ENERGY STAR® Residential Swimming Pool Pump Specification Framework

Technical Definitions

1. Pump Performance Curve: A curve comparing the total head in feet of water to the rate of flow in gallons per minute (GPM) for a given pump at a given motor speed.

6. Head (H): Head is the expression of the energy content of the liquid at any given point. It is expressed in units of energy per unit weight of liquid. The measuring unit for head is feet of ~~liquid~~ water.

Reason: Swimming pool and spa pumps are exclusively for fresh water, therefore the customary units is Feet of Water or Feet of H2O.

7. **Total Suction Head (HS):** The head in the inlet section of the pump, calculated as follows:

$$H_S = z_S + \frac{(p_S \times 1000)}{\rho g} + \frac{U_S^2}{2g}$$

- z_S is the height from the ~~ground~~ water level of the suction pressure measuring device,
- p_S is the suction pressure measured by the pressure measuring device,
- U_S is the mean velocity at the suction pressure measuring device.
- ρ is the density of the water (Mass per unit volume, frequently kg·m^{-3}), and
- g is the gravitational acceleration (velocity change per unit time, often m·s^{-2})

Reason: Test labs frequently use tanks of water sitting on the ground; therefore the water level of the tank is the reference point and not the ground. Also added definitions for the constants.

8. **Total Head (H):** The measure of the work increase per unit weight of the liquid, imparted to the liquid by the pump. Total head is equal to the difference between total discharge head and total suction head. Total head is calculated as follows:

$$H_D = z_D + \frac{(p_D \times 1000)}{\rho g} + \frac{U_D^2}{2g}$$

Where:

- z_D is the height from the ~~ground~~ water level of the discharge pressure measuring device,

- p_D is the discharge pressure measured by the pressure measuring device, and
- U_D is the mean velocity at the discharge pressure measuring device.
- ρ is the density of the water (Mass per unit volume, frequently kg·m^{-3}), and
- g is the gravitational acceleration (velocity change per unit time, often m·s^{-2})

Reason: Test labs frequently use tanks of water sitting on the ground; therefore the water level of the tank is the reference point and not the ground. Also added definitions for the constants.

Questions for Discussion:

(1) Are there any other sources that EPA should review for variations of, or additions to, this list of definitions?

Comment: APSP/ICC-15 includes additional definitions, consider:

Total horsepower, Full-speed, half-speed, lowest-speed, and best energy factor speed.

(2) EPA is interested in any comments, questions or concerns related to the above definitions.

Comment: See suggested revisions and reason above.

(3) Definitions based on technical attributes rather than marketing distinctions tend to be most effective at differentiating product types; therefore, EPA is interested in the key design or engineering differences, if any, that exist between pumps meant for commercial and residential applications, and between inground and above ground applications. Similarly, what key design differences are there between pool pumps and pumps meant for spa, waterfall, or booster applications? Where might there be overlap?

Comment: The differences between commercial, residential, inground, and above ground are primarily performance based, which is captured by the current technical attributes. It is generally agreed that residential pumps are $\leq$ 3 HP, although some 5 Hp equipment is occasionally used for water features. It is also common for many smaller commercial applications to utilize residential sized equipment. Secondary distinctions are in the mounting orientation (vertically mounted commercial pumps are more common), pipe connections, (flange connections for commercial) and quality of construction, which tends to be highest in commercial pumps and lowest in above ground pumps.

Comment: The industry distinction between high-head filtration/cleaner pumps and medium to low head waterfall type pumps is also captured by the current technical attributes, however the highest Energy Factor for high head pumps is typically outside their intended operation point. In application, Energy Factor alone should not decide the pump selection process. Instead the pump with the highest Energy Factor associated with an indicative System Curve should be used. The first step is to define the needed operating point (high head for spa therapy jets, cleaners, etc., low head for waterfalls, infinity edge pools, etc.) then selecting a pump with a high Energy Factor.

