CONTENTS

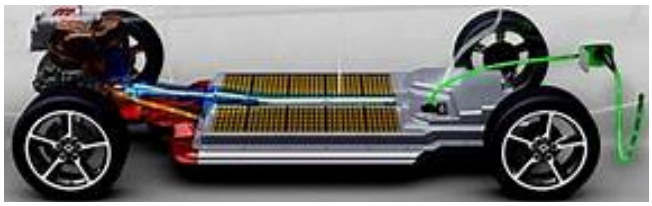
CONTENTS

•**Author's note**: Welcome to tomorrow!

Electric cars are the long-awaited transportation solution for the futurist ready to break free from the old-fashioned gasoline pump.

Very Interesting Predictions

Auto repair shops will go away. A gasoline engine has 20,000 individual parts. An electrical motor has 20. Electric cars are sold with lifetime guarantees and are only repaired by dealers. It takes only 10 minutes to remove and replace an electric motor. Faulty electric motors are not repaired in the dealership but are sent to a regional repair shop that repairs them with robots. Your electric motor malfunction light goes on, so you drive up to what looks like a Jiffy-auto wash, and your car is towed through while you have a cup of coffee and out comes your car with a new electric motor!



Gas stations will go away. Parking meters will be replaced by meters that dispense electricity. Companies will install electrical recharging stations; in fact, they've already started. You can find them at select Dunkin Donuts locations.

Most (the smart) major auto manufacturers have already designated money to start building new plants that only build electric cars.

Coal industries will go away. Gasoline/oil companies will go away. Drilling for oil will stop. So say goodbye to OPEC!

A baby of today will only see personal cars in museums.
The FUTURE is approaching faster than most of us can handle.

Autonomous cars: In 2018 the first self-driving cars are already here. In the next 2 years, the entire industry will start to be disrupted. You won't want to own a car anymore as you will call a car with your phone, it will show up at your location and drive you to your destination. You will not need to park it you will only pay for the driven distance and you can be productive while driving. The very young children of today will never get a driver's license and will never own a car.

(continued)

This will change our cities, because we will need 90-95% fewer cars. We can transform former parking spaces into parks.

1.2 million people die each year in car accidents worldwide including distracted or drunk driving. We now have one accident every 60,000 miles; with autonomous driving that will drop to 1 accident in 6 million miles. That will save a million lives plus worldwide each year.

Most traditional car companies will doubtless become bankrupt. Traditional car companies will try the evolutionary approach and just build a better car, while tech companies (Tesla, Apple, Google) will do the revolutionary approach and build a computer on wheels.

Look at what Volvo is doing right now; no more internal combustion engines in their vehicles starting this year with the 2019 models, using all electric or hybrid only, with the intent of phasing out hybrid models.

Many engineers from Volkswagen and Audi are completely terrified of Tesla and so they should be. Look at all the companies offering all electric vehicles. That was unheard of only a few years ago.

Insurance companies will have massive trouble because, without accidents, the costs will become cheaper. Their car insurance business model will disappear.

Electric cars will become mainstream about 2030. Cities will be less noisy because all new cars will run on electricity.

Cities will have much cleaner air as well. Electricity will become incredibly cheap and clean.

WELCOME TO TOMORROW – it actually arrived a few years ago.

Part I. General

625.1 Scope. This article covers the electrical conductors and equipment external to an electric vehicle that connect an electric vehicle to premises wiring for the purposes of charging, power export, or bidirectional current flow.

•**Author's note**: The difference between "car" and "vehicle" when reading the Code.

Car is the passenger compartment of an elevator as we read in Article 620. Vehicle is a piece of mechanized equipment. But, it gets confusing when you see "vehicles" in an elevator!



Definitions. There are 15 definitions.

Electric Vehicle. An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current. For the purpose of this article, electric motorcycles and similar type vehicles and off-road, self-propelled electric vehicles, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats, and the like, are **not** included.

