[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

[Docket No. EERE-2013-BT-TP-0055]

RIN: 1905-AD50

Energy Conservation Program: Test Procedure for Pumps

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Notice of proposed rulemaking and public meeting.

SUMMARY: The U.S. Department of Energy (DOE) proposes to establish a new test procedure for pumps. Specifically, DOE is proposing a test method for measuring the hydraulic power, shaft power, and electric input power of pumps, inclusive of electric motors and any continuous or non-continuous controls. The proposal, if adopted, would incorporate by reference the test procedure from the Hydraulic Institute (HI) -- Standard 40.6–2014, "Methods for Rotodynamic Pump Efficiency Testing." The proposed test procedure would be used to determine the constant load pump energy index (PEI_{CL}) for pumps sold without continuous or non-continuous controls or the variable load pump energy index (PEI_{VL}) for pumps sold with continuous or non-continuous controls. The PEI_{CL} and PEI_{VL} describe the power consumption of the rated pump, inclusive of an electric motor and, if applicable, any integrated continuous or non-continuous controls,

normalized with respect to the performance of a minimally compliant pump for each pump basic model. The proposal reflects certain recommendations made by a stakeholder Working Group for pumps established under the Appliance Standards Rulemaking Federal Advisory Committee (ASRAC). DOE is also announcing a public meeting to discuss and receive comments on issues presented in this notice of proposed rulemaking (NOPR).

DATES: DOE will hold a public meeting on Wednesday, April 29, 2015, from 9:00 a.m. to 1:00 p.m., in Washington, DC. The meeting will also be broadcast as a webinar. See section IV.M, "Public Participation," for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

DOE will accept comments, data, and information regarding this NOPR before and after the public meeting, but no later than [**INSERT DATE 75 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**]. See section IV.M, "Public Participation," for details.

ADDRESSES: The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 4A-104, 1000 Independence Avenue, SW., Washington, DC 20585. To attend, please notify Ms. Brenda Edwards at (202) 586-2945.

Persons can attend the public meeting via webinar. For more information, refer to the Public Participation section near the end of this proposed rule.

Comments may be submitted using any of the following methods:

1. Federal eRulemaking Portal: www.regulations.gov. Follow the instructions for submitting comments.
2. E-mail: Pumps2013TP0055@ee.doe.gov. Include the docket number and/or RIN in the subject line of the message.
3. Mail: Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, Mailstop EE-2J, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. If possible, please submit all items on a CD. It is not necessary to include printed copies.
4. Hand Delivery/Courier: Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza, SW., Suite 600, Washington, DC, 20024. Telephone: (202) 586-2945. If possible, please submit all items on a CD. It is not necessary to include printed copies.

For detailed instructions on submitting comments and additional information on the rulemaking process, see section IV.M of this document ("Public Participation").

Docket: The docket, which includes Federal Register notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at regulations.gov. All documents in the docket are listed in the regulations.gov index. However, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

A link to the docket webpage can be found at: http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/14. This webpage will contain a link to the docket for this notice on the regulations.gov site. The regulations.gov webpage will contain simple instructions on how to access all documents, including public comments, in the docket. See section IV.M for information on how to submit comments through regulations.gov.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact Ms. Brenda Edwards at (202) 586-2945 or by email: Brenda.Edwards@ee.doe.gov.

FOR FURTHER INFORMATION CONTACT:

Ms. Ashley Armstrong, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-6590. E-mail: ashley.armstrong@ee.doe.gov.

Michael Kido, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-8145. E-mail: Michael.kido@hq.doe.gov.

SUPPLEMENTARY INFORMATION:

Incorporation by reference under 1 CFR part 51

DOE proposes to incorporate by reference the following industry standards into 10 CFR part 431:

(1) ANSI/HI Standard 1.1-1.2, ("ANSI/HI 1.1-1.2–2014"), "Rotodynamic (Centrifugal) Pumps For Nomenclature And Definitions;" approved 2014, sections 1.1, "Types and nomenclature," and 1.2.9, "Rotodynamic pump icons."

(2) ANSI/HI Standard 2.1-2.2, ("ANSI/HI 2.1-2.2–2008 "), "Rotodynamic (Vertical) Pumps For Nomenclature And Definitions," approved 2008, section 2.1, "Types and nomenclature."

(3) HI 40.6–2014, ("HI 40.6–2014"), "Methods for Rotodynamic Pump Efficiency Testing," except for section 40.6.5.3, "Test report;" section A.7, "Testing at temperatures exceeding 30 °C (86 °F);" and appendix B, "Reporting of test results," approved 2014.

Copies of ANSI/HI 1.1-1.2–2014, ANSI/HI 2.1-2.2–2008 and HI 40.6–2014 can be obtained from: the Hydraulic Institute at 6 Campus Drive, First Floor North, Parsippany, NJ, 07054-4406, or by going to www.pumps.org.

(4) FM Class Number 1319, "Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type)," approved October 2008.

Copies of FM Class Number 1319 can be obtained from: Factory Mutual. 270 Central Avenue Johnston, RI 02919, 401-275-3000. www.fmglobal.com/

(5) NFPA Standard 20-2013, “Standard for the Installation of Stationary Pumps for Fire Protection,” approved 2013.

Copies of NFPA Standard 20-2013 can be obtained from: the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169, 617-770-3000. www.nfpa.org.

(6) UL Standard 448-2007, “Centrifugal Stationary Pumps for Fire-Protection Service,” approved 2007.

Copies of UL Standard 448-2007 can be obtained from: the Underwriters Laboratory, 333 Pfingsten Road, Northbrook, IL 60062. http://ul.com/

Also, this material is available for inspection at U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586-2945, or go to http://www1.eere.energy.gov/buildings/appliance_standards/.

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I. Authority and Background

Pumps are included in the list of "covered equipment" for which DOE is authorized to establish and amend energy conservation standards and test procedures. DOE does not currently regulate the energy efficiency of this equipment or have test procedures to measure the efficiency of such equipment. The following sections discuss DOE's authority to establish test procedures for pumps and relevant background information regarding DOE's consideration of test procedures for this equipment.

A. Authority

The Energy Policy and Conservation Act of 1975 (EPCA), Pub. L. 94-163, as amended by Pub. L. 95-619, Title IV, Sec. 441(a), established the Energy Conservation Program for Certain Industrial Equipment under Title III, Part C. (42 U.S.C. 6311–6317, as codified).[1] Included among the various types of industrial equipment addressed by EPCA are pumps, the subject of today's notice. (42 U.S.C. 6311(1)(A)) All references to EPCA refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Pub. L. 112-210 (Dec. 18, 2012).

[1]For editorial reasons, upon codification in the U.S. Code, Part C was re-designated Part A-1.

Under EPCA, the energy conservation program consists essentially of four parts: (1) testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. The testing requirements consist of test procedures that manufacturers of covered equipment must use as the basis for (1) certifying to DOE that their equipment complies with the applicable energy conservation standards adopted under EPCA, (42 U.S.C. 6295(s) and 6316(a)(1)), and (2) making representations about the energy consumption of that equipment. (42 U.S.C. 6314(d))

General Test Procedure Rulemaking Process

EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered equipment. EPCA provides, in relevant part, that any test procedures prescribed or amended under this section shall be reasonably designed to produce test results that measure energy efficiency, energy use, or estimated annual operating cost of covered equipment during a representative average use cycle or period of use and shall not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2))

In addition, before prescribing any final test procedures, DOE must publish proposed test procedures and offer the public an opportunity to present oral and written comments on them. (42 U.S.C. 6314(b)(1)-(2))

DOE is authorized to prescribe energy conservation standards and corresponding test procedures for statutorily-covered equipment such as pumps. While DOE is currently evaluating whether to establish energy conservation standards for pumps, (Docket No.

EERE-2011-BT-STD-0031), DOE must first establish a test procedure that measures the energy use, energy efficiency, or estimated operating costs of a given type of covered equipment before establishing any new energy conservation standards for that equipment. See generally 42 U.S.C. 6295(r) and 6316(a)

To fulfill these requirements, DOE is proposing to establish a test procedure for pumps concurrent with its ongoing energy conservation standards rulemaking for this equipment. See Docket No. EERE-2011-BT-STD-0031. The test procedure, if adopted, would include the methods necessary to: (1) measure the performance of the covered equipment; and (2) use the measured results to calculate a pump energy index (PEI_{CL} for pumps sold without continuous or non-continuous controls or PEI_{VL} for pumps sold with continuous or non-continuous controls) to represent the power consumption of the pump, inclusive of a motor[2] and any continuous or non-continuous controls, normalized with respect to the performance of a minimally compliant pump. DOE is also proposing to set the scope of those pumps to which the proposed test method would apply. DOE's proposals reflect certain recommendations made by a stakeholder Working Group for pumps established under the Appliance Standards Rulemaking Federal Advisory Committee (ASRAC), which is discussed further in section I.B. This group consisted of a wide variety of interested parties with a diverse set of interests with respect to pump efficiency.

[2] DOE is proposing to include pumps sold with all electric motors except single-phase induction motors in the scope of this rulemaking. The terms "motor" and "electric motor" are used synonymously and interchangeably in this document to refer to those motors to which the proposed test procedure would apply (i.e., all electric motors except single-phase induction motors). See section III.A.6.

If adopted, manufacturers would be required to use the proposed test procedure and metric when making representations regarding the energy use of covered equipment 180 days after the publication date of any applicable energy conservation standards final rule for those pumps that are addressed by the test procedure. See Docket No. EERE-2011-BT-STD-0031). See also 42 U.S.C. 6314(d)

B. Background

DOE does not currently regulate pumps. In 2011, DOE issued a Request for Information (RFI) to gather data and information related to pumps in anticipation of initiating rulemakings to formally consider test procedures and energy conservation standards for this equipment. 76 FR 34192 (June 13, 2011). In February 2013, DOE published a Notice of Public Meeting and Availability of the Framework Document to initiate the energy conservation standard rulemaking for pumps. 78 FR 7304 (Feb. 1, 2013). DOE posted the February 2013 Framework Document ("Framework Document") to its website.[3] In the Framework Document, DOE requested feedback from interested parties on how to test pump efficiency. DOE held a public meeting to discuss the Framework Document on February 20, 2013 (the "Pumps Framework Public Meeting"). While the comment period had been scheduled to close on March 18, 2013, DOE extended the comment period to May 2, 2013, to allow commenters sufficient time to formulate responses to the large number and broad scope of questions and issues raised

[3] www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/14

by DOE in the Framework Document. See 78 FR 11996 (Feb. 21, 2013). DOE received 12 comments in response to the Framework Document.

Concurrent with these efforts, DOE also began a process through the ASRAC to discuss conducting a negotiated rulemaking to develop standards and test procedures for pumps as an alternative to the route DOE had already begun. (Docket No. EERE-2013-BT-NOC-0039)[4] On July 23, 2013, DOE published a notice of intent to establish a negotiated rulemaking working group for commercial and industrial pumps ("CIP Working Group" or, in context, "Working Group") to negotiate, if possible, Federal standards for the energy efficiency of commercial and industrial pumps. 78 FR 44036. On November 12, 2013, DOE published a notice to announce the first meeting of the CIP Working Group and listed the 14 nominees that were selected to serve as members of the Working Group, in addition to one member from ASRAC and one DOE representative. 78 FR 67319. The members of the Working Group were selected to ensure a broad and balanced array of stakeholder interests and expertise, including representatives from efficiency advocacy organizations, manufacturers, and a utility (representing a user of pumps). Table I.1 lists the members and their affiliations.

[4] Information on the ASRAC, about the commercial and industrial pumps working group, and about meeting dates is available at http://energy.gov/eere/buildings/appliance-standards-and-rulemaking-federal-advisory-committee.

Table I.1 ASRAC Pump Working Group Members and Affiliations

Member	Affiliation
Lucas Adin	U.S. Department of Energy
Tom Eckman	Northwest Power and Conservation Council (ASRAC Member)
Robert Barbour	TACO, Inc.
Charles Cappelino	ITT Industrial Process
Greg Case	Pump Design, Development and Diagnostics
Gary Fernstrom	Pacific Gas & Electric Company, San Diego Gas & Electric Company, Southern California Edison, and Southern California Gas Company
Mark Handzel	Xylem Corporation
Albert Huber	Patterson Pump Company
Joanna Mauer	Appliance Standards Awareness Project
Doug Potts	American Water
Charles Powers	Flowserve Corporation, Industrial Pumps
Howard Richardson	Regal Beloit
Steve Rosenstock	Edison Electric Institute
Louis Starr	Northwest Energy Efficiency Alliance
Greg Towsley	Grundfos USA
Meg Waltner	Natural Resources Defense Council

The Working Group commenced negotiations at an open meeting on December 18 and 19, 2013, and held six additional meetings and two webinars to discuss scope, metrics, test procedures, and standard levels for pumps.[5] The CIP Working Group concluded its negotiations on June 19, 2014, with a consensus vote to approve a term sheet containing recommendations to DOE on appropriate standard levels for pumps as well as recommendations addressing issues related to the metric and test procedure for pumps ("Working Group Recommendations").[6] The term sheet containing the Working Group Recommendations is available in the CIP Working Group's docket. (Docket No. EERE-2013-BT-NOC-0039, No. 92) ASRAC subsequently voted unanimously to approve the Working Group Recommendations during a July 7 2014 webinar.

[5] Details of the negotiation sessions can be found in the public meeting transcripts that are posted to the docket for the Working Group (http://www.regulations.gov/#!docketDetail;D=EERE-2013-BT-NOC-0039).

[6] The ground rules of the CIP Working Group define consensus as no more than two (2) negative votes. (Docket No. EERE-2013-BT-NOC-0039, No. 18 at p. 2) Concurrence was assumed if absent, and overt dissent evidenced by a negative vote. Abstention was not construed as a negative vote. In this NOPR, only negative votes are discussed.

Those recommendations regarding issues pertinent to the test procedure and standard metric are addressed in this NOPR and reflected in DOE’s proposed pump test procedure. In this NOPR, DOE also refers to discussions from the CIP Working Group meetings regarding potential actions that may not have been formally approved as an addition to the Working Group Recommendations. All references to approved recommendations will be specified with a citation to the Working Group Recommendations and noting the recommendation number (for example: Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #X at p. Y); references to discussion or suggestions of the CIP Working Group not found in the Working Group Recommendations will have a citation to meeting transcripts (for example: Docket No. EERE-2013-BT-NOC-0039, No. X at p. Y).

DOE notes that many of those who submitted comments on the Framework Document later became members of the CIP Working Group. As such, the concerns of these commenters were fully discussed as part of the meetings, and their positions may have changed as a result of the compromises inherent in a negotiation. The proposals in this NOPR incorporate and respond to several issues and recommendations that were raised in response to the Framework Document. However, where a framework commenter became a member of the CIP Working Group, DOE does not reference or respond to comments made by that stakeholder regarding issues that were later discussed or negotiated in the CIP Working Group. Table I.2 lists the framework commenters as well as whether they participated in the CIP Working Group.

Table I.2 List of Framework Commenters

Commenter	Member of the CIP Working Group
Engineered Software, Inc.	No
Richard Shaw	No
Grundfos Pumps Corporation	Yes
Hydraulic Institute (HI)	Yes
Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Gas Company, and Southern California Edison (collectively, "the CA IOUs")	Yes
National Fire Protection Association (NFPA)	No
Air-Conditioning, Heating, and Refrigeration Institute (AHRI)	No
Colombia Engineering	No
Earthjustice	No
Edison Electric Institute (EEI)	Yes
The Appliance Standards Awareness Project (ASAP), Alliance to Save Energy (ASE), American Council for an Energy Efficient Economy (ACEEE), Earthjustice, and Natural Resources Defense Council (NRDC) (collectively, "the Advocates")	ASAP and NRDC
Northwest Energy Efficiency Alliance and the Northwest Power and Conservation Council (collectively, "NEEA/NPCC")	Yes

II. Synopsis of the Notice of Proposed Rulemaking

DOE is proposing to establish a new subpart Y to part 431 of Title 10 of the Code of Federal Regulations that would contain definitions and a test procedure applicable to pumps. Today's NOPR also contains related proposals for sampling plans for the purposes of demonstrating compliance with any energy conservation standards for pumps that DOE adopts. As part of the test procedure, DOE proposes to prescribe test methods for measuring the energy consumption of pumps, inclusive of motors and controls (continuous or non-continuous), if they are included with the pump when distributed in commerce. To do this, DOE's proposed test procedure includes measurements and calculations of the produced hydraulic power, pump shaft input power, electric input power to the motor, and electrical input power to the continuous or non-continuous controls, as applicable.

Consistent with the Working Group Recommendations, DOE proposes that these test methods be in accordance with HI Standard 40.6–2014, "Methods for Rotodynamic Pumps Efficiency Testing," ("HI 40.6–2014"), with slight modifications as noted in section III.C.2. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #10 at p. 4) Members of the pumps industry developed HI 40.6–2014, which contains methods for determining the energy performance of rotodynamic pumps without accounting for the impact of continuous or non-continuous controls. HI 40.6-2014 was developed following DOE's announcement in the Framework Document that DOE planned to develop a test procedure for pumps. In this NOPR, DOE also proposes to include testing and calculation methods to account for the energy performance of pumps sold with motors and continuous or non-continuous controls. DOE has reviewed HI 40.6–2014 and finds, for the reasons stated below and in detail in section III, that the procedure would be likely to produce test results that would reflect the energy efficiency, energy use, and estimated operating costs of a pump during a representative average use cycle. (42 U.S.C. 6314(a)(2)) DOE also has reviewed the burdens associated with conducting the proposed test procedure, including HI 40.6–2014 and, based on the results of such analysis, finds the proposed test procedure would not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2)) DOE's analysis of the burden associated with the proposed test procedure is presented in detail in section IV.B.

DOE's approach, which is consistent with the Working Group's recommendations, proposes to use a new metric, the pump energy index (PEI), to rate the energy performance of pumps covered by this proposed test procedure. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #11 at p. 5) The proposed test procedure contains methods for determining the constant load PEI (PEI_{CL}) for pumps sold without continuous or non-continuous controls and the variable load PEI (PEI_{VL}) for pumps sold with either continuous or non-continuous controls. The PEI_{CL} or PEI_{VL}, as applicable, describes the weighted average performance of the rated pump, inclusive of any motor and, if included, continuous or non-continuous controls, at specific load points, normalized with respect to the performance of a minimally compliant pump without controls. These indices, if adopted, would provide a representative measurement of the energy consumption of the rated pump under expected conditions of use since they are inclusive of a motor and any continuous or non-continuous controls at full and partial loading. The indices would also describe the performance of the rated pump in comparison to a minimally compliant pump of the same equipment class with no controls (see section III.A.2 for a discussion of pump equipment classes) and provide a description of a covered pump's energy performance that can be readily interpreted and used by customers and the market.

The proposed test procedure contains methods to determine the appropriate index for all equipment for which this test procedure would apply using either calculation-based methods and/or testing-based methods. While both methods include some amount of testing and some amount of calculation, the terms "calculation-based" and "testing-based" are used to distinguish between methods in which the input power to the pump is determined either by (a) measuring the pump shaft input power[7] and combining it with the efficiency, or losses, of the motor and any continuous control[8] at specific load points using an algorithm (i.e., calculation-based method) or (b) measuring the input power to the driver,[9] or motor, and any continuous or non-continuous controls[10] for a given pump directly at each of the load points (i.e., testing-based method). In both cases, the results for the given pump are divided by the calculated input power to the motor for a hypothetical pump (sold without a motor or controls) that serves an identical hydraulic load and minimally complies with any energy conservation standards that DOE may set as a result of the ongoing standards rulemaking. (Docket No. EERE-2011-BT-STD-0031) This normalized metric would effectively result in a value that is indexed to the standard (i.e., a value of 1.0 for a pump that is minimally compliant, and a value less than 1.0 for a pump that is less consumptive than the maximum the standard allows).

DOE notes that the calculation-based method discussed in section III.E.1 would only apply to certain pumps: (1) pumps sold without either a motor or controls (i.e., "bare pump," discussed later in section III.A.1.a), (2) pumps sold with motors that are subject to DOE's energy conservation standards for electric motors (with or without continuous controls), and (3) pumps sold with submersible motors (with or without continuous

[7] The term "pump shaft input power" is referred to as "pump power input" in HI 40.6-2014. The term "pump shaft input power" is used synonymously with that term in this document.
[8] DOE notes that for non-continuous controls, as defined in section III.E.1.c, PEI_{VL} can only be determined using a "testing-based" method. If a calculation-based method is desired, the pump would instead be rated as a pump sold with a motor and without speed controls using the PEI_{CL} metric. See section III.E.1.c for further discussion.
[9] The input power to the driver is referred to as "driver power input" in HI 40.6-2014. The term "input power to the driver" is used synonymously with that term in this document.
[10] In the case that a pump is sold with a motor equipped with either continuous or non-continuous controls and is rated using the testing-based method, the input power to the pump would be determined as the input power to the continuous or non-continuous control. See section III.E.2.c.

controls). This is because for other pumps, the necessary efficiency information is not available in a standardized, referenceable format and the assumptions inherent in the calculation-based approach do not apply. Specifically, for pumps sold with motors that are not subject to DOE's energy conservation standards for electric motors, except submersible motors, DOE has not established standards or default values for the nominal full load efficiency that can be used in the calculations. For pumps sold with any motors (i.e., covered, uncovered, or submersible motors) and non-continuous controls, the reference system curve is not applicable (see section III.E.1.c for more information). Under DOE's proposal, such pumps would be required to be tested using the testing-based methods discussed in section III.E.2. Conversely, only the proposed calculation-based method could be used to test a pump sold without a motor or controls because a PEI rating (which includes the efficiency of the motor) could not be determined based on a test of the pump without a motor. The specific test methods applicable to each class and configuration of pump model are described in more detail in section III.E.3.

DOE also proposes to establish requirements regarding the sampling plan and representations for covered pumps at subpart B of part 429 of Title 10 of the Code of Federal Regulations. The proposed sampling plan requirements are similar to those for several other types of commercial equipment and are appropriate for pumps based on the expected range of measurement uncertainty and manufacturing tolerances for this equipment. Regarding representations, for those pumps addressed by this proposal, DOE is also specifying the energy consumption or energy efficiency representations that may be made, in addition to the regulated metric (PEI_{CL} or PEI_{VL}).

DOE notes that equipment meeting the proposed pump definition is already covered equipment. However, DOE's proposal is more narrowly applied to a specific scope of pumps. Specifically, this proposal would apply to the limited scope of rotodynamic pumps[11] for which standards are being considered in DOE's energy conservation standards rulemaking and as proposed in section III.A of this NOPR. (Docket No. EERE-2011-BT-STD-0031) Manufacturers of those pumps that would be regulated as a result of DOE's parallel test procedure and standards rulemakings would be required to use the test procedure DOE adopts when certifying compliance with any applicable standard and when making representations about the efficiency or energy use of their equipment. (42 U.S.C. 6314(d))

Starting on the compliance date for any energy conservation standards that DOE may set, and assuming that the provisions of this NOPR are adopted, all pumps within the scope of those energy conservation standards would be required to be tested in accordance with the proposed subpart Y of part 431 and must have their testing performed in a manner consistent with the applicable sampling requirements. Similarly, all representations regarding the energy efficiency or energy use of pumps within the scope of pumps proposed for coverage by this test procedure would be required to be made based on the adopted pump test procedure 180 days after the publication date of

[11] A rotodynamic (or centrifugal) pump is a kinetic machine that continuously imparts energy to the pumped fluid by means of a rotating impeller, propeller, or rotor. This is in contrast to positive-displacement pumps, which have an expanding cavity on the suction side and a decreasing cavity of the discharge side that move a constant volume of fluid for each cycle of operation. DOE is proposing limiting the scope of the test procedure to only specific kinds of rotodynamic pumps.

any final rule establishing energy conservation for those pumps that are addressed by the test procedure. See 42 U.S.C. 6314(d).

