Variable Speed Pool Pumps

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Scope

Variable-speed pump with low head loss filter and piping layout

Install a single- or two-speed pool pump with a variable-speed pump while minimizing head pressure from system piping and filter.

- Program the pump to obtain adequate circulation at the lowest possible motor speed.
- Provide for seasonal or water feature flow adjustments where necessary.

See the **Compliance Tab** for related codes and standards requirements,

Description

Pool pumps provide an important function for in-ground pools by circulating water through the pool's filtration system. The filtration system keeps the water clean, clear, and sanitary for bathers by screening debris that falls into the pool and also removing algae and microorganisms that can pose potential health threats to swimmers. In addition, pumps may circulate water through heaters, cleaners (also known as sweeps), water features, or fountains. These single-speed pumps traditionally have a 1- or 2-horsepower motor that will run at least five to six hours per day, if not around the clock, consuming energy.

A variable-speed pool pump can reduce pool pump energy use by 50% to 90%. The majority of the savings is derived from a variable-speed pump's ability to reduce the rpm of the motor, thus reducing energy use. A typical 1½-horsepower (hp) pool pump draws about 2,000 watts and runs at 3,450 revolutions per minute (rpm). Reducing the pump speed and flow has a tremendous impact on wattage draw due to the Pump Affinity Law. For example, if you reduce the pump speed from 3,450 rpm to 2,400 rpm (30% reduction in speed) the wattage drops from 2,000 watts to 593 watts (70% reduction in power).

The primary reason that most single-speed pool pumps consume an excessive amount of electricity is that they are typically oversized and overused in the course of pool operation. A pool pump is called upon to perform multiple water circulation duties during the operation of the pool. While the primary function of the pool pump is to simply circulate water through the filtration system, other tasks can include powering spa jets, backwashing the filter, operating a chlorinator, providing water for the pool sweeper, circulating water through the heater, initiating flow to a solar panel and pumping water to waterfalls and other water features (Figure 1). These occasional tasks require more energy (a greater flow rate) than the circulation of pool water through the filtration system and account for roughly 10% of the pool pump's operation time. Often, pools have multiple pumps to provide some of the functions listed above (Figure 2).

Figure 1. Pool pumps perform many functions in a swimming pool including circulating water through the filtration system, powering spa jets, backwashing the filter, operating a chlorinator, providing water for the pool sweeper, circulating water through the heater, initiating flow to a solar panel, and pumping water to waterfalls and other water features (image courtesy of Steve Easley Associates).

Figure 2. Variable-speed pool pumps can cut energy use by 50% to 90% compared to standard single-speed pumps (image courtesy of Steve Easley Associates).

Single-speed pumps by design can't change their flow rate so they must be sized to perform the most demanding task. This means that during 90% of the operational time, single-speed pool pumps provide greater circulation than the pool filtration system requires. A standard pool pump is typically 1½ to 2 hp and operates using a single-speed induction motor generating excessive

filtration flow rates. At a pump speed of 3,450 rpm, between 1,500 and 2,500 watts of electricity are required depending on the service factor of the motor.

Although not common, two-speed pool pumps may be encountered. Two-speed pumps have been available for years and are marketed as an alternative to more expensive variable-speed pumps. The two-speed pump uses an induction motor and is basically two motors in one with a standard 3,450 rpm (full-speed) motor and a 1,725 rpm (half-speed) option. Ideally these motors may enable significant energy savings for the homeowner; however, if the half-speed motor is unable to complete the required water circulation task, the larger motor will operate exclusively. Because there are only two speed choices, it is much more difficult to fine-tune the flow rates required for maximum energy savings.

A variable-speed pool pump will allow the homeowner to achieve the ideal filtration flow rate with the least amount of energy consumption. Variable-speed pumps utilize permanent magnet motors (PMM), which use permanent magnets to create a magnetic field between the rotor and the windings. This configuration is similar to the motors used in hybrid cars. Efficiencies are gained by the magnets working to spin the rotor, as opposed to a standard induction motor that requires additional electricity to induce the magnetic field into the rotor. The PMM motor design is much more energy efficient when compared to the standard induction motor, achieving efficiency ratings of 90% while the average single-speed pump will have efficiency ratings between 30% and 80%. PMM pumps can produce the same gpm flow rate as single-speed induction motors if needed; they simply run much more efficiently.