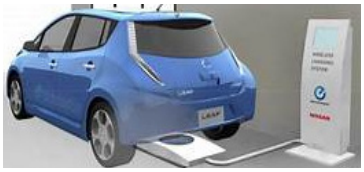

Electric Vehicle Supply Equipment (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors and the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle.




Informational Note: Electric vehicle power export equipment and electric vehicle supply equipment are somtimes contained in one piece of equipment, somestimes referred to as a bidirectional EVSE.

Wireless Power Transfer (WPT). The transfer of electrical energy from a power source to an electrical load via electric and magnetic fields or waves by a contactless inductive means between a primary and secondary device.

Wireless Power Transfer Equipment (WPTE). Equipment consisting of a charger power converter and a primary pad. The two devices are either separate units or contained within one enclosure.

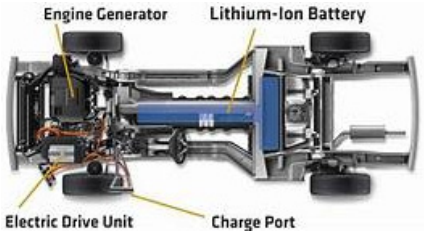


Wireless vehicle charging and wireless power transfer equipment allows the driver to simply park the car in the garage over a primary pad and charge the vehicle through induction instead of using a cord connection.

Across the globe, electric buses are becoming the norm; London's iconic double-decker buses are planning for wireless charging, as are bus systems in South Korea, Utah, and Germany.

Using WiTricity, invented by MIT scientists, electric cars can be charged wirelessly, and those cars can wirelessly charge your mobiles! (Using Qi charging, of course!) This wireless technology is convenient, to be sure, but it may also charge cars faster than plug-in charging can.

Wireless power techniques mainly fall into two categories, near field and far-field. In near field or non-radiative techniques, power is transferred over short distances by magnetic fields using inductive coupling between coils of wire, or by electric fields using capacitive coupling between metal electrodes. Inductive coupling is the most widely used wireless technology; its applications include charging handheld devices like phones and electric toothbrushes, RFID tags, and wirelessly charging or continuous wireless power transfer in implantable medical devices like artificial cardiac pacemakers, or electric vehicles.

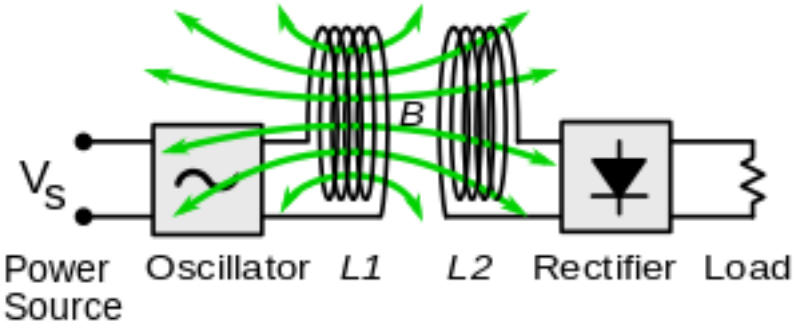


Wireless power transfer is a generic term for a number of different technologies for transmitting energy by means of electromagnetic fields.

In general, a wireless power system consists of a "transmitter" device connected to a source of power such as a mains power line, which converts the power to a time-varying electromagnetic field, and one or more "receiver" devices which receive the power and convert it back to DC or AC electric current which is used by an electrical load.

In inductive coupling (electromagnetic induction or inductive power transfer, IPT), power is transferred between coils of wire by a magnetic field. The transmitter and receiver coils together form a transformer. An alternating current (AC) through the transmitter coil (L1) creates an oscillating magnetic field (B) by Ampere's law. The magnetic field passes through the receiving coil (L2), where it induces an alternating EMF (voltage) by Faraday's law of induction, which creates an alternating current in the receiver. The induced alternating current may either drive the load directly, or be rectified to direct current (DC) by a rectifier in the receiver, which drives the load.

