We always recommend that you hire a licensed electrician to do all electrical work with your spa to ensure that it is done correctly.

Electricity is responsible for running pumps and motors, ignites gas heaters, and operates controls. When major renovation or installation of electrical circuits is required, call a professional electrician and subcontract the job. When troubleshooting short circuits or other specialized electrical problems, an electrician will solve and repair it faster than you can, so again, call a professional and let him do his job.

Water technician and electrician is required to make basic electrical connections, troubleshoot underwater lights that won't work, switch appliances from 110 volt to 220 volt, and so on. Understanding the basic concepts of how electricity works, is controlled, and is conducted, will keep you both safe and profitable.

Electrical Terms definitions are as below

- Amperage (amps) is the term used to describe the actual strength of the electric current. It represents the volume of current passing through a conductor in a given time. Amps = watts @ volts.
- Arc or arcing is the passage of electric current between two points without benefit of a conductor. For example, when a wire with current is located near a metal object, the electricity might arc (pass) between the two.
- Circuit is the path through which electricity flows.
- Conductor is any substance that carries electric current, such as a wire, metal, or the human body.
- Current refers to the rate of flow between two points.
- Cycle is a complete turn of alternating current (ac) from negative to positive and back again.
- Gauge refers to the size of an electric wire. Heavier loads can be carried on heavier gauge wires,; however the numbering system of wire gauges works in reverse. A 10-gauge wire, for example, is thicker than a 14-gauge wire.
- Line refers to a wire conducting electricity.
- Load is an appliance that uses electricity.
- Volts are a basic unit of electric current measurement expressing the potential or pressure of the current. Volts = watts @ amps.
- Watt is a measurement of the power consumption of an appliance. One watt is equal to the volume of one amp delivered at the pressure of one volt. Watts = amps x volts.

Electrical Testing Equipment and Miscellaneous Terminology

Item	Description
Multi-meters :	In order for you to service any spa equipment, you absolutely must have and know how to use a multi-meter capable of measuring 120 and 240 single phase voltage, ohms, and amperage. Without this equipment, any repairs made to the electrical parts of this equipment will be strictly by trial and error or guessing which usually results in parts replaced that weren't actually bad. If you do not have a meter capable of each of these functions, either buy one at a local electrical supply house or borrow one. Either way, you must have one to work

competently. Your meter instructions will explain how to hook up the test leads for each of the tests that follow.

Voltage Testing : Voltage tests of any circuit inside the equipment can be done using much the same principle as testing for good line service (covered in LINE SERVICE CHECK section of this guide). Simply decide what voltage you expect to find at a test point, set your meter (if not preset) for the scale showing this voltage, and apply your leads to the circuit in question. It is always best to put your test probes on the leads supplying the actual circuit, rather than in locations you would assume are of the same polarity.

When most people test, they conveniently apply one lead to the ground, and look for voltage with the other lead. The results of this method will easily mislead you because even a neutral wire carries electricity when a component is running. There's no reason not to expect to see voltage when tested in this fashion. If it is a 120 volt circuit, one lead must go to a neutral connection point, and the other to the point at which there should be 120 volts. A 240 volt test must include two separate points where individual 120 volt supply leads are providing power.

Amperage Testing : An amperage test can only be conducted when a component is actually running. The components that you might test with your ampmeter are the heater (120v should read 12.5 amps, 240 volt should read 25 amps), the blower (1 Hp will read 5-6 amps, 1-1/2 to 2 Hp will read 7-9 amps), and the pumps low and high speeds (look at the plates on the motor for the amperages you should see and your actual reading should be within 10% of that). If your voltage supply to the pack is lower than the 120 volts or 240 volts as mentioned, then your amperage draw will be somewhat lower as well, (especially noticeable on heaters).

On 120 volt tests, an amperage reading should only be taken on the lead actually supplying the voltage to a component (not on the neutral). For 240 volt components, either wire supplying power will give you a good reading.

WARNING: A reading several amps higher than the component is rated for will ultimately result in a premature failure of the equipment or worse, an electrical hazard.

