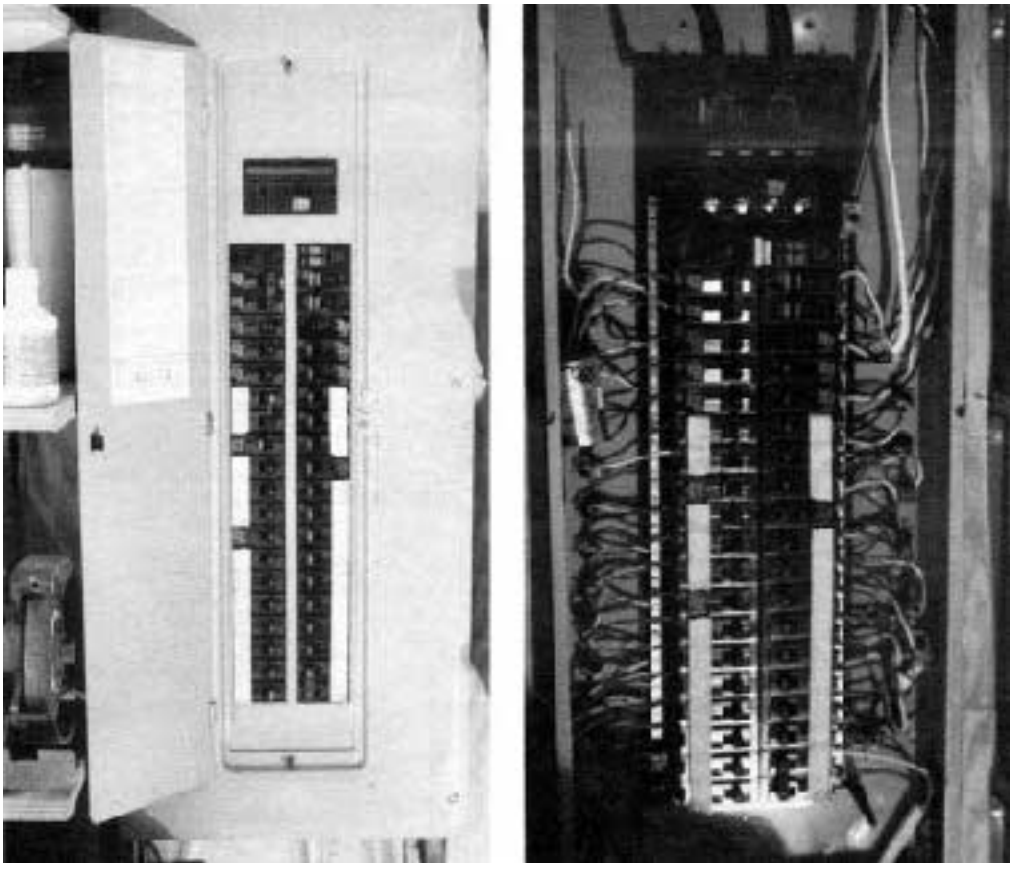
Moving the Service Entrance Panel

If the service entrance panel needs to be moved away from the power company's meter base, the electrical inspector may require you to add an additional disconnect to the system immediately adjacent to the meter base. This is easy to overlook, but is costly to correct. The logic here is that it is dangerous to have the service panel too far from the meter base since the service entrance (SE) cable is not fused until it gets to the service panel. If a nail is driven into the SE cable between the meter base and the service entrance panel, it can cause a fire since there is no fusing to open the circuit. Therefore many inspectors require a disconnect immediately adjacent to the meter base. The cost is significant, so be sure to add it to the contract if the inspector in your area requires it.

Baseboard Heating

Baseboard heaters are normally installed whenever low initial costs are being considered. Because they are moderate in price and install quickly, they fit a limited budget. But you need to watch out for some items that, if overlooked, can cause labor and material costs to skyrocket.