The largest energy savings of installing a PMM pump comes from the ability to program and reduce the flow rate to match the required pumping task. Unlike a single-speed pump that will operate at a maximum flow rate even for tasks that require minimum flow rates, the variable-speed pump can be slowed down to the optimum level, balancing flow rate needs with energy use.

How to Install a Variable-Speed Pool Pump

1. Inspecting the Pool Area: The health and safety of the pool pump installer, as well as the occupants, should be a critical part of the pool pump replacement process. Prior to beginning pump installation, the installer should carefully inspect the entire pool area for exposed wiring, trip hazards, pests, or animals. A thorough inspection of the pool pump containment area and any exposed plumbing should also be done to ensure that any leaks or damage to existing pool plumbing are identified and repaired. Finally, the installer should locate the main electrical circuit breaker panel and identify and confirm which breaker is designated for the pool pump.

2. Measuring the Pool and Calculating Pool Volume: There are two important reasons why an installer must accurately calculate the volume (in gallons) of water in the pool. First, the pool pump must have the correct flow rate (volume of water that passes through the pump) in order to meet the proper turnover rate and maintain clarity and sanitary conditions in the pool. The pump must have the capability to turn over the entire volume of water within a 12-hour period, although the 12-hour turnover is not typically required for daily filtering and sanitizing. A turnover every 24 hours is the minimum needed filtration flow rate for the pool pump. If the pool's entire volume of water is not turned over within a 24-hour period, the risk of algae and pathogens can increase. To calculate the minimum flow rate of the pool pump, divide the total volume of the pool in gallons by 1,440 (total minutes in a day).
   Total volume of pool / 1440 = Minimum Filtration Flow Rate (gpm)

   The minimum filtration flow rate is the least amount of water (gpm) the pool pump must circulate through the filtration system in order to achieve the minimum daily turnover.

   The second reason for calculating the pool volume is to determine the maximum pool filtration rate. The pool pump should not have a filtration rate greater than the rate needed to turn over the pool water volume in six hours, or 36 gallons per minute (gpm), whichever is greater. This equation was developed by the California Energy Commission and was adopted by the Association of Pool and Spa Professionals to help set guidelines for achieving the maximum energy efficiency in pool pump operation. To calculate the maximum filtration flow rate, divide the total volume of water in the pool by 360.

   Total volume of pool /360 = Maximum Filtration Flow Rate (gpm)

   For pools with less than 13,000 gallons, the pump must have a gpm rating of 36 gpm or less.

   Because pools come in countless designs, shapes, and depths, calculating pool volume is rarely simple. In order to calculate oblong, circular, sloped, nonlinear sloped, and custom pool designs, more advanced mathematical calculations are required. Use the **ENERGY STAR pool pump calculator**.

   Once the total pool volume in gallons has been determined, the installer can calculate the maximum and minimum filtration rates. This information will help calibrate the new pool pump to make sure it is operating at peak performance from both a health and energy efficiency standpoint.

3. Remove an Existing Pool Pump (if there is one; see the Retrofit tab).

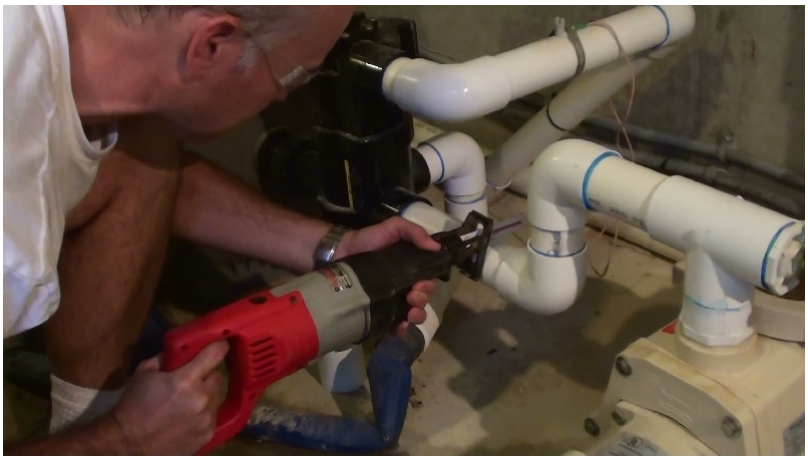

Figure 3. A reciprocating saw works well to cut PVC pipe during pool pump installation.

