Proposal Information Template for:
Residential Pool Pump Measure Revisions

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Proposal Information Template – Residential Pool Pump Measure Revisions

2008 Appliance Efficiency Standards

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Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regs,, §§ 1601 – 1608) This report specifically covers revisions to current Residential Pool Pump appliance standards which were adopted by the California Energy Commission on Oct 11, 2006.

This template covers the following 3 pool pump topics:

- Replacement pool pump motors
- High-efficiency multi-speed motor and control clarifications
- New pool pump test curve

Background

There are approximately one million private residential in-ground swimming pools in California, the vast majority of which use a single-speed filtration pump to circulate and filter swimming pool water in order to remove particulate debris and maintain clarity. Residential pump motors range in size from one half to three horsepower (hp), are operated an average of about 4.6 hours per day, but in some cases up to 10 hours per day, and draw approximately 1 kW per nominal horsepower.

Using pumps with two-speed motors offer a significant opportunity for energy savings by taking advantage of pump affinity laws. Operating a pump equipped with a two-speed motor at half speed for twice as long moves the same volume of water, but in theory uses only one-quarter the amount of energy. However, actual savings are closer to 50% for a couple of reasons: 1) While low-speed operation is generally adequate for filtering, high speed may be needed for a few hours daily to operate pool sweeps and skimmers, and 2) Two-speed motors are currently less efficient on low-speed (A.O. Smith has recently introduced a line of two-speed motors that are equally efficient in high and low speed operation).

Residential Pool Pumps were first included in the 2005 Title-20 appliance standards that were adopted at the end of 2005. These standards regulated pool pump motor types and required testing and listing of pool pumps effective January 1st, 2006. In addition, multi-speed motors and controls were required for pool pumps with a capacity of 1 total HP or greater effective January 1st, 2008. Residential Swimming Pool standards are also included in the 2008 Title-24 building standards which were adopted April 23, 2008 and will become effective July 1, 2009. The 2008 Title-24 standards require pool design standards that include minimum pool turnover times and maximum flow velocities.

Since the implementation of the standards there have been ongoing discussions between PG&E and the pool industry (principally the Association of Pool and Spa Professionals (APSP), but more recently the Independent Pool and Spa Service Association (IPSSA)) in regards to updates and revisions including the following:

- Accommodate new pool equipment such as variable-speed motors
- Clarify whether or not replacement motors are covered
- Add a third pool pump test curve to represent efficient pool piping design.
- Clarify whether the motor capacity refers to nameplate or total horsepower.

Overview

Replacement pool pump motors

The current pool pump standards do not refer to pool pumps, pool pump motors, and pool pump motor combinations consistently. In addition, pool pump motors are not explicitly identified in the scope of the standards. Because of this, it is currently the interpretation of the CEC that the standards do not cover pool pump motors sold for replacement purposes, although this was the intent of the those involved in writing the standards.

Description of Standards Proposal	The scope of Residential Pool Pumps should be amended to explicitly include the pump, pump motor, and motors sold for replacement purposes.
California Stock and Sales	There are approximately 1 million private, residential, in-ground swimming pools in California, with annual sales of 34,000. Approximately 113,000 pool pumps and motors are replaced each year.
Energy Savings and Demand Reduction	Energy savings of replacing an average single-speed pool pump motor with a two-speed motor is estimated to be 711 kWh/yr which will result in statewide savings of 402 GWh and 152 MW over the first ten years of the standard.
Economic Analysis	Installation of a two-speed motor is estimated to cost an average of $452 more than a single-speed motor. Net present value of the energy savings over the 10 year lifetime of the motor averages $450 with a 1.95 benefit-to-cost ratio.

Non-Energy Benefits	Operating swimming pool filtration equipment at low flow rates greatly reduces noise and can reduce entrapment issues due to high flow velocities.
Environmental Impacts	None
Acceptance Issues	Not all pool service companies have experience with two-speed motors. Increasing the cost of a pool pump motor replacement above $500 may require that it be done by a licensed contractor.
Federal Preemption or other Regulatory or Legislative Considerations	Pool pump motors are definite purpose motors and as such neither pool pumps nor pool pump motors are presently covered by federal efficiency regulations.