Inductive coupling is the oldest and most widely used wireless power technology, and virtually the only one so far which is used in commercial products.



Conclusion

While Tesla's dream of having power delivered wirelessly for everyone's use is still far from feasible, many devices and systems are using some form of wireless power transfer right now. From toothbrushes to mobile phones, from cars to public transportation, there are many applications for wireless power transfer.

625.4 Voltages. Unless other voltages are specified, the nominal ac system voltages of 120, 120/240, 208Y/120, 240, 480Y/277, 480, 600Y/347, 600, and 1000 volts and dc system voltages of up to 1000 volts shall be used to supply equipment covered by this article. Output voltages to the electric vehicle are not specified.

625.5 Listed. Electric vehicle power transfer system equipment for the purpose of charging, power export, or bidirectional current flow shall be listed.

Part II. Equipment Construction

625.17 Cords and Cables

(A) Power-Supply Cord. The cable for cord-connected EVSE supply equipment shall comply with all of the following:

(1) Be any of the types specified in 625.17(B)(1) or hard service, junior hard service cord, or portable power cable in accordance with Table 400.4. Hard service cord, junior hard service cord, or portable power cable types shall be listed, as applicable, for exposure to oil and damp and wet locations.

(2) Have an ampacity as specified in Table 400.5(A)(1) or, for #8 AWG and larger, in the 60°C (140º) columns of Table 400.5(A)(2).

(3) Have an overall length as specified in either of the following:

a. When the interrupting device of the personnel protection system specified in 625.22 is located within the enclosure of the supply equipment or charging system, the power-supply cord shall be not more than the length indicated in (i) or (ii):

(i) For portable equipment in accordance with 625.44(A), the power supply cord shall not be more than 12” long.

(ii) For fastened-in-place equipment in accordance with 625.44(B), the power supply cord shall not be more than 6’ long and the equipment shall be installed at a height that prevents the power supply cord from contacting the floor when it is connected to the proper receptacle.

b. When the interrupting device of the personnel protection system specified in 625.22 is located at the attachment plug, or within the first 12” of the power-supply cord length shall be a minimum of 6 feet and shall not be greater than 15 feet.

(B) Output Cable to Electric Vehicles. The output cable to electric vehicles shall be Type EV, EVJ, EVE, EVJE, EVT, or EVJT flexible cable as specified in Table 400.4.

625.17(C) Overall Cord and Cable Length. The overall length of the cable shall not exceed 25 feet unless equipped with a cable management system that is part of the listed electric vehicle supply equipment.

Not exceeding 25 feet

(1) Portable Equipment . For portable EVSE, the cord-exposed usable length shall be measured from the face of the attachment plug to the face of the electric vehicle connector.

(2) Fastened in Place. Where the electric vehicle supply equipment or charging system is fastened in place, the usable length of the output cable shall be measured from the cable exit of the electric vehicle supply equipment or charging system to the face of the electric vehicle connector.

Where the wireless power transfer equipment (WPTE) is fastened-in-place, the output cable to the primary pad shall be measured from the cable exit of the control box to the cable inlet at the primary pad.

(D) Interconnecting Cabling Systems. Other cabling systems that are integral parts of of listed EVSE and are intended to interconnect pieces of equipment within an EVSE system using **approved** installation methods shall be permitted.

625.22 Personnel Protection System. EVSE shall have a listed system of protection against electric shock of personnel. Where cord-and-plug-connected equipment is used, the interrupting device of a listed personnel protection system shall be provided according to 625.17(A). A personnel protection system shall not be required for EVSE that supplies less than 60 volts dc.

Part III. Installation

625.40 Electric Vehicle Branch Circuit. Each outlet installed for the purpose of supplying EVSE greater than 16 amperes or 120 volts shall be supplied by an individual branch circuit.

625.41 Overcurrent Protection. Overcurrent protection for feeders and branch circuits supplying EVSE, including bidirectional EVSE, and WPTE shall be sized for continuous duty and shall have a rating of not less than 125 percent of the maximum load of the equipment. Where noncontinuous loads are supplied from the same feeder, the overcurrent device shall have a current rating of not less than the sum of the noncontinuous loads plus 125 percent of the continuous loads.