III. Discussion

DOE's proposal would place a new pump test procedure and related definitions in a new subpart Y of part 431, and add new sampling plans and reporting requirements for this equipment in a new section 429.59 of 10 CFR part 429. This proposed subpart Y would contain definitions, materials incorporated by reference, and the test procedure for certain classes and configurations of pumps established as a result of this rulemaking, as well as any energy conservation standards for pumps resulting from the ongoing energy conservation standard rulemaking, as shown in Table III.1. (Docket No. EERE-2011-BT-STD-0031)

Table III.1. Summary of Proposals in this NOPR, their Location within the Code of Federal Regulations, and the Applicable Preamble Discussion

Location	Proposal	Summary of Additions	Applicable Preamble Discussion
10 CFR 429.59*	Sampling Plan	Number of pumps to be tested to rate a pump basic model and calculation of rating	Section III.G
10 CFR 431.461	Purpose and Scope	Scope of pump regulations, as well as the proposed test procedure and associated energy conservation standard	Section III.A
10 CFR 431.462	Definitions	Definitions pertinent to establishing equipment classes and testing applicable classes of pumps	Section III.A
10 CFR 431.463	Incorporation by Reference	Description of industry standards incorporated by reference in the DOE test procedure or related definitions	Section III.A and III.C
10 CFR 431.464 and Appendix A to Subpart Y of Part 431	Test Procedure	Instructions for determining the PEI_{CL} or PEI_{VL} for applicable classes of pumps	Section III.B, III.C, III.D, and III.E
10 CFR 431.466	Energy Conservation Standards	Energy conservation standard for applicable classes of pumps, in terms of PEI and associated C-Value	Section **Error! Reference source not found.** and Docket EERE-2011-BT-STD-0031

* Note: DOE also proposes minor modifications to 10 CFR 429.2; 429.11(a) and (b); 429.70; 429.72; and 429.102 to apply the general sampling requirements established in these sections to the equipment-specific sampling requirements proposed for pumps at 10 CFR 429.59.

The following sections discuss DOE's proposals regarding establishing new testing and sampling requirements for pumps, including:

1) scope;
2) rating metric;
3) determination of pump performance;
4) determination of motor efficiency;
5) test methods for different combinations of pumps and drivers and controls;
6) representations; and
7) sampling plans.

A. Scope

Although a "pump" is listed as a type of covered equipment under EPCA, that term is undefined. See 42 U.S.C. 6311(1)(A). As part of its collective efforts to help DOE craft an appropriate regulatory approach for pumps, the CIP Working Group made a series of recommendations regarding a variety of potential definitions that would have an impact on the overall scope and structure of the proposed test procedure and related energy conservation standards. In particular, the Working Group offered a definition for "pump" along with other related terms "bare pump," "mechanical equipment," "driver," and "controls." Each of these terms relate to particular pump components that are germane to DOE's efforts to set standards and establish a test procedure for this equipment. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendations #1 and 2 at pp. 1-2) Accordingly, DOE proposes to adopt these recommended definitions for these terms.

DOE notes that while the proposed definition of "pump" is broad, the scope of prospective energy conservation standards, as recommended by the Working Group, would be limited to a more narrow range of equipment. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendations #4 and 6-8 at pp. 2-4) DOE also notes that the scope of this proposed test procedure is intended to be consistent with the scope of the parallel standards rulemaking effort currently under evaluation. In other words, DOE proposes that only pumps subject to an energy conservation standard would have to be tested in accordance with the adopted test procedure. Finally, DOE notes that the broad definition of "pump" being considered in this proposal would provide DOE with flexibility to make any necessary adjustments to its regulations to address potential scoping changes in the future that DOE may consider.

After considering the Working Group Recommendations, DOE is proposing to define which pumps would need to be tested with the proposed test procedure by applying three criteria: (1) the equipment class; (2) the application; and (3) applicable performance specifications—i.e., horsepower (hp), flow rate, head, design temperature, and speed restrictions. For these three areas, DOE's proposed criteria for establishing which pumps would be subject to the proposed test procedure are discussed in sections III.A.2, III.A.3, and III.A.4, respectively.

DOE requests comment on its proposal to match the scopes of the pump test procedure and energy conservation standard rulemakings, as recommended by the Working Group.

1. Definitions Related to the Scope of Covered Pumps

To help set the scope for this proposal and the manner in which both the procedure and related standards would be applied to different pump configurations and classes of pumps, the aforementioned definitions for pump, certain pump components, and others, are discussed in the following subsections.

a. Pumps and Related Components

DOE proposes to include definitions in a new 10 CFR 431.462 that would describe the components comprising a pump for scoping purposes. Consistent with the intent of the Working Group Recommendations, DOE proposes to define the following terms:

1) Pump means equipment that is designed to move liquids (which may include entrained gases, free solids, and totally dissolved solids) by physical or mechanical action and includes at least a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, driver and controls.
2) Bare pump means a pump excluding mechanical equipment, driver, and controls.
3) Mechanical equipment means any component of a pump that transfers energy from a driver to the bare pump.
4) Driver means the machine providing mechanical input to drive a bare pump directly or through the use of mechanical equipment. Examples include, but are not limited to, an electric motor, internal combustion engine, or gas/steam turbine.
5) Control means any device that can be used to operate the driver. Examples include, but are not limited to, continuous or non-continuous speed controls, schedule-based controls, on/off switches, and float switches.

(Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendations #1-2 at pp. 1-2)

DOE notes that, while there was consensus among the members of the Working Group in favor of these definitions as part of the entirety of the Working Group Recommendations, there was one Working Group member who specifically objected to the "pump" definition that the Working Group developed,[12] see Recommendation #1.

DOE requests comment on the proposed definitions for "pump," "bare pump," "mechanical equipment," "driver," and "control."

b. Definition of Categories of Controls

The definition of "control" proposed by DOE and recommended by the CIP Working Group is broad. DOE acknowledges the proposed definition may be include many different kinds of electronic or mechanical devices that can "control the driver" of a pump (e.g., continuous or non-continuous speed controls, timers, and on/off switches). These various controls may use a variety of mechanisms to control the pump for operational reasons, which may or may not result in reduced energy consumption.

For this proposed test procedure, DOE is focusing on those controls that reduce energy consumption—i.e., controls that reduce pump power input at a given flow rate. As discussed by the CIP Working Group, DOE understands that speed controls achieve this goal and are the most common kind of control currently applied to pumps. After carefully examining the pump market, DOE has not found any mechanisms for controlling pump

[12] The voting procedures and consensus requirements agreed upon by the CIP Working Group did not require identification of the individual opposing or their reason for opposition and so is not noted in the transcript for that public meeting. (See ground rules: Docket No. EERE-2013-BT-NOC-0039, No. 18; and the public meeting transcript: Docket No. EERE-2013-BT-NOC-0039, No. 46 at p.165)

drivers that would reduce pump power input at a given flow other than those mechanisms used to control the driver's rotating speed. Consistent with this finding, DOE's proposal to establish test methods for those configurations in which a bare pump is configured with motors that have been paired with controls would address only such configurations using speed controls. Similarly, DOE also proposes that the PEI_{VL} metric would only apply to pumps sold with motors and speed controls. Conversely, pumps sold with motors and controls other than speed controls would be subject to the appropriate bare pump and motor test procedures and rated using PEI_{CL}.

To explicitly establish the kinds of controls that can apply the PEI_{VL} metric, DOE would define the terms "continuous" and "non-continuous" control (see section III.B.2 and III.E.3 for further discussion of the PEI_{VL} rating metric and its applicability to pumps with controls, respectively):

(1) Continuous control means a control that adjusts the speed of the pump driver continuously over the driver operating speed range in response to incremental changes in the required pump flow, head, or power output.[13] As an example, variable speed drives, including variable frequency drives and electronically commutated motors (ECMs) would meet the definition for continuous controls.

(2) Non-continuous control means a control that adjusts the speed of a driver to one of a discrete number of non-continuous preset operating speeds, and does not respond

[13] HI-40.6, as incorporated by reference, defines pump power output as "the mechanical power transferred to the liquid as it passes through the pump, also known as pump hydraulic power."

to incremental reductions in the required pump flow, head, or power output. As an example, multi-speed motors such as 2-speed motors would meet the definition for non-continuous controls.

While the proposed PEI_{VL} test procedure would only apply to pumps sold with continuous and non-continuous controls, DOE recognizes that including a broader definition of "control" provides the flexibility to address additional kinds of controls in future test procedure revisions, as was discussed in the CIP Working Group. (EERE-2013-BT-NOC-0039, No. 46 at pp. 179-85) To retain this flexibility, DOE proposes to maintain the broad definition of control presented above, which would include any device that operates a pump driver, regardless of its impact on energy consumption or rotational speed of the driver. However, pumps with a motor and controls that do not meet the proposed definitions of continuous or non-continuous controls would be required to be tested as a pump sold with a motor under the proposed test procedure.

DOE also notes that the definitions of continuous and non-continuous controls do not require the control to include the necessary sensors and feedback logic to automatically respond to changes in the required flow, head, or pump power output. DOE recognizes that such continuous or non-continuous controls (e.g., variable speed drives (VSDs) or multi-speed motors, respectively) will not reduce energy consumption unless some feedback is provided regarding the process requirements at any given time. However, DOE understands that many applications use such controls as part of a larger process or facility-wide energy management system. Similarly, such feedback sensors and control logic may also be custom-designed based on an application's specific design requirements. Consequently, while sensors and logic to enable automatic feedback and response of any speed control are available from pump manufacturers, they are not always required by, or included in, a given pump at the time of sale.

In summary, by not requiring continuous or non-continuous controls to be automatically actuating when distributed in commerce, DOE seeks to limit the costs and burdens of adding continuous or non-continuous controls to a given pump. Furthermore, DOE believes that the incremental cost of any continuous or non-continuous control is sufficiently high, making it extremely unlikely that a customer would buy a pump with such controls and not employ appropriate and application-specific sensors and feedback logic to achieve energy savings. As such, DOE is proposing to define continuous and non-continuous controls as devices that "adjust the speed" of the driver without requiring that adjustment to happen automatically.

DOE requests comment on the proposed definitions for "continuous control" and "non-continuous control."

DOE also requests comment on the likelihood of a pump with continuous or non-continuous controls being distributed in commerce, but never being paired with any sensor or feedback mechanisms that would enable energy savings.

c. Definition of Basic Model

In the course of regulating consumer products and commercial and industrial equipment, DOE has developed the concept of a "basic model" to determine the specific product or equipment configuration(s) to which the regulations would apply. For the purposes of applying the proposed pumps regulations, DOE is also proposing to define what constitutes a "basic model" of pump. Applying this basic model concept would allow manufacturers to group similar models within a basic model to minimize testing burden. In other words, manufacturers would need to test only a representative number of units of a basic model in lieu of testing every model they manufacture. By grouping models together, a manufacturer would be able to test a smaller number of units. However, manufacturers would need to make this decision with the understanding that there is increased risk associated with these groupings due to the potential for a wider impact from a noncompliance finding. Basic model groupings increase this risk because, if DOE determines a basic model is noncompliant, all models within the basic model are determined to be noncompliant.

In keeping with this practice, DOE also proposes to define a "basic model" for pumps so manufacturers can determine the pump models on which they must conduct testing to demonstrate compliance with a prospective energy conservation standard for pumps. The proposal would define a "basic model" in a manner similar to that for other commercial and industrial equipment, with the exception of two pump-specific issues. For most commercial and industrial equipment, DOE defines basic model to include all units of a given product or equipment type (or class thereof) manufactured by one manufacturer, having the same primary energy source, and having essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency.

For the purposes of establishing a basic model definition for pumps, DOE proposes modifying the general definition by addressing two particular characteristics that impact the energy consumption of pumps. First, radially split, multi-stage vertical in-line casing diffuser (RSV) and vertical turbine submersible (VTS) pumps for which the bare pump varies only in the number of stages would be required to be treated as the same basic model. Second, pumps for which the bare pump varies only in impeller diameter, or impeller trim, may be considered to be the same basic model or may optionally be rated as unique basic models. These exceptions are discussed in the following sections.

Variation in Number of Stages for Multi-Stage Pumps

The first modification to the basic model definition applies to variation in the number of stages for multi-stage pumps. DOE proposes that variation in the number of stages, while it may affect efficiency and will affect power, should not constitute a characteristic that would differentiate pump basic models. Specifically, any improvements in the hydraulic design of a single stage (or bowl) would be reflected in the measured performance of the pump with any number of stages. In addition, requiring testing for each stage version of a multi-stage pump would add significant testing burden. For these reasons, the CIP Working Group recommended each multi-stage pump be tested with a specified number of stages, as discussed in section III.C.2.c. DOE notes that any representations made with respect to PEI and pump energy rating (PER) for individual models with alternate number of stages within a single basic model: (1) must be on the same as the basic model with the specified number of stages required for testing under the test procedure and (2) must be rated using method A.1, “bare pump with default motor efficiency and default motor part load loss curve” (explained further in section III.E).

Basic Model Grouping for Pumps with Different Impeller Trims

The second modification DOE proposes to the typical basic model definition is that a trimmed impeller, though it may impact efficiency, would not be a basis for requiring units to be rated as unique basic models. This proposal is consistent with the Working Group recommendation that the rating of a given pump basic model should be based on testing at full impeller diameter only and that DOE not require testing at reduced impeller diameters. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #7 at p. 3) DOE understands that a given pump may be distributed to customers with a variety of impeller trims to meet a certain hydraulic load for a certain application, and impeller trim has a direct impact on a pump’s performance characteristics. However, DOE, in general, agrees with the Working Group’s proposal. Rather than requiring a manufacturer to certify to DOE a pump with any given impeller trim that may be requested by a customer, DOE is proposing to limit the number of specific pump models to certify, which would reduce the overall manufacturer burden from testing while helping ensure that a reasonably accurate measurement of a given pump’s efficiency is obtained. Rating at full impeller would typically reflect the most consumptive rating for that pump, due to the higher hydraulic power provided by the full impeller, as compared to a trimmed impeller in the same bare pump bowl. Therefore, any pump model with a bare pump that is otherwise identical (i.e., same casing, same bearings and seals, etc.) but with a trimmed impeller will, except in very limited cases, almost always consume less energy than the same pump with full impeller. Consistent with the CIP Working Group Recommendations, DOE proposes to base the certified rating for a given pump basic model on that model's full impeller diameter—all PEI and PER representations for the members of this basic model would be based upon the full impeller model.

Relevant to this requirement, DOE proposes to define the term "full impeller" as it pertains to the rating of pump models in accordance with the proposed test procedure. The European Union (EU) defines "full impeller" as "the impeller with the maximum diameter for which performance characteristics are given for a pump size in the catalogues of a water pump manufacturer."[14] DOE proposes to largely harmonize with this definition, but is proposing additional language to establish requirements for pumps for which performance data are not published in manufacturer catalogs, such as custom pumps. Specifically, DOE proposes to define full impeller as the maximum diameter impeller with which the pump is distributed in commerce in the United States or the maximum impeller diameter represented in the manufacturer's literature, whichever is larger. DOE understands that in most cases, these would be the same. However, for

[14] Council of the European Union. 2012. Commission Regulation (EU) No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps. Official Journal of the European Union. L 165, 26 June 2012, pp. 28-36.

pumps that may only be sold with a trimmed impeller due to a custom application, DOE is proposing to define the full impeller as the maximum diameter impeller with which the pump is distributed in commerce. DOE notes that the certified rating should represent the configuration based on the maximum diameter impeller offered by the manufacturer, regardless of the actual impeller size used with a given pump.

Under DOE's proposed definition for "full impeller," manufacturers would also be able to represent a model with a trimmed impeller as less consumptive than at full impeller. To do so, they must treat that trimmed impeller model as a different basic model and test a representative number of models at the maximum diameter distributed in commerce of that trimmed basic model listing. In such a case, the impeller trim with which the pump is rated becomes the "full impeller diameter," which is the "maximum diameter impeller used with a given pump basic model distributed in commerce or the maximum diameter impeller referenced in the manufacturer's literature for that pump basic model, whichever is larger." In these cases, manufacturers may elect to: (1) group individual pump units with bare pumps that vary only impeller diameter into a single basic model or (2) establish separate basic models (with unique ratings) for any number of unique impeller trims, provided that the PEI rating associated with any individual model is based on the maximum diameter impeller for that basic model and that basic model is compliant with any energy conservation standards established as part of the parallel pumps ECS rulemaking. (Docket No. EERE-2011-BT-STD-0031)

DOE notes that, while manufacturers may group pump models with various impeller trims under one basic model with the same certified PEI rating based on the full impeller diameter, all representations of PEI and PER for any individual model must be: (1) based on testing of the model with the full diameter impeller in the basic model and (2) rated using method A.1, "bare pump with default motor efficiency and default motor part load loss curve" (explained further in section III.E).

d. Basic Models for Pumps Sold with Motors or Motors and Speed Controls

DOE notes that, for pumps sold with motors and pumps sold with motors and continuous or non-continuous controls, pump manufacturers may pair a given pump with several different motors with different performance characteristics. Under the proposed definition, each unique pump and motor pairing would represent a unique basic model. However, consistent with DOE's practice with other products and equipment, pump manufacturers may elect to group similar individual pump models within the same equipment class into the same basic model to reduce testing burden, provided all representations regarding the energy use of pumps within that basic model are identical and based on the most consumptive unit. See 76 FR 12422, 12423 (March 7, 2011)).[15]

[15] These provisions allow manufacturers to group individual models with essentially identical, but not exactly the same, energy performance characteristics into a basic model to reduce testing burden. Under DOE's certification requirements, all the individual models within a basic model identified in a certification report as being the same basic model must have the same certified efficiency rating and use the same test data underlying the certified rating. The CCE final rule also establishes that the efficiency rating of a basic model must be based on the least efficient or most energy consuming individual model (i.e., put another way, all individual models within a basic model must be at least as energy efficient as the certified rating). 76 FR at 12428–29 (March 7, 2011).

For example, pumps that share the same bare pump but have different motors could be grouped into the same basic model based on the least efficient pump and motor combination as long as the manufacturer did not want to make representations of the more-efficient pump and motor combination. However, for pumps sold with trimmed impellers, DOE recognizes that a given pump with a trimmed impeller may be sold with a different motor than the same pump with a full impeller. As variation in impeller trim of the bare pump does not constitute a characteristic that would differentiate basic models, variation in motor sizing as a result of different impeller trims would also not serve as a basis for differentiating basic models.

Since the proposed pump basic model definition and certified rating are both based on the pump as tested with a full impeller and a specific number of stages, to the extent that the paired motor varies between a given pump unit and the same bare pump at full impeller diameter with the specified number of stages for testing, this difference would not constitute a characteristic that would define separate basic models.

DOE requests comment on the proposed definition for “basic model” as applied to pumps. Specifically, DOE is interested in comments on DOE’s proposal to allow manufacturers the option of rating pumps with trimmed impellers as a single basic model or separate basic models, provided the rating for each pump model is based on the maximum impeller diameter available within that basic model.

DOE requests comment on the proposed definition for “full impeller.”

DOE requests comment on the proposal to require that all pump models be rated in a full impeller configuration only.

DOE requests comment on any other characteristics of pumps that are unique from other commercial and industrial equipment and may require modifications to the definition of "basic model," as proposed.

2. Equipment Classes

Table III.2 presents a list of the specific pump categories that DOE considered in the context of its Framework Document. The treatment of these rotodynamic pumps was extensively discussed and debated among members of the CIP Working Group. Those pump categories that the Working Group recommended for inclusion as part of DOE's standards-setting efforts are marked accordingly. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #4 at p. 2)

Table III.2 Rotodynamic Clean Water Pump Equipment Overview and Recommended Scope of Pumps Test Procedure and Energy Conservation Standards

Pump Category	Sub-category	Stages	DOE Terminology	ANSI/HI Term	In CIP Working Group Scope
End Suction	Close-coupled	Single	End Suction Close-coupled (ESCC)	OH7	Yes
	Own Bearings/ Frame Mounted	Single	End Suction Frame Mounted (ESFM)	OH0, OH1	Yes
Vertical In-Line		Single	In-Line (IL)	OH3, OH4, OH5	Yes
Axial Split		Single	Double Suction (DS)	BB1, OH4 (double suction)	No
		Multi	Axially Split Multi-Stage (AS)	BB1 (2-stage), BB3	No
Radial Split		Multi	Radially Split Multi-Stage Vertical In-Line Casing Diffuser (RSV)	VS8	Yes*
		Multi	Radially Split Multi-Stage Horizontal (RSH)	BB2 (2-stage), BB4	No
Vertical Turbine	Non-Submersible	Any	Vertical Turbine (VT)	VS1, VS2	No
	Submersible	Any	Vertical Turbine Submersible (VTS)	VS0	Yes
Axial/Propeller and Mixed Flow		Any	Axial/Propeller and Mixed (AM)	OH00, VS3	No

*Multistage radial split vertical immersible pumps are excluded from the proposed scope.

Discussions regarding the inclusion and exclusion of certain categories of pumps can be found in the transcripts from the first several meetings of the CIP Working Group. (Docket No. EERE-2013-BT-NOC-0039, Nos. 8, 9, 14, 15, 46, 47, and 62) As recommended by the Working Group, DOE is applying a scope (for both the test procedure and in evaluating potential standards) that would include the following pump equipment classes: end suction close-coupled (ESCC), end suction frame mounted (ESFM), in-line (IL), radially split multi-stage vertical IL casing diffuser (RSV), and vertical turbine submersible (VTS) pumps. DOE notes that, while intended to be consistent with this test procedure proposal, the scope of any energy conservation standards proposed for pumps will be discussed as part of a separate rulemaking.

DOE requests comment on the proposed applicability of the test procedure to the five pump equipment classes noted above, namely ESCC, ESFM, IL, RSV, and VTS pumps.

a. Definitions of Pump Equipment Classes

To help manufacturers determine whether a given pump falls into one of the equipment classes that would be addressed by the scope of this proposal and the parallel energy conservation standards under consideration, DOE is proposing to define each pump equipment class that DOE would regulate. In developing these definitions, DOE considered the comments received in response to the Framework Document along with subsequent input provided during the CIP Working Group meetings. For example, HI preferred that DOE use the American National Standards Institute (ANSI) HI definitions for equivalent pump categories and nomenclature instead of the definitions tentatively proposed by DOE. (HI, No. 25 at p. 28)[16] Grundfos preferred that DOE use EU and HI definitions and resolve any conflicts through the existing Joint International Pump Industry Standardization Committee. Grundfos regarded the DOE definitions as ambiguous. (Grundfos, No. 24 at p. 10)

[16] A notation in this form provides a reference for information that is in the docket of DOE's rulemaking to develop energy conservation standards for commercial and industrial pumps (Docket No. EERE-2011-BT-STD-0031, which is maintained at www.regulations.gov). This particular notation refers to a comment: (1) submitted by HI; (2) appearing in document number 25 of the docket; and (3) appearing on page 28 of that document.

A joint comment submitted by the Appliance Standards Awareness Project (ASAP), Alliance to Save Energy (ASE), American Council for an Energy-Efficient Economy (ACEEE), Earthjustice, and the National Resources Defense Council (NRDC) (collectively referred to as "the Advocates")[17] criticized the HI definitions as narrow, increasing the risk that a manufacturer could make small changes to avoid DOE's regulations. To avoid this problem, the Advocates preferred DOE's broad definitions and offered some recommended modifications to those definitions. (Advocates, No. 32 at p. 4) Earthjustice also suggested adopting the Advocates' suggestions for modifying the definitions and added that DOE could provide illustrative references to the relevant HI nomenclature for further clarification. (Earthjustice, No. 30 at p. 1) Northwest Energy Efficiency Alliance (NEEA) and Northwest Power and Conservation Council (NPCC) made a similar suggestion, suggesting that the definitions be coupled with an appendix that would map to the appropriate ANSI/HI nomenclature and definitions. (NEAA/NPCC, No. 31 at p. 3)

While the CIP Working Group recommended establishing a test procedure and standards for specific classes of pumps, in the interest of time, the specific definitions of these pump equipment classes were not negotiated by the CIP Working Group. After considering the stakeholder comments on the Framework Document, DOE is proposing specific definitions for particular categories of pumps and specific pump equipment classes. DOE is proposing general definitions for some specific characteristics of pumps

[17] As noted in Table I.2, ASAP and NRDC were members of the CIP Working Group, while ASE, ACEE, and Earthjustice were not.

for which DOE is proposing that the test procedure be applicable; namely rotodynamic pump, single-axis flow pump, and end suction pump.

DOE proposes that rotodynamic pump refer to a pump in which energy is continuously imparted to the pumped fluid by means of a rotating impeller, propeller, or rotor. DOE proposes such a definition to help define the specific pump equipment classes to which the proposed test procedure is applicable and differentiate those from positive displacement pumps (i.e., non-rotodynamic pumps) with otherwise similar attributes.

DOE also proposes to define single axis flow pump as a pump in which the liquid inlet of the bare pump is on the same axis as the liquid discharge of the bare pump to clarify when specific pump equipment classes, discussed below, are proposed to exclude similar pumps in which the pumped liquid enters and exits the pump on different axes.

DOE proposes to define end suction pump as a specific variety of rotodynamic pump that is single-stage and in which the liquid enters the bare pump in a direction parallel to the impeller shaft and on the end opposite the bare pump's driver-end. Such a pump is not single axis flow because the liquid is discharged through a volute in a plane perpendicular to the shaft.