High-efficiency multi-speed motor and control clarifications

When the current standards were written the vast majority of residential pool pump motors were either single-speed or two-speed. Since then manufacturers have brought out an increasing variety of multi-speed and variable-speed motors. These can provide significant energy savings over conventional motors, but their performance is more difficult to characterize. Section 1605.3(g)(5)(B) needs to define what the lowest speed is.

New Pool Pump Test Curve

The 2008 Title-24 pool standards rely on a new pool system curve to size pumps for pools with 2" or larger pipeing. This curve, referred to as "Curve C", was suggested by pool pump stakeholders and represents the system curve of a well designed, low pressure-drop pool with 2" PVC piping. Adding Curve C to the test and listing requirements of filtration pumps will allow the data to be easily used for Title-24 compliance.

Methodology

The current appliance efficiency data base[1] for pool pumps was used to estimate the efficiency of typical single- and two-speed pumps. The data base was sorted by pump type and total capacity and all single- and two-speed pumps with total capacity of 1.25, 1.65, 2.2, and 2.6 horsepower were selected (these correspond to full-rated pumps with nameplate horsepower of ¾, 1, 1½, and 2 respectively). Specific pump power and flow were estimated by fitting a pump curve using the listed data for curves A and B for each pump and averaging the result for all pumps of the same capacity. Single-speed and high-speed operating hours were fixed. Low-speed operating hours were calculated by subtracting the amount of water filtered during the high-speed time from the total amount of water turned over by the single-speed operation and dividing by the low-speed flow rate. The formula is as follows:

$$T_L = (T_S \times F_S - T_H \times F_H) / F_L$$

[1] Pool_Pumps.xls dated 5/19/08

Where:

T = Time in hours per day for Single, High, and Low speeds
F = Flow in gpm for Single, High, and Low speeds

Analysis and Results

53 pool pumps were selected from the current CEC appliance data base. Original PG&E operating hour assumptions and pool system characteristics were challenged by IPSSA as not being representative of current California residential pools. PG&E continues to believe that its original assumptions and energy savings estimates are correct, but based on discussion and negotiations the following assumptions were used for the calculations:

Single-speed operation	4.2 hours per day
High-speed operation	2 hours per day
System curve coefficient	0.012 (half way between curves A and C)

Two-speed motors can replace single-speed motors directly in most pumps, but they require a new two-speed controller and wiring which requires additional labor to install. Pool pump motors have an expected lifetime of 10 years, although the pump head can last much longer. We estimate that 113,000 pool pump motors are replaced each year, and of these, we estimate:

- 30% will be replaced with a less than a 1 total hp motor and remain single-speed.
- 20% will replace the whole pump and will be covered by the current standard.
- 50% will be a motor replacement of greater than 1 total hp.

Currently, most pools with solar heating panels and a single pump cannot operate on low-speed for the entire time while flow is directed through the collectors due to the added head. We assume that 12% of California swimming pools have solar heating, 85% of these have a single pump, and that the collectors are operated three months out of the year. This results in 3% of pool pumps operating on high-speed only. Results for all pump sizes were weighted based on the distribution of pools pump sizes in California. Results of the calculations for the four pump sizes are summarized in the Table 1.

Table1: Pool Pump Operation

Total HP	*Weight*	*Motor*	*N*	*Flow (gpm)*	*Power (W)*	*EF (gal/Wh)*	*Run Time (hrs/day)*	*Energy (kWh/yr)*
1.25	31%	Single-speed	7	63.6	1395	2.74	4.2	2138
		High-speed	7	64.7	1542	2.52	2.0	1126
		Low-speed	7	36.0	342	6.31	3.8	478
1.65	35%	Single-speed	7	67.9	1699	2.40	4.2	2605
		High-speed	9	69.6	1898	2.20	2.0	1385
		Low-speed	9	37.2	442	5.05	3.9	633
2.2	23%	Single-speed	4	71.0	2040	2.09	4.2	3127
		High-speed	9	74.8	2019	2.22	2.0	1474
		Low-speed	9	37.4	432	5.20	4.0	627
2.6	10%	Single-speed	4	77.7	2347	1.99	4.2	3598
		High-speed	6	79.5	2276	2.09	2.0	1661
		Low-speed	6	41.8	475	5.28	4.0	695

Weighted Average Savings	**817**	**711**

The two-speed pumps operate an average of 6 hours per day, but due to the significantly lower power use on low-speed the average energy savings is 711 kWh/yr. Demand savings averaged over all speeds is 0.8 kW.

