Appliance Standards and Rulemaking Federal Advisory Committee

Circulator Pumps Working Group

Term Sheet

September 7, 2016

Background

On February 3, 2016, DOE issued a Notice of Intent To Establish the Circulator Pumps Working Group To Negotiate a Notice of Proposed Rulemaking (NOPR) for Energy Conservation Standards for Circulator Pumps. 81 FR 5658. This working group is established under the Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) in accordance with the Federal Advisory Committee Act (FACA) and the Negotiated Rulemaking Act (NRA). The purpose of the working group was to discuss available industry data and, if possible, reach consensus on scope of circulator pumps in question and potential test procedure or metric. The working group was to consist of representatives of parties having a defined stake in the outcome of the proposed standards, and will consult as appropriate with a range of experts on technical issues.

The working group consisted of 15 members, including one member from ASRAC and one DOE representative (see Appendix A). The working group met in-person or via webinar during 7 sets of meetings held March 29, March 31-April 1, May 4-5, June 16-17, July 12-13, August 10-11, and September 7, 2016. Up to this point, the working group has successfully reached consensus on the scope, metric, and test procedure. This document includes the working group's recommendations to ASRAC on these topics. The Working Group is continuing to meet to resolve remaining issues regarding scope, additional definitions, and energy conservation standards for circulator pumps and anticipates producing a second term sheet at the end of the negotiations addressing these items.

Rulemaking Scope

Recommendation #1A. Circulator Pumps comprise the following pump varieties distributed in commerce with or without a volute (as defined in recommendations #3A and #3B):

- Wet rotor circulator pumps
- Dry rotor close-coupled circulator pumps
- Dry rotor mechanically-coupled circulator pumps

The scope of analysis for this rulemaking will include the pump varieties listed above. In the second phase of this negotiation, based on further analysis, the working group may recommend energy conservation standards for some or all of these pump varieties.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #1B. The Working Group recommends that DOE analyze and establish standard level(s) for small vertical in-line pumps (SVIL) (as defined in Recommendation #3C) in the same rulemaking implementing the other Working Group recommendations with a compliance date that is equivalent to the CIP rule (January 27, 2020), unless such date is less than two years after the publication of the circulator pump energy conservation standards final rule. The Working Group recommends that SVIL be evaluated on the PEI_{CL} or PEI_{VL} metric, similar to CIP, and use the CIP test procedure to measure performance, with any additional modifications necessary as determined by DOE. The Working Group recommends that DOE establish standard levels for SVIL that are comparable with the CIP IL standard levels (C-Value).

Vote results: Consensus (1 'no' vote) on 9/7/2016

Recommendation #2A. The scope of this rulemaking will be limited to clean water pumps only, where clean water pump means a pump that is designed for use in pumping water with a maximum non-absorbent free solid content of 0.016 pounds per cubic foot (0.25 kilograms per cubic meter), and with a maximum dissolved solid content of 3.1 pounds per cubic foot (50 kilograms per cubic meter), provided that the total gas content of the water does not exceed the saturation volume, and disregarding any additives necessary to prevent the water from freezing at a minimum of 14 °F (-10 °C), as defined at 10 CFR 431.462.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #2B. The scope of this rulemaking will exclude the following varieties of pumps:

- Submersible pumps, defined as a pump that is designed to be operated with the motor and bare pump fully submerged in the pumped liquid; and
- Header pumps, defined as a pump that consists of a circulator-less-volute intended to be installed in an OEM piece of equipment that serves as the volute.
- The consultant team will investigate other characteristics, such as self-priming, to add as exclusions.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Definitions

Recommendation #3A. The following definition captures the intent of the working group and should be adopted as is or as modified in a manner that captures the same intent:

> **Wet rotor circulator pump** means a single stage, rotodynamic, close-coupled, wet rotor pump. Examples include, but are not limited to, pumps generally referred to in industry as CP1.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #3B. The following definitions capture the intent of the working group and should be adopted as is or as modified in a manner that captures the same intent:

Dry rotor, two-piece circulator pump means a single stage, rotodynamic, single-axis flow, close-coupled, dry rotor pump that:

1) has a hydraulic power less than or equal to five horsepower at best efficiency point at full impeller diameter,
2) is distributed in commerce with a horizontal motor, and
3) discharges the pumped liquid through a volute in a plane perpendicular to the shaft.

Examples include, but are not limited to, pumps generally referred to in industry as CP2.

Dry rotor, three-piece circulator pump means a single stage, rotodynamic, single-axis flow, mechanically-coupled, dry rotor pump that:

1) has a hydraulic power less than or equal to five horsepower at best efficiency point at full impeller diameter,
2) is distributed in commerce with a horizontal motor, and
3) discharges the pumped liquid through a volute in a plane perpendicular to the shaft.

Examples include, but are not limited to, pumps generally referred to in industry as CP3.

