How to Verify the Electrical System of a Pool is Safe in Accordance With the *NEC*

Warning: This document is only intended to be used with this video: How to Verify the Electrical System of a Pool is Safe in Accordance with the *NEC* *[1:48:16*].

Warning: This content is only appropriate for the instruction of qualified electrical professionals. The tests and examples in this document and the associated videos were produced in a highly controlled environment to mitigate risk. Attempting to reproduce these in any way will create a risk of injury or death. We do not support DIY electrical work in any capacity because the risks for shock and fire are too great. If you are a homeowner, we recommend you contact a qualified electrical contractor to do any electrical work in your home.

If you own, use, install, or service permanently installed swimming pools, there are many dangers that can exist due to improper installation or component failure. This document will identify the most common hazards that can occur and explain how to address them when a pool is being built. It will also address what to look for when inspecting an existing pool to ensure its safety in accordance with the *National Electrical Code*.

The requirements contained in Article 680 of the *NEC* apply to the installation of electrical wiring and equipment for swimming pools, spas, hot tubs, fountains, and hydromassage bathtubs. When these requirements aren't met, tragedy occurs.

Watch the following videos in the order listed; then watch them again, especially if there's something that confuses you.

- Electrical Safety Fundamentals, (1hour:13min:18sec)
- Equipment Bonding 250.4(A)(2) (10min:36sec)
- Neutral-to-Earth Voltage (NEV), (44min:53sec)
- Swimming Pool Equipotential Bonding 680.26, (1hours:58min:27sec)

Part I. Does the Pool Wiring Comply With the *NEC*?

The first step in the process is to verify that the electrical installation of the swimming pool complies with the general requirements of the *National Electrical Code*, Chapters 1 through 4.

Step 1. Turn Off Power. Turn off power to all electrical equipment and verify there are no exposed energized live parts in accordance with NFPA 70E.

Caution: Exposed metal parts connected to service conductors will remain energized even when the service disconnect has been turned off! But you know that…

Step 2. Remove Covers from All Electrical Equipment. Remove the covers from all electrical equipment such as the service disconnect, panels, time clocks, pool light transformers, pool light

junction boxes, switch boxes, the pool motor, heat pump, and other electrical equipment related to the swimming pool system.

Step 3. Inspect Service Equipment. Inspect the service equipment to ensure it's in compliance with the *National Electrical Code*.

- Confirm that the service equipment is grounded in accordance with the 250.24(A).
- Ensure that the covers for service equipment and breaker openings are installed and fit properly.
- Check all terminals to be sure they're torqued to 90 percent of the manufacturer's specification in accordance with NFPA 70B [110.14(D)].
- Verify that all circuit conductors are sized in accordance with the *NEC* for the loads to which they're connected.
- Ensure that all wiring is installed in accordance with the *NEC*, and that all equipment and fittings are identified for use in the location and/or environment in which they're installed.
- Confirm that all equipment is installed in accordance with the *NEC* and the manufacturer's instructions, and that it's identified for use in the location and/or environment where it's installed.
- Check each circuit to be sure proper overcurrent protection is provided [240.4].
- Verify that each conductor terminates on a single terminal in accordance with 110.14(A), except terminals for the equipment grounding conductor that are identified otherwise.
- Confirm that the neutral conductor is bonded to service equipment with a main bonding jumper in accordance with 250.24(C).
- Ensure that the wiring methods were installed in accordance with the *NEC* by checking things like strapping and the type of connectors.

Step 4. Inspect the Pool Panel. Inspect the pool equipment panel to ensure it's in compliance with the *National Electrical Code*.

- Verify that the cover for pool equipment panel is installed and fits properly, and that breaker openings are properly closed.
- Ensure that the neutral conductor does not contact the equipment grounding conductor except at the service equipment [250.6, 250.24(A)(5) and 250.142(B)].
- Check that all terminals are torqued to 90 percent of the manufacturer's specification in accordance with NFPA 70B [110.14(D)].
- Confirm that a neutral conductor has been brought to the pool panel in order for GFCI protection to function properly.
- Verify that all circuit conductors are sized in accordance with the *NEC* for the loads to which they are connected.
- Ensure that all wiring is installed in accordance with the *NEC* and suitable for the environment in which it's installed. Look for things such as missing or damaged covers, corrosion, proper weatherproof rating, and proper support of wet location connectors and make any needed repair recommendations.

