# Investigation Guideline

**PRODUCT: HOME ELECTRICAL DISTRIBUTION SYSTEM COMPONENTS**
**15- AND 20-AMPERE ELECTRICAL RECEPTACLES**
**Appendix: 86**
**Date Amended:January 9, 2004**

## I. INTRODUCTION

### A. Background Information

According to the 1998 Residential Fire Loss Estimates, receptacles were associated with an estimated 3,800 fires resulting in 30 deaths, 120 injuries, and $52.6 million in property losses. Despite the CPSC staff-proposed changes to Underwriters Laboratories (UL) Standard 498 (covering electrical receptacles) which became effective in 1995, the number of fire deaths and injuries (40 deaths and 120 injuries) remain similar to those estimated in 1994.

The purpose of this investigation is to learn more about the characteristics of electrical receptacles that overheat, arc, smoke or start fires and the circumstances under which such fires occur. The causes of receptacle fires may be many and varied; we would like as much detail as possible regarding the cause for each case. We are interested in data that capture (1) the physical characteristics of the electrical receptacle and (2) the design or installation features, including the outlet box, pigtail wiring, terminations, branch circuit wiring, and loading that may have contributed to the failure of the receptacle. The data collected may be drawn from a variety of sources, for instance, from: interviews, news clips, fire investigation reports, other official reports, and other relevant materials. We are interested in any information that is relevant to understanding the cause of the fire or fire hazard as well as environmental information in the immediate area around the receptacle.

Please remember that no guideline can cover all the pertinent factors that may apply to a particular incident. Include an explanation in your narrative of all factors that you believe to be relevant, even when these factors have not been specifically mentioned in this guideline.

### B. Product Description

The National Electrical Code (NEC) in Article 100, defines a *receptacle* as a "contact device installed for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A [duplex or] multiple receptacle is two or more contact devices on the same yoke." Consumers variously call them

by a range of names: wall socket, wall plug, electric or electrical outlet or, simply, outlet. The NEC is more specific in its distinctions:

•An *outlet* is "a point on the wiring system at which current is taken to supply utilization equipment [any equipment or apparatus that uses electric energy for some purpose]"

•A *receptacle outlet* is an outlet where one or more receptacles are installed.

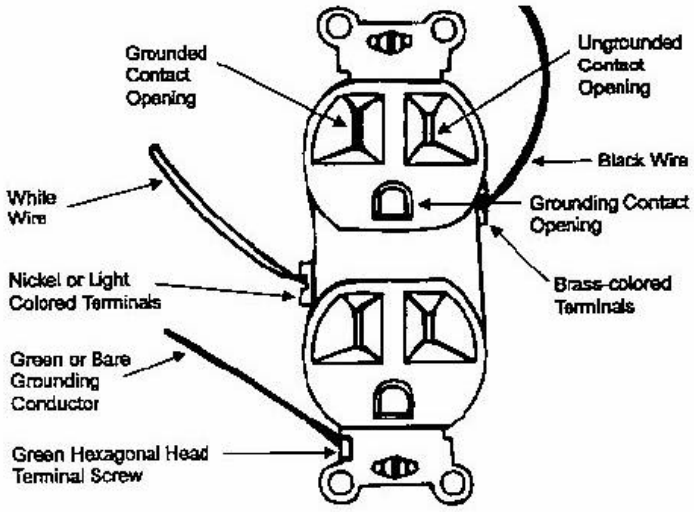


**Figure 1 - Side-wired Grounded Duplex 15A Receptacle (front view)**

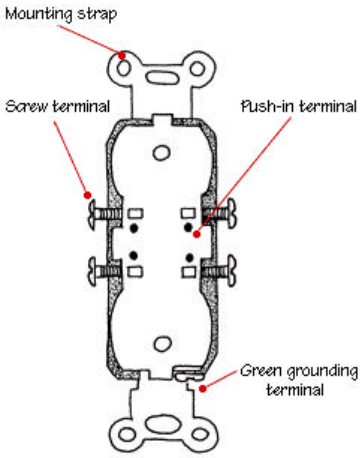


**Figure 2 - Back-wire Receptacle (rear view)**
The push-in terminals on the back (4 shown, or sometimes 8) are typically sized to accept 14AWG or 12AWG copper wire as appropriate for 15A or 20A receptacles. A slot next to each terminal hole allows inserting a flat-blade screwdriver to release wires from the terminals. Note here that a 1989 CPSC report suggested that removing wires and replacing them in the push-in terminals may reduce retention forces and weaken the electrical connection.

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**Outlet boxes:** Receptacles, switches, and fixtures (ceiling- or wall-mounted luminaires, for example) are typically required to be installed in outlet boxes that provide safe means to assemble and protect the electrical connections and to support the electrical device. The boxes may be either metal or non-metallic but should always be certified by a recognized national testing laboratory (such as Underwriters Laboratories, Inc. (UL), among others). The figure below shows a back-wired, grounded duplex receptacle installed in a molded, non-metallic outlet box (on the left) and two others, side-wired with screw terminals, ready to be installed in metal boxes (below and right). Notice that the center outlet is the end of a circuit while the outlet on the right is "daisy-chained." Power comes into the receptacle from one set of conductors. A second set of conductors, which is attached to the second set of terminal on the receptacle, supplies power to another outlet "downstream" on the same branch circuit. Notice that the grounding wires are spliced together with a "pigtail" wire that is attached to the single grounding terminal on the receptacle.