- Baseboard heaters cannot be placed under an electrical outlet. Lamp cords draped over the top of the heater could burn. In such locations, two smaller heaters may have to be placed on both sides of the outlet, staying several inches away from the receptacle. This small but significant problem increases material costs and may more than double the installation time. An alternative solution is to obtain baseboard heaters that have the outlets built in. However, you cannot use the 240-volt line that powers the baseboard for the 120-volt outlet. For that, a second cable or circuit will have to be installed. All existing receptacles immediately above the proposed heaters must be removed and blank plates installed.



On its face the circuit-breaker panel seems to have room for extra circuits (left). Inside, though, the author found the panel completely full (right).

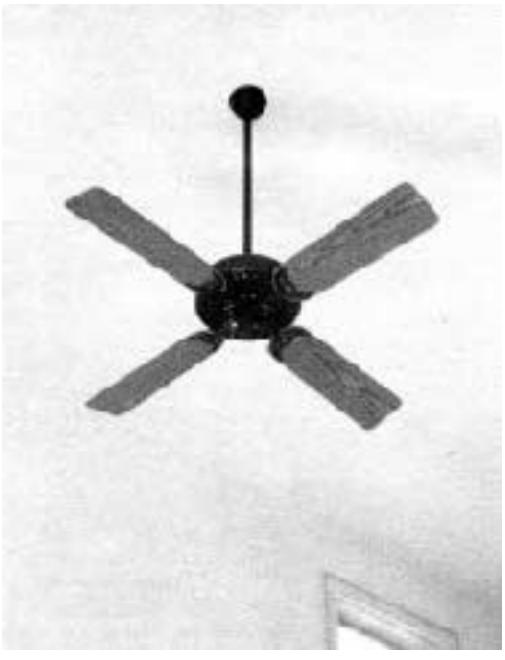
- Baseboard heaters place heavy current loads on the service panel; 250 watts or approximately 1 amp per foot is typical for 240-volt heaters. Several baseboard units can create such a heavy load that the contractor must be certain that the service panel can handle it. A load calculation may be required for this situation to determine if an expensive service upgrade is required. Do not make the mistake of saying to yourself "that this little extra load doesn't matter since I am only adding one or two heaters." If the panel is already overloaded, the extra load that you add may be the straw that breaks the camel's back.
- Baseboard heaters only install quickly if the thermostats are located in the unit itself. If the owner wants the thermostats in the walls, labor and material increase tremendously. If the walls are plaster-on-lath, the thermostats should remain in the heaters or be wired using conduit. Cutting holes in such walls risks cracking the plaster for several feet horizontally in both directions. Unless you have developed a method of sawing plaster-on-lath walls without cracking the adjacent plaster, I cannot emphasize too strongly not to try it.

HVAC

The most common electrical problem in hvac installations is overloading of the service entrance panel. As previously mentioned, just because there is room for the breaker doesn't mean the panel won't be overloaded when it's installed. If the service entrance is a 60- or 100-amp panel, it's probably not large enough. Be sure to allow enough money in the contract for the service upgrade. In addition, do not assume a 200-amp panel is large enough for the system, especially if an electric backup system is attached to the hvac unit. A load calculation should be done to verify that there is room for the extra load.

Though hvac units normally have the fusing requirements printed on the unit itself, even experienced electricians can miscalculate hvac loads. For example, does the compressor run all the time the electric backup heat is running, or does it automatically shut off? The compressor can add 20 to 30 amps to the house load, but can be overlooked in the load calculation. If the load calculations are already close to the maximum the service panel will allow, the extra load from the compressor may trip the breaker.

Wherever the hvac unit is installed, code now requires switched lighting at the point of entrance. Don't forget to add it to the estimate. And make sure that you do not split the 240 volts supplied for the hvac system for the required 120-volt lighting (against code). Tap into another 120-volt line in the immediate area or run a separate circuit.