Based on these three definitions describing general pump characteristics, DOE proposes to define the following five pump equipment classes to which the proposed test procedure would be applicable:

(1) End suction frame mounted (ESFM) pump means an end suction pump wherein:

- a) the bare pump has its own impeller shaft and bearings and so does not rely on the motor shaft to serve as the impeller shaft;
- b) the pump requires attachment to a rigid foundation to function as designed and cannot function as designed when supported only by the supply and discharge piping to which it is connected; and
- c) the pump does not include a basket strainer.

Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature OH0 and OH1, as described in the 2008 version of ANSI/HI Standard 1.1-1.2, "Rotodynamic (Centrifugal) Pumps For Nomenclature And Definitions" (ANSI/HI 1.1-1.2–2014).

(2) End suction close-coupled (ESCC) pump means an end suction pump in which:

- a) the motor shaft also serves as the impeller shaft for the bare pump;
- b) the pump requires attachment to a rigid foundation to function as designed and cannot function as designed when supported only by the supply and discharge piping to which it is connected; and
- c) the pump does not include a basket strainer.

Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature OH7, as described in ANSI/HI 1.1-1.2–2014.

(3) In-line (IL) pump means a single-stage, single axis flow, rotodynamic pump in which:

a) liquid is discharged through a volute in a plane perpendicular to the impeller shaft; and

b) the pump requires attachment to a rigid foundation to function as designed and cannot function as designed when supported only by the supply and discharge piping to which it is connected.

Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature OH3, OH4, or OH5, as described in ANSI/HI 1.1-1.2–2014.

(4) Radially split, multi-stage, vertical, in-line, diffuser casing (RSV) pump means a vertically suspended, multi-stage, single axis flow, rotodynamic pump in which:

a) liquid is discharged in a plane perpendicular to the impeller shaft;

b) each stage (or bowl) consists of an impeller and diffuser; and.

c) no external part of such a pump is designed to be submerged in the pumped liquid.

Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature VS8, as described in the 2008 version of ANSI/HI Standard 2.1-2.2, “Rotodynamic (Vertical) Pumps For Nomenclature And Definitions” (ANSI/HI 2.1-2.2–2008).

(5) Vertical turbine submersible (VTS) pump means a single-stage or multi-stage rotodynamic pump that is designed to be operated with the motor and stage(s) (or bowl(s)) fully submerged in the pumped liquid, and in which:

a) each stage of this pump consists of an impeller and diffuser and

b) liquid enters and exits each stage of the bare pump in a direction parallel to the impeller shaft.

Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature VS0, as described in ANSI/HI 2.1-2.2–2008.

DOE notes that any references to HI nomenclature in ANSI/HI 1.1-1.2–2014 or ANSI/HI 2.1-2.2–2008 are incorporated into the definitions of the aforementioned pump equipment classes as examples only. As several interested parties expressed their desire to reference the HI nomenclature to help provide clarity to the industry, DOE is proposing to list the relevant HI pump nomenclature in the definition of each pump equipment class. However, in some cases, the HI nomenclature can be vague or inconsistent.[18] In cases where there is a conflict between the description provided in ANSI/HI 1.1-1.2–2014 or ANSI/HI 2.1-2.2–2008, as applicable, and the proposed regulatory text, the language in the regulatory text would prevail. Accordingly, a manufacturer would need to carefully review the applicable regulatory text in determining how its equipment would be affected because DOE would be using these

[18] For example, ANSI/HI 1.1-1.2-2014 does not identify specific definitions for the considered pumps. Rather, it provides classification trees (as in Figure 1.1.3a of that document) as well as construction drawings (e.g. Figures 1.1.5a-bb). The words describing a given pump classification are not always exactly consistent between the tree and the drawing captions. For example, OH0 is variously described as "overhung – flexibly coupled – horizontal – frame mounted" and "overhung impeller – flexibly coupled – single stage – frame mounted."

provisions when applying the test procedure and setting the scope for any standards that DOE may develop.

DOE requests comment on the proposed definitions for end suction pump, end suction frame mounted pump, end suction close-coupled pump, in-line pump, radially split multi-stage vertical in-line casing diffuser pump, rotodynamic pump, single axis flow pump, and vertical turbine submersible pump.

DOE requests comment on whether the references to ANSI/HI nomenclature are necessary as part of the equipment definitions in the regulatory text, are likely to cause confusion due to inconsistencies, and whether discussing the ANSI/HI nomenclature in this preamble would provide sufficient reference material for manufacturers when determining the appropriate equipment class for their pump models.

With regard to the proposed definition for RSV pumps, DOE understands that, in such a pump, flow typically proceeds from the bare pump inlet through the stages in series, with each stage increasing the total head, and exits at the pump discharge. DOE requests comment on whether it needs to clarify the flow direction to distinguish RSV pumps from other similar pumps when determining test procedure and standards applicability.

One issue related to the above that DOE is currently considering is whether its proposed RSV pump definition requires further clarification to ensure that immersible pumps do not fall within the definition. As proposed, this definition would exclude immersible pumps that would otherwise meet the remaining characteristics detailed in the definition (i.e., "No external part of such a pump is designed to be submerged in the pumped liquid)." While DOE believes that this language should be sufficient to exclude any immersible pumps from being treated as an RSV pump for purposes of DOE's regulations, DOE requests comment on whether any additional language is necessary to make this exclusion clearer.

b. Circulators and Pool Pumps

Circulators, which are a specific kind of rotodynamic pump, are small, low-head pumps similar to the in-line or end suction close-coupled configuration pumps that are generally used to circulate water in hydronic space conditioning or potable water systems in buildings.

The CIP Working Group recommended that circulator pumps be addressed as part of a separate rulemaking process that would involve informal negotiation between stakeholders followed by an ASRAC-approved negotiation. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #5A at p. 2) DOE has not yet received any proposals or requests for negotiation from the stakeholders.

To explicitly exclude circulators from this rulemaking and the parallel energy conservation standards rulemaking, DOE proposes to define the term "circulator" as referring to either:

- An end suction pump with a pump housing that requires only the support of the supply and discharge piping to which it is connected to function as designed, or
- A single-stage, single axis flow, rotodynamic pump, with a pump housing that requires only the support of the supply and discharge piping to which it is connected to function as designed.

Under this definition, such a pump would not be able to function as designed without attachment to a rigid foundation. Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature CP1, CP2, or CP3, as described in ANSI/HI 1.1-1.2–2014.

Adopting this definition would help ensure that circulators can be clearly and unambiguously differentiated from other pumps that DOE may consider regulating and to which this proposed test procedure would apply. The proposed definition would rely on the unique and distinguishable design characteristics of circulators—namely, that circulators require only pipe-mounted support and do not need to be attached to a rigid foundation to function as designed. Conversely, ESCC, ESFM, and IL pumps, by definition, require attachment to a rigid foundation to function as designed. DOE believes that such a definition for a circulator would encompass all pumps commonly referred to as circulators by the industry, which the CIP Working Group recommended that DOE not regulate in this rulemaking. DOE proposes to also reference the ANSI/HI 1.1-1.2 – 2014 nomenclature for circulators, as included in the CIP Working Group Recommendations. (Docket No. EERE-2013-BT-NOC-0039, No. 92 at p. 2)

By defining circulators, ESCC, ESFM, and IL pumps as mutually exclusive from each other on the basis of design characteristics, it is unnecessary to include a size-based threshold in the proposed circulator definition, as had been suggested by stakeholders. (HI, No. 25 at p. 20; Docket No. EERE-2013-BT-NOC-0039, No. 14 at p. 338) DOE notes that it is uncommon for pumps larger than 3 hp to be supported only by their supply and discharge pipes. This is due to limitations on the structural weight loads that a piping system can support. The constraint imposed by the piping system, in effect, acts as an inherent upper size threshold for circulators.

The CIP Working Group also formally recommended that DOE initiate a separate rulemaking for dedicated-purpose pool pumps by December 2014. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #5A at p. 2) The CIP Working Group further sought to identify the unique characteristics of pool pumps that differentiate them from the other pump classes within the scope of this rulemaking to make clear that dedicated-purpose pool pumps are not required to be tested in accordance with the proposed procedure. During the March 26, 2014 CIP Working Group meeting, Xylem Inc. (Xylem) indicated that all dedicated-purpose pool pumps include an integrated basket strainer, unlike other end suction close-coupled pumps. (Docket No. EERE-2013-BT-NOC-0039, No. 62 at p. 195) To distinguish a “dedicated-purpose pool pump” from other pumps that DOE is currently considering regulating in this NOPR, DOE proposes to define this device as an end suction pump designed specifically to circulate water in a pool and that includes an integrated basket strainer.

DOE notes that this definition will be discussed in more detail in a separate rulemaking to consider potential energy conservation standards and test procedures for pool pumps.

DOE requests comment on its proposal to exclude circulators and pool pumps from the scope of this test procedure rulemaking. DOE also requests comment on the proposed definitions for circulators and dedicated-purpose pool pumps. Finally, DOE requests comment on the extent to which ESCC, ESFM, IL, and RSV pumps require attachment to a rigid foundation to function as designed. Specifically, DOE is interested to know if any pumps commonly referred to as ESCC, ESFM, IL, or RSV do not require attachment to a rigid foundation.

c. Axial/Mixed Flow and Positive Displacement Pumps

"Axial/mixed flow pump" is a term used by the pump industry to describe a rotodynamic pump that is used to move large volumes of liquid at high flow rates and low heads. These pumps are typically custom-designed and used in applications such as dewatering, flood control, and storm water management.

Positive displacement (PD) pumps are a style of pump that operates by first opening an increasing volume to suction; this volume is then filled, closed, moved to discharge, and displaced. PD pumps operate at near-constant flow over their range of operational pressures and can often produce higher pressure than a centrifugal pump, at a given flow rate. PD pumps also excel at maintaining flow and efficiency for liquids more viscous than water. When used in clean water applications, PD pumps are typically chosen for high pressure, constant flow applications such as high pressure power washing, oil field water injection, and low-flow metering processes.

The CIP Working Group recommended excluding both of these types of pumps from being subject to the prospective energy conservation standards DOE is considering. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #6 at p. 2) The primary reason for excluding these pumps at this time is their low market share in the considered horsepower range and low potential for energy savings. (Docket No. EERE-2013-BT-NOC-0039, No. 14 at pp. 114 and 372-373) In addition, the CIP Working Group acknowledged that PD pumps are more commonly used in non-clean water applications and provide a different utility than the categories of pumps addressed in this rulemaking. (Docket No. EERE-2013-BT-NOC-0039, No. 14 at p. 114) Therefore, DOE is considering excluding these pumps from the scope of this rulemaking and the parallel energy conservation standards rulemaking.

DOE believes that the pump equipment classes and scope parameters defined in sections III.A.2 and III.A.4, respectively, implicitly exclude positive displacement and axial flow pumps.

As mentioned previously, axial/mixed flow pumps are designed to accommodate high flow-to-head-ratio applications and are therefore implicitly excluded from the scope of pumps being considered in this NOPR based on the head, flow, and pump brake horsepower parameters proposed in section III.A.4. Additionally, the proposed definitions of ESCC, ESFM, and IL pumps would exclude axial/mixed flow pumps through the reference of a discharge volute, which is typically not present on equipment referred to as axial/mixed flow pumps. The proposed definition of RSV pumps would also exclude equipment referred to as axial/mixed flow pumps through implication by specifying that the liquid inlet is in a plane perpendicular to the impeller shaft, as compared to axial/mixed flow pumps where liquid intake is parallel to the impeller shaft. Finally, the proposed definition of VTS pumps would exclude equipment referred to as axial/mixed flow pumps because axial/mixed flow pumps are not designed to be completely submerged in the pumped liquid. Consequently, given the required characteristics of each of the proposed equipment class definitions, DOE believes additional clarification is unnecessary to effectively exclude axial/mixed flow pumps. If, however, additional facts suggest that further clarification is needed, DOE may consider the merits of adding clarifying language to the appropriate regulatory text.

As discussed previously, PD pumps are typically used to handle high viscosity liquids or handle extremely high head applications. PD pumps are not rotodynamic pumps and so do not meet the definition of any of the pump equipment classes discussed in section III.A.2.a that DOE is considering addressing in this rulemaking.

DOE requests comment on its initial determination that axial/mixed flow and PD pumps are implicitly excluded from this rulemaking based on the proposed definitions and scope parameters. In cases where commenters suggest a more explicit exclusion be used, DOE requests comment on the appropriate changes to the proposed definitions or criteria that would be needed to appropriately differentiate axial/mixed flow and/or PD pumps from the specific rotodynamic pump equipment classes proposed for coverage in this NOPR.

3. Scope Exclusions Based on Application

DOE initially considered limiting its rulemaking scope to address only rotodynamic pumps intended for use in pumping clean water, with the potential of further limiting the scope to exclude specific categories of pumps based on their design or application. (Docket No. EERE-2011-BT-STD-0031, No. 13 at pp. 2-6) DOE also discussed the possibility of defining "clean water pump" using physical characteristics rather than just defining "clean water" as in the EU Commission Regulation No 547/2012 EU 547.[19] After extensive discussions on this subject, the CIP Working Group recommended limiting the scope of the rulemaking to pumps designed for use in pumping clean water and excluding certain pumps, some of which are designed for use in pumping clean water and some of which are not, from being regulated for the purposes of this proposal and the standards currently under consideration. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #8 at pp. 3-4) However, in the interest of time, the CIP Working Group did not recommend specific definitions to help implement any of these recommendations.

In an effort to meet the intent and recommendations of the CIP Working Group, DOE is proposing to define "clean water pump." DOE is also proposing to define several kinds of clean water pumps that are designed for specific applications and that the Working Group had indicated should be excluded from the scope of this proposal and DOE's standards rulemaking efforts that are under development. These definitions would be laid out in a new 10 CFR 431.462.

[19] Council of the European Union. 2012. Commission Regulation (EU) No 547/2012 of 25 June 2012

a. Definition of Clean Water Pump

First, DOE proposes to define "clean water pump" as a pump that is designed for use in pumping water with a maximum non-absorbent free solid content of 0.25 kilograms per cubic meter, and with a maximum dissolved solid content of 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 -10 ºC.

DOE notes that, when determining whether a given pump would satisfy the definition of clean water pump, DOE would consider marketing materials, labels and certifications, equipment design, and actual application of such equipment.

To clarify the scope of "clean water pumps," DOE notes that several common pumps would not meet the definition of clean water pumps, as they are not designed for pumping clean water. The CIP Working Group specifically identified the following non-clean water pumps:

1) Wastewater, sump, slurry, or solids handling pump (i.e., a pump designed to move liquid with maximum dissolved solid content that exceeds the limits in the definition of clean water).

2) Pump designed for pumping hydrocarbon product fluids that meets the requirements of API's Standard 610–2010, "Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries" or ISO 13709:2009.[20]
3) Chemical process pump that meets the requirements of ANSI/ASME Standard B73.1–2012, "Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process;" ANSI/ASME B73.2–2002, "Specifications for Vertical In-Line Centrifugal Pumps for Chemical Process;" or International Organization for Standardization (ISO) 2858:1975, "End-suction centrifugal pumps (rating 16 bar) -- Designation, nominal duty point and dimensions," and ISO 5199:2002, "Technical specifications for centrifugal pumps -- Class II."
4) Sanitary pump that meets the requirements of 3-A Sanitary Standards, Inc. Standard 3A 02-11, "Centrifugal and Positive Rotary Pumps for Milk and Milk Products."

DOE also proposes to establish a specific definition for "clear water" for testing purposes that would describe the fluid to be used when testing pumps in accordance with the DOE test procedure. Specifically, DOE proposes to incorporate by reference the definition for "clear water" established in HI 40.6–2014. This definition would apply solely for the purposes of the test procedure and is distinct from the definition of "clean water," as defined in this section. The definition of "clear water" as it applies to the test fluid to be used in the testing of pumps under the proposed DOE test procedure is

[20] ISO 13709:2009 is an identical standard to API 610 and is included under the same cover.

narrower than the proposed definition of “clean water,” which would be used to establish the scope of the DOE test procedure and related energy conservation standards.

DOE also requests comment on the proposed definition for “clean water pump.”

DOE requests comment on its proposal to incorporate by reference the definition for “clear water” in HI 40.6–2014 to describe the testing fluid to be used when testing pumps in accordance with the DOE test procedure.

b. Exclusion of Specific Kinds of Clean Water Pumps

Also in accordance with the Working Group recommendations, DOE proposes to define several kinds of pumps that are clean water pumps, as defined, but would not be subject to the proposed test procedure. Specifically, DOE proposes that the test procedure would not apply to:

1) fire pumps;
2) self-priming pumps;
3) prime-assist pumps;
4) sealless pumps;
5) pumps designed to be used in a nuclear facility subject to 10 CFR part 50 -- Domestic Licensing of Production and Utilization Facilities; and
6) a pump meeting the design and construction requirements set forth in Military Specification MIL-P-17639F, “Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use” (as amended).

Accordingly, DOE proposes the following definitions for fire pump, self-priming pump, prime-assist pump, and sealless pump:

(1) Fire pump means a pump that is compliant with National Fire Protection Association (NFPA) Standard 20–2013, “Standard for the Installation of Stationary Pumps for Fire Protection,” and either (1) Underwriters Laboratory (UL) listed under UL Standard 448-2007, “Centrifugal Stationary Pumps for Fire-Protection Service,” or (2) Factory Mutual (FM) approved under the October 2008 edition of FM Class Number 1319, “Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type).”

(2) Self-priming pump means a pump designed to lift liquid that originates below the center line of the pump impeller. Such a pump requires initial manual priming from a dry start condition, but requires no subsequent manual re-priming.

(3) Prime-assist pump means a pump designed to lift liquid that originates below the center line of the pump impeller. Such a pump requires no manual intervention to prime or re-prime from a dry-start condition. Such a pump includes a vacuum pump or air compressor to remove air from the suction line to automatically perform the prime or re-prime function.

(4) Sealless pump means either:

a) A pump that transmits torque from the motor to the bare pump using a magnetic coupling, or

b) A pump in which the motor shaft also serves as the impeller shaft for the bare pump, and the motor rotor is immersed in the pumped fluid.

DOE notes that the proposal to exclude fire pumps is consistent with comments submitted in response to the Framework Document, including from from stakeholders that were not members of the CIP Working Group.[21] (NFPA, No. 27 at pp. 1-2; Colombia Engineering, No. 29 at p. 1) However, while Earthjustice suggested that DOE could require that fire pumps be marked “For use as a fire pump only,” (Earthjustice, No.30 at p.2) DOE declines to propose a mandatory label for fire pumps because it seems superfluous in that there is an increased cost of such pumps that is likely to inherently limit their sale to that specific application.

DOE reviewed the requirements for fire pumps, pumps designed to be used in a nuclear facility under 10 CFR 50, and pumps designed per military specification MIL-P-17639F (Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use). DOE believes that in all cases, the increased burden in design and test requirements provides a legitimate reason to exclude these from the scope of the proposed test procedure and standards.

According to Patterson Pumps, fire pumps are manufactured according to NFPA Standard 20, and certified according to either UL or FM standards. (Docket No. EERE-2013-BT-NOC-0039, No. 15 at p. 191-192) The CIP Working Group agreed to exclude

[21] DOE did not receive comments on the Framework Document regarding other types of pumps for exclusion from stakeholders not represented on the CIP Working Group.

pumps compliant with NFPA 20 as long as they are certified as “fire pumps” to the relevant UL or FM standard, noting that UL and FM are the only two certification bodies for fire pumps. (Docket No. EERE-2013-BT-NOC-0039, No. 15 at p. 193-194). The CIP Working Group also represented that it was unlikely manufacturers would attempt to sell pumps intended for other applications as fire pumps in an effort to circumvent a proposed DOE standard for pumps because of the high expense in testing to complete the certification process for UL or FM. Likewise, consumers would find the expense of buying a fire pump for a non-fire pump application would be higher than that of buying a pump that complies with an eventual DOE standard. (Docket No. EERE-2013-BT-NOC-0039, No. 14 at p. 125)

Nuclear facility pumps must have certified design specifications and must conform to many specific design and testing criteria. These include, but are not limited to, classification as ASME Code Class 1 of the ASME Boiler and Pressure Vessel Code, Section III, “Rule for Construction of Nuclear Facility Components,” for reactor coolant pumps. DOE understands that the design and construction of pumps in accordance with ASME Code Class 1 represent significant additional expense and significantly increases the cost of such pumps compared to the clean water pumps considered in this test procedure. Similar to fire pumps, DOE believes there is sufficient justification to exclude such nuclear facility pumps from the scope of this rulemaking without a risk of clean water pumps being marketed or sold as nuclear facility pumps for actual use in other applications.

Pumps designed to military specifications (commonly referred to as "MIL-SPEC"), such as MIL-P-17639F, must meet very specific physical and or operational characteristics and have complex and rigid reporting requirements.[22] Specifically, MIL-P-17639F requires significant amounts of design and test data be submitted to various military design review agencies to ensure that the pump can be operated and maintained in harsh naval environments. When considering if a pump is designed and constructed to the requirements set forth in MIL-P-17639F, DOE may request that a manufacturer provide DOE with copies of the original design and test data that were submitted to appropriate design review agencies, as required by MIL-P-17639F. Similar to fire and nuclear facility pumps, DOE believes there is sufficient justification to exclude MIL-SPEC pumps from the scope of this rulemaking without a risk of clean water pumps being marketed or sold as MIL-SPEC for actual use in other applications.

DOE requests comment on the proposed definition for "fire pump," "self-priming pump," "prime-assisted pump," and "sealless pump."

Regarding the proposed definition of a self-priming pump, DOE notes that such pumps typically include a liquid reservoir above or in front of the impeller to allow recirculating water within the pump during the priming cycle. DOE requests comment on any other specific design features that enable the pump to operate without manual re-priming, and whether such specificity is needed in the definition for clarity.

[22] United States General Accounting Office, Report to Congressional Committees, Acquisition Reform: DOD Begins Program To Reform Specifications and Standards, GAO/NSIAD-95-14. October 11, 1994. Washington, DC. pp. 2-3. http://www.gao.gov/archive/1995/ns95014.pdf

DOE requests comment on the proposed specifications and criteria to determine if a pump is designed to meet a specific Military Specification and if any Military Specifications other than MIL-P-17639F should be referenced.

DOE requests comment on excluding the following pumps from the test procedure: fire pumps, self-priming pumps, prime-assist pumps, sealless pumps, pumps designed to be used in a nuclear facility subject to 10 CFR part 50 -- Domestic Licensing of Production and Utilization Facilities, and pumps meeting the design and construction requirements set forth in Military Specification MIL-P-17639F, "Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use" (as amended).

4. Parameters for Establishing the Scope of Pumps in this Rulemaking

In addition to limiting the types of pumps that DOE would regulate at this time through pump definitions and their applications, DOE proposes to further limit its scope consistent with the Working Group's recommendation by applying the following performance and design characteristics:

1) 1–200 hp (shaft power at the best efficiency point, BEP, at full impeller diameter for the number of stages required for testing to the standard);[23]
2) 25 gpm and greater (at BEP at full impeller diameter);
3) 459 feet of head maximum (at BEP at full impeller diameter);

[23] The CIP Working Group also recommended that testing be required with 3 stages for RSV pumps and 9 stages for VTS pumps, unless a model is not available with that specific number of stages, in which case the pump would be tested with the next closest number of stages. This recommendation is discussed in more detail in section III.C.2.a.

4) design temperature range from -10 to 120 °C;
5) pumps designed for nominal 3,600 or 1,800 revolutions per minute (rpm) driver speeds; and
6) 6-inch or smaller bowl diameter for VTS pumps (HI VS0).

(Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #7 at p. 3)

Similarly, DOE proposes to apply the pump test procedure scope to the scope of pumps discussed in sections III.A.1 and III.A.3 possessing the characteristics presented by the CIP Working Group.

DOE notes that with respect to the limiting criterion proposed for VTS pumps (i.e., bowl diameter) DOE is also proposing to define this term to remove ambiguity and to ensure that all entities are calculating bowl diameter the same way. HI 40.6-2014 defines bowl diameter as follows: "Bowl diameter means the measure of a straight line passing through the center of a circular shape that intersects the circular shape at both of its ends." While DOE largely agrees with the HI definition, additional specificity is required with respect to that definition's use of the phrase "circular shape." As such, DOE proposes to define "bowl diameter" as it applies to VTS pumps as follows:

Bowl diameter means the maximum dimension of an imaginary straight line passing through and in the plane of the circular shape of the intermediate bowl or chamber of the bare pump that is perpendicular to the pump shaft and that intersects the circular shape of the intermediate bowl or chamber of the bare pump at both of its ends, where the intermediate bowl or chamber is as defined in ANSI/HI 2.1-2.2–2008.