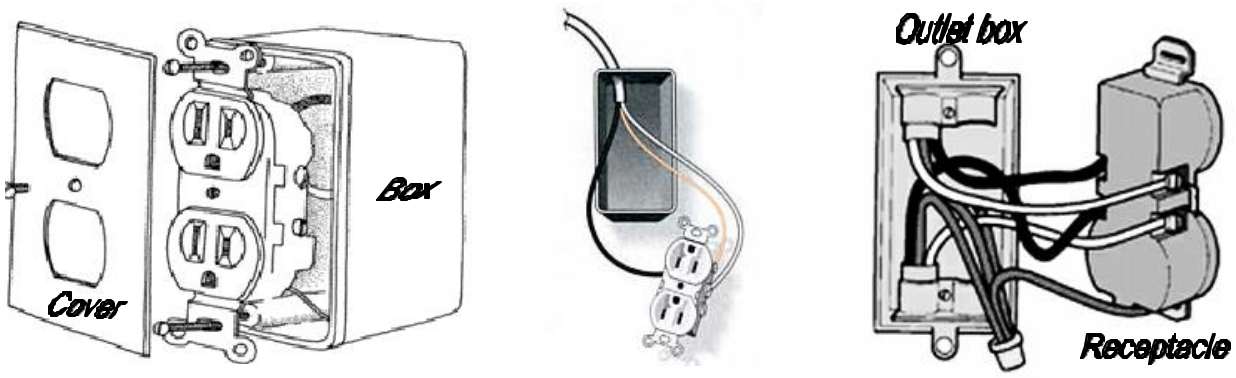


**Figure 3 - Outlet Boxes with Installed Grounded Receptacle**

Although grounded receptacles are typically installed with the ground pin contact beneath the plug blade line contacts, no requirement exists in the NEC for either orientation. Some have argued that the orientation illustrated in Figure 3 may allow the "knife-edge" of a fallen metal object to come across both blades of the loosened plug of an electrical cord and cause serious arcing that could ignite adjacent combustibles or may permit easier accidental contact with and electrical shock from the ungrounded plug blade. It is unknown if any studies have been done on this issue.

In addition to the typical wall-mounted receptacle, which may have one, two, four, or even more receptacles installed, single receptacles may be installed on the floor of a room in "floor box assemblies," such as the unit shown below.

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**Figure 4 - 15 Ampere Floor Box Assembly**

**Receptacle Identification:** The National Electrical Manufacturers Association (NEMA) has established a coding scheme for various receptacle and plug configurations. These can be used to identify and distinguish between 15- and 20-ampere-rated receptacles. Complete tables of NEMA configurations are in many references, including http://www.gwi.net/images/nema.pdf . The receptacles of primary concern to this investigation are the typical 115VAC (or NEMA 125V) outlets used in homes. The current NEMA configurations, typically found in household settings, are shown in Figure 5; their designations may be used in official reports.

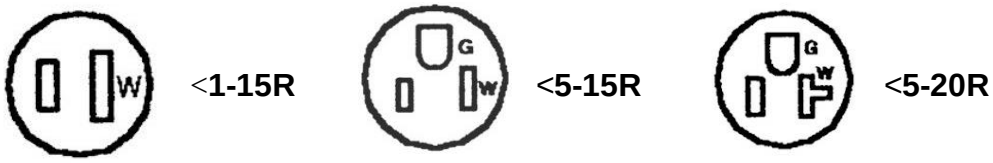


**Figure 5-NEMA Receptacle Configurations (found in typical household use)**

**Not shown in the figure** are the older, **non-polarized** receptacles in which the ungrounded (HOT) and grounded (NEUTRAL--labeled "W" on the NEMA configuration drawings) receptacle **slots are the same size**. For the sake of convenience, the designations "***1-15NR***" and "***5-15NR***" may be used to describe 2-wire and 3-wire receptacles that have flat blade openings the same size. (Note that 3-wire receptacles are, by default, polarized; a plug may be inserted in only one orientation, *so the Hot and Neutral slots may be the same size in some*

*older receptacles*. If the receptacle and power cord are properly wired, there is no likelihood of accidentally plugging the cord in reversed polarity. )

In addition to conventional receptacles, UL also certifies two specialized types of receptacles that should be used in residential areas. One is Ground Fault Circuit Interrupter (GFCI), which provides protection against severe electrical shock, especially in damp or wet areas. The other type is Arc Fault Circuit Interrupter (AFCI), which provides a degree of protection against electrical fires caused by arcing in electrical devices and installed wiring systems. The NEC code requires that GFCIs and AFCIs be installed in new homes and during residential renovations that involve the electrical wiring. GFCIs must be installed in every location (such as bathrooms, kitchens, basements, garages, outdoors, etc.) where water, moisture, and dampness may increase the risk of electrical shock and AFCIs must be installed to protect receptacles in bedrooms. While GFCI receptacles are widely available for a variety of manufacturers, AFCI receptacles are rare, almost nonexistent. This may be because of the current interpretation of the NEC requirements concerning AFCI protection. UL lists receptacle-type AFCIs made only by two manufacturers. However, neither one appears to be available in the United States in 2003-2004.