Ohms Test : Using the ohms scale on your meter, you can determine whether or not you have continuity in a circuit. Continuity is the ability for electricity to pass unrestricted between two ends of a wire or circuit. Ohms is the unit of measure of that restriction or resistance. The more resistance you have, the weaker the circuit is. Therefore, when testing a switch for continuity, your meter needle should read 0 ohms if the circuit is closed or "on" (unless the battery in your meter is weak in which case the needle will move but not all the way to 0). There should be infinite resistance such that the needle does not move at all if the circuit is open or "off".

WARNING: NEVER CONDUCT A CONTINUITY TEST ON A LIVE CIRCUIT It is recommended that you disconnect any switch or part being tested for continuity before conducting the test.

Line Service Check : Many installations have faulty line service. Before assuming that your problem is with the equipment, always check for the proper voltage coming into the equipment.

If after testing, you find an improper line service voltage, shut the power off at the circuit breaker and contact a licensed, qualified electrician to make the necessary corrections.

Ground Fault Circuit Interruption Protection (GFCI) : GFCI protection is necessary in case anything electrical should allow electricity to leak to grounded metal in connection with the spa. This is especially possible if after years of use a heater element should rupture and the ground wire (that may or may not have been originally connected) should happen to become disconnected. A GFCI will sense this leakage and shut the voltage to the power pack oft.

As of January 1, 1994, all equipment packs used with a spa or hot tub must be protected by a Class A ground fault circuit interrupter. This is called for in the N.E.C. code book in paragraph 680-42. If the equipment has a GFCI built into it,that GFCI may only protect certain components such as the blower, light ozonator, and sometimes the pump. The GFCI may not provide full protection, especially if the unit is wired for 240V service. To be sure, have a qualified electrician study the wiring diagram that came with your unit (or the manufacturer of the unit you are working on) for verification.

Keep in mind that when buying a 240 GFCI for an installation, be sure to get one that has neutral protection. The 60A Square D GFCI does not have neutral protection and therefore cannot be used on a hybrid equipment system. (Hybrid means the unit contains both 240V and 120V components.)

NOTE: Any GFCI protecting a circuit should be tested periodically to insure proper operating protection. If it fails to operate properly, it must be replaced.

240V Circuit Breaker Installation : There are two easily installed properly rated 240 volt GFCI breakers on the market today (as of the time this page was written). They are the Square D model QO 250GFI and the ITE Siemens model QF250, each rated for up to 50 amps. The square D 60 Amp GFCI can not be used with our equipment because it does not have load neutral protection.

Most people who install the Square D GFCI breaker do not follow the instructions accompanying it. A common mistake is made by connecting their load neutral (from the equipment), the large white pigtail on the GFCI, and the power supply neutral to the connection block on the mounting bracket. The instructions show where the load neutral is supposed to attach to the GFCI. Before suspecting a pack

malfunction, check the installation of this device (when used) and make sure it was installed correctly.

The connection points for the pack on the Siemens GFCI are more obvious, but again, make sure that only the load neutral is connected where indicated and that the white pigtail is only connected to the line service neutral.

Pumps : The pump is probably the hardest-working piece of equipment on your pool or spa. Its job? To keep water moving throughout the entire circulation system. The pump draws the water from the pool or spa, through the plumbing and on to the filter. It then pulls it through the heating process and pushes it back into the pool or spa. The pump also acts as a secondary sieve. Pumps of all varieties have a strainer pot or hair and lint trap that catches any small debris that made it through the skimmer, main drain or gutter. By trapping this debris, the pump helps ease the burden placed on the filter, leaving it free to catch the smaller pollutants in the water. This is just one part of a multi-step process to rid the water of impurities before it's sent back into the pool or spa. Indeed, keeping the water circulating is one of the best ways to help keep your pool or spa clean. It also requires very little attention from you. You need only program the system to automatically kick the pump on for a certain amount of time each day so all of the water moves through the filter at least once a day. Generally speaking, a pool pump should run at least six hours a day and a spa pump -- which in portable spas is part-and-parcel of the spa pack -- should run for at least two hours a day when the spa's not in use.

Motors : In the context of a pool or spa, the motor's function is to drive the circulation system. More specifically, the motor converts electrical energy into mechanical energy which is then used to operate the pump. Unless you are a mechanic, you should not get involved in any hands-on maintenance of the motor. However, it is a good idea to familiarize yourself with when it's set to run, and to watch for any symptoms -- such as grinding or other unusual noises -- that may indicate trouble. If the motor fails to operate properly -- or at all -- contact your retailer or a professional service technician for more information and assistance. As with any complicated piece of electrical equipment, troubleshooting and repairs are best handled by an expert.