625.42. Rating. The EVSE equipment shall have a sufficient rating to supply the load served. Electric vehicle charging loads shall be considered to be continuous loads for the purpose of this article. Service and feeder shall be sized in accordance with the product ratings, unless the overall rating of the installation can be limited through controls as permitted by 625.42(A) or (B).

(A) Energy Management System (EMS). Where an EMS in accordance with 750.30 provides load management of EVSE, the maximum equipment load on a service or feeder shall be the maximum load permitted by the EMS. The EMS shall be permitted to be integral to one piece of equipment or integral to a listed system consisting of more than one piece of equipment. When one or more pieces of equipment are provided with an integral load management control, the system shall be marked to indicate this control is provided.

(B) EVSE with Adjustable Settings. EVSE with restricted access to an ampere adjusting means complyimg with 750.30(C) shall be permitted. If adjustments have an impact on the rating label, those changes shall be in accordance with manufacturer's instructions, and the adjusted rating shall appear on the rating label with sufficient durability to withstand the envionment involved. EVSE as referenced shall be permitted to have an ampere ratings that are equal to the adjusted current setting.

625.43 Disconnecting Means. For EVSE and WPTE rated more than 60 amperes or more than 150 volts to ground, the disconnecting means shall be provided and installed in a readily accessible location. The disconnecting means shall be lockable open in accordance with 110.25. If the disconnecting means is installed remote from the equipment, a plaque shall be installed on the equipment denoting the location of the disconnecting means.

625.44 Equipment Connection. EVSE and WPTE shall be connected to the premises wiring system in accordance with one of the methods in 625.44(A) through (C).

(A) Portable Equipment. Portable equipment shall be connected to the premises wiring system by one of the following methods:
(1) A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated at 125 volt, single phase, 15 or 20 amperes.

(2) A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated 250 volts, single phase, 15 or 20 amperes.

(3) A nonlocking, 2-pole, 3-wire or 3-pole, 4-wire grounding-type receptacle outlet rated 250 volts, single phase, 30 or 50 amperes, or 125/250 volts, single-phase, 30, 50, or 60 amperes.

(4) A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated 60 volts dc maximum, single phase, 15 or 20 amperes.

(B) Fastened-in-Place Equipment. Equipment that is fastened in place in such a way as to permit ready removal for interchange, facilitation of maintenance or repair, or repositioning shall be connected to the premises wiring system by one of the following methods:
(1) A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated at 125 volts or 250 volts, single phase, up to 50 amperes.
(2) A nonlocking, 3-pole, 4-wire grounding-type receptacle outlet rated at 250 volts, three phase, up to 50 amperes.
(3) A nonlocking, 3-pole, 4-wire grounding-type receptacle outlet rated at 125/250 volts, single phase, 30, 50 or 60 amperes.
(4) A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated at 60 volts dc maximum, 15 or 20 amperes.

625.44(C) Fixed in place Equipment. All ESVE and WPTE equipment shall be permanently wired and fixed in place to the supporting surface.

625.46 Loss of Primary Source. Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the supply equipment to the premises wiring system unless permitted by 625.48.

625.47 Multiple Feeder or Branch Circuits. Where equipment is identified for the application, more than one feeder or branch circuit shall be permitted to supply the equipment.

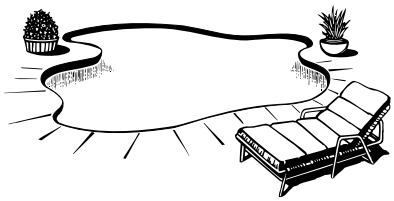
625.48 Interactive Equipment. EVSE or WPTE that incorporates a power export function and that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed shall be listed, evaluated for use with the specific electric vehicles and marked as suitable for that purpose. When used as an optional standby system, the requirements of Parts I and II of Article 702 shall apply; when used as an electric power production source, the requirements of Parts I and II of Article 705 shall apply. EVPE that provides a receptacle outlet as its point of power export shall be in accordance with 625.60.