**Summary of Receptacles:** There are a wide variety of 15- and 20-ampere receptacles that can be used in residential structures. The table below shows a summary of the receptacles discussed above. AFCI receptacles are included for completeness, although we are not likely to encounter them in current (2003 and earlier) installations.

| Type | Characteristics | Typical Use |
|---|---|---|
| Single | 1 connection point | Floor Outlet, Dedicated appliance |
| Duplex | 2 connection points | Most general-purpose residential applications |
| GFCI | "Test" and "Reset" Buttons and additional white wire | Kitchen, Bathroom, Basement and Outdoor Receptacles (esp. around water and moisture) |
| AFCI (rare) | "Test" and "Reset" Buttons and additional white wire | Required in Bedrooms per NEC 2002. Requirement probably met using circuit breaker AFCIs. |

### C. Specific Items of Interest

CPSC staff wants to learn as much as possible about receptacles that have suffered fire, overheating, or arc damage and the circumstances that led to the damage. Contact CPSC headquarters staff listed below if there are questions about the need for sample collection of damaged receptacles and/or identical exemplars. Because the receptacle is a mechanical and electrical point of interaction between the residential installed wiring and the electrical

appliances or tools being used by the consumer, the process of incident investigation and sample collection must explore the full range of the receptacle's installation and use.

**WARNING:** ***If conducting an on-site investigation, do not disturb or otherwise attempt to disassemble the receptacle and outlet box yourself. It is possible for such equipment to sustain internal damage that may not be visually obvious. Parts of such equipment may be energized even if other investigators have taken what they believe to be the steps necessary to remove power. Items in the data record sheet that require access to the interior of outlet boxes are to be addressed either by obtaining the information from the fire investigators, electricians, or others involved in the investigation and repair of incident damage or when accompanied by a qualified electrician who will disassemble the equipment when necessary for your inspection and collection. In some cases, you may be limited to recording and photographing markings and evidence that is visible from the outside.***

Photograph the receptacle and the area surrounding the installation if possible. It is best to capture a sequence of photographs of the device. Start with a panoramic view to show physical relationships and gradually move in to close-ups. If a power cord or extension cord plug that was involved in the incident under investigation is still attached to the receptacle, do not remove it until photos are taken, and then, only if the receptacle face is undamaged and the plug can be removed without causing additional damage to either the plug or receptacle. After close-up images have been captured of the front of the receptacle, remove the cover plate (if you can do so without damaging physical evidence). Attempt to photograph the interior and determine whether the receptacle has been side wired with the screw terminals or back-wired with the push-in terminals. If a plug and cord are still attached to the receptacle, slide the cover plate over the cord to clear the receptacle. ***DO NOT TOUCH*** the electrical components or loosen the receptacle from its mounting until you are certain that the circuit has been de-energized by removing the fuse or turning off the circuit breaker. Always ***TEST THE CIRCUIT*** with needle-point probes connected to a meter or test lamp, but not a "plug-in" tester. *Touch the probes across all three combinations: Hot-to-Neutral, Hot-to-Ground, and Neutral-to-Ground to be sure the light stays off, meaning that power is off.*

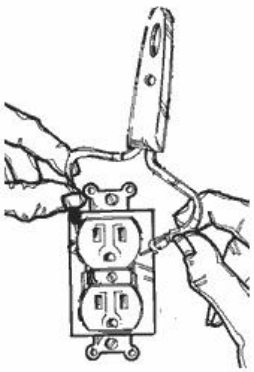

**Figure 6 - Test FIRST!**

•**Visible evidence of damage** -- Observing and documenting external signs of damage may offer clues to what sort of internal

damage may exist or what caused the events that led to the incident. External signs of mechanical damage may include a cracked, warped or broken cover plate or similar damage to the face of the receptacle. Of special concern is damage that may expose energized, ungrounded conductors, such as the wiring in the outlet box or internal components of the receptacle. Overheating related physical damage such as melting or bubbling, pyrolization (darkening, charring, other evidence of burning), ash or soot, is also important to note. Because UL generally requires thermoset (non-melting) plastic as construction material for receptacles and covers, evidence of melting may show that material other than the receptacle were involved in the fire--typically a power cord, plug, or a direct plug-in electrical device.

•**Concealed damage –** There may be internal damage such as poor or weakened electrical connections, which may be hidden from view while the receptacle remains installed in its outlet box. If the receptacle is not collected carefully, the evidence may be irretrievably lost. See detailed instructions in Section IV, pages 10 and 11 for possible methods of exposing concealed damage and collecting the incident sample.

### D. Headquarters Contacts

Robert Garrett, ES, 301 504-7563, rgarrett@cpsc.gov
Richard Stern, CRC, 301 504-7620, rstern@cpsc.gov
Risana Chowdhury, EPHA, 301 504-7334, rchowdhury@cpsc.gov

## II. INSTRUCTIONS FOR COLLECTING SPECIFIC INFORMATION

### A. Synopsis

Use the product code ***4061*** and use keyword ***electrical receptacle*** to ease the computer-based data retrieval process.

### B. Description of the Incident Environment

• Describe the structure where the receptacle fire (or overheating) occurred. What was the age and renovation history of the structure, the electrical wiring, and receptacles? Where was the receptacle located? Had there been problems with the device before the incident (for instance, portable lamp flickered or went out but bulb was good, outlet lost power or felt warm, complainant heard buzzing, hissing or crackling or saw arcing)?

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• Describe the course of related activities before the receptacle failure and the course of events directly prior to the fire breaking out. Include the electrical devices in use at the time, such as, the hair dryer, lamp, TV, or power tool, and whether the receptacle was installed indoors or outdoors, within the wall, surface-mounted, in a stud-mounted box or open (i.e. not in an outlet box). The photos below show some examples. Note the environmental (indoor and outside) conditions immediately before the incident. Describe, also, the historical environment/climate where the receptacle was located. (For example, was the structure ever flooded?)