Filters : In effect, we've now traveled through the pump and are on our way to the filter, which serves to remove dirt and other impurities from the water. There are three different types of filters available on the market today, each of which has its own unique advantages. • Diatomaceous Earth Filters are made of grids of extremely fine mesh that are coated with diatomaceous earth. The DE acts as an adhesive, trapping any small or microscopic dirt particles in the water. FYI: DE is made from crushed petrified bones that, if you were to look at it under a microscope, would look like a sponge with thousands of tiny pores. One of the advantages of DE is that it's organic and non-

polluting. In other words, it's environmentally inert. Do note, however, that some municipalities or other environmental authorities have strict regulations regarding the disposal of DE. This becomes a concern when it's time to clean the filter by backwashing it. For more information on what to do with the water that has been flushed through a DE filter, contact your local health department, pool/spa retailer or service technician. •Sand filters use -- you guessed it -- sand as a filter medium. Inside a sand filter is a certain amount of sand and gravel, which mix with water passing through, pulling out dirt and impurities. Small microscopic particles can escape capture in a sand filter. To prevent this, you can use a flocculant to coagulate the particles into larger particles the filter can catch before the water is sent back into the pool. Every several years, you may also need to add new sand to the filter. But do note: These filters require a very specific type of grain. For more information on when and how to replace the sand, contact your pool/spa retailer or service technician. •Cartridge filters, like DE filters, have a grid-like interior to catch pollutants. These types of filters can contain a number of grid cartridges. Spas usually require only one large cartridge while pools generally need either three large cartridges or up to 12 small ones. These cartridges are made with a fine, pleated mesh material -- and the pleats are the key to the filter's operation. The tight pleats, or folds, allow a large amount of material to be used in a small container. The more material used, the larger the surface area available to capture unwanted dirt or debris in the water.

Heaters : We won't go into great detail here about heaters, but you should know that the filtered water passes over the heater before re-entering the pool or spa. As is the case with motors, heaters don't need a lot of maintenance. You should, however, learn to recognize any unusual noises or other clues that may call for professional attention. The best thing you can do for your heater -- and indeed all of your equipment -- is to keep the water properly balanced. Imbalanced water will dissolve metals from the equipment or cause a calcium build-up that can eventually cause heater failure. For more information on water maintenance, check out Splashzone's section on Chemicals.

Warning - Please read this section completely!

This section is presented for the do-it-yourselfer who needs some help either troubleshooting or repairing their own hot tub spa. Here we are assuming that if you have chosen to work on your own unit, you have a basic knowledge of electricity. Please remember that water and electricity DO NOT MIX. If you are not capable of performing a repair yourself, please contact a local spa professional or a licensed electrician in your area.

Also realize that the wiring and equipment described herein represents the "average" spa equipment pack. Your unit may vary significantly from the components described below. If you are in doubt as to how to properly troubleshoot or repair your specific unit, please contact a local spa professional or a licensed electrician in your area Use any of the information contained herein AT YOUR OWN RISK. We will not be held liable for any injuries that may result from the troubleshooting or installation of any electrical components in your hot tub spa unit.

Electrical Theory

A detailed description of electrical theory would take a separate volume, so this section only outlines the basic concepts that make the specific applications a bit easier to understand.

Electricity is much easier to comprehend if you picture it as water flowing through pipes. For electric current to flow from one place to another there must be a difference in pressure, called potential. A wire, for example, with no current flowing through it has zero potential-there is no current there yet. When the wire comes in contact with something that has electrical potential, it will accept the current until the potentials are equal in both places. Electricity works the same way, flowing from the place of greater electrical charge to the place of lesser or no charge.

The earth has no electrical charge, it has zero potential. Therefore, electrical panels and appliances are grounded, so that if current takes an unexpected path it is attracted to the earth. Electric service to a home, for example, includes a copper stake or rebar driven into the soil that is attached to a connection bar in the electrical panel with a heavy gauge wire. Similarly, an appliance that is grounded includes a wire attached to the appliance, run back to the electrical panel, and attached to this grounding bar. In this way, if a wire inside a motor were to touch the metal case of the motor, for example, the current would be conducted harmlessly through the ground wire to the grounding bar and into the earth.