Where:

Horizontal motor means a motor that requires the motor shaft to be in a horizontal position to function as designed under typical operating conditions, as specified in manufacturer literature.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #3C. The following definition captures the intent of the working group and should be adopted as is or as modified in a manner that captures the same intent:

Small vertical inline pump means a single stage, single-axis flow, dry rotor, rotodynamic pump that:

1) has a shaft input power less than 1 horse power at best efficiency point at full impeller diameter,
2) is distributed in commerce with a motor that does not have to be in a horizontal position to function as designed, and
3) discharges the pumped liquid through a volute in a plane perpendicular to the shaft.

The consultant team will investigate how to exclude "non-circulator" SVIL, typically referred to as utility pumps or water transfer pumps (self-priming, rotodynamic, design, etc)

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #4. The different styles of circulator controls should be defined as follows:

> **External input signal control** means a variable speed drive that adjusts the speed of the driver in response to an input signal from an external logic and/or user interface.
> **Manual speed control** means a control (variable speed drive and user interface) that adjusts the speed of a driver based on manual user input.
> **Pressure control** means a control (variable speed drive and integrated logic) that automatically adjusts the speed of the driver in response to pressure.
> **Temperature control** means a control (variable speed drive and integrated logic) that automatically adjusts the speed of the driver continuously over the driver operating speed range in response to temperature.

The recommended definitions capture the intent of the working group and should be adopted as-written or as modified in a manner that captures the same intent.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Test Procedure and Metric

Recommendation #5. The metric for assessing compliance with the standard for each equipment class should be the Pump Energy Index (PEI_{CIRC}), which is a ratio of the Pump Energy Rating (PER_{CIRC}), for the rated circulator pump model, divided by the $PER_{CIRC,STD}$ for a pump serving the same hydraulic load:

$$PEI_{CIRC} = \left[\frac{PER_{CIRC}}{PER_{CIRC,STD}}\right]$$

The subscripting of PEI_{CIRC} may be modified to account for multiple equipment classes.

The Working Group will decide the value of $PER_{CIRC,STD}$ in the second phase of this negotiation based on subsequent analysis.

Vote results: Consensus (0 'no' votes) on 6/17/2016

Recommendation #6A. For circulators distributed in commerce with temperature controls, pressure controls, or circulators without manual speed controls, pressure controls, temperature controls or external input signal controls, the Pump Energy Rating (PER_{CIRC}) should be representative of the weighted average electric input power to the driver, over a specified load profile for each equipment class and should be calculated as follows:

$$PER_{CIRC} = \sum_i \omega_i (P_{in,i})$$

Where:

- PER_{CIRC} = Pump Energy Rating for Circulators (hp);
- w_i = weight at each test point i (in Recommendation #7);

- $P_{in,i}$ = power input to the driver at each test point i (hp); and
- i = test point(s), defined as 25%, 50%, 75%, and 100% of the flow at best efficiency point (BEP).

The subscripting of PER_{CIRC} may be modified to account for multiple equipment classes.

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #6B. For circulators distributed in commerce with manual speed controls or external input signal controls, the PER_{CIRC} should be calculated as the weighted average of $P_{in,max}$ (the weighted average input power at specific load points across the maximum speed curve) and $P_{in,reduced}$ (the weighted average input power at specific load points at reduced speed), gathered in accordance with Recommendation #9, as shown in the following equations:

$$PER_{CIRC} = z_{max}\left(P_{in_{max}}\right) + z_{reduced}\left(P_{in_{reduced}}\right)$$

Where:

- PER_{CIRC} = Pump Energy Rating for Circulators (hp);
- z_{max} = speed factor for maximum speed (in Recommendation #7);
- P_{in_max} = weighted average input power at maximum rotating speed of the circulator (hp);
- $z_{reduced}$ = speed factor for reduced rotating speeds (in Recommendation #7); and
- $P_{in\_reduced}$ = weighted average input power at reduced rotating speeds of the circulator (hp).

$$P_{in_{max}} = \sum_i \omega_{i_{max}}\left(P_{in,i_{max}}\right)$$

Where:

- P_{in_max} = weighted average input power at maximum speed of the circulator (hp);
- w_{i_max} = weight at each maximum speed test point i (in Recommendation #7);
- P_{in,i_max} = power input to the driver at maximum rotating speed of the circulator at each test point i (hp); and
- i = test point(s), defined as 25%, 50%, 75%, and 100% of the flow at best efficiency point (BEP).

$$P_{in_{reduced}} = \sum_i \omega_{i_{reduced}}\left(P_{in,i_{reduced}}\right)$$

Where:

- $P_{in\_reduced}$ = weighted average input power at reduced speeds of the circulator (hp);
- $w_{i\_reduced}$ = weight at each reduced speed test point i (in Recommendation #7);
- $P_{in,i\_reduced}$ = power input to the driver at reduced rotating speed of the circulator at each test point i (hp); and

- i = test point(s), defined as 25%, 50%, and 75% of the flow at best efficiency point (BEP) of max speed and head values at or above the reference curve (see Recommendation #8 and Recommendation #9).