(4) *Are there any technologies or product types which are not included in this document or within the proposed program scope that should be considered for inclusion in this ENERGY STAR specification? If so, could you supply market or performance data available for those products?*

Comment: For the reasons provided in the draft specification, we agree with the current product mix.

(5) *Certain multi-speed pumps require the installation of an aftermarket relay kit in order to function with a controller. These kits are not typically sold with the product and must be purchased separately. What percentage of multi-speed pump sales do these type of products account for? How common are systems converted using the relay kits?*

Comment: It is not clear what is meant by the term "relay kit", as there are a few items listed below that this could define:

1. A simple time clock operated relay switch

2. An "ice cube" style multi-speed relay contactor installed in an existing controller

3. A ~relay (translation module) that allows digitally controlled variable speed pumps to operate from analog signals.

- <u>If "relay kit" is refereeing to a simple time clock,</u> Pentair does not have this data. These time clocks do however offer a slightly lower cost compliance option under California Title 20/24 and APSP/ICC-15 as compared to pumps with onboard controllers, (cursory field study indicates that there is little difference between the price of multispeed pumps plus the additional external CEC-compliant controller versus the variable and multi-speed with integrated controller). The counterpoint is their much lower Energy

Factor as compared to their variable-speed counterparts. This reality is best documented in the California Appliance Efficiency Database and it may be that the current products will be excluded on energy efficiency alone. That being said, if they have a home in the specification and a clear minimum energy efficiency target, manufacturers may design and introduce new products. If this is the case, it would also make sense to include the onboard controller, which brings us full circle. Absent additional information, exclude them.

- If the term "relay kit" is refereeing to an "ice cube" style multispeed relay contactor installed in an existing automation controller, then these sales are quite low. Our data indicates that less that 10% of two-speed pumps sold in the market are utilizing these relays.

- If the term "relay kit" is refereeing to an electronic circuit board that allows digitally controlled variable speed pumps to receive analog signals, our data indicates that roughly 10% of the variable speed pumps are sold with this device.

(6) Current state-level energy efficiency standards, including California Energy Commission (CEC) CA Title 20 "California's Appliance Efficiency Regulations", require pumps be labeled with the following statement to encourage controller installation, "This pump, when used as a filter pump, must be installed with a two-, multi-, or variable-speed pump motor controller". Is there any data available on the prevalence of this label and the effectiveness of the messaging?

Comment: This labeling requirement was introduced as part of a minor revision to CEC Title 20 two years after introduction and this caused a lag in compliance as compared to the initial product offering and labeling requirements. This and the lack of ongoing contact with residential pool owners make data hard to acquire, if any exists. It further supports the conclusion that ENERGY STAR® should not include pump controllers sold separately. The sold separately is an important distinction because some multi-speed pumps do not include onboard controls, yet they will not function without one. This is not the case with some two-speed pumps which have a manual toggle switch located on the back of the pump motor. A logical destination might be "if the motor can be wired and operated without the controller, it does not qualify."

(7) Aside from labeling, what other methods may ensure proper controller implementation including but not limited to educational materials on the ENERGY STAR website?

Comment: See comment 6 above.

(8) Considering the importance of controls for achieving the intended

energy savings, should pumps without onboard controllers be excluded?

Comment: Yes- See comment 6 above.

(9) Are there any benefits or disadvantages to using Energy Factor (EF) as an evaluating metric?

Comments: This issue was discussed previously in response to Definition 3, with this question putting a finer point on the discussion. It appears there will need to be two or more classification based on maximum pump head. If not, most “waterfall” pumps with the high Energy Factor associated with their low total dynamic head systems will fall within the top quartile even though not suitable for many filter applications.