If adopted, only those VTS pumps with bowl diameters of 6 inches or less would be required to be tested under the proposed procedure.

DOE requests comment on the listed design characteristics (i.e., power, flow, head, design temperature, design speed, and bowl diameter) as limitations on the scope of pumps to which the proposed test procedure would apply.

DOE requests comment on the proposed definition for "bowl diameter" as it would apply to VTS pumps.

5. Non-Electric Drivers

DOE recognizes that some pumps, particularly in the agricultural sector, may be sold and operated with non-electric drivers, such as engines, steam turbines, or generators. During the CIP Working Group's negotiations, testing and coverage of non-electric drivers were discussed. To ensure simplicity and comparability when testing and certifying pumps with non-electric drivers, the CIP Working Group recommended that pumps sold with non-electric drivers be rated as a bare pump, excluding the energy performance of the non-electric driver. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #3 at p. 2) By requiring testing and certification in this manner, any hydraulic improvements made to the bare pump to comply with any applicable energy conservation standards that may apply to the bare pump would also result in energy savings if the pump is used with a non-electric driver. DOE notes that the proposed test procedure is applicable only to drivers that are electric motors. Therefore, when rating a pump with any driver other than an electric motor, or other bare pump, DOE would provide default rating calculations in the test procedure to represent the performance of the given bare pump with a default motor that is minimally compliant with DOE's energy conservation standards for electric motors. See 10 CFR 431.25. This procedure is described in more detail in section III.E.1.a. (In context, as noted earlier, the terms "electric motor" and "motor" are used interchangeably.)

The Working Group's approach, as described above, is likely to reduce the test burden and complexity of the regulation. DOE notes that, in order to accurately capture the energy performance of non-electric drivers in the DOE pump test procedure, separate test procedures would be necessary for each type of driver (e.g., turbines, generators), which are not currently available in HI 40.6–2014 or other relevant pump test standards and, thus, would add significant complexity and burden to the pump test procedure. DOE believes that there is insufficient technical merit or potential for additional energy savings to justify the additional burden associated with rating and certifying pumps sold with non-electric drivers inclusive of those drivers.

DOE requests comment on its proposal to test pumps sold with non-electric drivers as bare pumps.

6. Pumps Sold with Single-Phase Induction Motors

DOE recognizes that some pumps within the proposed scope of this rulemaking may be distributed in commerce with single-phase motors. However, DOE understands that the majority of pumps in the proposed scope of this test procedure rulemaking are sold with polyphase induction motors. One reason for the prevalence of polyphase motors is that the pumps for which the proposed test procedure would apply are typically sold into commercial and industrial applications where polyphase (three-phase) power is known to be commonplace. Additionally, single-phase induction motors are not widely available in motors with horsepower (hp) ratings greater than approximately 5 hp, while the proposed test procedure would apply to pumps from 1-200 hp, as discussed in section III.A.4. This circumstance further restricts the prevalence of single-phase motors in pumps for which the proposed test procedure would apply. According to the CIP Working Group, almost all pumps except for smaller pumps use three-phase motors, with the transition from single-phase to three-phase motors occurring at around ½ to ¾ hp. (Docket No. EERE-2013-BT-NOC-0039, No. 105 at p. 224-225)

In addition, DOE understands that most pumps within the scope of this proposed rulemaking that are distributed in commerce with single-phase induction motors are also distributed in commerce with polyphase induction motors of similar size to accommodate variation in power requirements among customers.

DOE understands that single-phase induction motors are, in general, less efficient than polyphase induction motors and, thus, would result in different energy consumption characteristics when paired with the same bare pump. Therefore, to establish the desired calculation-based methods for pumps paired with single-phase and polyphase motors, DOE would need to develop specific default motor efficiency assumptions and motor loss curves for both single-phase and polyphase motors. However, DOE believes that developing a separate rating methodology (including separate default motor efficiency assumptions) for pumps sold with single-phase induction motors is not justified at this time due to the small percentage of pumps sold with only single-phase induction motors. The CIP Working Group agreed that, based on the scope established for pumps being from 1-200 hp, it is more meaningful to focus the rating methodology on three-phase motors. (Docket No. EERE-2013-BT-NOC-0039, No. 105 at p. 226)

For these reasons, DOE has developed the proposed test methods to be based on polyphase induction motors in that the default nominal full load motor efficiency discussed in section III.D.1 would specify a minimum efficiency value for a National Electrical Manufacturers Association (NEMA) Design A, NEMA Design B, or IEC Design N electric motor, which are a specific kind of polyphase induction motor. However, DOE believes that such default nominal full load motor efficiency values are not applicable to single-phase induction motors. Therefore, in order not to penalize pumps sold with single-phase induction motors, DOE proposes that such pumps be tested and rated in the bare pump configuration, using the calculation-based method.

DOE notes that, if a pump distributed in commerce with a single-phase induction motor is also distributed in commerce in a bare pump configuration, this proposal would not increase the testing or rating burden on manufacturers. DOE also wishes to clarify that, to the extent that such a pump is also sold with an electric motor other than a single-phase induction motor, the pump must also be rated based on the PEI_{CL} or PEI_{VL} as determined for the pump when paired with that other motor.

DOE requests comment on its proposal that any pump distributed in commerce with a single-phase induction motor be tested and rated in the bare pump configuration, using the calculation method.

DOE requests comment from interested parties on any other categories of electric motors, except submersible motors, that: (1) are used with pumps considered in this rulemaking and (2) typically have efficiencies lower than the default nominal full load efficiency for NEMA Design A, NEMA Design B, or IEC Design N motors.

B. Rating Metric

One of the first and most important issues DOE must consider in designing a test procedure is selection of the regulatory metric. The most common metric used in the pump industry today to describe the performance of bare pumps (i.e., pumps sold alone, not inclusive of motors and controls) is pump efficiency, which is the ratio of hydraulic power (the product of flow, density, gravity, and head) to pump shaft input power, as shown in equation (1):

$$\eta_{pump} = \frac{P_{Hydro}}{P_i} \qquad \textbf{(1)}$$

Where:

η_{pump} = bare pump efficiency,

P_{Hydro} = pump hydraulic output power, and

P_i = shaft input power to the bare pump at rating point (i).

When a pump is tested for performance inclusive of a motor and/or controls, pump efficiency is not as useful a metric, as it does not capture the performance of the other components that are integral to the performance and utility of the pump when installed in the field. In the Framework Document, DOE discussed bare pump efficiency as well as overall pump efficiency (i.e., the efficiency of a pump coupled with a driver, as defined in HI 40.6-2014) and "wire-to-water," [24] power-based metrics. DOE also discussed the possible application of different metrics to pumps depending on how they are sold: (1) alone as bare pumps, (2) with motors, or (3) with motors and continuous or non-continuous controls.

1. Working Group and other Stakeholder Comments

The different rating approaches suggested in the Framework Document were also discussed in the negotiations of the CIP Working Group. The Working Group recommended that DOE use a wire-to-water, power-based metric for all pumps, regardless of how they are sold. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #11 at p. 5) The CIP Working Group recommended a similar metric for all pump configurations (i.e., bare pumps, pumps sold with a motor, and pumps sold with

[24] The term "wire-to-water" refers to the physically-tested, combined performance of the bare pump, motor, and any continuous or non-continuous controls. This is consistent with the testing-based methods discussed in section III.E.2.

a motor and continuous or non-continuous controls) to allow for better comparability and more consistent application of the rating metric for all pumps within the recommended scope. This way, the benefit of speed control, as compared to a similar pump without speed control, can be reflected in the measurement of energy use or energy efficiency.

In developing the metric proposed in this NOPR, DOE reviewed the CIP Working Group recommendations as well as the relevant comments made in response to the Framework Document. The Air-Conditioning, Heating, and Refrigeration Institute (AHRI), which was not a member of the Working Group, suggested that if DOE defines pumps to be inclusive of motors and/or controls, that DOE develop a combined pump/motor/control efficiency metric using a weighted average of measurements at specified rating points (as preferable to minimum levels at multiple points because it allows more design flexibility). (AHRI, No. 28 at p. 2) AHRI noted that a regulatory regime that includes controls must include appropriate part load levels and operating points, reflective of part load conditions typically in use. It cited AHRI 1210–2011, "2011 Standard for Performance Rating of Variable Frequency Drives," as an example of a relevant test procedure that requires that a variable frequency drive[25] (VFD) and motor be tested at four different speeds: 40, 50, 75, and 100 percent of full speed. AHRI

[25] Variable Frequency Drive (or VFD) is defined in AHRI 1210-2011 as "A power electronic device that regulates the speed of an alternating current (AC) motor by adjusting the frequency and the voltage of the electrical power supplied to the motor." This definition applies to asynchronous induction motors. The term "dynamic continuous control," as defined in section III.E.1.c, is synonymous with the term "variable speed drive (VSD)" and refers to a power electronic device that controls the output of a motor via continuous modulation rotating speed. This includes variable frequency drives, which control speed through changes in input frequency to the motor and are applicable only to AC motors, as well as direct-current machines such as electronically commutated motors. (HI, Europump, and DOE; "Variable Speed Pumping Systems: A Guide to Successful Applications," pg. 9) For the purposes of this rulemaking, "VSD" will be used when discussing speed control of pumps in general, as applicable to either AC- or DC-driven motors. VFD will only be used when specifically discussing continuous control of AC induction motors.

estimated that VFDs in pump/motor/VFD packages range from 50 to 100 percent of maximum speed, and average operation is approximately 75 percent of full speed. AHRI also noted that the methodology used to develop the Integrated Part Load Value (IPLV) metric in appendix D of AHRI standard 550/590 may be a useful reference. (AHRI, No. 28 at p. 2)

DOE notes that in general, AHRI's comments are in line with the CIP Working Group recommendation. Specifically, the metric recommended by the CIP Working Group is a weighted average of measurements at specified load points. The CIP Working Group recommended metric incorporates load points of 75, 100, and 110 percent of BEP flow for pumps without continuous or non-continuous controls, and 25, 50, 75, and 100 percent of BEP flow for a pump sold with continuous or non-continuous controls. The latter load points are similar to those specified in AHRI 1210. The reasoning behind these differing loading profiles is further discussed in section III.B.2.a.

2. Selected Metric: Constant Load and Variable Load Pump Energy Index

After carefully considering the Framework stage comments and the recommendations of the CIP Working Group, DOE is proposing to adopt the metric recommended by the CIP Working Group. That metric consists of a ratio of the representative performance of the pump being rated over the representative performance of a pump that would minimally comply with any prospective DOE energy conservation standard for that pump type. The representative performance is referred to as the "pump energy rating" (PER) and is calculated as the equally-weighted average of the electric input power to the pump at three or four load points. As recommended by the CIP Working Group, DOE is also proposing similar metrics for all pumps, regardless of whether they are sold with continuous or non-continuous controls.

For pumps sold without continuous or non-continuous controls, DOE proposes to use three load points near the BEP of the pump to determine the constant load pump energy rating (PER_{CL}). For pumps sold with continuous or non-continuous controls, DOE proposes to use four load points to determine the variable load pump energy rating (PER_{VL}).

To scale the rated pump performance (PER_{CL} or PER_{VL}) with respect to the weighted average electrical input power of a bare pump that would minimally comply with any prospective DOE energy conservation standard for that pump type, DOE proposes to define a "standard pump energy rating" (PER_{STD}) that represents the performance of a bare pump of the same equipment class that is minimally compliant with DOE's energy conservation standards serving the same hydraulic load. In other words, when determining the PER_{STD} for a bare pump, a pump with a motor, or a pump with a motor using either continuous or non-continuous controls, the PER_{CL} of a minimally compliant bare pump within the same class would be used. A more detailed discussion of the PER_{STD} value is provided in section III.B.2.b.

Specifically, for pumps sold without continuous or non-continuous controls, DOE proposes using the PEI_{CL} metric, which would be evaluated as shown in equation (2):

$$PEI_{CL} = \frac{PER_{CL}}{PER_{STD}} \qquad \textbf{(2)}$$

Where:

PER_{CL} = the weighted average input power to the motor at load points of 75, 100, and 110 percent of BEP flow (hp) and

PER_{STD} = the PER_{CL} for a pump of the same equipment class that is minimally compliant with DOE's energy conservation standards serving the same hydraulic load (hp).

Evaluating this metric for a given pump would entail the following steps:

1) determining the PER_{CL} for that pump in accordance with the specific methods discussed in section III.D,
2) determining the PER_{STD} for a pump of the same equipment class (i.e., pumps of the same configuration and performance characteristics to which a single standard would apply) that would be minimally compliant with the applicable energy conservation standards DOE may set, and
3) taking a ratio of the two values.

As shown in equation (3), the PER_{CL} would be evaluated as the weighted average input power to the motor at load points of 75, 100, and 110 percent of BEP flow:

$$\begin{aligned} PER_{CL} &= \sum_{i=75\%,100\%,110\%} \omega_i P_i^{in} \\ &= \omega_{75\%}\left(P_{75\%}^{in}\right) + \omega_{100\%}\left(P_{100\%}^{in}\right) + \omega_{110\%}\left(P_{110\%}^{in}\right) \\ &= {}^{1}\!/_{3} \times \left(P_{75\%}^{in}\right) + {}^{1}\!/_{3} \times \left(P_{100\%}^{in}\right) + {}^{1}\!/_{3} \times \left(P_{110\%}^{in}\right) \qquad \textbf{(3)} \end{aligned}$$

Where:

ω_i = weighting at each rating point (equal weighting),

P_i^{in} = measured or calculated input power to the motor at rating point i (hp), and

i = 75, 100, and 110 percent of BEP flow as determined in accordance with the DOE test procedure.

Similarly, for pumps sold with a motor and continuous or non-continuous controls, DOE is proposing using PEI_{VL}, which would be evaluated as shown in equation (4):

$$PEI_{VL} = \frac{PER_{VL}}{PER_{STD}} \quad \textbf{(4)}$$

Where:

PER_{VL} = the weighted average input power to the motor and continuous or non-continuous controls at load points of 25, 50, 75, and 100 percent of BEP flow (hp) and

PER_{STD} = the PER_{CL} for a pump of the same equipment class that is minimally compliant with DOE's energy conservation standards serving the same hydraulic load (hp). The procedure for determining PER_{STD} is described in detail in section III.B.2.b.

PEI_{VL} would be similarly evaluated for a given pump equipped with motors and continuous or non-continuous controls, by:

1) determining the PER_{VL} for that pump in accordance with the methods specified in section III.E.1.c,

2) determining the same PER_{STD} as for the same class of pump without continuous or non-continuous controls, and

3) taking a ratio of the two values.

PER_{VL} would then be calculated as a weighted average of input power to the motor and continuous or non-continuous controls at load points of 25, 50, 75, and 100 percent of BEP flow, as shown in equation (5):

$$PER_{VL} = \sum_{i=25\%,50\%,75\%,100\%} \omega_i P_i^{in}$$
$$= \omega_{25\%}(P_{25\%}^{in}) + \omega_{50\%}(P_{50\%}^{in}) + \omega_{75\%}(P_{75\%}^{in}) + \omega_{100\%}(P_{100\%}^{in})$$
$$= {}^1/_4 \times (P_{25\%}^{in}) + {}^1/_4 \times (P_{50\%}^{in}) + {}^1/_4 \times (P_{75\%}^{in}) + {}^1/_4 \times (P_{100\%}^{in}) \qquad \textbf{(5)}$$

Where:

ω_i = weighting at each rating point (equal weighting),

P_i^{in} = measured or calculated input power to the motor at rating point i (hp), and

i = 25, 50, 75, and 100 percent of BEP flow as determined in accordance with the DOE test procedure.

Under DOE's proposed approach, the performance of bare pumps or pumps paired with motors (but without continuous or non-continuous controls) would be determined for the appropriate load points along the single-speed pump curve by increasing head (i.e., throttling) as flow is decreased from the maximum flow rate of the pump. As the flow is decreased, the power will typically decrease slightly. Pumps sold with continuous or non-continuous controls, by contrast, can follow a system curve and achieve the desired flow points by reducing the pump's speed of rotation rather than controlling flow by throttling. By reducing speed, power would be reduced in proportion to the cube of speed, resulting in lower power requirements for any part load flow points. As such, the PEI_{VL} for a pump sold with continuous or non-continuous controls will be lower than the PEI_{CL} for the same pump sold without continuous or non-continuous controls. In essence, adopting both PEI_{CL} and PEI_{VL} would illustrate the inherent performance differences that can occur when coupling a given pump with continuous or non-continuous controls.

a. Load Profile

In order to determine the part load performance of pumps, DOE must define a load profile and establish specific part load rating points at which to test a given pump. DOE researched the variety of applications and usage profiles for the pumps considered for the scope of this rulemaking and determined that the data regarding typical duty profiles of covered pumps are extremely variable and not widely available. Thus, it is extremely difficult to generalize duty profiles for a given pump based on type, size, or other factors.

The CIP Working Group indicated that pumps sold as bare pumps and pumps sold with motors are more often installed in constant load applications that are intended to operate in applications with the design load closer to the BEP of the pump. Conversely, the Working Group added that pumps sold with continuous or non-continuous controls are typically applied in more variable applications with design conditions between 25 percent and 100 percent of the BEP flow and head conditions. (Docket No. EERE-2013-BT-NOC-0039, No. 73 at pp 80-82) Based on the assessment and recommendation provided by the Working Group, DOE is therefore proposing to adopt two distinct load profiles to represent constant speed and variable speed pump operation. See Table III.3.

Table III.3 Load Profiles Based on Pump Configuration

Pump Configuration	Load Profile	Load Points
Pumps Sold without Continuous or Non-Continuous Controls (i.e., bare pumps and pumps sold with motors)	Constant Load Profile	75%, 100%, and 110% of BEP flow
Pumps Sold with Continuous or Non-Continuous Controls	Variable Load Profile	25%, 50%, 75%, and 100% of BEP flow

Lack of field data on load profiles and the wide variation in system operation also make it difficult to select appropriate weights for the load profiles. For these reasons, the CIP Working Group members concluded that equal weighting would at least create a level playing field across manufacturers. (See, e.g., Docket No. EERE-2013-BT-NOC-0039, No. 63 at p. 125) DOE also proposes to equally weight the measured input power to the driver or driver and continuous or non-continuous controls at each of the specified flow points in both the constant load and the variable load case, as recommended by the CIP Working Group. Due to the wide range of operating conditions a given pump may experience in the field, DOE believes the proposed load points and weights adequately represent the operating range of pumps sold with and without continuous or non-continuous controls.

DOE requests comment on the proposed load points and weighting for PEI_{CL} for bare pumps and pumps sold with motors and PEI_{VL} for pumps inclusive of motors and continuous or non-continuous controls.

b. PER_{STD}: Minimally Compliant Pump

Within the PEI_{CL} and PEI_{VL} equations, the average input power to the motor or motor with continuous or non-continuous control in the numerator of these equations would be scaled based on a normalizing factor to provide a rating for each pump model that is indexed to a standardized value. DOE recognizes the benefit of scaling the PEI_{CL} and PEI_{VL} metrics based on a normalizing factor because it could help compare values across and among various pump types and sizes.

In recognition of these potential advantages, DOE proposes normalizing the weighted average input power to the pump being rated against the weighted average input power to a pump that would minimally comply with the applicable standard for the same class of pump. This approach is consistent with the CIP Working Group's recommendations. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #11 at pg. 5) This approach is also similar to the approach suggested by Europump, a trade association of European pump manufacturers. Europump's approach would normalize the tested input power to the tested pump with a motor and continuous or non-continuous controls, as measured at the input to the continuous or non-continuous control, relative to the reference shaft power for a minimally compliant pump with a minimally compliant motor at the given BEP.[26] Europump's approach relies on the EU's existing regulations for certain categories of rotodynamic pumps designed for pumping clean water which were first published in 2012.[27]

DOE is proposing implementing an approach that would approximate a baseline pump, inclusive of a minimally compliant default motor, to use as a reference pump for each combination of flow and specific speed. The minimally compliant pump would be defined as a function of variables descriptive of the bare pump's physical properties, such as flow and specific speed, as in the EU approach to regulating clean water pumps.[28] DOE proposes to use the same equation used by the EU to develop its standard, translated to 60 Hz electrical input power and English units[29] as shown in equation (6), to determine the efficiency of a minimally compliant pump:

$$\eta_{pump,STD} = -0.85 * \ln(Q_{100\%})^2 - 0.38 * \ln(Ns) * \ln(Q_{100\%}) - 11.48 * \ln(Ns)^2 + 13.46 * \ln(Q_{100\%}) + 179.80 * \ln(Ns) - (C - 555.6) \qquad \textbf{(6)}$$

Where:

[26] Europump. Extended Product Approach for Pumps: A Europump Guide. April 8, 2013.
[27] Council of the European Union. 2012. Commission Regulation (EU) No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps. Official Journal of the European Union. L 165, 26 June 2012.
[28] Council of the European Union. 2012. Commission Regulation (EU) No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps. Official Journal of the European Union. L 165, 26 June 2012, pp. 28-36.
[29] The equation to define the minimally compliant pump in the EU is of the same form, but employs different coefficients to reflect the fact that the flow will be reported in m^3/hr at 50 Hz and the specific speed will also be reported in metric units. Specific speed is a dimensionless quantity, but has a different magnitude when calculated using metric versus English units. DOE notes that an exact translation from metric to English units is not possible due to the logarithmic relationship of the terms.

$Q_{100\%}$ = BEP flow rate (gpm),

Ns = specific speed at 60 Hz, and

C = an intercept that is set for the two-dimensional surface described by equation (6), which is set based on the speed of rotation and equipment type of the pump model. The values of this intercept, or "C-values," used for determining pump efficiency for the minimally compliant pump would be established in the pump energy conservation standard rulemaking.

In the above equation (6), the specific speed (N_s) is a quasi-non-dimensional number used to classify pumps based on their relative geometry and hydraulic characteristics. It is calculated as a function of the rotational speed, flow rate, and head of the pump as shown in equation (7) below:

$$N_s = \frac{N \times \sqrt{Q_{100\%}}}{{H_{100\%}}^{0.75}} \quad \textbf{(7)}$$

Where:

N_s = specific speed,

N = speed of rotation (rpm),

$Q_{100\%}$ = BEP flow rate (gpm), and

$H_{100\%}$ = total head at BEP flow (ft).

Under this proposal, the calculated efficiency of the minimally compliant pump reflects the pump efficiency at BEP. As pump efficiency typically varies as a function of flow rate, DOE must also determine a method to specify the default efficiency of a minimally compliant pump at the load points corresponding to 75 and 100 percent of

BEP flow. To do so, DOE also proposes to follow the approach used in the EU regulations; that is, DOE proposes to scale the efficiency determined at 100 percent of BEP flow in equation (6) using nominal and standardized values that represent how pump efficiency typically changes at part load (75 percent of BEP flow) and over load (110 percent of BEP flow) load conditions. Namely, the efficiency at 75 percent of BEP flow is assumed to be 94.7 percent of that at 100 percent of BEP flow, and the pump efficiency at 110 percent of BEP flow is assumed to be 98.5 percent of that at 100 percent of BEP flow, as shown in equation (8):

$$PER_{STD} = \omega_{75\%}\left(\frac{P_{Hydro,75\%}}{0.947\times\left[\eta_{pump,STD}/_{100}\right]} + L_{75\%}\right) + \omega_{100\%}\left(\frac{P_{Hydro,100\%}}{\left[\eta_{pump,STD}/_{100}\right]} + L_{100\%}\right) + \omega_{110\%}\left(\frac{P_{Hydro,110\%}}{0.985\times\left[\eta_{pump,STD}/_{100}\right]} + L_{110\%}\right) \quad \textbf{(8)}$$

Where:

ω_i = weighting at each rating point (equal weighting or $^1/_3$ in this case),

$P_{Hydro,i}$ = the measured hydraulic output power at rating point i of the tested pump (hp),

$\eta_{pump,STD}$ = the minimally compliant pump efficiency, as determined in accordance with equation (6),

L_i = the motor losses at each load point i, as determined in accordance with the procedure specified for bare pumps in sections III.E.1.a. and III.D.2, and

i = 75, 100, and 110 percent of BEP flow, as determined in accordance with the DOE test procedure.