- Verify that all equipment is installed in accordance with the *NEC* and the manufacturer's instructions and identified for use in the location and/or environment in which it's installed.
- Check to be sure that an equipment grounding conductor of the wire type has been installed with the feeder conductors to the pool equipment panel and sized in accordance with 250.122.
- Confirm that each circuit has proper overcurrent protection [240.4].
- Ensure that each circuit conductor terminates on a single terminal in accordance with 110.14(A) except where terminals for the equipment grounding conductor are identified otherwise.
- Verify that the wiring methods were installed in accordance with the *NEC* by checking things like strapping and the type of connectors.

Step 5. Inspect Pool Equipment. Inspect pool equipment to ensure it's in compliance with the general requirements of the *National Electrical Code* and the rules in Article 680*.*

- Verify that an equipment grounding conductor of the wire type has been installed with all circuit conductors to pool equipment and is sized in accordance with 250.122.
- Ensure that any receptacles within 6 to 20 feet of the pool water have GFCI protection [680.22].
- Confirm that all covers for pool equipment are installed and fit properly.
- Check that all terminals are torqued to 90 percent of the manufacturer's specification in accordance with NFPA 70B [110.14(D)].
- Verify that all lighting is located at least 10 feet from pool water unless listed for the low-voltage contact limit and supplied by a transformer listed for swimming pools.
- Ensure that all switches and other electrical equipment are located at least 5 feet from the pool water [680.22].
- Confirm that all circuit conductors are sized in accordance with the *NEC* for the loads to which they are connected.
- Check to be sure all wiring is installed in accordance with the *NEC*, and that all equipment and fittings are identified for use in the location and/or environment in which they're installed.
- Verify that bonding devices and equipment terminals are identified for wet and corrosive environments [680.7].
- Ensure that each circuit has proper overcurrent protection [240.4].
- Confirm that each circuit conductor terminates on a single terminal in accordance with 110.14(A) except where terminals for the equipment grounding conductor are identified otherwise.
- Check to be sure that the voltage to the pool light(s) doesn't exceed 15V and is supplied by a listed transformer for swimming pools.

Step 6. Inspect Pool Wiring. Download one of the documents below containing the *NEC* requirements for swimming pools.

Swimming Pools, Spas, Hot Tubs, based on the 2020 *NEC*
Swimming Pools, Spas, Hot Tubs, based on the 2017 *NEC*
Swimming Pools, Spas, Hot Tubs, based on the 2014 *NEC*

Part II. Does the Equipment Grounding Conductor Have Sufficiently Low Impedance?

All electrical equipment must be connected to an effective ground-fault current path to ensure any fault will be cleared in the event of a ground fault [100 and 250.4(A)(2)]. An effective ground-fault current path is created by connecting the metal parts of electrical equipment to a circuit equipment grounding conductor that's sized and installed in accordance with the *NEC*.

Click here to watch the video below to understand the purpose of the circuit equipment grounding conductor.

Step 1. Turn Off Power. Turn off power to all electrical equipment associated with the swimming pool and verify that there are no exposed energized live parts in accordance with NFPA 70E.

Caution: Exposed metal parts connected to service conductors will remain energized even when the service disconnect has been turned off! But you know that…

Step 2. Remove 8 AWG Bonding Wires. Remove the 8 AWG bonding conductor from all terminals connected to pool equipment such as the pool motor, heat pump, salt chlorinator, pool junction box, and pool light.

Note: The reason you must remove the 8 AWG bonding wire from the pool equipment is to ensure that you only measure the resistance of the circuit equipment grounding conductor to the equipment.

Step 3. Measure Equipment Grounding Conductor Resistance. Measure and record the resistance of the equipment grounding conductor from the service equipment to the pool panel, and from the pool panel to the pool equipment such as the pool motor, heat pump, salt chlorinator, pool junction box, and pool light.