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #7. The weights used in determining PEI_{CIRC} for each circulator pump configuration should be:

Circulator Pump Configuration	Weight Type	Test Point(s) *i*, in percent of flow at BEP			
		25	50	75	100
Circulator without Temperature Controls, Pressure Controls, External Input Signal Controls, or Manual Speed Controls	Test Point weights (w_i)	0.25	0.25	0.25	0.25
Circulator with Temperature Controls or Pressure Controls*	Load profile weights (w_i)	0.05	0.40	0.40	0.15
Circulator with Manual Speed Controls or External Input Signal Controls*	Max speed weights (w_i)	0.25	0.25	0.25	0.25
	Reduced speed weights (w_i)	0.3333	0.3333	0.3333	0
	Speed factor weights (z_j) for Manual Speed Control	$z_{reduced}$ = 0.25 for reduced speed weighted average driver input power; z_{max} = 0.75 for maximum speed weighted average driver input power			
	Speed factor weights (z_j) for External Input Signal Control	$z_{reduced}$ = 0.70 for reduced speed weighted average driver input power; z_{max} = 0.30 for maximum speed weighted average driver input power			

*Except as specified in Recommendation #9 for external input signal controls

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #8. The reference system curve for circulators with manual speed controls; pressure controls; temperature controls; external input signal controls; or circulators without manual speed controls, pressure controls, temperature controls or external input signal controls is a quadratic function with a fixed head component of 20% BEP head as defined by the following equation:

$$H = \left[0.8 * \left(\frac{Q}{Q_{100\%}}\right)^2 + 0.2\right] * H_{100\%}$$

Where:

- H = the total system head (ft),
- Q = the flow rate (gpm),
- $Q_{100\%}$ = flow rate at 100 percent of BEP flow at max speed (gpm), and
- $H_{100\%}$ = total pump head at 100 percent of BEP flow at max speed (ft).

Vote results: Consensus (0 'no' votes) on 9/7/2016

***Recommendation #9*.** The testing for each type of circulator pump control is to be conducted as follows in accordance with Recommendation #10:

- **Manual speed controls:** test both: (1) along the maximum speed circulator pump curve to achieve the test point flow rates as described in Recommendation #6B for the max speed input power values and (2) based on manual speed adjustment to the lowest speed setting that will achieve a head at or above the reference curve (in Recommendation #8), at the test point flow rates (in Recommendation #6B) for the reduced speed input power values.
- **Pressure controls:** test with automatic speed adjustment based on factory selected control setting or with manual speed adjustment or with simulated pressure signal to trace factory selected control curve setting that will achieve the test point flow rates (in Recommendation #6A) with a head at or above the reference curve described in Recommendation #8. Automatic speed adjusted controls may be manually adjusted to achieve 100% BEP flow and head point at max speed. For adaptive pressure controls, test at the minimum thresholds for head based on manufacturer literature through manual speed adjustment to achieve the test point flow rates (in Recommendation #6A) with head values at or above the reference curve (in Recommendation #8).
    - Manufacturer is able to choose the factory control (curve) logic, when multiple options are available.
    - Manufacturer will report the control (curve) setting used and method of control to DOE with certification reporting
        - Automatic speed adjusted, manual speed adjusted or simulated pressure signal adjusted
        - Control curve used for rating
- **Temperature controls:** test based on manual speed adjustment or with simulated temperature signal to activate the temperature-based control to achieve the test point flow rates (in Recommendation #6A) with a head at or above the reference curve described in Recommendation #8.
- **External input signal control:** test with a simulated signal both: (1) along the maximum speed circulator pump curve to achieve the test point flow rates as described in Recommendation #6B for the max speed input power values and (2) with speed adjustment

using a simulated signal to the lowest speed setting that will achieve a head at or above the reference curve (in Recommendation #8), at the test point flow rates (in Recommendation #6B) for the reduced speed input power values. For circulators that only have an external input signal control and that cannot operate without an external input signal, test along the reference control curve (in Recommendation #8) to achieve the test point flow rates (in Recommendation #6B) with a head at or above the reference curve with the same weights as temperature- and pressure-based controls (in Recommendation #7).