The Association of Pool and Spa Professionals (APSP) has another pump standard in the writing process; this is the APSP-10 Pump Labeling Standard. This is a very simple standard intended to provide head, flow, watts, wire-to-water efficiency and Energy Factor in a boxed format suitable for inclusion on the pump, box, and literature. The purpose is to address the differences between high (60 ft), medium (40 ft), and low (10 ft) of head pumps. For example, it should prevent the user from choosing a waterfall pump (due to its high energy factor alone) and then try to apply it to a high head system where it would be inadequate. It is also intended to obsolete the marketing based “full-rated, up-rated” designations, which have no technical or engineering value.

Because waterfall pump cannot achieve 60 feet and because high head pumps may overload when used continuously at 10 feet, the standard allows the manufacturer to select which data points to publish, though they must publish at least two. The pump manufacturer may select, test and publish a custom dataset based on an operating head of their choosing. This was requested by the manufacturer of a purpose built waterfall pump that is intended to operate at 4 feet of head. In this example the manufacturer will publish data for 10 feet and 4 feet.

(10) Do the test procedures listed above accurately quantify residential inground swimming pool pump energy efficiency?

Yes

(11) Are any performance or energy efficiency criteria missing from existing test procedures that should be addressed by an ENERGY STAR test procedure?

No

(12) EPA understands that non-CA Title 20 compliant pumps (i.e. pumps with split-phase, shaded-pole, or capacitor start-induction run type motors, and single speed pumps greater than 1 HP) are typically not tested for EF. Are there any barriers to performing this additional testing to submit data to EPA? Is the draft ENERGY STAR Test Procedure sufficient for testing pumps with these types of motors?

Comment: The procedure is sufficient. Note that lab testing is very time consuming and costly and to require 100% testing of all products, especially those known to fall in the lower 50% could be burdensome. Manufactures would likely be willing to supply additional data on these products but would need more specific sampling requirements and test specifics before embarking on a data gathering initiative. Additionally, to meet the new test requirements, it is likely that significant test laboratory upgrades will be required.

Manufacturers should already have a limited amount of CEC-T20 data for larger horsepower single speed CSCR and PSC pumps. These larger horsepower single speed pumps were originally compliant (from ~2006 to 2008) and were at that time listed in the CEC database. They were removed during phase-2 implementation that limited single speed pumps to < 1 Total Hp.

The non-CA Title 20 compliant pumps have relatively low Energy Factors and would fall well outside the top quartile of all pumps. If data were more readily available the impact would likely expand the top quartile, however the CEC data suggests this would be a statistical impact and not a practical impact. The large Energy Factor differences between the induction motors most often associated with single-, two-, multi-speed pumps as compared to variable-speed pumps, precludes most induction motors from the top quartile.

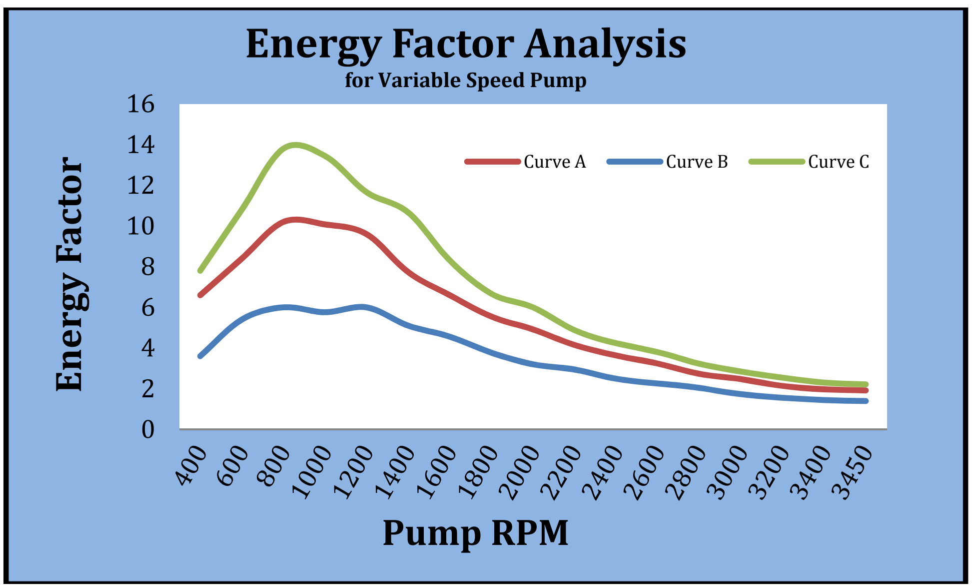
The lack of single-speed pump data larger than one total horsepower does not appear to be an issue because a subset of their data is represented by their two-speed counterparts in high speed. The main difference between the typical two-speed pool pump and the single-speed variant is the low-speed winding which appears to have minimal if any impact the high-speed Energy Factor. Manufacturers appear to test and publish data to the CEC Database for their high market share pumps and for this reason the CEC Database continues to be a valuable data source.