Equation (8) also demonstrates how the ratio between the minimally compliant pump efficiency and the hydraulic output power for the rated pump is used to determine the input power to a minimally compliant pump at each load point. Note that the pump hydraulic output power for the minimally compliant pump would be the same as that for the particular pump being evaluated. Under DOE's proposed approach, calculating the hydraulic power in equation (8) at 75, 100, and 110 percent of BEP flow, would require the following equation (9):

$$P_{Hydro,i} = \frac{Q_i \times H_i \times SG}{3956} \quad \textbf{(9)}$$

Where:

$P_{Hydro,i}$ = the measured hydraulic output power at rating point i of the tested pump (hp),

Q_i = the measured flow rate at each rating point i of the tested pump (gpm),

H_i = pump total head at each rating point i of the tested pump (ft), and

SG = the specific gravity of water at specified test conditions.

The calculated shaft input power for the minimally compliant pump at each load point is then combined with a minimally compliant motor for that default motor type and appropriate size, described in section III.D.1, and the default part load loss curve, described in section III.D.2, to determine the input power to the motor at each load point. The applicable minimum nominal full load motor efficiency is determined as a function of type (i.e., open or enclosed), pole configuration, and horsepower rating, as specified by DOE's electric motor standards. PER_{STD} would then be determined as the weighted average input power to the motor at each load point, as shown in equation (8).

The use of a reference denominator based on PER_{CL} for a minimally compliant bare pump (including assigned default motor losses), as described in the preceding paragraphs, was recommended by the CIP Working Group. The benefit of this approach is that it would consistently show the difference between a given pump's performance and the baseline performance of a pump with the same flow and specific speed. A value higher than 1.0 would indicate that the pump would exceed the applicable pump energy consumption standard and would not comply, while a lower value would indicate that the pump is less consumptive than the maximum allowed by the standard and would therefore comply.

To implement the Working Group's recommended approach, DOE's proposal would describe how to calculate PEI_{CL} and PEI_{VL} as a ratio of the weighted average input power of the tested pump model over the weighted average input power of a minimally compliant bare pump paired with a minimally compliant motor with no controls, as shown in equations (10) and (11):

$$PEI_{CL} = \frac{\omega_{75\%}(P_{75\%}{}^{in})+\omega_{100\%}(P_{100\%}{}^{in})+\omega_{110\%}(P_{110\%}{}^{in})}{\omega_{75\%}\left(\frac{P_{Hydro,75\%}}{0.947\times\left[\eta_{pump,STD}/_{100}\right]}+L_{75\%}\right)+\omega_{100\%}\left(\frac{P_{Hydro,100\%}}{\left[\eta_{pump,STD}/_{100}\right]\eta_{pump,STD}}+L_{100\%}\right)+\omega_{110\%}\left(\frac{P_{Hydro,110\%}}{0.985\times\left[\eta_{pump,STD}/_{100}\right]}+L_{110\%}\right)} \quad \textbf{(10)}$$

Where:

PEI_{CL} = the pump energy index for a constant load (applicable to bare pumps and pumps sold with a motor) (hp),

ω_i = weighting at each rating point (equal weighting or $^1/_3$ in this case),

P_i^{in} = measured or calculated input power to the motor at rating point i for the tested pump (hp),

$P_{Hydro,i}$ = the measured hydraulic output power at rating point i of the tested pump (hp),

$\eta_{pump,STD}$ = the minimally compliant pump efficiency, as determined in accordance with equation (6),

L_i = the motor losses at each load point i, as determined in accordance with the procedure specified for bare pumps in sections III.E.1.a. and III.D.2 (hp), and

i = 75, 100, and 110 of BEP flow, as determined in accordance with the DOE test procedure.

Equation (10) would apply to both bare pumps and pumps sold with a motor (but without any accompanying continuous or non-continuous controls). For pumps sold with motors inclusive of continuous or non-continuous controls, the PEI_{VL} would be calculated as defined in equation (11) below:

$$PEI_{VL} = \frac{\omega_{25\%}(P^{in}_{25\%}) + \omega_{50\%}(P^{in}_{50\%}) + \omega_{75\%}(P^{in}_{75\%}) + \omega_{100\%}(P^{in}_{100\%})}{\omega_{75\%}\left(\frac{P_{Hydro,75\%}}{0.947\times\left[\eta_{pump,STD}/_{100}\right]} + L_{75\%}\right) + \omega_{100\%}\left(\frac{P_{Hydro,100\%}}{\left[\eta_{pump,STD}/_{100}\right]} + L_{100\%}\right) + \omega_{110\%}\left(\frac{P_{Hydro,110\%}}{0.985\times\left[\eta_{pump,STD}/_{100}\right]} + L_{110\%}\right)} \quad \textbf{(11)}$$

Where:

PEI_{VL} = pump energy index for a variable load (applicable to pumps sold with a motor and continuous or non-continuous controls),

ω_i = weighting at each rating point (equal weighting $^1/_3$ or ¼ as applicable),

P^{in}_i = measured or calculated input power to the continuous or non-continuous controls at rating point i for the tested pump,

$P_{Hydro,i}$ = the measured hydraulic output power at rating point i of the tested pump (hp),

$\eta_{pump,STD}$ = the minimally compliant pump efficiency, as determined in accordance with equation (6),

L_i = the motor losses at each load point i, as determined in accordance with the procedure specified for bare pumps in sections III.E.1.a. and III.D.2, and

i = 25, 50, 75, 100, and 110 percent of BEP flow, as determined in accordance with the DOE test procedure, where the load points are as noted in equation (11).

DOE requests comments on the proposed PEI_{CL} and PEI_{VL} metric architecture.

<u>Default Motor Efficiency for the Minimally Compliant Pump</u>

DOE notes that the default motor efficiency discussed above varies as a function of motor horsepower. As such, DOE must prescribe a consistent method to determine the rated horsepower, and thus default efficiency, of the hypothetical minimally compliant motor used to determine PER_{STD}. DOE proposes that for bare pumps, which must be assigned a hypothetical default motor in order to calculate the proposed PEI_{CL} metric, the motor horsepower for the minimally compliant pump (PER_{STD}) would be determined using the bare pump (PER_{CL}), described in section III.D.1.a. This procedure would select the default motor's horsepower as equivalent to, or the next highest horsepower-rated level greater than, the calculated pump shaft input power of the pump when evaluated at 120 percent of BEP flow This approach would yield the same motor horsepower being selected for bare pumps and for their associated minimally compliant pump.

For pumps sold with motors and pumps sold with motors and continuous or non-continuous controls, manufacturers could choose to sell their pump with a motor whose horsepower varies from that assumed based on the default motor selection criteria. See section III.D.1.a., infra. In such a case, the horsepower of the default motor selected to calculate PER_{STD} may vary from that of the one sold with the evaluated pump. DOE believes that applying the same motor horsepower to both the pump being evaluated and the minimally compliant pump (PER_{STD}) would provide the most equitable and straight-forward comparison of pump performance. As a result, DOE is proposing to require that if a pump is sold with: (1) a motor or (2) a motor and continuous or non-continuous controls, the motor horsepower for the minimally compliant pump used in the calculation would be based on the horsepower rating of the motor with which that pump is sold. To determine the minimally compliant pump's associated motor part load losses at each load point, the nominal full load efficiency associated with that motor's horsepower would be determined based on a motor that minimally complies with the applicable DOE electric motor energy conservation standards (or in the case of submersible motors, as described in section III.D.1.b) and using the procedure for calculating part load losses described in section III.D.2.

DOE requests comment on its proposal to base the default motor horsepower for the minimally compliant pump on that of the pump being evaluated. That is, the motor horsepower for the minimally compliant pump would be based on the calculated pump shaft input power of the pump when evaluated at 120 percent of BEP flow for bare pumps and the horsepower of the motor with which that pump is sold for pumps sold with motors (with or without continuous or non-continuous controls).

C. Determination of Pump Performance

To determine PEI_{CL} or PEI_{VL} for applicable pumps, the proposed test procedure would require physically measuring the performance of either: (1) the bare pump, under the calculation-based methods (see section III.E.1), or (2) the entire pump, inclusive of any motor, continuous control, or non-continuous control, under the testing-based methods (III.E.2). Specifically, the input power to the pump at 75, 100, and 110 percent of BEP flow for $PEI_{CL,}$ or at 25, 50, 75, and 100 percent of BEP flow for $PEI_{VL,}$ is required for input into the PEI_{CL} or PEI_{VL} equations, respectively. Depending on whether the calculation-based method or testing-based method is applied, a slightly different test method would apply for measuring pump performance. In the case of the calculation-based method, only the bare pump performance is physically measured—the performance of the motor and any continuous or non-continuous controls would be addressed through a series of calculations. In the case of the testing-based method, the full wire-to-water performance of the pump is physically measured and the measured input power to the pump at the motor or at the continuous or non-continuous control, if any, is used to calculate PEI_{CL} or PEI_{VL}. In either case, DOE's test procedure, as proposed, would require instructions for how to physically measure the performance of bare pumps, pumps with motors, and pumps with motors and continuous or non-continuous controls in a standardized and consistent manner.

1. Referenced Industry Standards

In developing this proposal, DOE reviewed domestic and international industry test procedures. Table III.4 shows a number of industry test methods that relate to the pumps for which DOE is considering adopting a test method and standards.

Table III.4 Overview of Currently Available Pump Test Procedures

Test Procedure	Origin	Notes
ANSI/HI 14.6–2011, "Rotodynamic Pumps for Hydraulic Performance Acceptance Tests"	United States	Harmonized with ANSI/HI 11.6 and ISO 9906–2012
HI 40.6–2014, "Methods for Rotodynamic Pump Efficiency Testing"	United States	Developed, in coordination with DOE and the CIP Working Group, to support DOE's pump test procedure
ANSI/HI 11.6–2012, "Submersible Pump Tests"	United States	Harmonized with ANSI/HI 14.6
ASME PTC 8.2–1990, "Centrifugal Pump"	United States	References dated measurement techniques
ISO 9906–2012 Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1, 2 and 3	International	Harmonized with ANSI/HI 14.6 and referenced in EU regulations*
ISO 5198–1999 Centrifugal, mixed flow, and axial pumps. Code for hydraulic performance tests. Precision class	International	Provides guidance for measurement of very high accuracy. Includes specification of an optional thermodynamic method for direct measurement of pump efficiencies.
AS 2417–2001 Rotodynamic pumps - Hydraulic performance acceptance tests - Grades 1 and 2	Australia	Based on ISO 9906–2012
GB/T 3216–2005	China	Based on ISO 9906–2012
NOM-010-ENER–2004 Submersible deep well clean water motor pumps	Mexico	Based on ISO 9906–2012
NOM-001-ENER–2000 Vertical turbine pumps with external vertical electric motor for pumping clean water for irrigation, municipal supply, or industrial supply	Mexico	Based on ISO 3555 (predecessor to 9906–2012)

*Council of the European Union. Commission Regulation (EU) No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps. Official Journal of the European Union. L 165, 26 June 2012, pp. 28-36.

As presented in the Framework Document, DOE determined that ANSI/HI 14.6–2011: (1) is the most widely used test standard in the pump industry for evaluating pump performance; (2) defines uniform methods for conducting laboratory tests to determine flow rate, head, power, and efficiency at a given speed of rotation; and (3) applies to all pumps that DOE is considering regulating. See section III.A., supra. In the Framework

Document, DOE requested comments from interested parties on the use of several test procedures, including ANSI/HI 14.6–2011, as a basis for developing DOE's test procedure. HI, Grundfos, and AHRI all recommended the use of ANSI/HI 14.6–2011 for stand-alone pump testing (i.e., testing of a bare pump without a motor and without continuous or non-continuous controls). (HI, No. 25 at p. 34, Grundfos, No. 24 at p. 17, and AHRI, No. 28 at p. 2)

After publication of the Framework Document, HI convened a group of subject matter experts to, in coordination with DOE and the CIP Working Group, revise ANSI/HI 14.6–2011 to make the test protocol more relevant for incorporation by DOE as part of the DOE test procedure. The new, revised standard was issued by HI in July 2014 as HI 40.6–2014 and incorporates several improvements over the previous testing standard, including greater precision and accuracy in describing evaluation techniques and mandatory language. The CIP Working Group recommended that whatever procedure the DOE adopts, it should be consistent with HI 40.6–2014 for determining bare pump performance. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #10 at pg. 4)

DOE has reviewed HI 40.6–2014 and determined that it contains the relevant test methods needed to accurately characterize the performance of the pumps that would be addressed by this rulemaking. These test methods include a means to determine pump shaft input power (for the calculation-based methods) and input power to the motor or motor and continuous or non-continuous controls (for the testing-based methods) at the specified load points. Specifically, HI 40.6–2014 defines and explains how to calculate pump power input,[30] driver power input,[31] pump power output,[32] pump efficiency,[33] bowl efficiency,[34] overall efficiency,[35] and other relevant quantities. HI 40.6–2014 also contains appropriate specifications regarding the scope of pumps covered by the test methods, test methodology, standard rating conditions, equipment specifications, uncertainty calculations, and tolerances. Additionally, HI 40.6–2014, when coupled with the minor modifications specified in section III.C.2.a, would provide clarity regarding certain mandatory requirements when performing the test procedure, such as the test conditions and instrumentation requirements necessary to ensure testing accuracy and repeatability.

To limit the overall burden presented by this proposal, DOE has chosen an approach that is as closely aligned as possible with existing and widely used industry test procedures. Although HI 40.6–2014 is a new test standard, its methods are substantially the same as those specified in ANSI/HI 14.6-2011 and currently used to evaluate pumps in the industry. Accordingly, in DOE's view, HI 40.6–2014, as a procedure based on an already widely used and recognized industry-developed procedure, is an appropriate

[30] The term "pump power input" in HI 40.6-2014 is defined as "the power transmitted to the pump by its driver" and is synonymous with the term "pump shaft input power," as used in this document.
[31] The term "driver power input" in HI 40.6-2014 is defined as "the power absorbed by the pump driver" and is synonymous with the term "pump input power to the driver," as used in this document.
[32] The term "pump power output" in HI-40.6 is defined as "the mechanical power transferred to the liquid as it passes through the pump, also known as pump hydraulic power." It is used synonymously with "pump hydraulic power" in this document.
[33] The term "pump efficiency is defined in HI 40.6-2014 as a ratio of pump power output to pump power input.
[34] The term "bowl efficiency" is defined in HI 40.6-2014 as a ratio of pump power output to bowl assembly power input and is applicable only to VTS and RSV pumps.
[35] The term "overall efficiency" is defined in HI 40.6-2014 as a ratio of pump power output to driver power input and describes the combined efficiency of a pump and driver.

method for evaluating bare pump/pump and motor performance. For this reason, DOE is proposing to incorporate this testing standard as part of DOE's test procedure for measuring the energy consumption of pumps, with the minor modifications and exceptions listed in the following sections III.C.2.a through III.C.2.f.

DOE requests comment on using HI 40.6–2014 as the basis of the DOE test procedure for pumps.

2. Minor Modifications and Additions to HI 40.6-2014

In general, DOE finds the test methods contained within HI 40.6–2014 are sufficiently specific and reasonably designed to produce test results which measure energy efficiency and energy use. However, in DOE's view, a few minor modifications are necessary to ensure repeatable and reproducible test results and to provide measurement methods and equipment specifications for the entire scope of pumps that DOE is addressing as part of this proposal.

a. Sections Excluded from DOE's Incorporation by Reference

While DOE proposes to reference HI 40.640.6–2014 as the basis for its proposed test procedure, DOE notes that some sections of the standard are not applicable to DOE's regulatory framework. Specifically, section 40.6.5.3 provides requirements regarding the generation of a test report and appendix "B" provides guidance on test report formatting, both of which are not required for testing and rating pumps in accordance with DOE's proposed procedure. As such, DOE proposes to not incorporate by reference section 40.6.5.3 and appendix B of HI 40.6–2014.

HI 40.6–2014 also contains relevant requirements for the characteristics of the testing fluid to be used when testing pumps in section 40.6.5.5, “Test conditions.” Specifically, section 40.6.5.5 requires that “tests shall be made with clear water at a maximum temperature of 10–30 °C (50–86 °F)” and clarifies that “clear water means water to be used for pump testing, with a maximum kinematic viscosity of 1.5×10^{-6} m^2/s (1.6×10^{-5} ft^2/s) and a maximum density of 1000 kg/m^3 (62.4 lb/ft^3).” DOE agrees with these requirements and proposes to include them in the incorporation by reference of HI 40.6–2014. However, in section A.7 of appendix A, “Testing at temperatures exceeding 30 °C (86 °F),” HI 40.6–2014 addresses testing at temperatures above 30 °C (86 °F). DOE does not intend to allow testing with liquids other than those meeting the definition of clear water presented above, including water at elevated temperatures.[36] As such, DOE also proposes to exclude section A.7 from the incorporation by reference of HI 40.6–2014.

DOE requests comment on its proposal to not incorporate by reference section 40.6.5.3, section A.7, and appendix B of HI 40.6–2014 as part of the DOE test procedure.

[36] Testing at higher temperatures may be conducted by manufacturers when their pumps are designed for a specific, higher-temperature application. However, for DOE’s purposes in developing a test procedure to determine the energy use of pumps, testing outside the nominal, standardized rating conditions is unnecessary.

b. Data Collection and Determination of Stabilization

In order to ensure the repeatability of test data and results, the DOE pump test procedure must provide instructions regarding how to sample and collect data at each load point such that the collected data is taken at stabilized conditions that accurately and precisely represent the performance of the pump at that load point. HI 40.6–2014 provides that all measurements shall be made under steady state conditions, which are described as follows: (1) no vortexing, (2) margins as specified in ANSI/HI 9.6.1 Rotodynamic Pumps Guideline for NPSH Margin, and (3) when the mean value of all measured quantities required for the test data point remain constant within the permissible amplitudes of fluctuations defined in Table 40.6.3.2.2 over a minimum time of 10 seconds before data are collected. However, HI 40.6–2014 does not specify the frequency of data collection. As such, determining stabilization, as specified, could occur based on a minimum of two data points (as a minimum of two data points are necessary to calculate a mean) or many data points based on a 1 second or sub-second data sampling frequency. DOE believes that, at a minimum, two data points should be used to determine stabilization and, as such, data must be collected at least every 5 seconds. DOE believes that two data points are necessary because at least two data points are necessary to determine an average. DOE proposes to specify that data shall be collected at least every 5 seconds for all measured quantities.

As noted above, section 40.6.3.2.2 of HI 40.6–2014, "Permissible fluctuations," provides permissible amplitude of fluctuations for various measured quantities throughout the test. As specified in that section, all measurements must be less than these thresholds for the duration of the measurement period for a valid measurement. The section also describes permissible dampening devices that may be used to minimize noise and large fluctuations in the data. DOE proposes to incorporate by reference section 40.6.3.2.2 except that dampening devices would only be permitted to integrate up to the data collection interval, or 5 seconds, to ensure that each data point is reflective of a unique measurement.

DOE requests comment on its proposal to require that data be collected at least every 5 seconds for all measured quantities.

DOE requests comment on its proposal to allow dampening devices, as described in section 40.6.3.2.2, but with the proviso noted above (i.e., permitted to integrate up to the data collection interval, or 5 seconds).

c. Modifications Regarding Test Consistency and Repeatability

Sections 40.6.5.6 and 40.6.5.7 of HI 40.6–2014 specify test arrangements and test conditions. However, DOE finds that the standardized test conditions described in these sections are not sufficient to produce accurate and repeatable test results. Specifically, the nominal pump speed, the input power characteristics, and the number of stages to test for multi-stage pumps are not addressed, all of which could impact the measured test result for a given pump unit. To address these potential sources of variability or ambiguity, DOE proposes to adopt several additional requirements to further specify the procedures for adjusting the test data to standardized rating conditions.

HI 40.6–2014 specifies that testing shall be done with clear water and defines clear water for the purposes of pump testing. HI 40.6–2014 also provides a standardized description of the method for configuring pumps for testing. However, additional specifications not present in HI 40.6–2014 are also required regarding the speed of rotation, the characteristics of the power supply, and the configuration of specific pump types for the purposes of testing pumps and for use in any subsequent calculations to determine the PEI_{CL} or PEI_{VL}.

Pump Speed

The rated speed of a pump affects the efficiency and PEI_{CL} or PEI_{VL} of that pump. To limit variability and increase repeatability within the test procedure, DOE is proposing to include nominal rating speeds of 3,600 and 1,800 rpm at 60 Hz. For pumps sold without motors, the nominal rating speed would be selected based on the speed of rotation for which the pump is designed. Specifically, pumps designed to operate at any speed of rotation between 2,880 and 4,320 rpm would be rated at 3,600 rpm and pumps designed to operate at any speed of rotation between 1,440 and 2,160 rpm would be rated at 1,800 rpm, as noted in Table III.5.

Table III.5 Nominal Speed of Rotation for Different Configurations of Pumps

Pump Configuration	Pump Design Speed of Rotation	Style of Motor	Nominal Speed of Rotation for Rating
Bare Pump	2,880 and 4,320 rpm	N/A	3,600 rpm
	1,440 and 2,160 rpm		1,800 rpm
Pump + Motor OR Pump + Motor + Control	N/A	2-pole Induction Motor	3,600 rpm
	N/A	4-pole Induction Motor	1,800 rpm
	N/A	Non-Induction Motor Designed to Operate between 2,880 and 4,320 rpm	3,600 rpm
	N/A	Non-Induction Motor Designed to Operate between 1,440 and 2,160 rpm	1,800 rpm

DOE proposes that pumps designed to operate at speeds that include both ranges would be rated at both nominal speeds of rotations. DOE notes that each nominal speed rating would represent a different basic model of pump. DOE selected these operating speed ranges consistent with the tolerance about the nominal rating speed allowed for in the test procedure. Specifically, section 40.6.5.5.2 of HI 40.6–2014 requires that the tested speed be maintained within 20 percent of the rated speed, or the specified nominal speed of rotation in this case. Therefore, any pump “designed for operation” at any speed of rotation between, for example, 2,880 and 4,320 rpm would be able to be tested under the proposed test procedure at the design speed of rotation and the results corrected to the rated nominal speed of rotation of 3,600 rpm.

DOE notes that these speed ranges are not exclusive. That is, if a pump were to be designed to operate from 2,600 to 4,000 rpm, such a pump would have a nominal speed of rotation of 3,600 rpm for the purposes of testing and rating the pump.

For pumps sold with motors, DOE proposes that the nominal speed of rotation be selected based on the speed(s) for which the motor is designed to operate. Specifically, as shown in Table III.5, pumps sold with 2-pole induction motors would be evaluated at 3,600 rpm, and pumps sold with 4-pole induction motors would be evaluated at 1,800 rpm. Pumps sold with non-induction motors (e.g., DC motors and ECMs) would be evaluated at the nominal rating speed that falls within the operating range of the motor with which the pump is being sold. If the pump is sold with a non-induction motor that is designed to operate at any speed of rotation between 2,880 and 4,320 rpm, that pump would be rated at a nominal speed of rotation of 3,600 rpm. If the pump is sold with a non-induction motor that is designed to operate at any speed of rotation between 1,440 and 2,160 rpm, that pump would be rated at 1,800 rpm. If the operating range of the non-induction motor with which the pump is distributed in commerce includes speeds of rotation that are both between 2,880 and 4,320 rpm and between 1,440 and 2,160 rpm, the pump would be rated at both 3,600 and 1,800 rpm and each nominal speed of rotation would represent a separate basic model.

However, DOE acknowledges that it may not be feasible to operate pumps during the test at exactly 3,600 or 1,800 rpm. Therefore, DOE proposes that all data collected as a result of the test procedure at the speed measured during the test be adjusted to the nominal speed prior to use in subsequent calculations and that the PEI_{CL} or PEI_{VL} of a given pump be based on the nominal speed. For pumps sold with motors and continuous or non-continuous controls and that are tested using the testing-based method described in section III.E.2.c, this adjustment to the nominal rating speed would apply only at the 100 percent of BEP flow rating point -- subsequent part load points would be measured at reduced speed and would not be adjusted. DOE proposes to use the methods in HI 40.6–2014 section 40.6.6.1.1, "Translation of the test results into data based on the specified speed of rotation (for frequency) and density" to adjust any data from the measured speed to the nominal speed.

In all cases, as required by HI 40.6–2014, the tested speed maintained during the test at each rating point must be maintained within 20 percent of the nominal speed and the speed of rotation recorded at each test point may not vary more than ±1 percent to ensure accurate and reliable results.

DOE requests comment on its proposal to require data collected at the pump speed measured during testing to be normalized to the nominal speeds of 1,800 and 3,600.

DOE requests comment on its proposal to adopt the requirements in HI 40.6–2014 regarding the deviation of tested speed from nominal speed and the variation of speed during the test. Specifically, DOE is interested if maintaining tested speed within ±1 percent of the nominal speed is feasible and whether this approach would produce more accurate and repeatable test results.