- **No manual speed controls, pressure controls, temperature controls, or external input signal controls:** test along the maximum speed circulator pump curve to achieve the test point flow rates as described in Recommendation #6A

Vote results: Consensus (0 'no' votes) on 9/7/2016

Recommendation #10. All test points discussed in Recommendation #6A and #6B will be tested on a wire-to-water basis, in accordance with HI 40.6-2014. DOE and/or the Working Group may propose minor modifications in order to ensure test repeatability, including:

Addition or Modification	Description
Frequency of Data Collection	Minimum of 2 data points used to determine stabilization; damping devices are only permitted to integrate up to the data collection interval
BEP Speed	Testing at max speed with no adjustment to nominal; may require reporting of max speed
Electrical Measurement Equipment	Use equipment capable of measuring true RMS current, true RMS voltage, and real power up to the 40th harmonic of fundamental supply source frequency with a combined accuracy of ±2.0% of the measured value
Relevant Parameters at Specific Load Points	For single speed circulators, the measured input power and flow data corresponding to the load points from 60% of expected BEP flow to 120% of expected BEP flow be linearly regressed and the input power at the specific load points of 25, 50, 75, and 100% of BEP flow be determined from that regression equation. For circulators with pressure, manual speed, temperature, and external signal controls, all tested flow values must be within ±10% of the target flow load points as specified by the reference system curve. Adjust the measured driver input power to the specified flow and head points, except do not adjust for the head values that are above the reference curve by more than 10%. If the tested head value is below the reference curve by more than 10%, that test point must be retested.
Rounding Values for Calculation and Reporting Purposes	All calculations be performed with the raw measured data, to ensure accuracy, and that the resultant PER_{CIRC} and PEI_{CIRC} be reported to 3 significant figures

Power Supply Characteristics	Must have ±3.0% tolerance on voltage unbalance, ±5.0% on voltage tolerance, ±1.0% on frequency tolerance, and have THD ≤ 12% on voltage waveform distortion

This recommendation captures the intent of the Working Group. If an updated version of HI 40.6 is published prior to publication of the test procedure final rule, DOE will review and incorporate that updated version consistent with the intent of this Working Group recommendation.

Vote results: Consensus (0 ‘no’ votes) 9/7/2016

Recommendation #11. To test twin head circulators, one of the two impeller assemblies is to be incorporated into an adequate, single impeller volute and casing. An adequate, single impeller volute and casing means a volute and casing for which any physical and functional characteristics that affect energy consumption and energy efficiency are essentially identical to their corresponding characteristics for a single impeller in the twin head circulator volute and casing.

Vote results: Consensus (0 ‘no’ votes) on 6/17/2016

Recommendation #12. To test circulators-less-volute, pair the circulator-less-volute with specific volute(s) with which the circulator is advertised to be paired, based on manufacturer’s literature, to determine the PEI rating for each circulator-less-volute and volute combination.

Vote results: Consensus (0 ‘no’ votes) on 9/7/2016

Non-Binding Recommendation to the Secretary #1. Voluntary reporting of true RMS current, true RMS voltage, real power, and the resultant power factor value at the measured data points closest to the specified load points described in Recommendation #6A and Recommendation #6B for the applicable circulator variety.

Vote results: Consensus (0 ‘no’ votes) on 6/17/2016

Non-Binding Recommendation to the Secretary #2. For header pumps distributed in commerce with regulated equipment, DOE should consider modifying the test procedure and metric for such regulated equipment during their next round of applicable rulemakings to account for the energy use of header pumps in a modified metric. For header pumps distributed in commerce with non-regulated equipment, DOE should consider test procedures and standards for such pumps or equipment at a later date.

Vote results: Consensus (0 ‘no’ votes) on 9/7/2016

This term sheet has been approved by the ASRAC Circulator Pumps working group by consensus (1 ‘no’ vote) on 09/7/2016.

Appendix A—Members

U.S. Department of Energy—ASRAC

Circulator Pumps Negotiated Rulemaking Working Group

Name	**Affiliation**	**Alternate**
Charles White	Plumbing-Heating-Cooling Contractors Association	Mark Riso
Gabor Lechner	Armstrong Pumps, Inc.	Brent Ross
Gary Fernstrom	California Investor-Owned Utilities	David Jagger
Joanna Mauer	Appliance Standards Awareness Project	Andrew deLaski
Joe Hagerman	U.S. Department of Energy	Ashley Armstrong
Laura Petrillo-Groh	Air-Conditioning, Heating, and Refrigeration Institute	Frank Stanonik
Lauren Urbanek	Natural Resources Defense Council	Rachel Fakhry
Mark Chaffee	TACO, Inc.	Steve Thompson
Mark Handzel	Xylem Inc.	Jack Kang
Peter Gaydon	Hydraulic Institute	Michael Michaud
Richard Gussert	Grundfos Americas Corporation	Kirk Vigil
David Bortolon	Wilo Inc.	Don Kahn
Russell Pate	Rheem Manufacturing Company	Karen Meyers or Robert Glass
Don Lanser	Nidec Motor Corporation	John Filla
Tom Eckman	Northwest Power and Conservation Council (ASRAC member)	N/A