(13) Currently the Draft ENERGY STAR Test Procedure calls for testing of all three curves, A, B, and C. However, if only curve A is utilized in the evaluation,

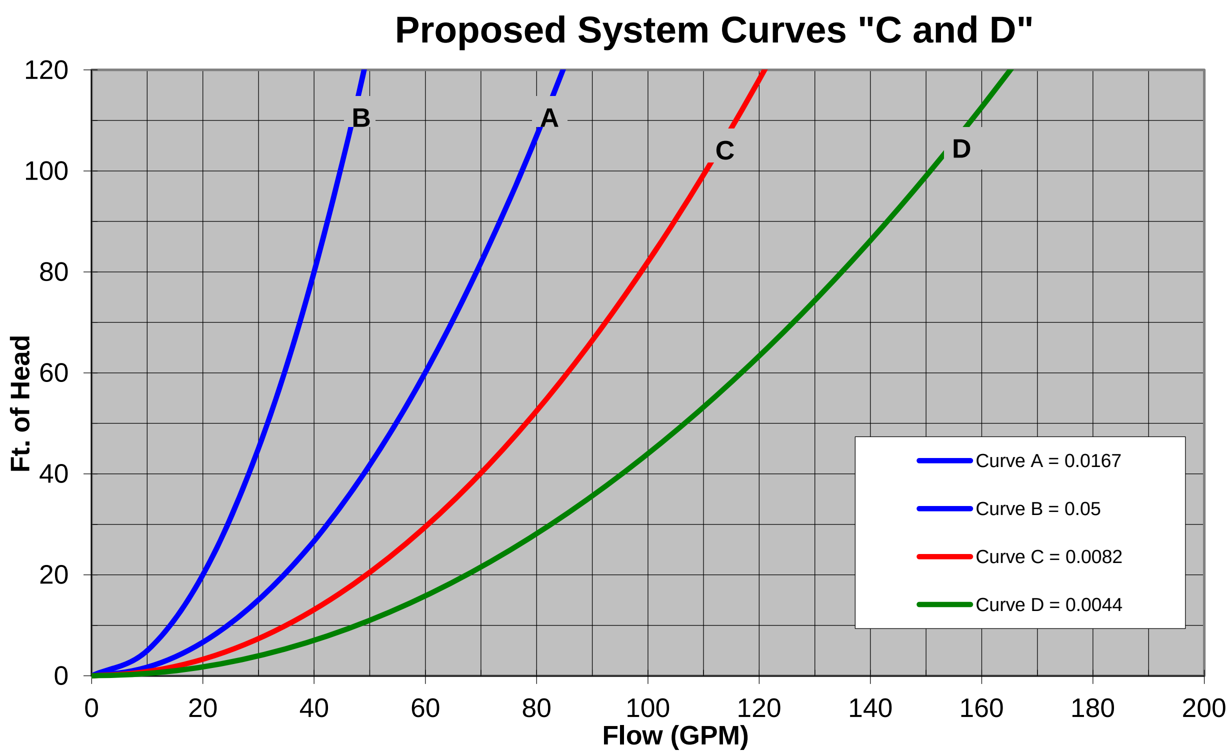
is there any benefit to testing and supplying data for all curves?