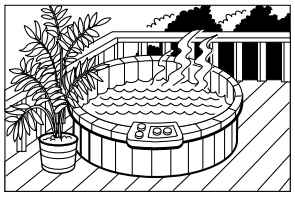
625.49 Island Mode. EVPE and bidirectional EVSE that incorporate a power export function shall be permitted to be a part of an interconnected power system operating in island mode.

625.50 Location. The EVSE shall be located for direct electrical coupling of the EV connector (conductive or inductive) to the electric vehicle. Unless specifically listed and marked for the location, the coupling means of the EVSE shall be stored or located at a height of not less than 18" above the floor level for indoor locations or 24" above the grade level for outdoor locations. This requirement does **not** apply to portable EVSE constructed in accordance with 645.44(A).

Part I. General

680.1 Scope. The provisions of this article apply to the construction and installation of electrical wiring for, and equipment in or adjacent to, all swimming, wading, therapeutic, and decorative pools; fountains; hot tubs; spas; and hydromassage bathtubs, whether permanently installed or *storable*, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment. The term *body of water* used throughout Part I applies to all bodies of water covered in this scope unless otherwise amended.





•**Author's note**: Electrification of swimming, wading, therapeutic, and decorative pools, along with fountains, hot tubs, spas, and hydromassage bathtubs, has been the subject of extensive design and Code development over recent years. The main job Article 680 tries to do is keep electricity and water separated, so that when people are in the water or in contact with related equipment, they are also separated from electricity.

Definitions. There are 26 definitions.

Cord-and-Plug-Connected Lighting Assembly. A lighting assembly consisting of a luminaire intended for installation in the wall of a spa, hot tub, or storable pool, and a cord-and-plug-connected transformer.

Dry-Niche Luminaire. A luminaire intended for installation in the wall of a pool or fountain in a niche that is sealed against the entry of pool water.

Electrically Powered Pool Lift. An electrically powered lift that provides accessibility to and from a pool or spa for people with disabilities.

Fixed (as applied to equipment). Equipment that is fastened or otherwise secured at a specific location.

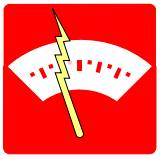
Forming Shell. A structure designed to support a wet-niche luminaire assembly and intended for mounting in a pool or fountain structure.

Fountain. An ornamental structure or recreational water feature from which one or more jets or streams of water are discharged into the air, including splash pads, ornamental pools, display pools, and reflection pools. The definition does **not** include drinking water fountains or water coolers.

Hydromassage Bathtub. A permanently installed bathtub equipped with a recirculating piping system, pump, and associated equipment. It is designed so it can accept, circulate, and discharge water upon each use.

Immersion Pool. A pool for ceremonial or ritual immersion of users, which is designed and intended to have its contents drained or discharged,

Low Voltage Contact Limit. A voltage not exceeding the following values:
(1) 15 volts (RMS) for sinusoidal ac
(2) 21.2 volts peak for nonsinusoidal ac
(3) 30 volts for continuous dc
(4) 12.4 volts peak for dc that is interrupted at a rate of 10 to 200 Hz



Maximum Water Level. The highest level that water can reach before it spills out.

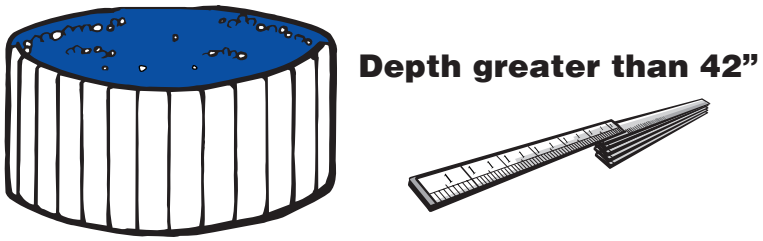
No-Niche Luminaire. A luminaire intended for installation above or below the water without a niche.