4. Connecting Fittings and Making Electrical Connections: After all fittings and connections have been made, reconnect the electrical conduit and wires per national, state, and local codes. Also, ensure the ground bonding wire is connected to the pump's bonding lug (Figure 4).

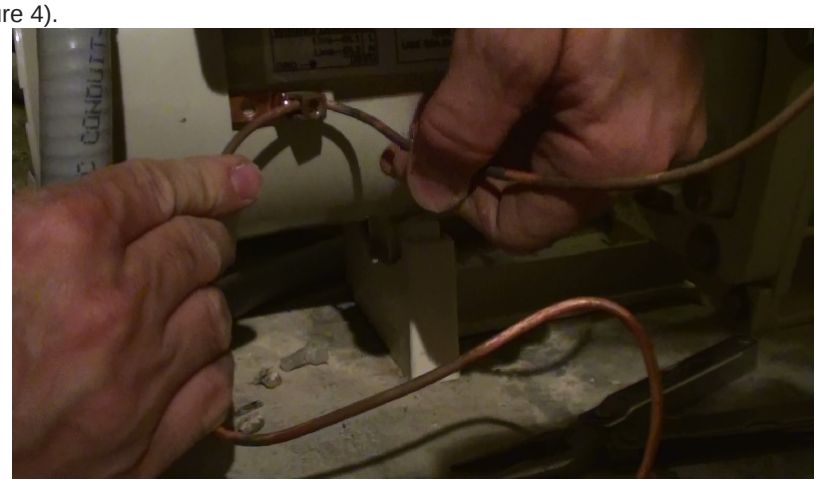

Figure 4. Make sure the ground bonding wire is securely fastened to the pump's bonding lug.

Most existing single-speed pumps are electrically powered through a timer or automation system to schedule their daily operation. Newer variable-speed pumps have the time clock and scheduling feature inherent in their control system. For these pumps, it is preferable to wire them directly, bypassing the existing time clock. For installations with remotely operated automation systems, the pump may be controlled through relays. This is done to ensure that the pump has a continuous uninterrupted power supply.

5. Calibrating Variable-Speed Pump for Optimum Performance: After installation is complete, the installer must program the new pump to obtain adequate filtration, in-pool circulation, sanitation, and water clarity while using the lowest possible motor speed.

Filters only capture what is suspended in the water passing through them and only what is large enough to collect on the filter media. Once debris and sediment enters the pool water, one of three things will happen: it will float, sink, or get suspended in the water. Floating matter can be skimmed off the surface, but once it sinks to the pool floor, it will stay there without some kind of help to remove it. Variable-speed pumps need to run longer to accomplish the required turnover due to their lower flow rates. As a result, the pool spends much more time skimming the water and preventing debris from sinking. The result is a cleaner pool with improved water clarity, which is another benefit derived from running pumps at a slower rate and for longer periods of time.

The variable-speed pump should be set up to operate at a speed that will turn over the pool volume at least once during every 24-hour period. For pools with high debris and/or bather loads, additional turnovers may be required to maintain adequate water quality. In no event should the turnover time be less than six-hours during normal operation.

Reducing the flow through main drains by throttling the drain's return line valve (if applicable) can improve skimmer performance by providing the pump with most, or all of the water from the skimmer. However, this configuration must be tested to confirm the pump is supplied with enough water when operating the pump at the highest speed needed by the pool. This is often not the highest speed at which a pump can operate and should only be high enough to achieve the intended purpose, such as operating cleaner therapy jets, or a water feature. Essentially, the goal is always to provide sanitation and to accomplish operation of any water features at the lowest flow rate. The start-up flow rate may need to be higher for several minutes to fully prime the pump, purge air from the filter, and fill solar panels with water. Once these start-up tasks have been completed, the pump speed can be reduced to the energy-efficient low-speed setting.