**Fig. 7 -- Surface Mounted**

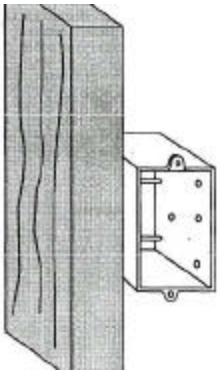

**Fig. 8 -- Stud-mounted**

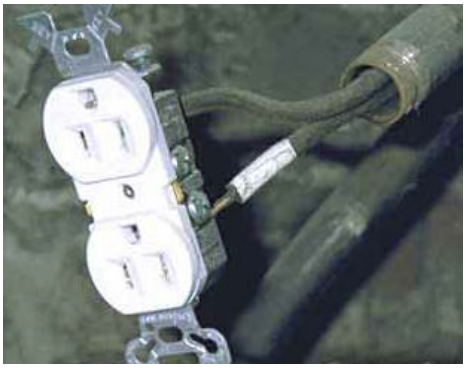

**Fig. 9 -- Open, unmounted receptacle**

• Record statements concerning the suspected cause of the receptacle failure. State who made the determination of cause. Try to determine exactly what happened to precipitate the fire. Describe the way the fire unfolded.

• Did anyone witness the fire event? Was anyone in the room with the receptacle when the fire started? Did anyone enter the room while the fire was already in progress?

• Once the fire started, did the user try to extinguish the fire (him)(her)self? If so, how successful was the attempt? What means did (s)he use to extinguish the fire? Was the fire department called? Did the fire department respond? If so, what was the extent of the fire department's involvement?

• Describe any damage done to the area where the receptacle was located, e.g., burn marks, scorch marks, blistering, etc.

• Recount who was injured and how badly. Did anyone require hospital care? Was anyone permanently injured? Did anyone die? Please record the age, sex, and general health of the injured persons. Briefly describe the treatments the injuries required and whether any permanent injuries were incurred.

• How severe was the property damage and loss? Please provide an estimated dollar value for destroyed or damaged property and possessions and the source of the estimate.

• Was the receptacle installed in a bedroom and protected by an AFCI?

**C. Description of Product**

(Full description of the physical receptacle to be collected on the Data Record Sheet.)

• Describe use patterns and characteristics.

• What company manufactured the receptacle? What was the model number, UL markings?

• When was the receptacle installed (or replaced)?

• Describe how the receptacle was installed and the material it was attached to (for example, flush- or surface-mounted and drywall, concrete block, wooden or metal stud, etc ).

• Did the consumer notice any unusual characteristics about the way receptacle performed? For instance, did the branch circuit breaker or fuse trip often, or did the receptacle ever seem warm?

**D. Product Safety Standards**

UL 498 – *Attachment Plugs and Receptacles*
UL 514A – *Metallic Outlet Boxes*
UL 514C – *Nonmetallic Outlet Boxes, Flush-Mounted Boxes and Covers*
UL 943 – *Ground-Fault Circuit-Interrupters*
UL 1699 – *Arc-Fault Circuit-Interrupters*

## III. PHOTOGRAPHS/DIAGRAMS OF INCIDENT SCENE

If the incident receptacle or any remnants are available, conduct a physical investigation. In order to document the condition of the receptacle and/or outlet box, take as many photographs as possible before it is removed. These photographs should include close-ups of any markings/labels on the receptacle as well as clear illustrations of where and how the receptacle was installed and what damage was done to the room or structure by the event involving the

receptacle. If the user/owner/complainant took pictures or videotapes of the receptacle, obtain copies of them. Diagram the room where the receptacle was located, if possible, showing attached electrical appliances and nearby combustibles.

## IV. OBTAINING SAMPLES AND DOCUMENTS RELATED TO THE INVESTIGATION

•**Samples:** Samples of receptacles and attached plugs are critical to the investigation. However, due to the nature of receptacle failures, the best samples may be difficult to collect. Severely damaged receptacles will be the most readily available for collection but will provide the least amount of information as to the cause of the failure. Nevertheless, it is important to collect these samples when available.

Incidents where the failure was detected early and minimal damage occurred to the receptacle and surrounding area would provide the most useful information. It may be more difficult to collect the slightly damaged sample because careful collection methods may cause some damage to finished areas where the receptacle is installed. In some cases, purchasing the sample and repairing the damage incidental to its collection will be necessary. Contact CPSC staff listed in section I to determine whether the sample should be purchased or not.

When a sample is collected, it is best to retrieve the receptacle intact and still installed in the outlet box, including portions of the attached electrical appliances (or, at least, their power cord plugs) by cutting their wires approximately six inches away from the receptacle and outlet box or from the damaged portion of the power cord. Then the entire outlet box can be removed from its mounting location. This should not be a problem for severely damaged samples but for moderately damaged samples, an additional cost to replace the power cord plug(s), receptacle, outlet box, installed wiring, and some wall board may be required.

Package the sample in a manner that will not further damage the sample or lose any loose parts.

**Detailed Collection Instructions:**

***Sample collection will require the services of a licensed electrician*** unless the investigator is properly qualified to perform the needed electrical work. If it is possible to do so, collect the receptacle and box with the branch circuit wiring and connected appliance or extension cords undisturbed and still attached to it. Be certain that electrical power is removed from the circuit before starting. ***TEST THE CIRCUIT!***