Packaged Spa or Hot Tub Equipment Assembly. A factory-fabricated unit consisting of water-circulating, heating, and control equipment mounted on a common base, intended to operate a spa or hot tub. Equipment can include pumps, air blowers, heaters, lights, controls, sanitizer generators, and so forth.

Packaged Therapeutic Tub or Hydrotherapeutic Tank Equipment Assembly. A factory-fabricated unit consisting of water-circulating, heating, and control equipment mounted on a common base, intended to operate a therapeutic tub or hydrotherapeutic tank. Equipment can include pumps, air blowers, heaters, lights, controls, sanitizer generators, and so forth.

Permanently Installed Decorative Fountains and Reflection Pools. Those that are constructed in the ground, on the ground, or in a building in such a manner that the fountain cannot be readily disassembled for storage, whether or not served by electrical circuits of any nature. These units are primarily constructed for their aesthetic value and are not intended for swimming or wading.

Permanently Installed Swimming, Wading, Immersion, and Therapeutic Pools. Those that are constructed in the ground or partially in the ground, and all others capable of holding water in a depth greater than 42", and all pools installed inside of a building, regardless of water depth, whether or not served by electrical circuits of any nature.



Pool. Manufactured or field-constructed equipment designed to contain water on a permanent or semipermanent basis and used for swimming, wading, immersion, or therapeutic purposes.

Pool Cover, Electrically Operated. Motor-driven equipment designed to cover and uncover the water surface of a pool by means of a flexible sheet or rigid frame.

Portable (as applied to equipment). Equipment that is actually moved or can be easily moved from one place to another in normal use.

Self-Contained Spa or Hot Tub. Factory-fabricated unit consisting of a spa or hot tub vessel with all water-circulating, heating, and control equipment integral to the unit. Equipment can include pumps, air blowers, heaters, lights, controls, sanitizer generators, and so forth.

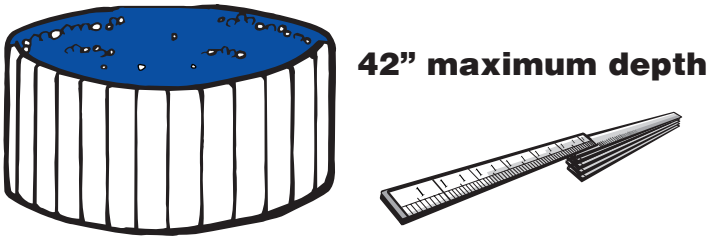
Self-Contained Therapeutic Tubs or Hydrotherapeutic Tanks. A factory-fabricated unit consisting of a therapeutic tub or hydrotherapeutic tank with all water-circulating, heating, and control equipment integral to the unit. Equipment may include pumps, air blowers, heaters, light controls, sanitizer generators, and so forth.

Spa or Hot Tub. A hydromassage pool, or tub for recreational or therapeutic use, not located in health care facilities, designed for immersion of users, and usually having a filter, heater, and motor-driven blower. It may be installed indoors or outdoors, on the ground or supporting structure, or in the ground or supporting structure. Generally, a spa or hot tub is not designed or intended to have its contents drained or discharged after each use.

Splash Pad. A fountain with a pool depth of 1" or less, intended for recreational use by pedestrians. This does not include showers intended for hygienic rinsing prior to use of a pool, spa, etc.

Stationary (as applied to equipment). Equipment that is **not** moved from one place to another in normal use.

Storable Swimming, Wading, or Immersion Pool; or Storable/Portable Spas and Hot Tubs. Swimming, wading, or immersion pools that are intended to be stored when not in use, constructed on or above the ground and are capable of holding water to a maximum depth of 42", or a pool, spa, or hot tub constructed on or above the ground, with nonmetallic, molded polymeric walls or inflatable fabric walls regardless of dimension.