Pools sometimes need higher turnover flow rates, for example, following a storm or pool party. It is advantageous to have this feature set up in advance to provide the pool owner with a mode that will temporarily override the normal filtration flow rate without the need for reprogramming the pump controller.

6. Verification and Filtration Flow Rate Testing: Always follow the pump manufacturer's instructions and guidelines, especially the warning and safety instructions. The instructions listed here are not intended to be comprehensive and are not a substitute for adherence to the manufacturer's instructions.

   During the removal and installation process, air can enter the system and become pressurized. Excessive pressure can result in an explosion of the filter housing. Before system start-up, the pump and system must be manually primed and evacuated of air. Care should be taken to vent system air through the filter's manual relief valve.

   Caution: do not run the pump dry. To prime, remove the strainer pot lid and fill the pump with water until the level reaches the suction port, and then replace the strainer pot lid. This prevents the pump from running dry, which will damage the mechanical seal. Start by opening the manual relief valve on top of the filter and then press the button to start the pump. Next, you must bleed air from the filter until a steady stream of water comes out, and then close the manual air relief valve.

   Remember, the basic premise of variable speed energy-saving pump operation is "run it slower and run it longer." By running the pump slower, a slight reduction in water flow (gpm) will greatly reduce the electrical demand (kW). By reducing the flow rate, runtime will have to increase to ensure that the water is adequately filtered and mixed.

   After the pump has been started and is successfully circulating water through the filtration system, filtration flow rates need to be verified. Water is supplied to the pump from both the skimmers and main drains; however, the skimmers should supply the majority of the flow. Minimum filtration flow rates need to ensure that the skimmers function adequately. Most skimmers take approximately 25 gallons per minute (GPM) of flow for adequate performance. Verification of performance can usually be accomplished by visually observing surface water drawn into the skimmer face and over the weir door. Skimmer baskets need to be checked and cleaned regularly. Main drain flow should complement the skimmer flow but should be minimized to prevent suction entrapment hazards. The main drain and suction covers should be visually observed and verified to be VGB 2008 compliant. A noncompliant, broken, or missing drain cover poses a serious health risk and should be replaced immediately, even before the pool is returned to service.

7. Programmable Pumps and Maintenance: Note that some variable-speed pumps may be capable of producing a maximum flow rate higher than the existing single-speed pump. Excessive flow rates can present hazards such as suction entrapment. Use caution when installing and programming to limit a pump's performance potential with old or questionable equipment and to avoid suction entrapment hazards.

Many variable-speed pumps have the ability to schedule features throughout the day. As such, the pump may unknowingly start to initiate a scheduled feature. Never leave a powered pump unattended while the pump is in an unsafe condition unless the pump's programming cycles are understood (for example, strainer pot lid removed or pipes not connected and system not primed).

Maintenance for variable-speed pumps is generally the same as that for single-speed pumps.
Pump strainer baskets (sometimes referred to as the "hair and lint pot") must be kept clean of leaves and debris at all times. A dirty basket can impact pump and system performance and make the system difficult to prime.

Protect motors from heat by ensuring that there is shade from the sun and that ample ventilation is available. Particular attention should be paid to the motor's fan cover and cooling fins to ensure there are no obstructions to air flow. Motors should also be protected from dirt and moisture. Avoid splashing motors with water. Do not store or spill chemicals next to the motor. Avoid installations next to lawn sprinklers and protect them from the weather.

Some variable-speed pumps come equipped with freeze protection to assist with winterization. This feature will automatically start the pump when temperatures reach a predetermined level to prevent pipe freezing. Whenever systems are drained, power should be removed from the pump to avoid inadvertent starting of the pump.

8. Educate the Homeowner. Once the variable speed pool pump has been successfully installed and tested, the next critical step is to train the homeowner on the capabilities, functions, operation, maintenance, programming, and potential risks associated with the new pump. In order to ensure that energy savings are actualized, the homeowner must understand that the lower flow rates will provide adequate filtration for the pool. However, it is also important to educate the homeowner on the signs of a potentially unclean pool and equip them with information and knowledge to maintain a healthy swimming environment.