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1) With side-wired receptacles, if you can not also collect the outlet box, receptacle-only collection may be accomplished by removing the screws above and below the receptacle, which secure it to the outlet box. Gently pull the receptacle from the box to avoid altering the quality of the electrical connections. Be particularly careful if any wires appear to be loose under the terminal screw heads. Cut the wires (noting whether they are copper or aluminum) at least 2 inches or more from the connections. If the insulation is damaged, cut the wires at least 2 inches back from the damage.
2) With back-wired receptacles, removing the receptacle from the outlet box can significantly alter the condition of the connections and destroy evidence. *If enough residential wiring is left in the wall to replace a new outlet box (if necessary), dismounting and collecting the entire box is the best approach.* Some of the wall board around the outlet box will likely have to be removed to get full access to the box unless it is a surface mounted box (Figure 7). After removing the nails or screws that hold the box in place, cut the sheathed branch circuit wiring at least 2 inches, preferably 6 inches, from its entry into the box.
3) If collecting the entire outlet box is not feasible, first use a similar approach as with the side-wired receptacle to loosen the mounting of the back-wired receptacle.
    a. Once the mounting screws are removed, try to reach in behind the receptacle with needle-nose pliers to grasp the BLACK (Hot) and WHITE (Neutral) wires that are connected to the back of the receptacle.
    b. ***Pull on the wires*** (NOT the body of the receptacle) to draw the receptacle very gently out of the box.
    c. If you can not initially reach the wires and there is no other way to get it clear of the box, pull as gently and slowly as possible on the receptacle to expose them. Then grasp the wires as soon as they are accessible to reach with needle-nose pliers and pull the receptacle clear of the box.
    d. Holding each wire with pliers to absorb mechanical shock, use diagonal cutters or a similar tool to cut the wires at least 2 inches from their terminations on the back of the receptacle.
4) Protect the exposed wires of a removed receptacle from contact and bending by forming a shell with stiff cardboard of other similarly rigid material around the receptacle so that the wires are suspended in space, not touching the walls of the shell.

5) Pack the enclosed receptacle in a larger box, well-surrounded with loose-fill styrofoam packing material to absorb impacts from shipping. Label the box for special handling (Handle Like Glass!) before shipping it to the Sample Custodian.

•**Documents:** Obtain copies of the fire incident report, insurance documents, and any other investigative reports of the incident. If the incident site is a school, church, or some other type of institution, attempt to obtain their official records

## V. CORONER'S REPORT AND DEATH CERTIFICATE

In cases that involve death(s), procure the coroner's report and the death certificate(s).

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## DATA RECORD SHEET FOR RECEPTACLE OVERHEATING AND FIRES

1. **Task Number** _____
2. **Sample Number** _____
3. **Date of incident** _____
4. **Date purchased / installed** _____
5. **Characteristics of receptacle:**
   a. **Manufacturer/Model number:** _____

   b. **Type (single / duplex) and NEMA designation:** (Circle choices and add "N" for non-polarized)

   **1-15R >** **5-15R >** **5-20R >**

   c. **Marked Rating (Volts/Amps/Hz)?** _____

   d. **Terminations used?:** **Screw** ☐ **Push-in** ☐ **Both** ☐ (Circle choice)

   e. **Properly polarized (Black = HOT, White = NEUTRAL)?** **Y** ☐ **N** ☐

   f. **Was Ground Wire Terminal (NEMA 5-) used?** **Y** ☐ **N** ☐ **Bare Copper?** ☐ **Green Insulated?** ☐

   g. **Condition of receptacle (Brief description):**_____
   _____

   h. **Is the receptacle a GFCI type?** **Y** ☐ **N** ☐
6. **Characteristics of Installation:**
   a. **Location of Outlet Box and Receptacle:** _____

   b. **Environmental Conditions and History:** _____
   _____
   _____

   c. **Outlet Box dimensions (L x W x D):** _____

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**d. Outlet Box Material: Metal ☐ Plastic ☐** (Circle choice)

**e. Condition of Outlet Box: _____**
**(dirt, heat, moisture, mechanical or other damage)**

**f. Outlet Box Fill? No. of wires_____ No. of Splices _____**

**Type : Wire Nut, ☐ Crimp, ☐ Solder and Tape, ☐ Other ☐ _____**

**g. Wire Type: Copper ☐ Aluminum ☐ Mixed ☐ Other ☐** (circle choice) **Comments:**
**_____**

**h. Feed-through Wiring:**
**Is receptacle at the end of the circuit, connected to one set of two or three wires? Yes/No**
**Or** ☐ ☐
**Is there a second set of wires connected to the second set of terminals--daisy-chained-- to carry power out of the box to another location? ___ Yes / No ___**

**If yes, how many additional outlets (including lighting fixtures) were connected downstream? _____**

**i. No. of wires directly attached to the receptacle? HOT___ NEUTRAL___ GROUND___**

**j. Over current protection provided by: Fuse ☐ Circuit Breaker ☐ GFCI CB ☐ AFCI CB ☐** (circle choice)

**Brand/Model:_____**
**Rating: _____/_____Volts/Amps.**

**Was device open after incident? Yes/ No** ☐ ☐

**k. Receptacle installed by: Unknown ☐ Electrician ☐ Homeowner ☐ Other _____** (circle choice)

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**7. Electrical Load on Damaged Receptacle:**

**a. Describe what was connected (plugged into) Receptacle:**

| | | | | |
|---|---|---|---|---|
| **Appliance Type** | | | | |
| **Ampere Rating** | | | | |
| **On/Off Switch?** | **Yes ☐ ☐No** | **Yes ☐ ☐No** | **Yes ☐ ☐No** | **Yes ☐ ☐No** |
| **No. of Daily Uses** | | | | |
| **Smoke /sparks seen?** | **Yes ☐ No ☐** | **Yes ☐ No ☐** | **Yes ☐ No ☐** | **Yes ☐ No ☐** |
| **Did Power Cord Plug Fit Properly?** | **☐ Too tight ☐Tight enough ☐ Too loose** | **☐ Too tight ☐Tight enough ☐ Too loose** | **☐ Too tight ☐Tight enough ☐ Too loose** | **☐ Too tight ☐Tight enough ☐ Too loose** |