Economic calculations for the weighted average pump are shown in Table 2. The weighted average incremental cost of a two-speed motor is $212, but an additional $160 is required for the controller and $80 for the added installation labor.

Table 2: Life Cycle Economics

Design Life (years)	*Annual Energy Savings (kWh)*	*LCC ($/kWh)*[2]	*Present Value of Energy Savings*	*Incremental Cost*	*Net Customer Present Value*	*BCR*
10	711	1.268	$902	$452	$450	1.95

Statewide savings estimates are shown in Table 3. 30% of motor replacements are assumed to be with less than one total HP single-speed motors, and 20% are assumed to be whole pump change-outs, resulting in on one-half of required motor replacements being two-speed replacements. Full savings are realized in 2019 after all existing single-speed motors have been replaced. Demand savings are based on one-third of pool pumps operating on-peak.

Table 3: Statewide Energy and Demand Savings

Annual Motor Replacements	*Fraction Replaced with 2-speed*	*Energy Savings (GWh/year)*		*Demand Savings (MW)*	
		First Year	*2019*	*First Year*	*2019*
113,000	50%	40	402	15	152

Recommendations

1602(g) Pool Heaters, Portable Electric Spas, ~~Residential~~ Pool Pumps sold for use in residential filtration applications, and Pool Pump Motors sold for use in residential filtration applications

"~~Residential p~~Pool pump" means a pump-motor combination consisting of a pump housing, impeller, and motor used to circulate and filter pool water in order to maintain clarity and sanitation.

"Pool pump motor" means a definite purpose motor designed for use in a pool pump.

"Total ~~horsepower~~capacity (of ~~an AC~~a pool pump motor)" means a value equal to the product of the motor's service factor and the motor's nameplate (rated) horsepower.

[2] 10 year life cycle cost of electricity calculated using electricity prices from *Staff Forecast: Average Retail Electricity Prices 2005 To 2018,* CEC-200-2007-013-SD, June, 2007, and assuming a discount rate of 3%.

1604(g) Pool Heaters, Portable Electric Spas, ~~Residential~~ Pool Pumps sold for use in residential filtration applications, and Pool Pump Motors sold for use in residential filtration applications

(3) Test Method for ~~Residential~~ Pool Pumps

(A) ~~IEEE 114-2001 shall be used for measurement of motor efficiency~~ Reported motor efficiency shall be verifiable by test method IEEE 114-2001 (Corrected).

(B) ANSI/HI 1.6-2000 shall be used for the measurement of pump ~~and motor combinations~~ efficiency.

(C) ~~Two~~ Three curves shall be calculated:
Curve A: H = 0.0167 x F2
Curve B: H = 0.050 x F2
Curve C: H = 0.0082 x F2
Where:
H is the total system head in feet of water.
F is the flow rate in gallons per minute (gpm).

(D) For each curve (A~~&~~,B&C), the pump head shall be adjusted until the flow and head lie on the curve. The following shall be reported for each curve and pump speed (~~two~~multi-speed pumps shall be tested and reported at both high and low speeds).
~~1. Head (feet of water)~~
1. Motor nominal speed (rpm)

1605.3(g)(5) Pool Heaters, Portable Electric Spas, ~~Residential~~ Pool Pumps sold for use in residential filtration applications, and Pool Pump Motors sold for use in residential filtration applications

(A) Motor Efficiency. Pool pump motors manufactured on or after January 1, 2006 may not be split-phase or capacitor start-induction run type.

EXCEPTION 1. TO SECTION 1605.3(g): 48-frame motors designed for use with above-ground pool pumps.