When bidding a paddle fan installation, remember to include the cost of the extension pipe and a UL-approved electrical box to support the weight of the fan.

Kitchens and Dining Areas

The kitchen is usually the most miswired room in a house. A kitchen requires several circuits; if you're doing a kitchen remodel, make sure the service panel has room enough for any additional circuits you may need.

The NEC codes that apply to the kitchen also apply to the dining room, breakfast room, and pantry. If any renovation is to be done, the local inspector may require updating the wiring to current codes. This is extremely expensive as there are many code articles that apply. As a reminder:

- A minimum of two circuits (20 amp, 12 AWG wire) must feed the countertop receptacle outlets. The outlets must be no further apart than 4 feet. I normally use the kitchen sink as a reference: to the left, one circuit; to the right, the second.
- All receptacle outlets within 6 feet of the kitchen sink (straight line distance) must have GFCIs (ground fault circuit interrupters).
- The lights must not be on same circuit as the kitchen/dining/pantry receptacle outlets. In addition, it is not good practice, and most of the time against code, to install the lights on the same circuit as the undercounter appliances.
- Additional circuits must be brought into the kitchen to power the fixed appliances such as the dishwasher, garbage disposal, compactor, etc., since these appliances cannot be powered by the kitchen/dining room/pantry receptacle outlets. Usually these appliances require their own separate circuits; be sure to read the instructions.
- An island is required to have receptacle outlets, and getting the wire there is sometimes labor intensive. How and where to place the receptacle without having a drawer slide into it is always a problem.
- The most common kitchen wiring error is installing the microwave on one of the kitchen receptacle circuits. The NEC doesn't specifically mention the microwave, but it does state that you must follow manufacturer's recommendations. Most manufacturers of medium and large microwave appliances require them to be put on a separate circuit. Read the instructions!

Porches

Open porches do not count in house loading, but specific codes do apply to special applications. If the owner wants electrical service on the porch area, and the porch is at or close to ground level, the receptacle outlets must have expensive GFCI protection. As before, verify that the branch circuit you are tapping into doesn't exceed the maximum number of allowed receptacle outlets, and that the house wiring is grounded and in good condition. In addition, if a door was added to the house to obtain entrance to the porch, a switched light must be added at the point of entrance. Walls that are to be removed normally have electrical wires inside, so be sure to allow finances to cover their splicing and relocation.

Garages

Do not make the error of bidding on a garage without the bid price reflecting the increased cost of GFCIs, which are required for general purpose outlets in garages. Dedicated and inaccessible receptacle outlets, however, are exempt; for example, receptacles for garage door openers, freezers, refrigerators, fans, etc.

If standard household receptacles are installed in the garage, be prepared for complaints. These receptacles are fine as long as heavy duty grounded cords aren't plugged in and out on a daily basis. Being made out of a brittle plastic, the grounding plug will break them apart in short order if they are wiggled up and down as they are inserted and withdrawn. For such locations, it would be best to recommend to the owner the use of receptacles made out of nylon (about $6 apiece). If he refuses, he can't later complain to you about breakage.

Miscellaneous

Suppose your customers want to add one or two bedrooms to their house. Besides the required carpentry work, there are some code-required electricals that they'll have to have. Here are some items to watch for.

Smoke alarms. The new bedrooms will need hard-wired smoke alarms in the adjacent hallway. These can no longer be powered by batteries alone; I use hard-wired with a battery backup. If the bedrooms share the same hallway and are reasonably close to each other, one smoke alarm will normally suffice. However, if the renovation requires bedrooms that are separated from each other, you will need alarms for each. Further, the alarms will all have to be wired together so that when one sounds they all sound. Labor, as well as the wire itself, is not cheap. Don't be forced to "eat it" because you forget to "add it."