**b. If the receptacle was daisy-chained and fed power to other outlet, what was the downstream load? _____ (Amperes)**

**8. Had there been any additions, modifications, or repairs made to the receptacle or outlet prior to the incident? Yes ☐ No ☐**

**9. If so, what was done? _____**
_____
_____
_____

**10. By whom? _____**

**11. Contact the person(s) who did the work described in Item 9 to determine the reason(s) for the work. If repairs were necessary to correct a prior incident, obtain a detailed explanation of the repairperson's opinion as to the cause of the previous incident. Obtain any information which may be available to support that opinion, e.g., an invoice listing the parts that were replaced, etc. _____**

**12. For the incident under investigation, determine if the fire investigators, electricians, or other involved in the investigation or repair of the incident damage have developed opinions on the cause(s) of the incident. Obtain and attach detailed explanation of the opinion(s) and the information on which the opinion(s) is/are based. _____**

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**13. Were there smoke detectors in the home? Yes / No**
☐ ☐

**14. If yes, how many and where?** _____

**15. Did it sound an alarm?** _____

**16.Was there a sprinkler system in the home? Yes / No**
☐ ☐

**17.If yes, did it operate?** _____

**18. Identify the source(s) of information used to answer the above questions** _____
_____

**19. Please refer to the articles attached in the Appendix for more detailed safety information.**

**Additional Comments ( If continuing answers from above, include Question Number at left margin)** _____

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## Appendix

| Article 1 | Article 2 | Article 3 | Article 4 |
| --- | --- | --- | --- |
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| Acrobat Documen | Acrobat Documen | Acrobat Documen | Acrobat Document |

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caution

## Safety Information

Do not attempt to adjust, test or make a repair if you do not have basic repair skills or if you do not fully understand the directions provided in this web site, through the "Ask the Expert" service or by ACME PARTS.com, Inc. or its affiliates. Furthermore, if your project, equipment, tools or any component differs from those described, you should not attempt the repair based upon the instructions provided.

⚠ **Electrocution can cause injury or death.** Never assume the power is off. Before servicing an electrical device, disconnect it from its electrical source either by unplugging the device or turning off the power at the breaker or fuse box. Some devices can store a hazardous electrical charge even when disconnected from an electrical source, always discharge these devices before attempting service. If you are unfamiliar with a device or its components, consult with a professional before attempting service.

When you turn off the electricity, do it at the main breaker, not just a wall switch. Furthermore, mark the breaker with tape and a note, so that no one will reset it while you are working.

When working with electrical current wear rubber-soled shoes, avoid damp locations and hold all tools by their insulated handles. Never touch conductive surfaces. Avoid shorting electrical circuits.

Serious injury can result from sharp edges. Your appliance may have sharp edges. Use caution when working with an appliance.

Always practice proper and reasonable safeguards as well as those suggested by the manufacturer of the devices and tools you use.

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# How To Check for Proper Wiring





⚠ Caution: Read our advisory about working with electricity

**Items Needed:**

Multimeter
or
Continuity tester

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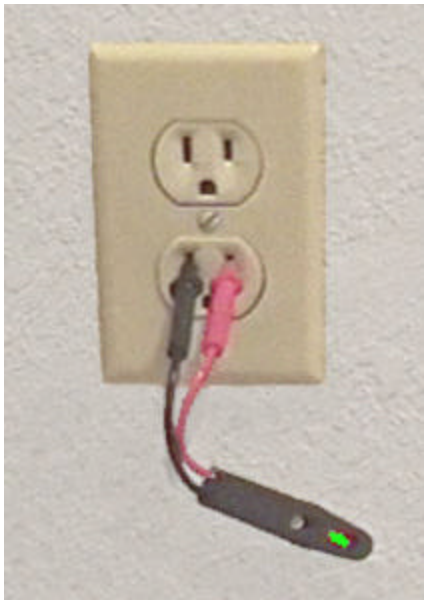
The wiring in your home consists of the "line" or "hot" wire, the neutral wire and in for at least the past couple decades, a ground wire. In the United States the common color coding for these wires are black or red for the hot wire, white for the neutral wire and green for the ground wire.

To test whether an outlet is properly grounded, you will need an inexpensive tool called a circuit tester (you can also use a multimeter set to AC voltage appropriate for the outlet you are testing). Standard outlets have a large slot, a small slot and a "U" shaped hole. In a properly wired outlet, the smaller slot is "hot", the large slot is neutral and the "U" shaped hole is ground.



Insert one probe of the circuit tester into the small slot and the other probe into the large probe. If the circuit tester lights up, you have power to the outlet. Now place one probe in the small slot and the other probe into the "U" shaped ground hole. The indicator should light up if the outlet is grounded. Test both outlets because they can be wired separately. The fact that one is properly wired does not guarantee that they are both properly wired.

If the tester does not light, then place one probe into the large slot and the other probe in the ground hole. If it does light, then the outlet is grounded but the "hot" and neutral wires are reversed. If it still does not light, then the outlet is NOT grounded. If the outlet is miswired or not grounded, it should NOT be used until the problem is corrected.

