
Swimming Pool Equipotential Bonding¹

Mild shocks can be experienced by swimmers around pools even when there is nothing wrong with the installation. A small voltage, high enough to be felt by humans in these wet conditions, can arise from problems with the wiring on other circuits in the home or building, or at a neighbor's property. The voltage can even come in on the utility's grounded wire. The perception of an electrical sensation is the result of current flow through the body. It is voltage that causes the current to flow. The lower the resistance of the body the higher the current for a given value of voltage. For a person who has been in the water for some time body resistance can drop to as low as 500 ohms. At this low resistance enough current can flow through the body to be felt as a slight tingle at as little as 1 volt. The electrical code now requires equipotential bonding of pool installations to prevent humans from being exposed to shocks from these voltage sources.

Stray voltage is a name given to the condition where a small voltage can be measured between metal objects and the earth or concrete floor in and around livestock barns. Livestock farmers have been aware of this condition and dealing with it as far back as 30 years. A very small voltage is common arising from the use of power in buildings and the power delivery system across the countryside. Sometimes this voltage can rise to a level high enough to be felt by livestock standing on a wet floor or the earth. When that happens, steps are taken to reduce the voltage level or prevent the livestock from becoming a part of the stray voltage circuit. Humans in and around swimming pools can be exposed to this same condition, and if the voltage level gets high enough they can feel a tingling sensation as shown in Figure 1. Since it requires an electrical pump to circulate the pool water, operate a pool cover, and provide in-pool as well as area lighting, care must be taken to make sure the wiring is safe and the pool installation minimizes exposure to perceptible levels of touch voltages.



Figure 1. When standing in the water of a swimming pool and making contact with a metal object such as a ladder, a person can become a part of a neutral-to-earth voltage circuit and receive a mild shock.

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Metal objects associated with the swimming pool such as ladder, metal plumbing, pool cover frames, metal lighting fixtures in the pool walls, and the water circulating pump are required by the electrical code to be connected together with a solid copper wire that is at least size AWG 8 or larger. This ensures that a voltage cannot develop between the different metal objects that can pose a hazard to humans. This bonding wire, as it is called, does usually connect to the house electrical system neutral terminal, and that terminal is generally the source of this low level neutral-to-earth voltage (stray voltage). When a person stands bare-footed on a paved walkway and touches a metal object or is standing in the pool and touches a metal object such as a ladder, the person makes a connection between the metal object and the earth. Enough current can flow through the person's body to cause a mild shock. This is illustrated in Figure 1. If the pool wall and plumbing are made of nonmetallic materials with no metal objects touching the water the person does not complete an electrical circuit when touching metal objects.

Objects such as a metal ladder, underwater lights, or metal plumbing making contact with water in the pool can be a way that this voltage gets to the pool water from the electrical system neutral. Even if the pool wall is made of nonmetallic materials a person can complete a path to earth by sitting on the edge of the pool and dangling their feet in the water. This is illustrated in Figure 2.

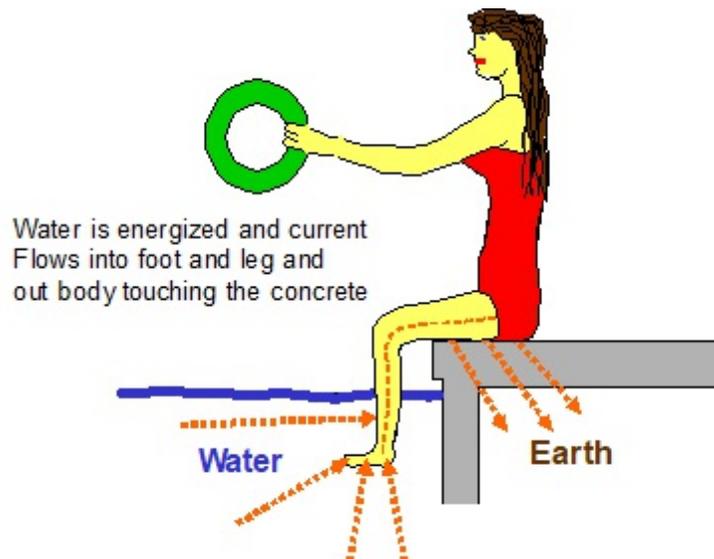


Figure 2. A neutral-to-earth voltage circuit can sometimes occur when a person sits on a walkway and dangles their feet in the water.

Borrowing a technique from livestock farmers, the electrical codes across the country are changing to require an equipotential bonding grid to be installed in the walls and floor of all poured concrete swimming pools, and in a paved walkway around any type of swimming pool. This metal grid in the pool wall and floor makes sure the pool walls, floor, and water are at nearly the same voltage potential as any metal object associated with the pool that can be a source of this neutral-to-earth voltage (stray voltage). Notice in Figure 3 that current may flow into the earth due to stray voltage, but the person in the pool does not become a part of the circuit. This equipotential grid can be created by installing sheets of reinforcing steel in the pool floor and walls before the concrete is poured. A copper wire is secured to these sheets of steel and extended out of the wall so they can be properly connected to other metal objects. This wire is required by the electrical code to be solid copper and size AWG 8 or larger.