Power Supply Characteristics

Because pump power consumption is a component of the proposed metric, inclusive of any motor and continuous or non-continuous controls, measuring power consumption is an important element of the test. The characteristics of the power supplied to the pump affect the accuracy and repeatability of the measured power consumption of the pump. As such, to ensure accurate and repeatable measurement of power consumption, DOE is also proposing to specify nominal characteristics of the power supply. Namely, DOE is proposing nominal values for voltage, frequency, voltage unbalance, total harmonic distortion, and impedance levels, as well as tolerances about each of these quantities, that must be maintained at the input terminals to the motor, continuous control, or non-continuous control, as applicable.

To determine the appropriate power supply characteristics testing pumps with motors (but without continuous or non-continuous controls) and pumps with both motors and continuous or non-continuous controls, DOE examined applicable test methods for electric motors and VSD systems. DOE determined that IEEE Standard 112–2004 ("IEEE Standard Test Procedure for Polyphase Induction Motors and Generators"), which is the test method incorporated by reference at 10 CFR 431.16 for electric motors, is the most applicable test method for electric motors when considering testing and rated values for motors that are integrated with a pump. DOE identified both AHRI 1210–

2011, "2011 Standard for Performance Rating of Variable Frequency Drives," (AHRI 1210–2011) and the 2013 version of the Canadian Standards Association (CSA) Standard C838, "Energy efficient test methods for three-phase variable frequency drive systems," (CSA C838–2013) as applicable methods for measuring the performance of VSD control systems.

IEEE 112–2004, AHRI 1210–2011, and CSA C838–2013 all specify that voltage and frequency must be maintained at the rated voltage and frequency of the motor ±0.5 percent. In addition, all three standards specify that the power source "voltage unbalance" shall not exceed 0.5 percent during the test. Voltage unbalance is calculated as the maximum voltage deviation from the average measured voltage divided by the average measured voltage.

DOE recognizes that any harmonics in the power system can affect the measured performance of the pump when tested with a motor or motor and continuous or non-continuous control. IEEE 112–2004 and CSA C838–2013 also include requirements to maintain total harmonic distortion below 5 percent. When measuring the input power to the continuous or non-continuous controls that are paired with an electric motor-driven pump, AHRI 1210–2011 and CSA C838–2013 also specify impedance levels of the incoming power supplied to the VSD. AHRI 1210–2011 requires that source impedance not exceed 1 percent, while CSA C838–2013 requires that source impedance shall be greater than 1 percent but not exceed 3 percent for VFDs under 500 hp.

DOE is also proposing to establish these requirements for voltage, frequency, voltage unbalance, total harmonic distortion, and impedance in the DOE pump test procedure when testing pumps that either have motors (but without controls) or pumps with motors with continuous or non-continuous controls.

While some pump manufacturers may be capable and equipped to accurately measure pumps sold with motors and continuous or non-continuous controls in accordance with the proposed power supply characteristics, DOE recognizes that there may be some variability among manufacturers in this regard. Consequently, these requirements may represent a significant incremental burden for some testing facilities. To lessen this burden, DOE proposes to require that power supply requirements would apply only to pumps being evaluated using a physical testing-based method or pumps being tested using a calibrated motor. Pumps evaluated based on the calculation method where the input power to the motor is determined using equipment other than a calibrated motor would not have to meet these requirements, as variations in voltage, frequency, and voltage unbalance are not expected to affect the tested pump's energy performance.

DOE requests comment on the proposed voltage, frequency, voltage unbalance, total harmonic distortion, and impedance requirements that must be met when performing a wire-to-water pump test or when testing a bare pump with a calibrated motor. Specifically, DOE requests comments on whether these tolerances can be achieved in typical pump test labs, or whether specialized power supplies or power conditioning equipment would be required.

Number of Stages for Multi-Stage Pumps

RSV and VTS pumps are typically multi-stage pumps that may be offered in a variety of stages (also known as bowls), each with its own energy consumption characteristics, which scale approximately linearly with each additional bowl. With these pump designs, any improvements in the hydraulic design of the bowl would be reflected in the measured performance of the pump with any number of stages. Thus, to simplify certification requirements and limit testing burden, DOE proposes to require that certification of RSV and VTS pumps be based on testing with the following number of stages:

- RSV: 3 stages; and
- VTS: 9 stages.

If a model is not available with that specific number of stages, the model would be tested with the next closest number of stages distributed in commerce by the manufacturer. This proposal was part of the Working Group Recommendations. (Docket No. EERE-2013-BT-NOC-0039, No. 92, Recommendation #14 at p. 6)

DOE requests comment on its proposal to test RSV and VTS pumps in their 3- and 9-stage versions, respectively, or the next closest number of stages if the pump model is not distributed in commerce with that particular number of stages.

d. Determination of Pump Shaft Input Power at Specified Flow Rates

HI 40.6–2014 provides a specific procedure for determining BEP for a given pump based on seven data points at 40, 60, 75, 90, 100, 110 and 120 percent of the expected BEP flow of the pump. The test protocol in HI 40.6–2014 requires that the hydraulic power and the pump shaft input power, or input power to the motor for pumps tested using the testing-based methods, be measured at each of the seven data points. HI 40.6–2014 further specifies that the pump efficiency be determined as a ratio of hydraulic power divided by shaft input power, as described in equation (1), or the measured input power to the motor multiplied by the known efficiency of a calibrated motor, depending on how the pump is tested.

The pump efficiency at each of these points is then used to determine the tested BEP for a given pump. Then, based on the determined BEP flow, the pump shaft input power or input power to the motor is determined at each of the specified load points, as discussed in section III.B.2.a. However, the specific data points measured in the test protocol may not be exactly at 75, 100, or 110 percent of the BEP flow load points specified in the proposal. Thus, the relevant test values -- specifically, pump shaft input power, input power to the pump at the driver, or input power to the continuous or non-continuous controls -- must be adjusted to reflect the power input at the load points specified in the test procedure.

Consistent with the CIP Working Group's recommendations, (Docket No. EERE-2013-BT-NOC-0039, No. 107 at pp. 35) DOE proposes to address this issue by requiring that the pump shaft input power at the defined load points be obtained by performing the pump test across a complete range of flow rates (i.e., sweeping the pump curve) and determining the pump shaft input power at a number of load points between shutoff (no flow) and overload (max flow), as specified in HI 40.6–2014. In this method, the established pump curve could then be used to find BEP (as described in section III.C.2.d). The pump shaft input power at the specific load points of 75, 100, and 110 percent of BEP flow could be determined by regressing the pump shaft input power with respect to flow between 75 and 110 percent of BEP flow. Specifically, the regressed test points would include the test points beginning with the next standard flow point below 75 percent of BEP flow (e.g., the load point corresponding to 60 percent of expected BEP flow) and continuing to the highest flow rate measured during the test.

This method would provide a low testing burden, as test data would only have to be collected at each of the specified seven load points with no measurements required at subsequent load points (e.g., 75 or 110 percent of BEP flow if the previously collected load points collected based on the expected BEP of the pump were not sufficiently close to the necessary load points based on the actual BEP of the pump). By design, the method relies on the relationship between pump shaft input power and flow being fairly linear across the flow rates of interest. To verify the assumption of linearity, DOE researched the relationship of pump shaft input power to flow using publicly available pump performance data. Based on this research, DOE observed that the relationship of pump shaft input power to flow rate was very nearly linear, but sometimes decreased slightly in slope at higher flow rates. These data indicate that, as a general matter, applying a linear regression approach across the flow range between 75 and 110 percent of BEP flow to determine the pump shaft input power at the proposed specified flow points would provide a reasonably accurate measurement of pump shaft input power.

DOE recognizes that this method may overestimate pump shaft input power in cases where the pump shaft input power increases less significantly above BEP flow, which would result in a slightly higher PER_{CL} for the given pump. However, DOE's contractors analyzed the impact of the linear regression approach on the pumps in their pump database[37] and found that the linear regression method was, on average, within approximately 1 percent of the measured pump shaft input power values. DOE also notes this method would be applied equivalently to all pumps, result in a worst-case rating, and offer the least burdensome approach.

DOE discussed this proposed method with the CIP Working Group, which informally agreed with DOE's proposed approach to linearly regress the measured pump shaft input power at the relevant flow points to determine the pump shaft input power at the specific flow points of 75, 100, and 110 percent of BEP flow. (Docket No. EERE-2013-BT-NOC-0039, No. 107 at p. 35)

DOE requests comment on its proposal to use a linear regression of the pump shaft input power with respect to flow rate at all the tested flow points greater than or

[37] DOE's contractors have created a database of available pump models being proposed for coverage under this test procedure and the associated energy conservation standards. The database represents a significant portion of the pump market and is based on data supplied to DOE's contractors directly from pump manufacturers and aggregated data supplied by HI. DOE's contractors developed this database over the course of the CIP Working Group negotiations, and the database is described in more detail in the docket for those meetings. (Docket No. EERE-2013-BT-NOC-0039)

equal to 60 percent of expected BEP flow to determine the pump shaft input power at the specific load points of 75, 100, and 110 percent of BEP flow. DOE is especially interested in any pump models for which such an approach would yield inaccurate measurements.

<u>Determination of Pump Shaft Input Power for Pumps with BEP at Run Out</u>

HI 40.6–2014 contains a method for determining the BEP of tested pumps based on the flow rate at which the maximum pump efficiency occurs. DOE recognizes that there may be some unique pump models that do not exhibit the typical parabolic relationship of pump efficiency to flow rate. Instead, for some pumps, pump efficiency will continue to increase as a function of flow until pump run-out—the maximum flow that can be developed without damaging the pump. For such pumps, it may not be possible to use the procedure described in HI 40.6–2014 to determine BEP, since the pump cannot safely operate at flows of 110 and 120 percent of the expected BEP of the pump (assuming the pump was designed intentionally to have the BEP occur at run-out or the maximum flow rate). In such cases, DOE proposes that the seven flow points for determination of BEP be 40, 50, 60, 70, 80, 90, and 100 percent of expected BEP flow instead of the seven data points described in section 40.6.5.5.1 of HI 40.6–2014.

In addition, since 100 percent of BEP flow corresponds to the maximum flow rate of the pump, there are no data corresponding to 110 percent of BEP flow, or any flow rates above BEP flow. Therefore, in cases where the BEP flow is at run-out, DOE proposes that the specified constant load flow points be 100, 90, and 65 percent of the

BEP (or maximum) flow rate. DOE notes that, for pumps sold with motors and continuous or non-continuous controls, no modification would be necessary since there are no load points above 100 percent of BEP flow in the variable load profile.

DOE requests comment on its proposal that, for pumps with BEP at run-out, the BEP would be determined at 40, 50, 60, 70, 80, 90, and 100 percent of expected BEP flow instead of the seven data points described in section 40.6.5.5.1 of HI 40.6–2014 and that the constant load points for pumps with BEP at run-out shall be 100, 90, and 65 percent of BEP flow, instead of 110, 100, and 75 percent of BEP flow.

e. Measurement Equipment for VFD Wire-to-Water Test

HI 40.6–2014 does not contain all the necessary methods and calculations to determine pump power consumption for the range of equipment that would be addressed by this proposal (i.e., pumps inclusive of motors and continuous or non-continuous controls). For the purposes of determining pump shaft input power, motor input power, input power to the continuous or non-continuous controls, and pump hydraulic power, certain equipment is necessary to measure head, speed, flow rate, torque, electrical power, and temperature. To specify the appropriate equipment to accurately and precisely measure relevant parameters, DOE proposes to incorporate by reference HI 40.6–2014, appendix C, which specifies the required instrumentation to measure head, speed, flow rate, torque, temperature, and electrical input power to the motor. However, for the purposes of measuring input power to the pump for pumps sold with a motor and continuous or non-continuous controls, the equipment specified in section C.4.3.1, "electric power input to the motor," of HI 40.6–2014 may not be sufficient.

In response to the Framework Document, several commenters discussed the instrumentation needed to test a pump inclusive of motor and continuous or non-continuous controls. The CA IOUs mentioned that most VFDs introduce non-linear, or non-sinusoidal, wave forms into the utility system, which will affect the total harmonic distortion experienced in the power system.[38] As such, it would be important to measure their power and energy use with true root mean square (RMS) power-measuring

[38] Total harmonic distortion results from the introduction of non-linear loads into the power system, which introduces wave forms that are out of phase with the voltage and can affect power quality and the efficiency of power distribution.

equipment to capture the impact of such harmonic distortion on the measured input power to any pump sold with a motor and continuous or non-continuous control. (CA IOUs, Framework Public Meeting Transcript No. 19 at p. 236) In addition, HI stated that testing pumps inclusive of motors and continuous or non-continuous controls would require an upgrade to the test instrumentation to measure the input power into a VFD to compensate for the disruption of the input power by the VFD. (HI, No. 25 at p. 35) However, HI added that this additional instrumentation is manageable and within the capabilities of what most of the HI members are doing today. (HI, Public Meeting Transcript, No. 19 at p. 235)

To determine the appropriate electrical measurement equipment for pumps tested with a motor and continuous or non-continuous controls, DOE consulted CSA C838–2013 and AHRI 1210–2011, since these test standards are the most relevant references for measuring input power to such controls. Both CSA C838–2013 and AHRI 1210–2011 require that electrical measurements for determining variable speed drive efficiency be taken using equipment capable of measuring current, voltage, and real power up to at least the 40th harmonic of fundamental supply source frequency[39] and have an accuracy level of ±0.2 percent of full scale when measured at the fundamental supply source frequency. In addition, AHRI 1210–2011 prescribes that such electrical measurement equipment must be designed as per International Electrotechnical Commission (IEC) Standard 61000-4-7–2002, “Electromagnetic compatibility (EMC) – Part 4-7: Testing

[39] CSA C838–2013 requires measurement up to the 50th harmonic. However, DOE believes that measurement up to the 40th harmonic is sufficient, and the difference between the two types of frequency measurement equipment will not be appreciable.

and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto."

Because some variable speed control methods have the potential to introduce harmonics to the power system, which can reduce power factor[40] and affect the performance of certain electrical equipment, such as motors, DOE proposes that the electrical measurement equipment specified in AHRI 1210–2011 and CSA C838–2013 be required for the purposes of measuring input power to a pump sold with a motor and continuous or non-continuous controls. DOE agrees with interested parties that specific electrical measurement equipment capable of capturing the disruption or distortion of input power should be used to ensure measurement accuracy. Also, DOE does not anticipate that this proposed requirement would be likely to introduce an undue burden on pump manufacturers since many of them are already using this type of specialized equipment to test pumps equipped with motors having continuous or non-continuous controls. The burden associated with this test procedure, and in particular the required test equipment, is discussed further in section IV.B.

[40] Power factor is defined as the ratio of the real power supplied to the load over the apparent power in the circuit and is a dimensionless number between -1 and 1. Higher values of power factor (closer to 1) indicate that more real power is being supplied to the load relative to the current and voltage flowing in the circuit. When non-linear loads are applied that distort the wave form, less real power is available relative to the current and voltage in the circuit.

DOE requests comment on the type and accuracy of required measurement equipment, especially the equipment required for electrical power measurements for pumps sold with motors having continuous or non-continuous controls.

f. Calculations and Rounding

DOE notes HI 40.6–2014 does not specify how to round values for calculation and reporting purposes. DOE recognizes that the manner in which values are rounded can affect the resulting PER or PEI, and all PER or PEI values should be reported with the same number of significant digits. DOE proposes to require that all calculations be performed with the raw measured data, to ensure accuracy, and that the PER_{CL} and PEI_{CL} or PER_{VL} and PEI_{VL} be reported to the nearest 0.01. Therefore, the values obtained from any corrections to nominal speed or calculations performed prior to obtaining the final PER or PEI values would not be rounded.

DOE requests comment on its proposal to conduct all calculations and corrections to nominal speed using raw measured values and that the PER_{CL} and PEI_{CL} or PER_{VL} PEI_{VL}, as applicable, be reported to the nearest 0.01.

D. Determination of Motor Efficiency

The PEI_{CL} and PEI_{VL} metrics both describe the performance of a pump and its accompanying motor and continuous or non-continuous controls, if applicable. As such, the performance of the applicable motor must be determined to calculate the PEI_{CL} or PEI_{VL} of a given pump model. For determining pump performance for bare pumps and determining the default motor efficiency of a minimally compliant pump (PER_{STD}), DOE is proposing to specify a standardized default motor nominal efficiency.

For determining pump performance for pumps sold with motors or with motors and continuous or non-continuous controls, DOE is proposing to use either (1) the physically tested performance of the motor paired with that pump when using testing-based methods, or (2) the nominal full load motor efficiency of the motor (other than submersible) paired with that pump model when using the calculation-based test method to determine the PER_{CL} or PER_{VL} for that pump. See section III.E.1.b, infra, describing the proposed calculation-based method for pumps sold with motors and the use of the nominal motor efficiency when calculating overall pump power consumption.

The default nominal or rated nominal full load motor efficiency, as represented by the motor manufacturer, would then be used to determine the full load losses, in horsepower, associated with that motor. The full load losses would then be adjusted using an algorithm to reflect the motor performance at partial loads, corresponding to the load points specified in the DOE test. The specific procedures for determining the default nominal and rated nominal motor part load losses are described below.

1. Default Motor Efficiency

To calculate PER_{CL} for a pump sold in the bare pump configuration and determining its PER_{STD}, default motor losses would be added to the pump shaft input power at each rating point, and the sum would be multiplied by a weighting factor. In order to calculate the default motor losses at each rating point, DOE proposes to adopt default motor efficiency values based on the nominal full load motor efficiency values for general purpose, polyphase, NEMA Design A, NEMA Design B, and IEC Design N motors defined in 10 CFR 431, subpart B for medium and large electric motors. Based on the Working Group discussions, DOE believes that most motors sold with pumps under the scope of this rulemaking are sold with motors covered by DOE's updated electric motors standards and test procedures. (Docket No. EERE-2013-BT-NOC-0039, No. 09 at pp. 57-58) See section III.D.1.c, infra., for a discussion regarding submersible motors.

Subpart B of 10 CFR 431 contains DOE's energy conservation standards for electric motors, which DOE recently updated. See 79 FR 30934 (May 29, 2014). That rule established energy conservation standards for a number of different categories of electric motors DOE had not previously regulated, such as partial motors. In addition, although it did not change the required minimum efficiency of electric motors currently covered as general purpose electric motors (subtype I), it did increase the required efficiency for electric motors currently defined by DOE under the category of general purpose electric motors (subtype II), which includes close-coupled pump motors. Motors that are regulated must be manufactured in compliance with these updated standards beginning on June 1, 2016. 79 FR at 30944.

DOE proposes to use the applicable minimum nominal full load motor efficiency values at 10 CFR 431.25 for the category and horsepower of electric motors with which pumps are typically paired (i.e., NEMA Design A, NEMA Design B, and IEC Design N motors). Specifically, DOE believes that the minimum efficiency of a NEMA Design A, NEMA Design B, or IEC Design N motor is an applicable default minimum motor efficiency to apply to all pumps to which the proposed test procedure would apply, except submersible motors. At the time of writing, the values in Table 5 of 10 CFR 431.25(h) define the nominal minimum efficiency for motors paired with bare pumps sold alone and for determining the PER_{STD} (see section III.B.2.b). Table 5 defines the minimum nominal efficiency for NEMA Design A, NEMA Design B, and IEC Design N electric motors from 1 to 500 hp meeting the following criteria:

1) are single-speed, induction motors;
2) are rated for continuous duty (MG 1) operation or for duty type S1 (IEC);
3) contain a squirrel-cage (MG 1) or cage (IEC) rotor;
4) operate on polyphase alternating current 60-hertz sinusoidal line power;
5) are rated 600 volts or less;
6) have a 2-, 4-, 6-, or 8-pole configuration;
7) are built in a three-digit or four-digit NEMA frame size (or IEC metric equivalent), including those designs between two consecutive NEMA frame sizes (or IEC metric equivalent), or an enclosed 56 NEMA frame size (or IEC metric equivalent);
8) produce at least 1 hp (0.746 kW) but not greater than 500 hp (373 kW); and
9) meet all of the performance requirements of one of the following motor types: A NEMA Design A or B motor or an IEC Design N.

79 FR at 31012 (to be codified at 10 CFR 431.25(g)-(h)).

a. Default Motor Selection

For bare pumps, DOE proposes to specify the selection of the default motor used for calculating PER_{CL} and PER_{STD} based on the nominal speed and measured shaft input power of the rated pump. DOE proposes that the number of poles selected for the default motor be equivalent to the nominal speed of the rated pump (i.e., 2 poles corresponds to 3600 rpm and 4 poles corresponds to 1800 rpm). DOE also proposes that the motor horsepower selected for a given pump would be required to be either equivalent to, or the next highest horsepower-rated level greater than, the measured pump shaft input power at 120 percent of BEP flow. DOE also proposes that the shaft input power at the 120 percent of BEP flow point be calculated based on a linear extrapolation of the 100 and 110 percent of BEP flow points, similar to the approach proposed for determining the input power to the pump at these specified flow points, discussed in section III.C.2.d.

DOE notes that the energy conservation standards for motors, found in Table 5 in 10 CFR 431.25(h), include minimum nominal full load motor efficiency values for both open and enclosed motor construction. In general, motors with an open construction have a lower minimum nominal full load efficiency value; however, for some pole and horsepower combinations, this relationship does not hold. Therefore, for bare pumps and the minimally compliant pump in PER_{STD}, DOE proposes to specify selection of the minimum efficiency value listed in Table 5 of 10 CFR 431.25(h) for the lower value of either the open or enclosed construction at the appropriate motor horsepower and number of poles.

As noted in section III.B.2.b, for pumps sold either with motors or with motors and continuous or non-continuous controls, the motor horsepower and number of poles selected for determining the minimally compliant full load nominal efficiency from Table 5 in 10 CFR 431.25(h)) (or the submersible motor table, in the case of submersible motors, see section III.D.1.b) and used in the equation for PER_{STD} should be equivalent to the horsepower and poles of the motor actually sold with the pump. In other words, the horsepower and number of poles of the minimally compliant motor in PER_{STD} would be the same as the motor with which the pump is being rated. In such a case, the minimum full load nominal efficiency corresponding to the minimally compliant motor in PER_{STD} shall still be the minimum of the open and enclosed values. That is, regardless of the motor construction (i.e., open or enclosed) of the motor with which the pump is being rated, the minimum efficiency value listed in the table at 10 CFR 431.25(h) for the given motor horsepower and number of poles shall be used.

DOE requests comment on its proposal to determine the default motor horsepower for rating bare pumps based on the pump shaft input power at 120 percent of BEP flow. DOE is especially interested in any pumps for which the 120 percent of BEP flow load point would not be an appropriate basis to determine the default motor horsepower (e.g., pumps for which the 120 percent of BEP flow load point is a significantly lower horsepower than the BEP flow load point).

DOE requests comment on its proposal to specify the default, minimally compliant nominal full load motor efficiency based on the applicable minimally allowed nominal full load motor efficiency specified in DOE's energy conservation standards for NEMA Design A, NEMA Design B, and IEC Design N motors at 10 CFR 431.25 for all pumps except pumps sold with submersible motors.

b. Rated Nominal Motor Efficiency for Pumps Sold with Motors

For pumps sold with motors and rated using the calculation-based approach, DOE proposes that the motor nominal full load efficiency used in determining the PER_{CL} or PER_{VL} would be the measured nominal full load efficiency determined in accordance with the DOE electric motor test procedure specified at 10 CFR 431.16 and appendix B to subpart B of part 431. For pumps sold with submersible motors and rated using the calculation-based approach, the motor full load efficiency values are discussed in section III.D.1.c. For pumps sold with motors not addressed by DOE's electric motor test procedure (except submersible motors), the calculation-based methods described in section III.E.1 would not apply and no assumption regarding nominal efficiency of the motor paired with the pump would be required when determining PER_{CL} or PER_{VL}. However, an assumption regarding the default efficiency of the minimally compliant motor that could be paired with a given pump would still be required to calculate PER_{STD}. See section III.D.1.a., supra.

c. Submersible Motors

DOE notes that submersible motors are not currently subject to the DOE energy conservation standards for electric motors specified at 10 CFR 431.25. For the purposes of calculating PEI_{CL} for bare VTS pumps or PER_{STD} for any pumps sold with submersible motors, DOE requires a default assumption regarding full load efficiency for submersible motors. DOE surveyed the literature and equipment catalogs of pump and motor manufacturers producing submersible motors and collected full load efficiency data. The data collected are the representations made in manufacturer literature regarding the full load efficiency of the motor, but do not indicate whether these reported efficiency values comprise tested, nominal, or rated values, as submersible motors are not covered by DOE's energy conservation standards or test procedures.