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## How To Test an Outlet for Current

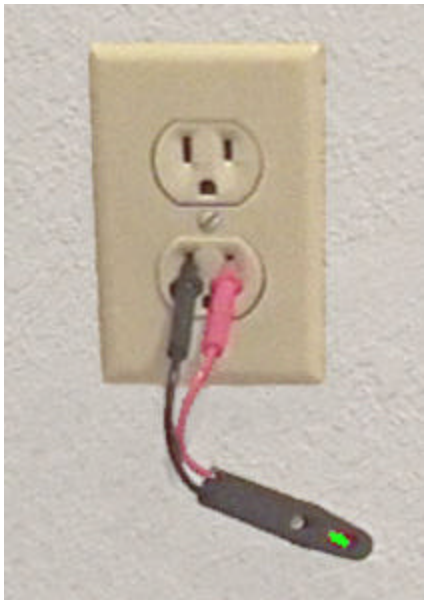
⚠ Caution: Read our advisory about working with electricity

**Items Needed:**

Multimeter
or
Circuit tester
or
Shop light

You can test an outlet to determine if current is present with a current tester. If you don't have a current tester, simply use a shop light or other convenient electrical device. Start by making sure the tester is working and plug it into a circuit you know is working. Note that if you need to test a 220v outlet, use only a device rated for that voltage.

Be sure to test both outlets, sometimes only one of the two will work. To test whether the outlet is properly grounded, follow this link to the article on grounding.



If there is no current, make certain that the outlet isn't controlled by a switch. Try all nearby switches and check whether the tester lights up.

Another possibility, if there is no current, is that the fuse has blown or the circuit breaker has tripped. Click on the links below for more information on checking fuses and circuit breakers.

If the circuit breakers were not tripped, the outlet may be in a circuit with a GFCI outlet (ground fault circuit interrupt). If the GFCI outlet has been tripped, it may cause other outlets on the same circuit to lose current. Look for an outlet that has a "Test" and "Reset" button. They are often located near water such as in a bathroom or kitchen. If the outlet has been tripped, unplug anything that may have caused the fault and then press the "Reset" button.

nal screw on the right side of the outlet. (Be careful not to touch the terminals with your fingers or any part of your hand.) You should read about 120 volts ac on the meter. If you do, repeat step “4” or “5” above. If you do not measure voltage at the slots of the outlet, but you do measure voltage at the terminals, the outlet is damaged and should be replaced. Turn OFF the power at the panel before replacing the outlet.

**7. Where To Go From Here.**

Hopefully by now you have found and fixed the problem. However, if you still do not measure any voltage at the terminal screws on the sides of the outlet, the problem is likely either in the wiring, or the circuit breaker. You should contact a qualified, licensed electrician to troubleshoot and repair the wiring. You can also read the booklet *“How to Troubleshoot Circuit Breakers”* for information on things you can do to check the circuit breaker.

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**Electrical #1**

# Meterman How-to *Test it Yourself*

## Electrical outlets

## Problem:

**Problem:**

Have you ever plugged a radio or lamp into the wall only to find it didn’t work? Your natural reaction may be to assume the radio is broken, but it could also be a faulty outlet, a tripped circuit breaker, broken wiring, or some other failure.

## Task Summary:

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This booklet will lead you through the steps to safely test for power at a wall outlet then troubleshoot and fix the common causes if there isn’t. To properly repair or replace an electrical outlet, first check the outlet for power, then for proper grounding and polarity (making sure the wires are connected to the proper terminals). If the outlet checks out OK, the next step is to check the wiring. Note: These same basic procedures can be used to test ceiling fixtures and wall switches.

## Recommended Tools:

**Recommended Tools:**

For this project you will need a basic digital multimeter (DMM) that measures ac voltage and resistance. You should also consider using a DMM that has a built-in Safety Tester. This is an extra feature that gives a quick indication whether voltage is present or not, even if the DMM batteries are dead. This booklet assumes you already know how to use a DMM to make basic voltage and resistance measurements. If not, read the booklet “Basic DMM Measurements” and your DMM owner’s manual before you start this project.

Illustrations of recommended tools *(What tool should be shown?)*

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# How-to safely test electrical outlets