Click Here to watch a video on how to measure the resistance of the circuit equipment grounding conductor from service equipment to the pool panel.

Set the ohmmeter to the lowest resistance setting then measure the resistance of the ohmmeter conductor leads. The resistance of the ohmmeter leads is dependent on conductor size and length, as well as the conductivity of the conductor terminal device.

Terminate one lead of the ohmmeter to the equipment grounding terminal where the circuits originate then touch the other lead to the metal parts of the equipment.

Note: You must drain the water below the pool light in order to measure the resistance of the circuit equipment grounding conductor to the underwater pool light frame.

Maximum Recommended Resistance. The resistance of the circuit equipment grounding conductor must provide sufficiently low impedance to permit the circuit overcurrent protective device to open in the event of a ground fault.

There's no maximum resistance specified in the *NEC* for the circuit equipment grounding conductor. However, after years of research I recommend the resistance not exceed the value calculated from the following formula.

Resistance = 120V/(Circuit Protection Rating x 2)

Examples:

20A Pool Pump; R = 120V/(20A x 2), 120V/40A = 3 ohms

30A Pool Panel; R = 120V/(30A x 2), 120V/60A = 2 ohms

50A Heat Pump; R = 120V/(50A x 2), 120V/100A = 1.20 ohms

Note: If the resistance of the circuit equipment grounding conductor is greater than the above values, then you must ensure that the power to all pool equipment is turned off and notify the customer that the pool is unsafe and shouldn't be used.

Part III. Are Metal Parts Bonded?

Equipotential bonding of metal pool equipment, handrails, ladders, and other metal parts within five feet of pool water, and the pool structure and perimeter surface area is to ensure that in the event of a ground fault and a failed equipment grounding conductor, the metal parts in and around a pool will have the same potential (voltage). If all metal pool parts have the same potential (voltage), then people can't get shocked while they're in the pool's water.

To validate that all metal pool parts are bonded together, you must verify that there is electrical continuity between the metal pool parts.

Step 1. Continuity Between Pool Motor and Bonded Parts.

To determine if the metal parts of a pool are bonding together in accordance with 680.26, you need to perform a continuity test between the two metal parts. If there is electrical continuity between the two metal parts, a tone is emitted.

Click Here to watch a video on how to determine if there is electrical continuity between the pool pump motor and other metal pool parts.

Step 2. Verify That Metal Parts are Bonded to Service Equipment.

The fact that the metal parts of a pool are bonded together and to the pool motor does not ensure you have a safe installation. The metal pool parts must also be connected to the equipment grounding conductor, and the equipment grounding conductor must be bonded to the neutral at the service equipment.

This can be accomplished by confirming that the neutral-to-earth voltage (NEV) for all metal parts required to be bonded in accordance with 680.26 is equal to the service equipment NEV.

Click here *to access more information about Neutral-to-Earth Voltage (NEV).*

Step 3. Verify That the Conductive Pool Shell, or the Water in a Nonconductive Pool Shell, is Bonded to Service Equipment.

One of the most important parts of testing pool system bonding is to verify that all of the conductive elements of a pool structure are bonded in accordance with 680.26(B)(1).

For nonconductive pool structures, you need to verify that (in addition to bonding any conductive parts) the pool water is bonded in accordance with 680.26(C). This can be verified by confirming that the NEV in the pool water is equal to the service equipment NEV.

Click Here to watch a video on how to verify that metal pool equipment, pool parts, and the pool shell and perimeter area are bonded.

Conductive Pool Shell. The fact that the metal parts of a pool are bonded together doesn't ensure you have a safe installation. You need to verify that the conductive pool shell (which contains the pool water) is also connected to an equipment grounding conductor that is bonded at service equipment. This can be accomplished by confirming that the NEV in the water at all points of a conductive pool shell is equal to the service equipment NEV.

To measure and record the NEV of the pool water, terminate one lead of a voltmeter to the remote earth and drop the other lead into the pool water. Walk around the pool (with the lead in the water) watching and recording the NEV in the water. If the NEV measured in the pool water is approximately the same value as the service equipment NEV, then the conductive pool structure is bonded.