Ensuring Success

- Before system start-up, the pump and system must be manually primed and evacuated of air.
- Whenever systems are drained, power should be removed to avoid inadvertent starting of the pump.
- After installation is complete, the installer must program the new pump to obtain adequate filtration, in-pool circulation, water clarity, and sanitation while using the lowest possible motor speed.
- When installing and programming a variable-speed pump, use caution with old or questionable equipment that can limit pump performance potential and address any suction entrapment hazards.
- Train the homeowner on the capabilities, functions, operation, maintenance, programming, and potential risks associated with the new pump.

Climate

No climate specific information applies.

Training

Right and Wrong Images

None Available

CAD

None Available

Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Qualified Product list and Energy Savings calculator

ANSI/APSP/ICC-15 American National Standard for Residential Swimming Pool and Spa Energy Efficiency

4.2.1. Pool pump motor controls for use with a two-speed, multi-speed, or variable-speed pumps shall have the capability of operating the pool pump at least at two speeds. The control's default filtration speed setting shall be no more than one-half of the motor's maximum rotation rate. Any high-speed override capability shall be for a temporary period not to exceed one 24-hour cycle without resetting to default settings.

5.1.2. For maximum energy efficiency, pool filtration should be operated at the lowest possible flow rate for a time period that provides sufficient water turnover for clarity and sanitation.

5.3.4. Filtration pumps shall be sized, or if programmable, shall be programmed, so that the filtration flow rate is not greater than the rate needed to turn over the pool water volume in 6 hours or 36 gpm, whichever is greater.

5.3.7. Multi-speed pumps must have controls that default to the filtration flow rate when no auxiliary pool loads are operating. The controls must also default to the filtration flow rate setting within 24 hours and must have a temporary override capability for servicing.

5.5.4. All elbows shall be sweep elbows or elbow-type that have a pressure drop of less than the pressure drop of straight pipe with a length of 30 pipe diameters.

More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

None Available

References and Resources*

1. **ANSI/APSP Standards & Specifications List for Residential Swimming Pools and Spas**
   Author(s): The Association of Pool & Spa Professionals
   Organization(s): The Association of Pool & Spa Professionals
   Publication Date: July, 2015
   View the APSP/ANSI Standards and codes below to get information about ANSI specifications for pools, spa and hot tubs.

2. **ENERGY STAR Certified Pool Pumps Criteria**
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: July, 2018
   Table of criteria for pool pumps to achieve ENERGY STAR certification.

3. **Installing and Operating an Efficient Swimming Pool Pump**
   Author(s): Department of Energy
   Organization(s): DOE
   Publication Date: July, 2018
   You can save energy and maintain a comfortable swimming pool temperature by using a smaller, higher efficiency pump and by operating it less.

4. **Make a Savings Splash with ENERGY STAR Certified Pool Pumps**
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: April, 2017
   Factsheet with information on energy efficient pool pumps.

5. **Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings**
   Author(s): Hunt, Easley
   Organization(s): BARA, National Renewable Energy Laboratory, Building Media
   Publication Date: May, 2012
   Research study showing that for a relatively small investment, a variable speed pool pump can reduce pool pump energy use by 50% to 75%.

6. **Pools & Spas: Codes and Standards Enhancement (CASE) Initiative**
   Author(s): Owrth, Ludovici, Joyce, Fernstrom
   Organization(s): California Investor-owned Utilities
   Publication Date: July, 2013
   This CASE report proposes updates and revisions to the standards for residential swimming pool filtration pumps, new and replacement single phase pump motors under 5 horsepower (HP), controllers, portable electric spas as well as expanding the scope of the current standards to include light emitting diode (LED) pool lighting.

7. **Revised Analysis of Efficiency Standards for Pool Pumps and Motors, and Spas**
   Author(s): California Energy Commission
   Organization(s): California Energy Commission
   Publication Date: June, 2016
   This report discusses proposed updates to the pool pumps and motors, and portable electric spas standards in the Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601 to 1609). These proposed updates are part of the 2012 Appliance Efficiency Rulemaking, Phase I (Docket #15-AAER-02).

8. **Savings Calculator for ENERGY STAR Certified Inground Pool Pumps**
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: October, 2016
   ENERGY STAR pool volume calculator in a spreadsheet format.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

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