Electricity, like water, takes the path of least resistance. Therefore, in the preceding example if you were to touch that motor case, the electricity would travel through you to the earth, unless that path were broken in some way, by rubber soled shoes for example.

This unintentional route to the ground without first returning to the electrical panel is called a ground fault. As noted, if you are part of the path to the ground, you will be shocked. Another way to be shocked is to become part of the circuit. If you touch a metal casing that is electrified, then touch another conductive surface, the electricity will pass through you as if you were a wire. In other words, you become part of the circuit. This can also occur if you touch a hot line and a neutral or ground line, again becoming part of the circuit. These examples are called short circuits.

The human body is operated by electricity-very small electrical impulses that stimulate muscles or transmit information as energy in the brain. Therefore, the body is designed to be an excellent conductor of electricity. As with any appliance, however, too much electric current delivered to the appliance can destroy it, especially the heart and brain. An electric current of 30 milliamps (1 milliamp = 0.001 amp) will cause muscles to contract uncontrollably, meaning if you grab a hot line of more than that you probably won't be able to let go. In a short time, the current disrupts the normal heartbeat and breathing, causing death. Children can be killed in this manner with as little as 10 milliamps. To put that in perspective, a 40-watt lightbulb at 110 volts uses about 0.3 amp, or ten times the 30 milliamps that can kill you. Taking that further, a typical pool motor drawing 10 amps is using enough current to kill you 300 times.

Conductors are any substance that allows the free movement of electric current. Insulators, on the other hand, are substances that do not conduct. Examples of each are;

Conductors	Insulators
Silver	Dry air

Copper	Glass
Aluminum	Rubber
Brass or bronze	Plastic
Iron or steel	Ceramic

Every conductor offers some resistance to the movement of electric current, like friction inside a water pipe. Some conductors conduct better than others because they offer less resistance. Although there is variations in resistance, it is important to know the concept and terminology. Ohms are the units used in measuring resistance. The better the conductor, the lower the ohms reading. The shorter the length of a conductor, the lower the ohms.

Alternating current (ac) travels in one direction then the other (alternating), so the appliance does not have to be connected to the power source in any special order. Unlike direct current (dc) voltage, ac can be stepped up or down with a transformer, permitting the transmission of high voltage along municipal power lines that is transformed to lower voltages at each home or business. Because of this inherent versatility, ac is used in virtually all residential and commercial applications.

Alternating current is delivered to the home for consumption by appliances designed to accept it at either 110 volts or 220 volts (there are larger voltages in heavy-duty commercial applications, but those are best left to the electricians). Both designations are averages, since current supply varies slightly and operates most appliances in a range of 108 to 127 volts and 215 to 250 volts. Thus, you will sometimes see voltages expressed for appliances as 110, 115, 120 or 220, 230, 240.

Alternating current is also delivered at a certain rate. As noted, the alternating of the current one way, then the other, creates one complete cycle each time it reverses direction. The speed of that reversal can be controlled and makes a difference to appliances such as CD players or tape recorders that depend on a certain rate. In the United States, power is delivered at 60 cycles per second (60 hertz). in Europe and much of the rest of the world, it is delivered at 50 hertz. That is why you can take a voltage converter on vacation to step the voltage down from 220 to 110, but you can't operate appliances that require a certain cycle timing.

Electrical Panel

The home power supply enters as two or three if there is heavy equipment use lines (phases) of 110-volts ac and one neutral line in a protected metal box called the electrical panel.

The power supply enters the panel and is connected to bars. Circuit breakers are attached to the bars. If the breaker is attached to one phase, it delivers 110 volts (single phase) to anything that is connected to it. If the breaker is designed to be connected across both phases, it delivers 220 volts (dual phase). All neutral lines returning to the panel are connected to the neutral bar, which is in turn connected to a ground. In this way, both 110- and 220-volt ac breakers are found in the same panel.

Circuit Breakers

The supply lines are generally designed to carry 100 amps for the typical residential user. Each circuit breaker is designed to carry a specific load and break the circuit open when the load exceeds that value. Typical circuit breakers are 15, 20, 25, 30, and 50 amps, depending on the

requirements of the appliances. Wiring attached to the breaker leading to the appliances is sized in accordance with the amperage of the breaker.

