Consulting, Resource, Education, Training, and Support Services for Home Inspectors
"A candle loses no light when it lights another candle."

HOW GFCI DEVICES WORK

A non-GFCI overcurrent protection device (circuit breaker or fuse) is designed and intended to disconnect only the hot conductor from the circuit when an overcurrent condition occurs. However, GFCI devices (both receptacles and circuit breakers) are designed and intended to disconnect both the hot conductor (also referred to as the "ungrounded" or "phase" conductor) and the grounded/neutral conductor (also referred to as the "grounded" or "common" conductor) from the circuit both at and downstream from the such devices. This explains why there are two terminals on a GFCI circuit breaker as well as a permanently attached white insulated (usually coiled) pigtail. The white pigtail is to be attached to the neutral bus and both the hot and neutral circuit conductors are to be attached to their respective terminals on the breaker. When the GFCI breaker trips both the hot and the neutral conductors are disconnected from the electrical supply. Tripping a GFCI device disconnects the hot and the neutral conductors. When a GFCI breaker is installed in a subpanel, the coiled pigtail is attached to the floating or isolated neutral bus. In a main distribution panel, if there are separate grounding and neutral buses, the coiled pigtail may be attached to either the grounding or the neutral bus since the two buses are connected and, therefore, electrically continuous in the main panel.

A GFCI device is designed to monitor the current potential between the hot conductor and the neutral conductor and to trip by opening internal current conducting contacts when it senses a very small difference in current potential, typically three to six milliamps (0.003+/-mA - 0.006mA). It will typically perform this function in the event of either a hot-to-ground fault where current takes a path to ground other than through the neutral or in the event of a grounded neutral fault caused by the neutral and the equipment grounding conductors being electrically connected by a low resistance path between them somewhere downstream of the GFCI device. When a grounded neutral fault condition exists, the GFCI device will trip the instant current is introduced on the circuit whether or not anything is connected to the GFCI device.

Normally, the difference in potential between the hot and neutral conductors is zero. The component in a GFCI device that monitors current and senses an imbalance or difference between the current flowing out on the hot conductor and the current flowing back to ground on the neutral conductor is referred to as a differential current transformer. In the event that some of the current returning to ground is passing through you instead of the neutral conductor, the transformer will sense the imbalance and open the internal contacts to stop the flow of current through the GFCI device and through you.

This also explains why GFCI receptacles (which are three-pin type receptacles) can replace two-pin type receptacles in two conductor wiring systems and still provide ground fault protection. Attachment of an equipment grounding conductor is not necessary for a GFCI device to sense a ground fault and to trip. However, the "test" button function of a GFCI cube-type receptacle tester is designed to use the system grounding to create a difference in potential and to trip causing the receptacle to become internally electrically disconnected on both the hot and neutral sides when the cube "test" button is depressed. In a two-wire system there is no means for the GFCI receptacle to connect to a grounding source through the receptacle's grounding terminal. This is why depressing the "test" button on a GFCI cube-type will not trip and will not disconnect a receptacle installed in a two-wire system.

There is a method for externally testing GFCI receptacles installed in two-wire systems. This method requires the use of certain types of electrical continuity testing devices with metal tips on the probes. One probe of the continuity tester is inserted into the hot/phase slot of the GFCI receptacle and the other probe is touched to a confirmed grounding source such as metallic water or waste lines or a metallic HVAC duct.

Now, we will discuss situations where a fully functional GFCI device will not provide protection from shock or electrocution. Remember, the GFCI device is designed and intended to provide protection against ground faults – that is, situations where some or all of the current takes a path to ground other than on the neutral conductor. So, if you are not grounded and, with one hand you touch the exposed energized end of a conductor connected to the hot side of a GFCI protected receptacle and with the other hand you touch the exposed end of a conductor connected to the neutral side of the same GFCI protected receptacle, the GFCI will not respond and disconnect the power. Why? Because the current is still going out on the hot and returning on the neutral – it just happens to be passing through you on the journey. Since you are ungrounded and, therefore, not providing an alternate path to ground, there is no current imbalance and the internal contacts in the GFCI device will remain in the closed position allowing the current to continue to flow.

Another situation where a properly installed and functioning GFCI device will not provide protection against shock or electrocution can exist when you are not grounded (good shoes), you are using an ungrounded power saw with a nice conductive metal case (because you like antique power tools), and you have plugged the saw into a GFCI protected receptacle. In the course of cutting into a wall, floor, or ceiling, you accidentally slice into the energized wiring of a circuit other than the circuit that is protected by the GFCI device. The potential exists here for current to flow on the hot conductor of the unprotected circuit wiring, through the saw and you, and back along the neutral conductor of the same unprotected circuit wiring. Because there is no imbalance in the current flowing on then GFCI protected circuit, the GFCI will not trip.

Lastly, consider the following scenario. You are inspecting an older home which is still wired with two-conductor wiring (no equipment grounding conductor). To provide a measure of safety against a potential ground fault condition, the original two-wire receptacle on the exterior of the home has been replaced with a GFCI receptacle and a metal weatherproof receptacle cover has been installed over the receptacle.

In this type of installation the metal screw which secures the metal weatherproof cover plate to the receptacle is screwed into the threaded hole in the metal portion of the receptacle. In turn, the metal portion of the receptacle is electrically continuous with the equipment grounding pin contacts in the grounding pin holes of the receptacle. So the cover, the screw, and the grounding pin contacts in the receptacle are all electrically continuous. Remember, this is wired into a two-conductor circuit so the grounding portion of the receptacle is not connected to any grounding source.

Now, being a thorough inspector, you kneel on the patio or ground in front of the receptacle and hold the little spring-loaded cover/door over the receptacle open with one hand at the same time insert your push button GFCI receptacle tester into the receptacle with your other hand and push the “test” button. If the surface you are kneeling on is damp or wet and your pants are not waterproof, you are grounded through your knees and you get shocked. You think, “What the…?” Well, when you pushed the “test” button on your cube-type tester, you introduced test current on the grounding pin contacts in the receptacle (that is what your tester is designed to do in order to test GFCI receptacles that are installed in three-conductor 120 V [nominal] circuits). Because the grounding contacts in the receptacle are electrically continuous with the cover door that you are touching, current passes through your hand and to the ground via your knees. To sum it up, understand GFCI devices and be careful. Do not become complacent just because a GFCI is installed in a circuit.

You can find out more about GFCI devices and a lot of other electrical information including some good photos at: www.electrical-contractor.net