Comment: Absolutely Yes, Submission of data for all three curves is extremely important. As proven by the CEC-T20 database, the availability of this data serves as an invaluable tool to determine the industry's product performance over a wide range of hydraulic conditions. This data has served invaluable for the development of accurate energy savings calculators. For example, we can now determine the performance of the "industry average" 1.5 Hp single speed pump at various hydraulic conditions. With this data, we can better refine savings estimates for more accurate payback analysis for consumers.

Below is a chart showing energy factor as it varies with speed for a specific pump model. After reviewing the CEC database, most every manufacturer of variable speed pump have chosen a voluntary data point that reflects a high performing energy factor. For all manufacturers, this best point occurs between ~800 rpm and ~1200 rpm. This appears to be a "sweet spot" for energy factors and pump performance, and it also is the typical range where these pumps operate in the field for the daily filtration cycles. It is recommended that a data point in this RPM range be reported to better reflect the pump's operation in a typical application.



Background - Initially CEC-T20 called for only curves A and B. It was the pool industry that requested the addition of curve C to better reflect current construction techniques. The APSP-10 sub-committee responsible for determining the Curve C coefficient of **0.0082**, also strongly considered at that time requesting a forth curve D with a coefficient of **0.0044** to reflect the hydraulic conditions of larger pools typically constructed with large piping, fittings, and equipment and very low TDH. There are products from many manufactures currently available that are designed and optimized for these higher flow rates and lower TDH systems needed for these larger pools and the curve D performance reflects their superior savings potential. This may be the appropriate time to expand the data collection to include curve D since much of the products are likely to be re-tested to meet the stringent new test procedures.



There are also benefits for the reasons discussed under definition 3 and under question 6. Absent data at specified head levels (the APSP-10 Pump Labeling Standard's approach), there is no home for pumps properly sized for pools above 17,000 gallons (national average is 22k gallons according to PK Data) and above.

The use of Curves A and C by CA CEC Title 24 and ANSI/APSP/ICC-15 is useful for limiting the size/performance of residential filtration pumps, however the head to head comparison provided by APSP-10 (60ft, 40ft, and 10ft) may be a better choice for ENERGY STAR. This approach does not limit flow, which varies from pool to pool (6-hour turnover flow rate) and application to application (filtration, spa, waterfall, etc.).

(14) Is there any data to support the idea that small sized pumps will not operate on Curve A?

- Comment: We know of no data to support that smaller pumps cannot operate on curve A for testing purposes. Note that curve A (and B and C) represent only the total “dynamic” portion of the head resistance. For example, it assumes the pump is installed at water level. In real-world applications there are often static head conditions which add to the dynamic component such as when the pump is installed above water level in a “lift” application. The extra static head when added to the dynamic component could result in a condition that renders the smaller pump’s flow less than adequate. This can especially occur with two speed pumps where the low speed operation proves ineffective at providing sufficient flow. As a result, the pump spends most all of its time running on high speed where the EF is no better, if not worse, than the equivalent sized single speed pumps. Variable speed pumps have proven much more effective at avoiding this condition by allowing small increases in speed to provide just enough flow to maintain clarity and sanitation while avoiding excessive flow conditions – i.e. “right-sizing” of the pump. Do to these challenges; the variable speed pumps outsell the 2-speeds by a margin of over 10:1.

Questions 15, 16, and 17

The criteria and functionality described in this section is an effort well worth pursuing. The lack of standardized communication protocols have made it difficult for manufactures to dedicate many resources towards this initiative. If this Energy star initiative could function to provide this standardization then the industry is likely to positively respond with capable products.