When electrical volume exceeds the rating of the breaker, it opens the circuit and disconnects the power supply to the appliance or circuit in question. Such overload might occur as the result of an unintentional ground or short circuit at the appliance (or wiring to it).

Depending on the design of the breaker, resetting is accomplished in one of several ways. Sometimes it is not obvious which breaker has tripped. One style of breaker looks as if it is still on. You need to push the switch fully to off, then back to on to reset it. Another style pops halfway between on and off, again requiring a hard push to off before going back to on. Another has a small window displaying a red flag when the breaker is off. Some of these require waiting up to 30 seconds before the breaker can be reset. Another type is off when a tab pops out and is reset by pushing the tab back in. In short, be aware that a tripped breaker might require some detective work.

Troubleshooting and replacement

When a breaker will not reset, it might mean that the breaker is faulty or the circuit is overloaded (demanding too much current). An overloaded circuit can be the result of an appliance that is faulty, an unintentional ground, or a short circuit in the wiring, or it might be that there are too many appliances on the same circuit (or one that is too large for the circuit.)

Troubleshooting is simple. First, check the appliances on the circuit. Does their total amperage exceed the rating of the breaker? If so, remove the extra appliances or wire them to a circuit that can handle the load.

If that is not the problem, disconnect each appliance from the circuit one at a time, resetting the breaker after each disconnection. Be sure the disconnected wires are taped off and no bare wires are touching each other. When you have removed the faulty appliance, the breaker will stay on. You now know which appliance to repair.

If the breaker is still tripping, the problem might be in the wiring between the breaker and the appliance. Make a visual inspection (with the breaker off) of all the wiring that is accessible. If you don't find a frayed or broken wire or two bare wires touching each other, disconnect the wiring from the breaker. To do that, turn off the main service breaker that feeds the entire panel. Remove the faceplate from the breaker panel. Make sure the breaker in question is off (an added safety in case the main breaker is still on for any reason). Unscrew the wire lug screw at the base of the breaker and pull the load wires from the breaker. Turn the main service back on and reset the breaker in question. If it still pops off under this no load condition, then the breaker itself is faulty and must be replaced.

Never try to repair a breaker. if you are unable to locate a replacement and need to get the equipment operating again, look at the remainder of the breakers in the panel. Often there are spare breakers in the panel that can be used for replacement. Sometimes a breaker of a comparable amperage is servicing a circuit that is not needed as much as the pool equipment and you can make a temporary switch. Always replace a breaker with one of the same amperage.

To replace a breaker, turn off the main service breaker. Place your flat-blade screwdriver on the front, top edge of the breaker and pry it out of the panel. Some breakers fit tightly, so apply firm, even pressure. If you have not disconnected the load wires, do so as described earlier. Look at the

back of the breaker and the design of the hook connection that fits into the electric bar of the panel. When you have your replacement, reconnect the load wires to the new breaker, and return it to the panel reversing the steps taken to remove it. Put the panel faceplate back on and turn on the main service breaker.

If the breaker did not trip when you disconnected the load, the reason for the breaker tripping off must be in the wiring between the breaker and the appliance. Since you were unable to find a problem with the wiring during your visual inspection, you might need to replace the wiring. Here it is advisable to call an electrician.

Sometimes electrical problems at the appliance or the tripping of a breaker is caused by a loose breaker. If you find that the breaker is loose when you first try to remove it, try pushing it back into the panel, and try your appliance again. If it won't seat firmly, replace the breaker.

Older homes might still have fuses. Fuses perform the same function as circuit breakers, but fuses must be replaced each time the overload breaks the circuit (blows the fuse). Fuses either clip or screw in place. As with breakers, always replace a fuse with one of the same amperage.

If you are planning to work on a panel, it's best to have a helper around to get help in case of electric shock. Whenever you approach a breaker panel, do so with great respect. Water, frayed wiring, or a poor previous service work might have created problems at the panel that you cannot anticipate. Other safety measures include wearing rubber gloves and boots, standing on a piece of dry wood to further insulate you from the ground, and leaving one hand in your pocket, so you can't inadvertently touch one hand to a live wire or panel and the other to a ground.