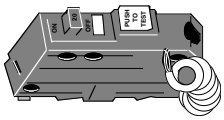
Through-Wall Lighting Assembly. A lighting assembly intended for installation above grade, on or through the wall of a pool, consisting of two interconnected groups of components separated by the pool wall.

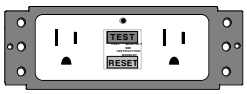
Wet-Niche Luminaire. A luminaire intended for installation in a forming shell mounted in a pool or fountain structure where the luminaire will be completely surrounded by water.

Author's note: The word niche appears often and needs to be defined.
niche. A recess in the concrete wall. A swimming pool has a niche in the wall to install the underwater light.

680.4 Inspections After Installation. The authority having jurisdiction shall be permitted to require periodic inspection and testing.

680.5 Ground-Fault Circuit Interrupters (GFCI) and Special Purpose (SPGFCI) Protection.
(A) General. The GFCI and SPGFCI requirements in this article, unless otherwise noted, are in addition to the requirements in 210.8.



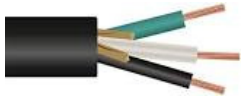


(B) 150 Volts or Less to Ground. Where required in this article, ground-fault protection of receptacles and outlets on branch circuits rated 150 volts or less to ground and 60 amperes or less, single or 3-phase, shall be provided with a Class A GFCI.

(C) Above 150 Volts to Ground. Where required in this article, ground-fault protection of receptacles and outlets on branch circuits operating at voltages above 150 volts to ground, not exceeding 480 volts phase-to-phase, single-or-3 phase, shall be provided with SPGFCI protection not to exceed 20-mA ground-fault current.

680.6 Listing Requirements. All electrical equipment covered by this article shall be listed.

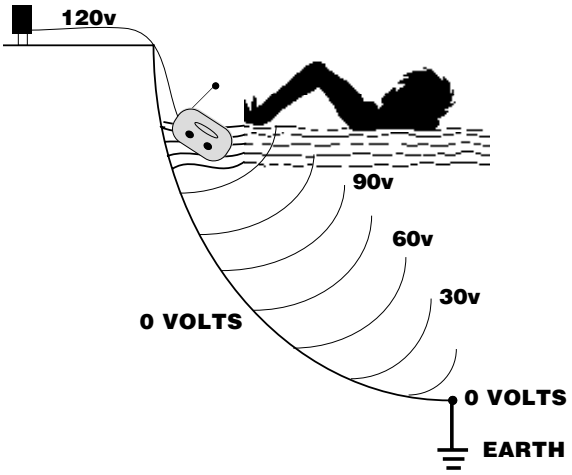
680.7 Grounding and Bonding.
(A) Feeders and Branch circuits. Feeders and branch circuits installed in a corrosive environment or wet location shall contain an EGC that is an insulated copper conductor sized in accordance with Table 250.122, but not smaller than #12 AWG.



(B) Cord-and-Plug Connections. The flexible cord shall contain an EGC that is an insulated copper conductor sized in accordance with Table 250.122, but not smaller than #12 AWG. The flexible cord shall terminate in a grounding type attachment plug having a fixed grounding contact member.

(C) Terminals. Terminals used for bonding and equipment grounding shall be identified for use in wet locations or corrosive enviornments shall be composed of copper, copper alloy, or stainless steel and shall be listed fo direct burial use.

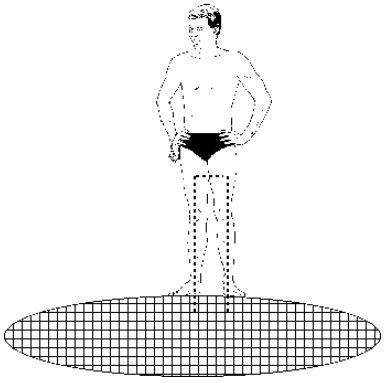
From working as an electrician, one has most likely experienced shock from touching a "hot" wire or a metal enclosure that is energized. The picture shows *voltage gradients* as a radio plugged in a 120v receptacle falls into the swimming pool.