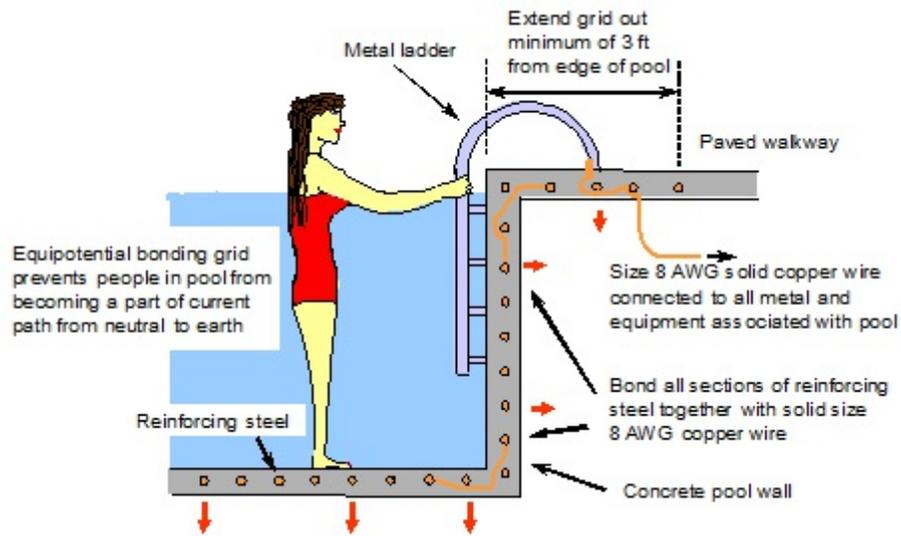


Figure 3. Metal steel reinforcing installed in swimming pool concrete walls and floor forms an equipotential grid that prevents a person in the pool from becoming part of a neutral-to-earth voltage circuit.

Even though a person may not be exposed to this stray voltage while in some swimming pools, they are still likely to be exposed to this voltage when standing or sitting on a paved walkway around the pool. The new electrical code rules for swimming pool installations requires that this metal equipotential grid be installed in all paved walkways around swimming pools extending out from the pool at least 3 feet. Figure 4 illustrates a person sitting on the edge of a pool with feet dangling in the water. The metal grid in the walkway prevents the person from becoming a part of the stray voltage circuit.

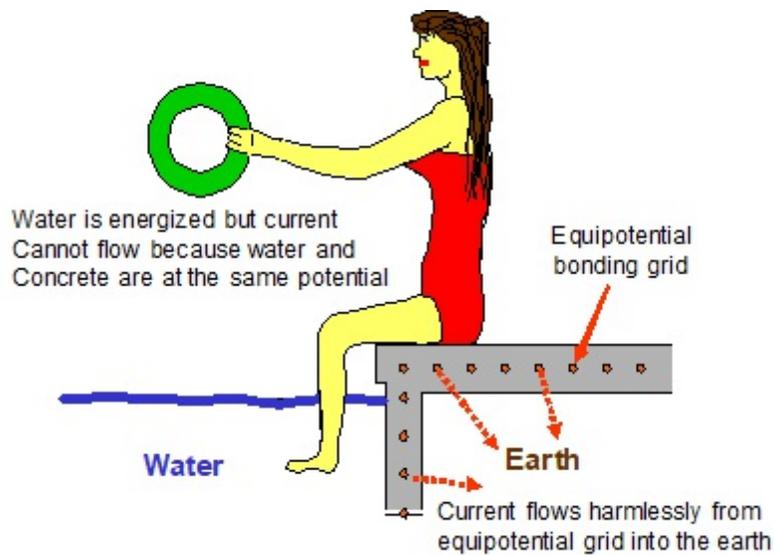


Figure 4. An equipotential grid should be installed in walkways around the pool and extending out from the edge of the pool at least 3 feet.

Be aware of the possibility of a voltage condition around a swimming pool that can get high enough to be perceived by humans as a tingling or mild shock. In the event this condition is detected, many electrical contractors are trained to investigate neutral-to-earth voltage conditions. Electrical utilities also have trained personnel that can check-out neutral-to-earth voltage conditions around swimming pools as well as around livestock areas of farms. If the shock seems severe, there may be a dangerous condition with the pool equipment. In that case keep people away from the pool and call a pool equipment service provider or a qualified electrical contractor.

The new rules for installing equipotential bonding grids in swimming pool floors, walls and walkways are now a requirement in Michigan. Anyone who installs a new swimming pool or make improvements to an existing installation must give consideration to these new rules. Once the installation is completed it is very difficult to go back and make a retrofit installation of an equipotential grid. The requirements are explained in *Article 680* of the *National Electrical Code* and the 2015 edition of the *Michigan Residential Code*. To minimize the chances of electrical shocks around swimming pools, make sure equipotential bonding of pool concrete, metal pool associated equipment, and walkways around the pool meet the requirements of the electrical code.

Conclusion: Installers of swimming pools should be aware of the requirements in the electrical code for bonding and grounding of equipment associated with a swimming pool and requirements for locating pool associated equipment as well as electrical outlets that are located in the area of a pool. For a brief discussion of the sources of low levels of neutral-to-earth voltage that can result in mild shock conditions in and around swimming pools see Tech Note 337.