Closets. Closets are always problem areas. Closet lighting requirements (NEC Section 410-8) are extremely strict in the type and placement of the lights. Low-cost, bare incandescent bulbs can no longer be installed in closets. If the bulb is broken, the hot filament can fall on top of clothes or storage items and start a fire. Incandescent bulbs must be totally enclosed and be mounted at least 12 inches away from all clothes and storage items.

If fluorescent lights are to be installed in the closet, be sure the owner knows that these fixtures normally emit a 60-cycle hum. Also, NEC Section 410-8 applies severe restrictions to fluorescent lights as well. This article is far too complex to detail here, but it is

imperative that it be understood by the contractor (see "Builder's Guide to Common Code Violations," 12/91).

Recessed lighting. If the owner wants recessed lighting in the ceiling, be careful. Some recessed fixtures, especially the high wattage ones, cannot be placed next to insulation. Unless the light is rated "IC" (insulated ceiling) or equivalent, all insulation must be removed from the area determined by the requirements of that specific fixture. This means that if loose insulation is in the attic, barriers may have to be built around the light to keep the insulation away from the fixture. Failure to do so may cause a fire. If you have to keep costs down, a low-voltage, battery-operated light fixture can be installed.

Switches. Be sure to ask how the client wants the lights switched. Switched outlets and three-way switching are much more expensive and labor intensive than standard switched lighting. You may assume the owners want a switched overhead light when what they really wanted was switched outlets. Do not put yourself in the position of having to pay for the increased cost of the latter because you didn't think to ask.

Dimmer controls. If the owner wants dimmer controls on his trac lighting, outside lighting, chandeliers, or any other heavily loaded lighting system, be wary. A standard low-cost dimmer is rated for only 600 watts. This limits the lighting to no more than four 150-watt bulbs. And there is no way to limit the amount of lights installed on a trac. Also, low-cost dimmers get hot with only a minimum load applied.

Don't assume you can use $5 dimmer controls and then find out later you really needed $50 high-wattage units. Question the owners to determine if they plan to add additional lamps at some time in the future. If you install the trac lighting with four 150-watt lights controlled by a 600-watt dimmer and later the owners add a few more trac lights, the dimmer control could overheat and cause a fire. A 1,000-watt or larger dimmer has a heatsink located outside the wall which dissipates the heat and provides protection. But even with the expensive, high-wattage dimmers, the contractor should specify in the contract the maximum number of trac lights or floods allowed on the circuit if a dimmer is installed.

Ceiling fans. If the owners want one or more paddle fans, the contractor should realize that only UL-listed boxes may now be used for hanging them. These boxes are expensive, so be sure to include the extra cost. If the owner wants the fans on a variable speed control, make sure you use one that doesn't "sing," or complaints will follow. In addition, if the fan is hanging on a vaulted ceiling, an expensive extension pipe will be required to lower the fan so the blades won't hit the ceiling.

Splicing. When tying into existing circuits, splices cannot be covered up and left inside walls. All in-house splices are considered maintainable items, and access must be allowed. Splices are normally put in standard receptacle boxes with a blank plate.

Summary

In my opinion, the trick to contracting is to cover all the bases. Talk to the owners, tell them all the alternatives, disadvantages, and advantages of what is happening. If there is an option on how to do something, let them make the decision. That way if something doesn't work out as expected, the owners blame themselves, not you, for the increased expense. If your customer wants so many corners cut that you cannot do the job properly or legally, don't do the job. Hopefully, you have a reputation to protect. Don't risk it on a customer who only wants the job done cheap and not right.

Your best protection is knowledge. Read the NEC and subscribe to the technical magazines. You not only need to know and understand the code, you must know what is happening in the industry — the trends, what works and what doesn't work, and what mistakes other people have made, so you won't make them. If you don't have the time, hire a competent electrician to advise you. Above all else, don't be caught in the biggest trap a contractor can lay for himself: ignorance. ■

Rex Cauldwell is a master electrician, master plumber, and licensed contractor in Copper Hill, Va.