Wiring

Pulling new wires in a circuit or adding a circuit is a job best left to a professional electrician, but it is advisable to know a few things about requirements.

Gauge and type

The gauge of the wire refers to its thickness and is designed to operate under high temperatures and also its ability to handle volume and pressure of current (amps and volts).

Whenever you run wire for any reason, make sure you use the correct type. Remember you can always use wire that is heavier (lower AWG number) than the breaker and appliance require, but never use wire that is thinner (higher AWG number) than required.

Wire is stranded or solid. There is less resistance in solid wire than stranded, so this should be your first choice. Wire is generally available in copper. If aluminum was used for wiring homes, it should be replaced whenever possible.

Wires are sold in various colors. The standard are that Green wire is always ground, Black and Red are used for hot lines, White for neutral. If you must use a wire color not in keeping with this code, tape the correct color tape over the wire or clearly label it. Never assume that the previous technician used the correct colored wire. Check everything as you go and try to leave wiring better than you found it.

Always encase the wires in conduit. Be aware that wires of different voltage should not be run in

the same conduit. You can run numerous circuits of the same voltage in a conduit, but you need to run a separate conduit for every group of circuits of different voltage. Never run anything else in an electrical conduit, such as air hoses or water lines. Use flexible, waterproof conduit and connectors for outdoor installations, such as wires from heaters or motors to J-boxes or time clocks. Often a sub panel (a small breaker panel supplied from the main household panel with one large circuit) is located in the pool equipment area.

When terminating wires to be attached to connections in appliances or at other terminal posts, use crimp connectors rather than simply wrapping the bare end of the wire around the post. Wrapping can come loose or be squeezed off the post. Bend the wire in the same direction as you will tighten the screw, so when you tighten the screw it also tightens the wrap. The connectors are available in various sizes and with various connection ends (called the tongue). The insulation is stripped off to accommodate the barrel of the connector. Using a crimping tool, secure the wire to the connector.

Since most pool and spa applications are wired directly between appliances and switches, you won't be dealing with too many outlets. With portable spas, however, you might encounter a few. It is important to recognize the appearance of outlets so you don't try to plug 110-volt appliances into 220-volt outlets. These outlets are designed so that the plug can be inserted only one way to prevent reverse polarity. With ac, polarity is important with some appliances.

Bonding and grounding

A bonding wire is an important safety component of any pool or spa equipment area since the bonding wire is a path of less resistance than the human body, so any stray current is conducted along it instead of you becoming part of the circuit.

A bonding wire is a solid 8-gauge wire that is connected to a lug on the exterior of each appliance in the equipment package. No conduit is needed because current is not normally carried by this wire. The gauge of the ground wire of any appliance must be as large as the hot wire(s) so it is capable of efficiently conducting electricity away from the appliance in the event of a short circuit or stray current. Similarly, at the breaker panel, the main ground wire must be as large as the largest hot wire in use.

All pool and spa equipment must be grounded.

Ground Fault Circuit Interrupter (GFCI)

When equipment or wiring fails it might draw more current than the appliance can use, burning out the appliance. The circuit breaker is designed to break the circuit when demand exceeds the rating of the breaker. Thus circuit breakers are designed to protect equipment, not humans.

The GFCI is designed to protect humans. It is a circuit breaker that detects problems at a low enough level to protect you before lethal doses are delivered. it breaks a circuit when it detects a ground fault. . The GFCI constantly measures the current going out of the appliance and coming back into it. If by chance any grounding takes place, such as if the metal case of an appliance were electrified, and you touch it, completing a pathway for current to the ground, the GFCI detects the drop in the current it is receiving and breaks the circuit. The GFCI detects variations as low as 0.005 amp, . The GFCI cuts the circuit within one-fortieth of one second, so it is not only sensitive, it's quick.

There are three basic styles of GFCI that you will likely encounter in pool and spa work. The first looks like a standard circuit breaker in the electrical panel, with a test button in the face of the breaker in addition to the on/off breaker switch. By pressing the test button, you simulate an unbalanced current condition inside the breaker and thereby testing the efficiency of the GFCI. The GFCI breaker resets the same way a normal panel breaker does.