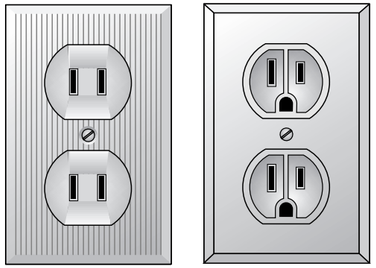

figure 1

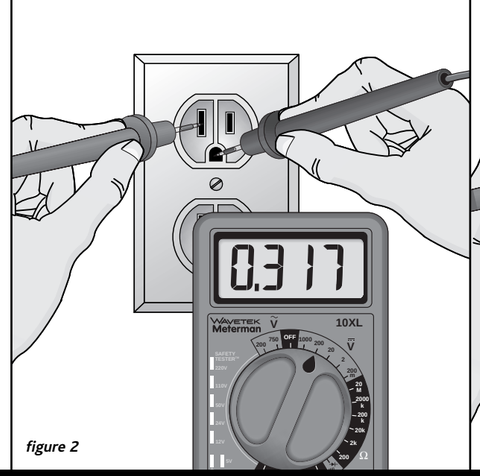


figure 2

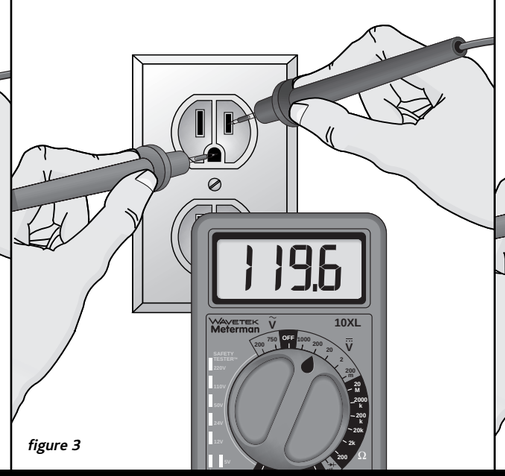


figure 3

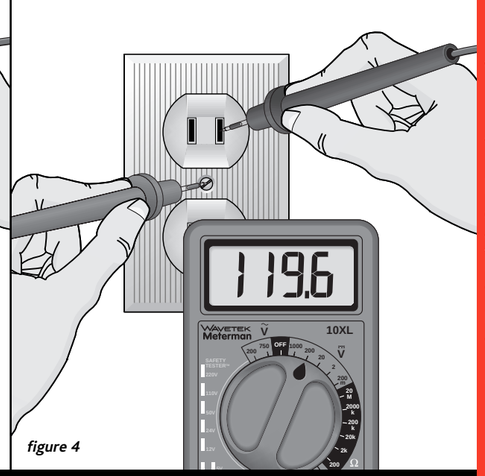


figure 4

## Step by step troubleshooting:

**1. Check the Device.**

Before you spend a lot of time troubleshooting the outlet, make sure the device you are plugging in to the outlet is working. Try plugging the device into an outlet that you know is working. If it still doesn't work, the problem is most likely with the device. (See the booklet *"How to Troubleshoot Common Household Appliances"* for more information.)

**2. Check for Damage.**

Inspect the outlet for signs of damage, such as burn marks, soot, melted plastic, or cracked or broken plastic. These are indications there may be a short inside the outlet, or that the receptacle is broken. It is best to replace any outlet that shows visible signs of damage. Turn the power OFF at the breaker panel before attempting to replace an outlet.

**3. Check for Power.**

To check an electrical outlet for power, first make sure the breaker is not tripped. (If the breaker is tripped, or trips again when you reset it, read the booklet *"How to Troubleshoot Circuit Breakers"* for more information.) If the outlet is controlled by a wall switch, make sure the switch is in the ON position.

Set the multimeter to the ac voltage function, 200 volt range (ranges may vary on different meters, check your meter manual if you are unsure of settings), and connect the test leads to the COM and V inputs. Insert the probes, one at a time, into the long and short slots of the outlet. *(See figure 1.)* Make sure the probes make contact with the metal conductors inside the outlet slots. Check both the top and bottom receptacle. With some outlets, the top and bottom receptacles are wired separately from each other – one may work while the other does not.

The voltage on an electrical outlet is usually about 120 volts. If the circuit is disconnected or turned off at the electrical panel or wall switch then the voltage should be less than 1 volt.

**4. Testing for Grounding and Polarity on a 3-Slot Outlet:**

A 3-slot outlet has a "hot" slot, a neutral slot and a grounding slot as shown in Figure 2. The short slot should be the hot, the long slot should be the neutral, and the U-shaped slot should be the ground. Incorrect wiring on an electrical outlet not only leads to problems with electronic equipment and appliances, it can also present a safety hazard.

With the meter set to the 200 volt ac range, place one probe in the U-shaped slot and the other in the long slot. The meter should read less than 1 volt. Move the probe from the long slot to the short one. *(See Figure 3)* The meter should now show about 120 volts. If your readings are the opposite, the hot and neutral wires are reversed. Turn OFF the power at the panel and re-wire the outlet.

**5. Testing for Grounding and Polarity on a 2-Slot Outlet:**

While most homes are equipped with 3-slot electrical outlet, some older homes still have 2-slot. In these homes the outlet box should be grounded. In order to test for grounding and polarity you'll have to make sure that there is no paint on the cover plate screw (if the screw has paint on it, temporarily replace it with an unpainted screw to conduct this test).

With the meter set to the 200 volt ac range, place one probe in the long slot. Hold the other probe on the screw head. You should read less than 1 volt.

Move the probe from the long slot to the short one. You should now read about 120 volts on the meter. *(See Figure 4)* If your readings are the opposite, the hot and neutral wires are reversed. Turn OFF the power at the panel and re-wire the outlet.

**6. Check the Wiring.**

If your readings so far still show no voltage, you'll have to test the wiring inside the junction box. First, turn OFF the power at the circuit breaker panel. Remove the outlet cover plate and remove the screws at the top and bottom of the outlet bracket. If your DMM has a Safety Tester™ feature, use it to check for voltage at the screw terminals on either side of the outlet to make sure the power is turned OFF. Otherwise use your meter in the 200 volt ac range and probe the screw terminals to verify that power is OFF. Carefully pull the outlet out of the junction box. Look for broken or loose wires going to the receptacle. Tighten any loose connections on the outlet or in the wire nuts inside the junction box. Replace any broken wires.

Set the outlet aside making sure the side terminal screws are not touching anything inside or outside the junction box. Turn ON the power at the circuit breaker panel (remember to also turn on the wall switch if there is one). With the meter set to the 200 volt ac range, place one probe on the head of the terminal screw on the left side of the receptacle. Touch the other probe on the head of the termi-

*(continued on back)*

## Work safely!

**Electricity can be dangerous. Protect yourself and your home by remembering to follow a few simple rules when working with electrical circuits:**

- **Always turn the power off at the electrical panel before handling wires or terminals. Don't assume that you know which wire is hot! Use your meter to verify the power is off before handling any wires or terminals.**
- **Make sure your meter is working with a 3-point check: Measure a known live circuit, next measure the circuit you're working on and finally re-check the known live circuit.**
- **Use caution when measuring live circuits. Don't stand in water, use one hand to probe whenever possible, and don't wear metal jewelry.**
- **Only use a meter that has the proper voltage ranges for the job at hand and make sure the meter has the proper safety ratings and protection.**