Nonconductive Pool Shell. To measure and record the NEV of the pool water, terminate one lead of a voltmeter to the remote earth and drop the other lead into the pool water. Walk around the pool (with the lead in the water) watching and recording the NEV in the water. If the NEV measured in the pool water is approximately the same value as the service equipment NEV, then the nonconductive pool structure is bonded.

Danger: If the NEV in the pool water of a conductive or nonconductive pool shell is zero at any point, then the water is NOT bonded. In this event, you must ensure that the power to all pool equipment is turned off and notify the customer that the pool is unsafe and shouldn't be used.

Step 4. Verify That the Pool Perimeter Area is Bonded to the Service Equipment.

You can confirm that the pool perimeter is bonded by verifying that the pool perimeter area NEV is equal to the service equipment NEV.

To measure and record the pool perimeter area NEV, terminate one lead of a voltmeter to remote earth and touch the other lead to a wet perimeter surface area.

Click Here to watch a video on how to verify that metal pool equipment, pool parts, the pool shell, and/or the perimeter area are NOT bonded.

Steel Perimeter Area Bond. If the perimeter area uses structural steel as the bonding grid, then the pool perimeter area NEV reading at all points should be approximately the same as the service equipment NEV.

If the pool perimeter area NEV is zero at any point, it means that point of the perimeter area isn't properly bonded. Until the perimeter area is properly bonded, you must ensure that the power to all pool equipment is turned off and notify the customer that the pool is unsafe and shouldn't be used.

Copper Perimeter Area Bond. If the perimeter area uses an 8 AWG copper conductor located between 18 and 24 in. from the pool water and buried 6 in. below the deck for bonding, then the NEV directly above the bonding conductor will be approximately the same as the service equipment NEV. The NEV at points within the perimeter area that aren't directly above the conductor will be slightly less than the service equipment NEV.

Note: The following links contain research details on the use of a copper conductor for perimeter bonding as permitted by 680.26(B)(2)(b).

- Fire Protection Research Evaluation of "Alternate Equipotential Bonding Means" to Reduce Voltage Gradients in Pool Areas
- Swimming Pool Stray and Contact Voltage Research Outcomes

Step 5. Verify That Metal Pool Parts are Connected to Service Equipment.

Measure and record the pool metal parts NEV by terminating one lead of a voltmeter to remote earth and the other lead to the bonded metal parts. If the pool metal parts NEV is approximately the same value as the service equipment NEV, then the pool metal parts are connected to the service equipment.

If the pool metal parts NEV value is zero, then the pool metal parts are NOT connected to the service equipment. In this event, you must ensure that the power to all pool equipment is turned off and notify the customer that the pool is unsafe and shouldn't be used.

Click Here to watch a video on how to verify that metal pool equipment, metal parts, the pool shell, and the perimeter area are connected to service equipment.

Conclusion

The bottom line is that one must ensure that the wiring associated with a swimming pool is installed in accordance with the *National Electrical Code*, that all circuits have an equipment grounding conductor, and that all metal parts associated with the pool are bonded in accordance with Article 680. If this is done properly, people in a swimming pool won't be electrocuted when a ground fault occurs while the equipment grounding conductor has failed.

Danger: If an energized part is placed in a swimming pool, people in the water will be electrocuted even if the pool is *NEC* compliant.

Click Here to watch a video on what happens if a pool is bonded properly in accordance with the *NEC*.

Click Here to watch a video on what happens if an energized part is inserted in a pool that's bonded in accordance with the *NEC*.

If you would like to understand more about Electric Shock Drowning, please purchase the text book *Electric Shock Drowning Causes and Prevention* by G. S. Cargill III.

If you have any comments or suggestions, please send them to Mike@MikeHolt.com, AFTER you have read this document and watched all videos at least twice.

Recommended Swimming Pool Safety Expert:

John Cavaroc, Ph.D., P.E., Electrical Engineer
SAFE Laboratories and Engineering Corp.
Sanford, NC 27330
919-718-9150 (office)
jcavaroc@safe-labs.com

Jacob Muller, Electrical Contractor
Jake Electric LLC
Elkhorn, Nebraska 68022
402-616-5845
Jake@jakeelectric.com