EXCEPTION 2. TO SECTION 1605.3(g): The low-speed section of two-speed pool pump motors may be capacitor start – induction run type.

(B) ~~Two~~Multi-**Speed Capability**.

1. **Pool Pumps**. Pool pumps that have motors with a total capacity of 1 HP or more which are manufactured on or after January 1, 2008, shall have the capability of operating at two or more speeds with ~~a low~~ the lowest speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate.
2. **Pool Pump Motors**. Pool pump motors with a total capacity of 1 HP or more which are manufactured on or after January 1, 2010, shall have the capability of operating at two or more speeds with the lowest speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate.

3. **Pool Pump Controls**. Pool pump motor controls manufactured on or after January 1, 2008 that are sold for use with a multi-speed pool pump shall have the capability of operating the pool pump at ~~least~~ a minimum of two speeds. The control shall have a default circulation speed ~~shall be the lowest speed, with a high speed override capability being for a temporary period not to exceed one normal cycle.~~ which is no more than one-half of the motor's maximum rotation rate. Any override capability that operates the pump at a speed higher than the default speed shall return to the default speed within twenty four hours.

1606

1606 Table X Data Submittal Requirements

	Appliance	*Required Information*	*Permissible Answers*
G	Residential Pool Pumps	Motor Construction	PSC, Cap Start-Cap Run, ECM, Cap Start-induction run, split-phase
		Motor Design	Single-speed, two-speed, multiple-speed, variable-speed
		Frame	48, 48Y, 56C, 56J, 56Y, other
		Motor has Capability of Operating at Two or More Speeds with the Low Speed having a Rotation Rate that is No More than One-Half of the Motor's Maximum Rotation Rate	Yes, no
		Motor Total Capacity (in HP)	
		~~Pool Pump~~ Motor Service Factor	
		Motor Efficiency (%)	
		Motor Nameplate Horsepower	
		High-Speed (in rpm)	
		Low-Speed (in rpm)	data, NA
		High-Speed Flow for Curve 'A' (in gpm)	
		High-Speed Power for Curve 'A' (in watts)	
		High-Speed Energy Factor for Curve 'A' (in gallons per watt-hour)	
		High-Speed Flow for Curve 'B' (in gpm)	
		High-Speed Power for Curve 'B' (in watts)	
		High-Speed Energy Factor for Curve 'B ' (in gallons per watt-hour)	
		High-Speed Flow for Curve 'C' (in gpm)	
		High-Speed Power for Curve 'C' (in watts)	
		High-Speed Energy Factor for Curve 'C ' (in gallons per watt-hour)	
		Low-Speed Flow for Curve 'A' (in gpm)	data, NA
		Low-Speed Power for Curve 'A' (in watts)	data, NA
		Low-Speed Energy Factor for Curve 'A' (in gallons per watt-hour)	data, NA
		Low-Speed Flow for Curve 'B' (in gpm)	data, NA
		Low-Speed Power for Curve 'B' (in watts)	data, NA
		Low-Speed Energy Factor for Curve 'B ' (in gallons per watt-hour)	data, NA
		Low-Speed Flow for Curve 'C' (in gpm)	data, NA
		Low-Speed Power for Curve 'C' (in watts)	data, NA
		Low-Speed Energy Factor for Curve 'C ' (in gallons per watt-hour)	data, NA
H	Residential Pool Pump Motors	Motor Construction	PSC, Cap Start-Cap Run, ECM, Cap Start-induction run, split-phase
		Motor Design	Single-speed, two-speed, multiple-speed, variable-speed
		Frame	48, 48Y, 56C, 56J, 56Y, other
		Motor has Capability of Operating at Two or More Speeds with the Low Speed having a Rotation Rate that is No More than One-Half of the Motor's Maximum Rotation Rate	Yes, no
		Motor Total Capacity (in HP)	
		Motor Service Factor	
		Motor Efficiency (%)	

		Motor Nameplate Horsepower	
		High-Speed (in rpm)	
		Low-Speed (in rpm)	data, NA

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