These rings of voltage radiate out from the pool walls from 120v at the ratio to 0 volts at the grounded wall.

Gradient voltages are found in the entire swimming pool water in varying voltages.

A swimmer subjected to voltage gradients as low as 4 volts in pool water can be immobilized by the disabling effects of current passing through the brain from water in the ears, nose and other body openings.



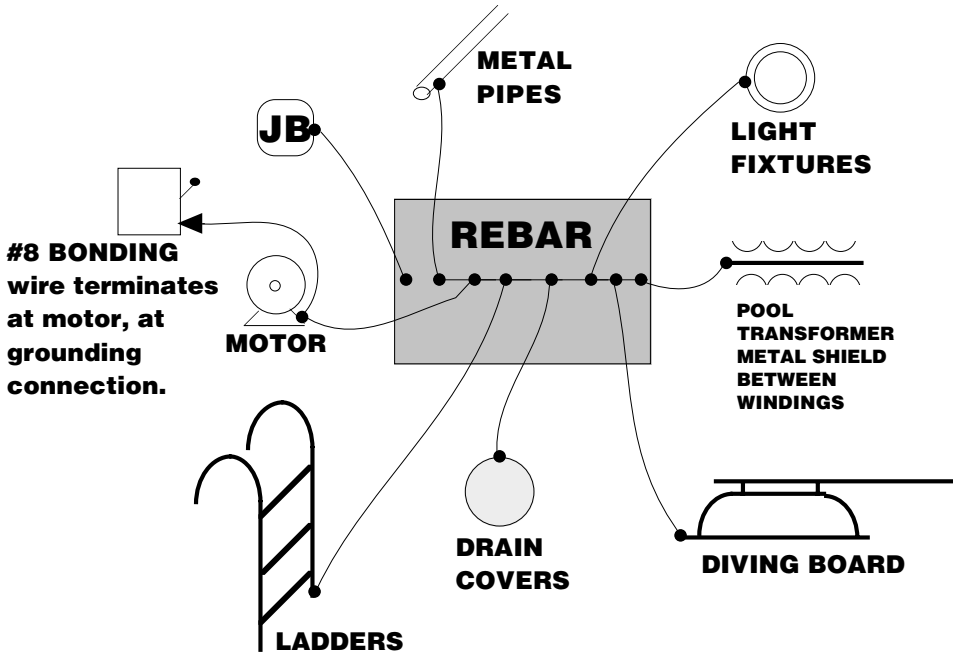
If a difference of potential (voltage) occurs between two points on the pool slab, a current can flow from one foot through the legs to the other foot completing the circuit.

BONDING and GROUNDING

Bonding and grounding are different and you must first understand the difference. Bonding is the connecting together of all *metal* surfaces to limit the possibility that the surfaces might be energized at different voltages, thus, creating a shock hazard for a person touching two metal surfaces at the same time. Bonding minimizes voltage differences between exposed *metal* parts.

Grounding is extending the bonding circuit to the grounding electrode by means of an *equipment grounding* conductor to bring everything within touch to the same potential; *earth* potential. Grounding provides a low-resistance path to ground for the fault currents. If a metal object would become energized because of an insulation failure, proper equipment grounding **will open the overcurrent device**.

All metal parts that are within 5' of the inside walls of a pool must be bonded together with a reliable corrosion-resistant electrical connection unless separated by a permanent barrier. This is to eliminate shock hazard from any stray currents that may be induced to the metal parts around the pool.



The bonding conductor is required to be a #8 solid minimum. It may be bare, covered or insulated, and may be directly buried. Bonding conductors if insulated do not follow any color coding rules. The equipment grounding conductor is green. The bonding conductor has no color identification rules. Where connections are made below grade or embedded in concrete, the connectors (brass, copper, or copper-alloy) must be marked to show suitability for the application.

The sketch below would *not* be recommended as the way to connect the metal parts. The loosening at one of the parts would open the bonding path.