Based on the available information, DOE constructed a table of motor full load efficiencies by motor horsepower, similar to the table of energy conservation standards for electric motors at 10 CFR 431.25(h). DOE notes that because submersible motors are only available in enclosed construction, full load efficiency values are only provided for enclosed constructions.

To construct the submersible motor full load efficiency table, DOE conducted research to determine the least efficient motor commercially available within each specified horsepower and pole configuration (where data were available). DOE selected the least efficient submersible motor available because DOE recognizes that, by selecting a value higher than the minimum available, DOE could unintentionally drive the submersible motor market without explicitly regulating it. Based on the available data, DOE identified the number of "bands"[41] below the minimum full load efficiency values

[41] Because motor efficiency varies from unit to unit, even within a specific model, NEMA has established a list of standardized efficiency values that manufacturers use when labeling their motors. Each incremental step, or "band," constitutes a 10 percent change in motor losses. NEMA MG 1-2011 Table 12-10 contains the list of NEMA nominal efficiencies. See Electric Motors Final Rule, 79 FR 30933 (May 29, 2014)

for NEMA Design A, NEMA Design B, and IEC Design N motors, as presented in Table 5 of 10 CFR 431.25(h).

The “minimum observed efficiency” column in Table III.6 reflects the least efficient motors found by DOE. As it is not DOE’s intent to impact the rated efficiency of submersible motors through this rulemaking, DOE deflated the minimum observed submersible motor efficiency by using the maximum number of “bands” across a horsepower range to ensure that the value represented a worst-case value. Where no data were available, DOE applied the same number of NEMA bands across the range of motor horsepower and numbers of poles. The observed and default number of “bands” below the minimum full load efficiency values for NEMA Design A, NEMA Design B, and IEC Design N motors from Table 5 of 10 CFR 431.25(h), are presented in Table III.6 below.

Table III.6. Two-Pole Motor Submersible Motor Full Load Efficiency by Motor Horsepower Relative to the Full Load Efficiency in in Table 5 of 10 CFR 431.25(h)

Motor Horsepower (hp)	Minimum Observed Full Load Efficiency (2-poles) (%)	Observed Number of "bands" below the Full Load Efficiency in in Table 5 of 10 CFR 431.25(h)	Default Number of "bands" below the Full Load Efficiency in in Table 5 of 10 CFR 431.25(h)
1	67	6	11
1.5	67	11	
2	73	9	
3	75	9	
5	76	10	
7.5	77	10	15
10	75	13	
15	72.2	15	
20	76.4	13	
25	79	12	
30	79.9	12	12
40	83	10	
50	83	11	
60	84	11	
75	83.8	12	
100	87	10	14
125	86	13	
150	86	13	
175	88	12	
200	87	14	
250	87	14	

The resulting proposed default minimum electric motor full load efficiencies for submersible motors, as presented in the "default minimum efficiency" column in Table III.7, can then be calculated by applying the number of "bands" below the minimum full load efficiency values for NEMA Design A, NEMA Design B, and IEC Design N motors in Table 5 of 10 CFR 431.25(h), as presented in Table III.6, to the actual efficiency values listed in the same Table 5 of 10 CFR 431.25(h).

Table III.7. Default Submersible Motor Full Load Efficiency by Motor Horsepower

Default Submersible Motor Full Load Nominal Efficiency		
Motor Horsepower	**Pole configurations**	
	2	**4**
1	55	68
1.5	66	70
2	68	70
3	70	75.5
5	74	75.5
7.5	68	74
10	70	74
15	72	75.5
20	72	77
25	74	78.5
30	78.5	82.5
40	80	84
50	81.5	85.5
60	82.5	86.5
75	82.5	87.5
100	81.5	85.5
125	84	85.5
150	84	86.5
200	85.5	87.5
250	86.5	87.5

DOE requests comment on the proposed default minimum full load motor efficiency values for submersible motors.

DOE requests comment on defining the proposed default minimum motor full load efficiency values for submersible motors relative to the most current minimum efficiency standards levels for regulated electric motors, through the use of “bands” as presented in Table III.6.

DOE proposes to apply this table of default minimum efficiency values for submersible motor full load efficiency when calculating PER_{STD} for VTS pumps and to calculate the PEI_{CL} for pumps sold with submersible motors or PEI_{VL} for pumps sold with a submersible motor and continuous or non-continuous controls, using the calculation-based approach described in section III.E.1. This aspect of DOE's proposal would result in a conservative calculation of energy consumption for the rated pump model, since the submersible motor with which the rated pump model is paired may be more efficient than the default minimum full load efficiency assumed in Table III.7. Allowing the calculation-based method to be used for pumps sold with submersible motors may also reduce the testing burden for some manufacturers. If manufacturers wish to account for the use of submersible motors with a higher efficiency than the minimum default full load efficiency, they may choose to rate the pump model through using the testing-based, wire-to-water method described in section III.E.2.

In summary, DOE proposes allowing the use of the default minimum submersible motor full load efficiency values presented in Table III.7 to rate (1) VTS bare pumps, (2) pumps sold with submersible motors, and (3) pumps sold with submersible motors and continuous or non-continuous controls as an option instead of wire-to-water testing.

DOE requests comment on the proposal to allow the use of the default minimum submersible motor full load efficiency values presented in Table III.7 to rate: (1) VTS bare pumps, (2) pumps sold with submersible motors, and (3) pumps sold with submersible motors and continuous or non-continuous controls as an option instead of wire-to-water testing.

2. Determining Part Load Motor Losses

To determine the full load losses of the motor, the proposal would require that the full load motor efficiency described in section III.D.1 be used. Using this value, DOE would apply an algorithm to determine the part load losses of the motor at each of the rating points.

To obtain the losses of the motor used at a fraction of full load under the proposal in this NOPR, manufacturers would be required to calculate the part load motor losses at each specified load point in accordance with the following three steps:

1) Determine the part load loss factor (y_i) for each rating point, where part load loss factor at a given point represents the part load losses at the given load divided by full load losses, as shown in equation (12):

$$y_i = \left(-0.4508 \times \left(\frac{P_i}{MotorHP}\right)^3 + 1.2399 \times \left(\frac{P_i}{MotorHP}\right)^2 - 0.4301 \times \left(\frac{P_i}{MotorSize}\right) + 0.6410\right) \quad \textbf{(12)}$$

Where:

y_i = the part load loss factor at load point i,

P_i = the shaft input power to the bare pump (hp),

MotorHP = the motor horsepower (hp), and

i = percentage of flow at the BEP of the pump.

2) Calculate full load losses for the motor as shown in equation (13):

$$L_{full,default} = \frac{MotorHP}{\left[\eta_{motor,full}/_{100}\right]} - MotorHP \qquad \textbf{(13)}$$

Where:

$L_{full,default}$= default motor losses at full load (hp),

MotorHP = the motor horsepower (hp), and

$\eta_{motor,full}$ = the full load motor efficiency as determined in accordance with section III.D.1 (%).

3) Multiply the full load losses by each part load loss factor to obtain part load losses at each rating point, as shown in equation (14):

$$L_i = L_{full,default} \times y_i \qquad \textbf{(14)}$$

Where:

L_i= default motor losses at rating point i (hp),

$L_{full,default}$= default motor losses at full load (hp),

y_i = part load loss factor at each rating point i, and

i = rating points corresponding to 75, 100, and 110 percent of BEP flow for uncontrolled pumps and 25, 50, 75, and 100 percent of BEP flow for pumps sold with a motor and continuous or non-continuous controls as determined in accordance with the DOE test procedure.

DOE determined the cubic polynomial used to describe the part load loss factor (y_i) based on part load efficiency data provided by the NEMA electric motors subcommittee.[42] The cubic polynomial represents the measured part load performance of motors from 1–200 horsepower from seven manufacturers that are members of the NEMA subgroup. These data were provided at part load values of 25, 50, 75, and 100 percent of the rated motor load. To determine how motor losses changed as a function of motor load over the range of those motors addressed in this rulemaking, the data were normalized based on the minimum full load efficiency of the motors.

DOE acknowledges that losses may vary as a function of the motor's rotating speed (2-pole vs. 4-pole), motor design (open vs. enclosed), or the motor's horsepower rating. However, based on the data provided by NEMA, as well as additional data DOE gathered using DOE's MotorMaster database[43] and DOE's Motor Challenge Program Fact Sheet,[44] DOE did not observe any significant or generalizable trends of motor efficiency or fractional motor losses with respect to a motor's number of poles, category, or horsepower. DOE conducted a sensitivity analysis based on each of these factors and, in every case, the maximum impact on the rated pump PEI_{CL} or PEI_{VL} was less than 1 percent. DOE's sensitivity analysis can be found in the docket for this rulemaking. As such, DOE does not believe the additional complexity associated with multiple curves describing small variations in a motor's part load performance is justified and proposes to use the single cubic polynomial presented in equation (12).

[42] During the CIP Working Group negotiations, the NEMA motor and drive working group provided DOE contractors with a table of representative nominal motor efficiency values, broken out by horsepower and motor load, to support development of the part load loss curves.
[43] Department of Energy. September 21, 2010. MotorMaster+. Version 4.01.01. www.energy.gov/eere/amo/articles/motormaster
[44] Department of Energy. Determining Electrical Motor Load and Efficiency. pp. 13-14. www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/10097517.pdf

These calculated part load motor losses at each of the specified load points would then be combined with the measured pump shaft input power and weighted equally to calculate PER_{CL} or PER_{VL} and PER_{STD}, as described in section III.B.2.

DOE requests comment on the development and use of the motor part load loss factor curves to describe part load performance of covered motors and submersible motors, including the default motor specified in section III.D.1 for bare pumps and calculation of PER_{STD}

E. Test Methods for Different Pump Configurations

As previously discussed, the PEI_{CL} and PEI_{VL} for a given pump would be determined by first calculating the PER_{CL} or PER_{VL}, as applicable, for the given pump. The PER_{CL} or PER_{VL} would then be scaled based on a calculated PER_{STD} (i.e., the PER_{CL} of a pump that would comply with the applicable standard). (Docket No. EERE-2011-BT-STD-0031) The process for determining the PER_{STD} is described in section III.B.2.b.

The PER_{CL} and PER_{VL} are a weighted average of input power to the pump over a range of full and part load operating flow rates, and can potentially be determined using a number of different test methods, based on the way the pump model is sold. For example, the test method for pumps sold alone (i.e., bare pumps) will be different than that for pumps sold with motors or pumps sold with motors and continuous or non-continuous controls. However, the DOE test procedure for pumps will have a similar format for each configuration in that each will describe (1) the physical test method, testing conditions, and required data collection to ensure consistent and accurate test results and (2) the calculation method that defines how the collected data will be used to determine the final PER_{CL} or PER_{VL} for that model.

Some test methods that DOE considered rely more on the performance of physical tests to obtain rating data (i.e., testing-based methods), which increases testing burden but may be more accurate than test procedures that rely more heavily on calculations. In a testing-based approach, each pump basic model must be individually tested, which is considerably more burdensome than calculating the rating. However, the wire-to-water performance of the product would be determined directly as a result of the test rather than by determining it through a calculation method, and the unique performance of each component at full and partial loading would be accurately captured.

In contrast, a calculation-based approach to determine PER_{CL} or PER_{VL} (i.e., the numerator of the PEI_{CL} or PEI_{VL}, respectively) for a given pump model can reduce the number of tests by allowing for the independent measurement of each component. That is, the input power to the bare pump, motor efficiency, or performance of a motor with continuous controls would be determined separately and subsequently combined through an equation to obtain the overall PER_{CL} or PER_{VL} rating for the pump. The equations could be used to determine ratings for unique basic models made up of different combinations of bare pumps, motors, and continuous controls without the need to test each unique combination.

Calculation-based test methods are extremely repeatable and straightforward to conduct. However, calculation-based methods may not account for the efficiency or energy use impact of all theoretical designs of a given component. For example, to calculate the performance of a pump sold with a motor and continuous control, assumptions regarding how the continuous control affects the input power to the pump would be required at full and part load, and this assumed "system curve" may not reflect the actual measured performance of different types or brands of continuous controls available.

In the subsequent sections, DOE discusses calculation-based and testing-based test methods for different pump configurations.

1. Calculation-Based Test Methods

Calculation-based test methods have the benefit of being repeatable, straightforward, and minimally burdensome. DOE proposes that the following calculation-based test methods would be used to rate (1) pumps sold as bare pumps (Method A.1); (2) pumps sold either with (a) motors that are regulated by DOE's electric motor standards or (b) submersible motors (Method A.2); and (3) pumps sold with motors that are either (a) regulated by DOE's electric motor standards or (b) submersible motors, and that are equipped with continuous controls[45,46] (Method A.3).

[45] The calculation-based test method was designed to capture the dynamic response of a control that can continuously respond to changes in load and reduce power consumption at all load points below BEP. Therefore, pumps sold with non-continuous controls would instead use the testing-based method described in section III.E.2.c, which captures some reduction in power consumption at some reduced flow rates. DOE discussed this approach with the CIP Working Group, which generally agreed with it, although such a

In general, the calculation-based test method for the applicable pump types would include physical testing of the bare pump, in accordance with HI 40.6–2014, and subsequent calculations to determine the PEI_{CL} or PEI_{VL}, as applicable. The general steps of the calculation-based procedure would be as follows:

1) Determine performance of the bare pump in accordance with HI 40.6–2014.
    a) Measure the flow rate (gpm), head (ft), rotational speed (rpm), and torque (inches-pounds force) at 40, 60, 75, 90, 100, 110, and 120 percent of the flow rate at the expected BEP of the pump and determine the pump efficiency at each point.
    b) Determine the actual BEP by finding the maximum point of the pump efficiency curve, as measured, with respect to flow rate.
    c) Determine pump input power (torque multiplied by speed) and regress pump shaft input power with respect to flow to find a linear relationship for all flow points greater than or equal to 60 percent of expected BEP flow. Use this regression to determine pump shaft input power at 75, 100, and 110 of actual BEP flow.
    d) Adjust all values to nominal speed.

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recommendation was not specifically included in the CIP Working Group Recommendations. (Docket No. EERE-2013-BT-NOC-0039, No. 107 at pp. 49-50)

[46] DOE notes that some pumps sold with continuous controls, such as pumps sold with ECMs, may not be eligible to apply the calculation-based method based on the fact that ECMs are not: (1) a type of motor covered by DOE's energy conservation standards for covered motors or (2) a submersible motor (see section III.E). These pumps would instead apply a testing-based method.

2) Determine the part load losses of the motor and any continuous or non-continuous controls applicable to the rated pump model at each load point.

   a) For bare pumps sold alone, the part load losses at each load point shall be determined based on the default motor efficiency of an appropriately sized motor that minimally complies with DOE's energy conservation standards for electric motors and the default motor loss curve, as described in section III.D. Motor selection requirements are discussed in section III.D.1.a

   b) For pumps sold with motors that are regulated by DOE's energy conservation standards, the part load losses at each load point shall be determined based on the rated full load motor efficiency of the motor that is paired with that pump and the default motor loss curve described in section III.D.2. For pumps sold with submersible motors, the part load losses at each load point shall be determined based on the default minimum submersible motor efficiency from Table III.6 and the default motor loss curve described in section III.D.2.

   c) For pumps sold with applicable motors and continuous controls, the part load losses at each load point shall be determined based on the rated full load motor efficiency of the motor that is paired with that pump and the default motor and continuous control loss curve described in section III.E.1.c.

3) Determine PER_{CL} or PER_{VL}, as applicable, for the given pump

a) Sum the pump shaft input power at nominal speed and the calculated part load motor losses at each load point in the constant load or variable load profiles, as applicable, to determine the input power to the pump.

b) Average the calculated values of input power to the pump at the applicable rating points.

4) Determine PER_{STD} for the minimally compliant pump, as described in section III.B.2.

5) Divide PER_{CL} or PER_{VL} from step 3 by the PER_{STD} for that pump model to determine PEI_{CL} or PEI_{VL}, respectively.

The specific test methods for bare pumps, pumps sold with motors, and pumps sold with motors and continuous controls are described in more detail in the following sections III.E.1.a, III.E.1.b, and III.E.1.c, respectively.

a. Calculation-Based Test Method A.1: Bare Pump

As described previously, the bare pump PER_{CL} would be measured based on the pump shaft input power at 75, 100, and 110 percent of BEP flow. Section III.C of this notice describes the proposed test method for determining pump shaft input power at the designated load points, which is based on HI 40.6–2014. The measured pump shaft input power at the three constant load flow points would then be combined with the part load motor losses at each flow point and equally weighted to determine PER_{CL} for that bare pump, as shown in equation (15):

$$PER_{CL} = \omega_{75\%}\left(P_{75\%}^{in}\right) + \omega_{100\%}\left(P_{100\%}^{in}\right) + \omega_{110\%}\left(P_{110\%}^{in}\right)$$

$$= \omega_{75\%}(P_{75\%} + L_{75\%}) + \omega_{100\%}(P_{100\%} + L_{100\%}) + \omega_{110\%}(P_{110\%} + L_{110\%}) \quad \textbf{(15)}$$

Where:

ω_i = weighting at each rating point (equal weighting or $^1/_3$ in this case),

P_i^{in} = calculated input power to the motor at rating point i (hp),

P_i = the shaft input power to the bare pump (hp),

L_i = default motor losses at each load point i (hp), and

i = 75, 100, and 110 percent of BEP flow as determined in accordance with the DOE test procedure.

The part load motor losses would be determined for the bare pump based on an assumed default motor efficiency representative of a motor that is minimally compliant with DOE's electric motor energy conservation standards (or the default minimum motor efficiency for submersible motors), as described in section III.D.1, and the default motor loss curve, as described in section III.D.2.

The PEI_{CL} can then be calculated as the PER_{CL} for a given pump divided by the PER_{STD} for a pump that is minimally compliant with DOE's pump standards with no controls, as shown in equation (16):

$$PEI_{CL} = \left[\frac{PER_{CL}}{PER_{STD}}\right] \quad \textbf{(16)}$$

Where:

PER_{STD} = the PER_{CL} for a pump of the same equipment class that is minimally compliant with DOE's energy conservation standards serving the same hydraulic load (hp). The procedure for determining PER_{STD} is described in detail in section III.B.2.b.

b. Calculation-Based Test Method B.1: Pump Sold With a Motor

In cases where a pump's efficiency can be independently measured and that pump is sold with an applicable motor, the primary test procedure would be similar to that for pumps sold alone (A.1) except that the motor efficiency, or losses, would be that of the motor with which the pump is sold when determining PER_{CL}, as opposed to the default motor efficiency assumed in the bare pump case. For motors covered by DOE's electric motor standards, DOE proposes to use the measured nominal full load efficiency determined in accordance with the DOE electric motor test procedure specified at 10 CFR 431.16 and appendix B to subpart B of part 431 (see section III.D.1.b). For pumps sold with submersible motors rated using the calculation-based method, the full load motor efficiency would be determined based on the default minimum submersible motor efficiency from Table III.6 (see section III.D.1.c). DOE notes that this calculation-based method would not apply to pumps sold with motors that are not subject to DOE's electric motor standards (except for submersible motors).

The PEI_{CL} for pumps sold with motors would then be calculated using a similar approach that would be applied to bare pumps shown in equation (15) and (16), above, except that the default part load losses of the motor at each load point i would be determined based on the nominal full load efficiency for the motor, as described in section III.D.2.

As previously discussed in section III.B.2.b, in determining PER_{STD}, DOE would base the nominal full load motor efficiency of the minimally compliant pump on the electric motor efficiency standards listed at 10 CFR 431.25(h) for pumps sold with motors other than submersible motors. Similarly, for pumps sold with submersible motors, DOE proposes that the default motor efficiency be that specified in Table III.7 in section III.D.1.c for both the rated pump model and PER_{STD}.

DOE currently requires motor manufacturers to rate only full load efficiency. See 10 CFR 431.16. The extrapolation of the certified full load efficiency data to the required rating points representative of 75, 100, and 110 percent of the BEP flow for the paired pump using default part load curves is the least burdensome approach for determining part load efficiency of regulated motors when sold with pumps. This method would also allow for consistency and repeatability of results for a given pump. However, if the motor manufacturer makes certain changes to the motor design that improve part load performance without impacting efficiency at full load, this difference would not be reflected in the calculated PEI_{CL} using this proposed approach.

DOE requests comment on its proposal to determine the part load losses of motors covered by DOE's electric motor energy conservation standards at 75, 100, and 110 percent of BEP flow based on the nominal full load efficiency of the motor, as determined in accordance with DOE's electric motor test procedure, and the same default motor part load loss curve applied to the default motor in test method A.1 for the bare pump.

DOE requests comment on its proposal to determine the PER_{CL} of pumps sold with submersible motors using the proposed default minimum efficiency values for submersible motors and applying the same default motor part load loss curve to the default motor in test method A.1 for the bare pump.

DOE also requests comment on its proposal that pumps sold with motors that are not addressed by DOE's electric motors test procedure (except submersible motors) would be rated based on a wire-to-water, testing-based approach.

c. Calculation-Based Test Method C.1: Pump Sold With a Motor and Continuous Controls

For pumps sold with motors and continuous controls, the PEI_{VL} metric would account for the power reduction resulting from reducing speed and, thus, head, to achieve a given flow rate as opposed to throttling. In this case, the PEI_{VL} is determined as the PER_{VL} of the given pump divided by the PER_{STD}. The PER_{STD} would be determined in accordance with the procedures in section III.B.2.b. The PER_{VL} would be determined as the weighted average input power to the pump at 25, 50, 75, and 100 percent of BEP flow, as shown in equation (17):

$$PER_{VL} = \omega_{25\%}\left(P_{25\%}^{in}\right) + \omega_{50\%}\left(P_{50\%}^{in}\right) + \omega_{75\%}\left(P_{75\%}^{in}\right) + \omega_{100\%}\left(P_{100\%}^{in}\right) \qquad \textbf{(17)}$$

Where:

ω_i = weighting at each rating point (equal weighting or ¼ in this case),

P_i^{in} = measured or calculated input power to the pump at the input to the continuous or non-continuous controls at rating point i, and

i = 25, 50, 75, and 100 percent of BEP flow, as determined in accordance with the DOE test procedure.

The input power to the pump when sold with motors and continuous controls would be determined by adding together the pump shaft input power and the combined losses from the motor and continuous controls at each of the load points i. However, in the case of determining PER_{VL} for pumps sold with motors and continuous controls, the proposal would require that only the input power at the 100 percent of BEP flow point be determined through testing and the remaining 25, 50, and 75 percent load points be calculated based on an assumed system curve.

DOE understands that the system curve a given pump will follow in the field is based on the specific dynamics of the system (e.g., the amount of static head, or fixed pressure, in a system) and the characteristics of the continuous or non-continuous control (e.g. how the given control adjusts speed in response to changes in the required flow, head, or pump output power may vary among control types, as discussed in section III.E.1.c). However, DOE also believes that a single representative curve is sufficiently representative for the default calculation method as it equally applies to all pumps sold with motors and continuous or non-continuous controls, thereby reflecting the input of the CIP Working Group regarding an appropriate and representative reference curve. DOE also proposes that the combined performance of the motor and continuous controls be determined based on a loss curve that describes the decreased efficiency of the motor and continuous controls at full and part load points. DOE notes that the CIP Working Group informally agreed with this approach. (Docket No. EERE-2013-BT-NOC-0039, No. 107 at pg. 94-96)

With respect to VFDs, AHRI recommended that DOE take time to develop a sound method for testing pump/motor/VFD packages and consider typical VFD operation in those packages. (AHRI, No. 28 at p. 2) AHRI noted that AHRI Standard 1210–2011 will soon provide performance maps for VFDs tested with standard NEMA Design B four-pole motors that meet the criteria of NEMA Standard MG-1, "Motors and Generators," Part 31. (AHRI, No. 28 at p. 2) AHRI noted that it launched an AHRI VFD certification program and expected to publish performance data in 2014.[47] AHRI further noted that a systemic efficiency calculation for the majority of pump/motor/VFD packages may then be possible by combining VFD, motor, and pump performance maps, and that a random selection of calculated system efficiency metrics could be verified by test. (AHRI, No. 28 at p. 2) DOE considered these comments in making its proposal. The relevant definitions and specific calculation procedures are described in detail in the subsequent sections.

[47] To date, variable frequency drives are listed as one of the product types to which AHRI certification programs apply (see http://www.ahrinet.org/App_Content/ahri/files/Certification/CERT_PROGS_ENG.pdf); however, no certification data are available through AHRI's certification database (see https://www.ahridirectory.org/ahridirectory/pages/home.aspx).