The second type of GFCI is built into a wall outlet, containing a test button and a switch to reset the GFCI as you might install for plugging in a portable spa.

The third type is a portable GFCI, a unit that plugs into a wall outlet. The appliance is then plugged into the GFCI, making the outlet a GFCI outlet.

All types of GFCIs, like any other mechanical device, are subject to failure and should be tested from time to time.

Though GFCI provide so much safety, why aren't all breakers and outlets GFCIs? The first answer is probably cost, for they cost two to four times as much as a standard one. Practical reason is that some appliances or circuits operate normally with slight variations in current, so the GFCI would constantly be breaking circuits for the wrong reason. In fact, slight variations might occur in the pool or spa equipment, causing the GFCI to trip even though everything is functioning properly. For this reason, it is best to locate the GFCI as close to the appliances as possible.

If a GFCI keeps breaking the circuit, you troubleshoot the problem in the same manner as any other breaker. As described earlier, start by disconnecting the appliance and resetting the breaker, check the wiring, disconnect the load at the breaker. If you have a GFCI serving a skid pack, the problem can exist in any single piece of equipment, so these must be disconnected one at a time and the GFCI reset after each to detect the appliance with the problem. Start with the light, then proceed to the blower, electric heater, pump motor, control devices for, the problem might exist in the control panel.

The National Electric Code (NEC) specifies that electrical outlets located within 15 feet of the water's edge must be protected by a GFCI and that circuits for all underwater lighting be so equipped. Underwriter's Laboratory (UL) requires all portable spas be wired with a GFCI.

Switches

To control the operation of each appliance circuits are interrupted at some point by switches A breaker should never be used as the on/off switch for an appliance because repeated switching will weaken the breaker.

Air switches, time clocks, and other control devices all these are switches, turning appliances on or off by completing or breaking an electrical circuit. An understanding of the basic concept of switches will help you troubleshoot electrical problems.

A basic switch, which is a break in the hot line of a circuit. This is the most basic on/off switch, called a single pole, single throw (SPST) switch. This switch handles one circuit (single pole) each time the switch is thrown. The SPDT second drawing depicts a single pole, double throw (SPDT) switch. In this case, there is still only one circuit of electric current, but when this switch is thrown one direction, it electrifies one appliance, and when it is thrown the other way, it electrifies another appliance. Depending on the appliance(s), you might use several variations of poles

(circuits) and throws (destinations for the current). By understanding these basic concepts, you will recognize whatever type of switch you encounter.

The other concept regarding switches that you will encounter with pools and spas is multiple switching. There is often more than one control or switch on each appliance. For example, there might be a wall switch and a time clock, either of which can turn on a pool light. There are often air switches and time clocks controlling spa equipment and a simple on/off switch attached to each appliance so you can shut it off easily for service work.

There are two kinds of circuits and so two kinds of switching. First, switches wired in series are those which operate together. The electric current cannot pass along the line unless each switch is closed. An example of a series circuit and series switches is the control circuit in a heater, where each control switch must be closed before the entire circuit is completed and the ignition of the heater is fired.

The other type of circuit and switching is parallel. A parallel circuit, where there is more than one way for the circuit to be completed, each independent of the other. The drawing shows that the current will reach the appliance if either switch is closed. But closing both is not necessary, and if they are it does not deliver any more or less current to the appliance because both switches depend on the same source of current. An example of parallel circuits and switches is the pool light that is controlled by a switch in the home and by a time clock in the equipment area. By understanding these concepts, you will be able to detect why an appliance is not operating or why it is operating after you turned the switch off.

Relays

A relay is a switching device on a circuit that controls current flow in another circuit. When the relay circuit is electrified, it energizes an electromagnet that pulls the two halves of the relay together. in doing so, the contacts of the controlled circuit are brought in contact, completing the circuit. Relays are normally used as safety devices. The purpose of this type of control is to use a low-voltage circuit (the relay circuit) to turn on or off a higher voltage circuit (controlled circuit). For example, a safe 12-volt circuit can be used near a pool or spa to control a dangerous 220-volt circuit that operates a pump motor or blower.

Relays can also be used to control low-voltage situations, like a millivolt control on a heater cannot be located more than 20 feet from the heater. If you want a heater switch inside your home, for example, you might run a standard 110-volt switch that activates a relay in the equipment area, which in turn controls the low-voltage millivolt circuit of the heater. Relays allow you to run thinner, less expensive wires over long distance. Since the small electromagnet of the relay uses a small amount of current, you can run much smaller, cheaper wires along to control the relay, which can be located near the appliance. The heavier wiring for the appliance only needs to travel to the nearby relay and back.

Relays are just switches so some control and time clock makers include relays in their designs. Instead of requiring you to flip a switch however, the relay turns on or off when powered by electric current, thus turning on or off the appliance.

Testing

Testing for the presence of current at a connection or appliance is simple for you need a

multimeter and set the tester on the range of voltage you expect to find and the type of current, ac or dc. The multimeter has multiple functions, testing circuit voltages, continuity, and resistance. It has a positive and a negative test lead and a switching device to set the meter for reading de or ac (reading various ranges of each), resistance, or continuity. The meter is battery powered for continuity and resistance testing because you must send current into a line to test if it is continuous (unbroken) or broken and to test the amount of resistance in a conductor.

When testing the control circuit of a millivolt-controlled heater, for example, you would set the meter for dc current in a voltage range of 0 to 1 volt (since you will be testing a circuit with up to 750 millivolts, which is equal to 0.75 volt). In the same manner, if you are looking for the presence of current at your motor, you set the meter for ac in the voltage range of either 0 to 110 or 0 to 220 volts. Electronically controlled heater circuits operate on 25-volts ac, so you would set the meter for ac in a range of 0 to 50 volts. Generally you can't harm the meter by feeding it less current than the range you have chosen, but you can destroy it by feeding it more. So, if you are uncertain about the voltage being tested, start with the 220-volt range and work down.

When testing dc circuits, remember that polarity (positive and negative) makes a difference. You must touch the positive meter lead to the positive contact of the appliance or switch and the negative lead to the negative contact. If you reverse these, you will see the meter register negative voltage. When testing ac voltage, the polarity doesn't matter, and you can touch either lead to either side of the circuit.

When testing 110-volts ac, touch one lead to the suspected hot line and one to a neutral line or to ground. When testing 220-volts ac, perform the same test on each of the two hot lines, then touch one lead to each hot line at the same time. If each line individually reads 1 10 volts, but when tested together it does not read 220 volts, it means the two hot lines are being supplied by the same phase of the power supply and therefore will not deliver 220 volts. This usually denotes a faulty breaker.

When buying a multi-meter, make sure it can test millivoltage for working on millivolt heaters. Some meters won't accurately read less than 10 volts, and therefore are useless with millivoltage. Most electronic meters are pocket-size and can self-range, which is to say you need only dial in ac or dc and the meter will detect the voltage and adjust accordingly.

When you suspect a broken connection, continuity testing is useful To test continuity of a line, first be sure all the current is turned off, then set your meter for continuity testing and touch one lead to each end of the suspect circuit. If the meter reads positive or beeps, it means there is continuity. Before conducting such tests, make sure your meter is working properly, and that the battery which electrifies the circuit is working, by touching the two test leads together. This should represent a good connection and a complete circuit, and you should get a positive reading.

Since most of the wiring and installation you do uses good conductors, you will probably not use the resistance measuring function of the multi-meter much. If the continuity tester on your meter is not working for some reason, you can use the resistance test to check for continuity. Resistance is measured in units called ohms. The higher the ohms, the more resistance exists in the circuit. If there is no resistance, however, it means there is not a complete circuit, thereby also verifying continuity.

When appliances are operating poorly, there might be a drop in voltage between the panel and the appliance. Check the voltage at the appliance, then at the breaker, while the appliance is operating. There will be a slight difference because of some voltage drop as a result of heat loss

and resistance along the length of wire, but it should be no more than 2 to 5 volts. If it is greater, follow the troubleshooting procedures outlined previously to determine where the loss is being created. Like water that is not flowing in a pipe (pressure is the same everywhere in the pipe), when the appliance is not operating, the voltage (pressure) should be the same everywhere along the line.

To test amperage you need an amp probe. The amp probe is a meter with a large, open clip on the end. The clip is looped over the wire and the amperage in the wire is detected by the probe without actual contact with the current.

Electrical work must be prefect and in accordance with local and state codes. So make sure the job is done right.