Reference System Curve

For pumps tested without continuous or non-continuous controls, no reference system is required as measurements are taken at various loading points along a pump curve at the nominal rating speed only. For pumps tested inclusive of motors and continuous or non-continuous controls (using a calculation-based or testing-based method), a reference system curve must be implemented to standardize the system curve shape on which multiple points will be calculated. Such a system curve describes the relationship between the head and the flow at each load point.

AHRI 1210–2011 specifies a quadratic (or nearly quadratic) system curve, which would maximize the benefits of the speed control provided by continuous or non-continuous controls. A quadratic system curve, theoretically, is more representative of system curves in the field.[48] This system curve will also likely more closely match the system curve in the test labs and, thus, linear extrapolation may be applied without significant loss of accuracy if a quadratic relationship is used. However, during the Working Group negotiations, interested parties suggested that DOE implement a static head offset instead of a completely quadratic relationship. Interested parties commented that this static head offset would be representative of a static head component of the system curve and would reasonably approximate the system curve pumps experience in the field. Specifically, HI suggested that DOE use a system curve with a static head

[48] American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). "2012 HVAC Systems and Equipment, Chapter 44: Centrifugal Pumps."

component representative of 20 percent of head at BEP flow. (Docket No. EERE-2013-BT-NOC-0039, No. 63 at p. 226)

Consistent with these suggestions, DOE proposes to use a quadratic reference system curve which goes through the BEP and offsets the y-axis, as specified in equation (18):

$$a = \frac{H_{100\%} - H_{static}}{(Q_{100\%})^2} \quad \textbf{(18)}$$

Where:

a = static offset correction factor for the system curve which is a scalar quantity,

$H_{100\%}$ = total pump head at 100 percent of BEP flow (ft),

H_{static} = system head at zero flow rate (ft), and

$Q_{100\%}$ = flow rate at 100 percent of BEP flow (gpm).

For this test procedure, the system head at zero flow rate (H_{static}) is assumed to be 20 percent of BEP head, as recommended by the CIP Working Group. Therefore, as shown in equation (19) and depicted in Figure III.1:

$$H = \left[0.8 * \left(\frac{Q}{Q_{100\%}}\right)^2 + 0.2\right] * \mathrm{H}_{100\%} \quad (19)$$

Where:

H = the total system head (ft),

Q = the flow rate (gpm),

$Q_{100\%}$ = flow rate at 100 percent of BEP flow (gpm), and

$H_{100\%}$ = total pump head at 100 percent of BEP flow (ft).

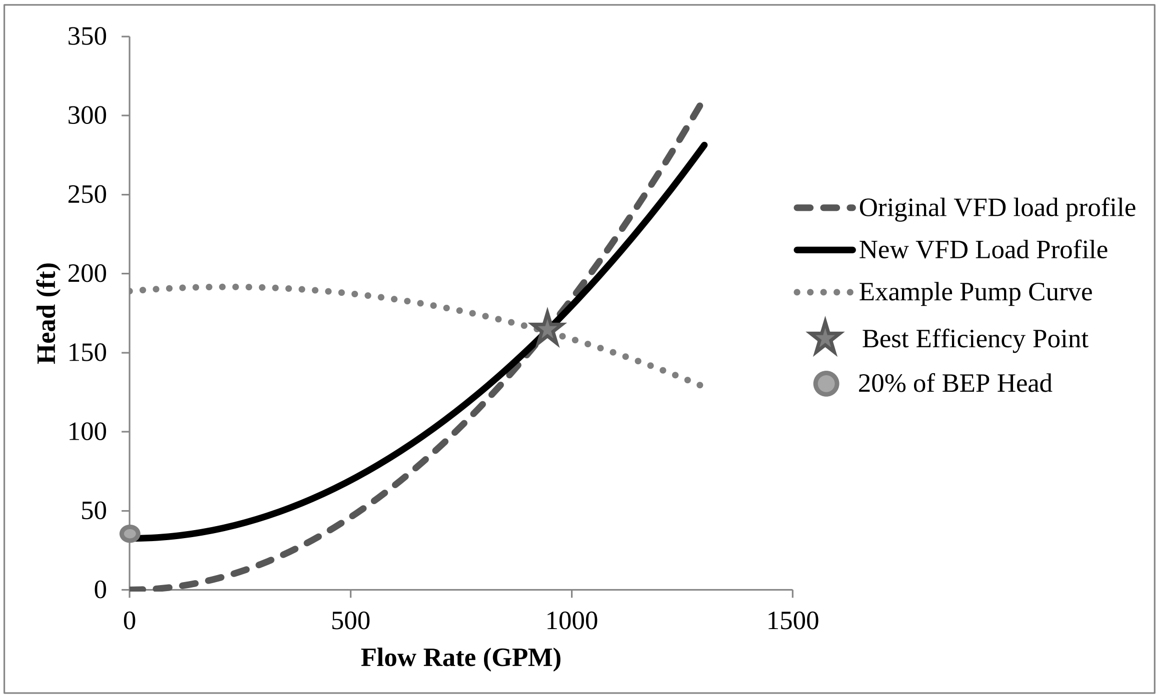

Figure III.1 System Control Curve for Head with Respect to Flow for Pumps Sold with Continuous Controls. Statically offset curve and pure quadratic curve plotted with identical BEP flows. Static offset set at 20 percent of BEP head.

DOE notes that this reference system curve would apply to pumps sold with a motor and continuous controls that are tested using this calculation-based method as well as to pumps sold with a motor and continuous or non-continuous controls that are tested using the wire-to-water testing-based methods discussed in section III.E.2.c. As mentioned in section III.A.1.b, the calculation-based approach is not applicable to non-continuous controls, as such controls will not follow the assumed system curve precisely, as continuous controls would. Accordingly, DOE believes that the power consumption calculated along this reference curve would not be representative of the energy consumption of such pumps. Instead, DOE is proposing that pumps with a multi-speed motor, for example, or other non-continuous controls, would be rated using a physical “wire-to-water” test, which would capture some reduction in power consumption as measured by the test procedure at some reduced flow rates. Such a pump would be rated using the testing-based method for pumps sold with motors and controls, described in section III.E.2.c. DOE discussed this proposal with the CIP Working Group and the CIP Working Group generally agreed with DOE's approach, although such a recommendation was not specifically included in the CIP Working Group Recommendations. (Docket No. EERE-2013-BT-NOC-0039, No. 107 at pp. 49-50).

DOE requests comment on the proposed system curve shape to use, as well as whether the curve should go through the origin instead of the statically loaded offset.

Determination of Bare Pump Shaft Input Power

Under the proposed calculation-based approach for pumps sold with motors and continuous controls, the rated efficiency of the motor and continuous control would be combined with the pump shaft input power at the specified load points to calculate the PER_{VL} of the pump. To determine the bare pump input power at the prescribed load points, only the pump shaft input power at 100 percent of BEP flow must be determined experimentally, in accordance with HI 40.6–2014, and at the nominal full load operating speed of the pump (i.e., 1,800 rpm or 3,600 rpm), as discussed in section III.C. However, DOE notes that the full HI 40.6–2014 test would still need to be conducted, and the pump hydraulic output power at 75, 100, and 110 percent of BEP flow would still be necessary for determining the PER_{STD} of the given pump.

The pump shaft input power at 25, 50, and 75 percent of BEP flow would then be determined by applying the reference system curve discussed in section III.E.1.c and assuming continuous speed reduction is applied to achieve the reduced load points. Specifically, the reduction in pump shaft input power at part loadings is assumed to be equivalent to the relative reduction in pump hydraulic output power assumed by the system curve.[49] The relative reduction can be determined as the product of the relative reductions in flow and head, as shown in equation (20):

$$\frac{P_i}{P_{100\%}} = \frac{P_{Hydro,i}}{P_{Hydro,100\%}} = \frac{H_i}{H_{100\%}} \times \frac{Q_i}{Q_{100\%}} = \left(\frac{0.8 \frac{H_{100\%}}{{Q_{100\%}}^2} {Q_i}^2 + 0.2 H_{100\%}}{H_{100\%}} \right) \times \frac{Q_i}{Q_{100\%}}$$

$$= \left(0.8 \frac{{Q_i}^3}{{Q_{100\%}}^3} + 0.2 \frac{Q_i}{Q_{100\%}} \right) \quad \textbf{(20)}$$

Where:

P_i = shaft input power to the bare pump at rating point i (hp),

$P_{100\%}$ = pump shaft input power at 100 percent of BEP flow (hp),

$P_{Hydro,i}$ = pump hydraulic output power at rating point i (hp),

$P_{Hydro,100\%}$ = pump hydraulic output power at 100 percent of BEP flow (hp),

H_i = total pump head at rating point i (ft),

$H_{100\%}$ = total pump head at 100 percent of BEP flow (ft),

Q_i = flow rate at rating point i (gpm),

$Q_{100\%}$ = flow rate at 100 percent of BEP flow (gpm), and

i = 25, 50, and75 percent of BEP flow as determined in accordance with the DOE test procedure.

[49] Note, this assumes that bare pump efficiency is constant across the system curve.

Based on this relationship, the pump shaft input power can be determined at each of the load points by multiplying the calculated ratio by the measured pump shaft input power at BEP, as shown in equation (21):

$$P_i = \left(0.8\frac{{Q_i}^3}{{Q_{100\%}}^3} + 0.2\frac{Q_i}{Q_{100\%}}\right) \times P_{100\%} \quad \textbf{(21)}$$

Where:

P_i = pump shaft input power at rating point i (hp),

$P_{100\%}$ = pump shaft input power at 100 percent of BEP flow (hp),

Q_i = flow rate at rating point i (gpm),

$Q_{100\%}$ = flow rate at 100 percent of BEP flow (gpm), and

i = 25, 50, and 75 percent of BEP flow as determined in accordance with the DOE test procedure.

DOE requests comment on the proposed calculation approach for determining pump shaft input power for pumps sold with motors and continuous controls when rated using the calculation-based method.

Determination of Efficiency of the Motor and Continuous Controls

DOE recognizes that determining the PER_{VL} of a pump sold with a motor and continuous controls using the calculation-based method requires accounting for the efficiency of the motor and continuous control in combination with the measured pump shaft input power at the specified load points. Compared to an uncontrolled motor, the motor and continuous control together incur additional losses as a result of inefficiencies from the continuous control and increased inefficiencies in the speed-controlled motor due to harmonic distortion. Because of the interactions between the motor and control, treating the motor and control together would provide the most accurate measurement of the overall efficiency of a pump that has been paired with these two devices.

DOE notes that, although a new test method for determining combined efficiency of motors and VFDs is available (AHRI 1210–2011), DOE does not currently require VFD manufacturers to test and certify their drives in accordance with that procedure or any other available test procedure for VFDs or other applicable speed controls. Therefore, consistent and standardized information regarding the efficiency of speed controls (combined with or separate from motor efficiency) is not available at this time. As such, requiring controller efficiency to be measured in a specific manner and used to determine performance of a pump sold with a motor and continuous or non-continuous controls would represent a significant additional burden for pump manufacturers. In addition, such a requirement may also have the potential of requiring controller manufacturers to perform a specifically prescribed test.

The Working Group also indicated that applying a standardized set of loss curves for determining the inefficiencies associated with motor and speed control components together would greatly simplify the method for calculating the total power consumption of the tested pump and present the least burdensome approach for manufacturers to implement. (EERE-2013-BT-NOC-0039, No. 107 at p. 218) For these reasons, DOE proposes to use a method similar to that applied to single-speed motors for determining the efficiency at part load points, discussed in section III.D.2, for the motor and continuous control.

In order to develop the default part load loss equation to allow the calculation of the losses associated with motor and continuous control components, DOE used performance data generated from testing five motor and VFD combinations according to the AHRI 1210–2011 test method and examined additional data for 24 VFDs tested per AHRI 1210–2011, provided confidentially to DOE's contractors by one VFD manufacturer.

The DOE combined motor and VFD tests, conducted in accordance with AHRI 1210–2011, consisted of expanding upon the test points specified in the test procedure and taking up to 16 measurements of input power for each model tested based on permutations of 4 prescribed torque points tested at each of 4 speeds. Efficiency at each combination of torque and speed was determined by taking the ratio of the output power of the motor and input power to the VFD, where the output power was determined by the measured rotational speed and torque produced by the motor. The test data for the 24 VFD models provided by the VFD manufacturer included eight measurements at full load and part load.

Based on the VFD performance data collected, DOE proposes using four part load loss equations to represent the combined efficiency of the motor and continuous control as a function of the output power of the continuous control. When analyzing the continuous control and motor efficiency as a function of the horsepower rating of the continuous control, DOE observed a significant variation by horsepower range and is proposing to account for this situation by establishing four equations as a function of the VFD's horsepower (see Table III.8).

DOE proposes to describe the part load loss curves for the combined motor and continuous control as a function of the brake horsepower, or output power, of the motor (i.e., the power that would be supplied to the pump). DOE recognizes that using a relationship as a function of motor brake horsepower rather than a two-dimensional equation as a function of torque and speed represents a simplification and may sacrifice some accuracy in determining the efficiency of a given motor and continuous control. For example, DOE observed that the speed and torque of the VFDs impacted the magnitude of the VFD's losses. DOE considered developing part load loss relationships as a function of speed and torque based on the test results. However, DOE notes that it is not clear whether the trends it observed during testing are universally applicable to motor and continuous and non-continuous control systems available in the market, as each type of continuous or non-continuous control may impact motor efficiency differently based on the specific control approach. DOE believes that the available data are insufficient to create robust and representative relationships for all of the motors and continuous or non-continuous controls that might be paired with pumps within the scope of this test procedure rulemaking. DOE notes that, based on its analysis of the available data, the proposed simplification would likely impact the resultant PEI_{VL} for a given pump by a magnitude of less than 1 percent.

To derive the part load losses equations, DOE analyzed the results of all AHRI 1210–2011 test results to establish the maximum values of the ratio of VFD and motor losses to the motor full load losses (or part load loss factor). DOE determined this ratio at several motor load points using a regression as a function of the motor load percentage to derive the coefficients of the polynomial equation. The polynomial equation used to represent the part load loss factor is defined in equation **(**22**)**:

$$z_i = (a * \left(\frac{P_i}{MotorHP}\right)^2 + b * \left(\frac{P_i}{MotorHP}\right) + c) \qquad \textbf{(}22\textbf{)}$$

Where:

z_i = the part load loss factor for the motor and continuous controls at load point i;

a,b,c = coefficients based on VFD horsepower, see Table III.8;

P_i = the shaft input power to the bare pump (hp);

MotorHP = the horsepower of the motor with which the pump is being rated (hp); and

i = 25, 50, 75, and 100 percent of BEP flow as determined in accordance with the DOE test procedure.

Table III.8. Motor and Continuous Control Part Load Loss Factor Equation Coefficients for Equation 23

	Coefficients of Equation (23).		
Motor horsepower (hp) between or equal to	**a**	**b**	**c**
≤5	-0.4658	1.4965	0.5303
>5 and ≤20	-1.3198	2.9551	0.1052
>20 and ≤50	-1.5122	3.0777	0.1847
>50	-0.8914	2.8846	0.2625

To calculate the part load losses of the motor and continuous control, manufacturers would apply the part load loss curve polynomial, with the appropriate coefficient as established in Table III.8, to the nominal full load losses for the motor being sold with that pump in the same manner as that for determining the part load losses for single-speed motors (see equation (14) in section III.D.2).

DOE recognizes that the loading of the motor and continuous control when paired with a particular pump model may differ from those observed during DOE's testing and that this may affect the specific losses associated with a given pump. However, DOE believes that it is likely pump manufacturers would select a motor with a similar horsepower and control combinations to pair with a particular pump, as significantly oversized equipment will add unnecessary additional expense for the customer.

DOE requests comment on the proposal to adopt four part load loss factor equations expressed as a function of the load on the motor (i.e., motor brake horsepower) to calculate the losses of a combined motor and continuous control, where the four curves would correspond to different horsepower ratings of the continuous control.

DOE also requests comment on the accuracy of the proposed equation compared to one that accounts for multiple performance variables (speed and torque).

DOE requests comment on the proposed 5 percent scaling factor that was applied to the measured VFD efficiency data to generate the proposed coefficients of the four part load loss curves. Specifically, DOE seeks comment on whether another scaling factor or no scaling factor would be more appropriate in this context.

DOE requests comment on the variability of control horsepower ratings that might be distributed in commerce with a given pump and motor horsepower.

DOE requests comment and data from interested parties regarding the extent to which the assumed default part load loss curve would represent minimally efficient motor and continuous control combinations.

d. Other Calculation Methods for Determination of Pump Performance Determination

DOE is proposing to require that each bare pump model be physically tested in accordance with the test procedure rather than to allow the use of calculation methods for determining performance of a bare pump with a similar design. DOE notes that the proposed calculation-based test procedure for certain applicable pumps already contains provisions for tested bare pump performance to be combined with default or tested performance data regarding the motor or motor with continuous or non-continuous controls to calculate the PER of multiple pump basic models. This proposal would apply to: (1) bare pumps; (2) pumps sold with either (a) motors regulated by DOE's electric motor standards or (b) submersible motors; and (3) pumps sold with continuous-controlled motors that are either (a) motors regulated by DOE's electric motor standards or (b) submersible motors. DOE also notes that, beyond the calculations proposed in this NOPR, DOE is not considering permitting use of other algorithms or alternative efficiency determination methods to determine the rated performance of covered pumps or pump components (i.e., motors or controls).

DOE requests comment on its proposal to require testing of each individual bare pump as the basis for a certified PEI_{CL} or PEI_{VL} rating for one or more pump basic models.

DOE requests comment on its proposal to limit the use of calculations and algorithms in the determination of pump performance to the calculation-based methods proposed in this NOPR.

In summary, DOE proposes to establish the calculation-based methods discussed in this section III.E.1 for determining PEI_{CL} or PEI_{VL} as the required test procedure for bare pumps and as one of two test methods that could be used for (1) pumps sold either with (a) motors that are regulated by DOE's electric motor standards or (b) submersible motors, and (2) pumps sold with continuous-controlled motors that are either (a) regulated by DOE's electric motors standards or (b) submersible motors. For pumps whose energy consumption cannot be calculated using the proposed calculation-based method, DOE proposes that the PEI_{CL} or PEI_{VL} rating be determined based on testing only methods, as discussed in the next section, section III.E.2.

2. Testing-Based Methods

Testing-based methods directly measure the input power to the motor, continuous control, or non-continuous control at the load points of interest (i.e., 75, 100, and 110 percent of BEP flow for uncontrolled pumps and 25, 50, 75, and 100 percent of BEP flow for pumps sold with a motor and speed controls). As such, these methods cannot be applied to bare pumps. In addition, these test methods are the only test methods applicable to pumps sold with motors that are not addressed by DOE's electric motor test procedure (except submersible motors) or that are sold with non-continuous controls.

DOE is also proposing providing these “wire-to-water” testing-based methods as an optional procedure for all pumps sold with motors or motors with continuous controls. The benefit of using a testing-based approach is that the test protocol is straightforward and accurate for a given pump sold with a motor or pump sold with a motor and continuous control combination. In these cases, it may be appropriate to use this testing-based approach for custom equipment that is already being tested for a specific customer. However, for standard pump models that may be paired with a variety of motors or continuous or non-continuous controls, testing each combination would significantly increase the burden of testing as compared to the calculation-based approach presented in section III.E.1.

The following sections describe how to determine BEP for pumps rated using the testing-based method, as well as the specific test methods for pumps sold with motors (Method B.2) and pumps sold with motors and continuous or non-continuous controls (Method B.3).

a. The Best Efficiency Point for Pumps Testing Using Testing-Based Methods

DOE notes that when testing some pumps using the testing-based methods, it is not possible to determine BEP as a ratio of pump input power over pump hydraulic power unless additional measurements are made of bare pump performance or pump shaft input power, in addition to input power to the motor. See section III.C.2.d, supra.

In the case of pumps sold with motors or motors with continuous or non-continuous controls for which input power to the shaft is not measured directly, DOE proposes to determine the BEP using what is typically known as overall efficiency. Overall efficiency is the input power to the driver or continuous control, if any, divided by the pump hydraulic output power with no speed control (i.e., at the nominal rated speed). Overall efficiency is found by conducting a similar procedure involving sweeping the pump curve and fitting a curve to the rated points, as discussed in section III.C.2.d. This leads to a BEP value comparable with those determined based on direct application of the HI 40.6 method.

To maintain consistent nomenclature, DOE proposes to define BEP for pumps tested using testing-based methods as the maximum measured value of the ratio of driver input power over pump hydraulic output at a single, nominal speed. Under this proposal, DOE would require use of the procedure specified in section III.C.2.d, except that the BEP would be determined based on the combined pump and motor efficiency instead of the bare pump efficiency.

DOE requests comment on its proposal to determine BEP for pumps rated with a testing-based method by using the ratio of input power to the driver or continuous control, if any, over pump hydraulic output. DOE also seeks input on the degree to which this method may yield significantly different BEP points from the case where BEP is determined based on pump efficiency.

b. Testing-Based Test Method B.2: Pump Sold With a Motor

For pumps sold with motors, the PEI_{CL} can be determined by wire-to-water testing, as specified in HI 40.6–2014 section 40.6.4.4. In this case, the PER becomes an average of the measured power input to the motor at the three rating points, as shown in equation (23):

$$PER_{CL} = \sum_{i=75\%,100\%,110\%} \omega_i P_i^{in}$$

$$= \omega_{75\%}\left(P_{75\%}^{in}\right) + \omega_{100\%}\left(P_{100\%}^{in}\right) + \omega_{110\%}\left(P_{110\%}^{in}\right) \quad \textbf{(23)}$$

Where:

ω_i = weighting at each rating point (equal weighting or $^1/_3$ in this case),

P_i^{in} = measured or calculated input power to the motor at rating point i, and

i = 75, 100, and 110 percent of BEP flow as determined in accordance with the DOE test procedure.

The PEI_{CL} determined using the tested wire-to-water method may vary slightly from that determined using the PEI_{CL} for pumps rated using calculation-based test methods B.1 or C.1 and will generally result in a better rating than the default calculation-based methods.

c. Testing-Based Test Method C.2: Pump Sold With a Motor and Speed Controls

For pumps sold with motors and continuous or non-continuous controls, DOE proposes that the PEI_{VL} may be determined by wire-to-water testing, based on the procedure specified in HI 40.6, section 40.6.4.4, except that:

(1) the input power is the “driver input power,” defined in table 40.6.2.1 of HI 40.6-2014 and referenced in table 40.6.3.2.3, section 40.6.4.4, and section 40.6.6.2 refers to the input power to the continuous or non-continuous control and the input power to the continuous or non-continuous control and

(2) is determined in accordance with the tolerances and requirements for measuring electrical power described in AHRI 1210–2011 and CSA C838–2013, as proposed in section III.C.2.e.

With this approach, pump manufacturers would determine the BEP of the pump, inclusive of motor and continuous or non-continuous controls, as described in section III.E.2.a, and then adjust the operating speed of the motor and the head until the specified head and flow conditions are reached (i.e., 25, 50, and 75 percent of BEP flow and the associated head pressures determined by the reference system curve in section III.E.1.c).

DOE recognizes that each test lab may have a similar but unique system curve that is representative of the specific valves, elbows, and other system components present in the test loop. As such, DOE proposes to specify the specific load points that must be determined based on the reference system curve to ensure repeatability among labs. However, DOE also recognizes that it may not be possible to achieve the exact load points given measurement and experimental uncertainty. To address this issue, DOE also proposes to establish an acceptable tolerance around each load point. The use of tolerances in this context is not unique. For example, EU 641 regulation[50] for circulators adopts a 10 percent tolerance around the specified load points for circulators greater than 100 watts (0.13 hp). To provide some level of measurement tolerance, DOE is proposing a tolerance level of 10 percent about (i.e., above and below) the target flow and head load points defined on the reference system curve for each pump.

DOE recognizes that it is still important for the input power values to represent the power at each specific load point. As such, DOE also proposes to require that load points determined via testing that are within the specified 10 percent tolerance band be extrapolated to the reference system curve to normalize the test data to the exact load points specified by the system curve. In this case, the pump shaft input power at the head at tested point i (e.g., head at 25 percent BEP flow) on the tested system curve, $P_{T,i}$ in, can be linearly extrapolated to the pump shaft input power at the specified head and flow rate (e.g., at 50 percent for BEP flow) based on the reference system curve, $P_{R,i}$, using the following equation (24):

$$P_{R,i} = \left(\frac{H_{R,i}}{H_{T,j}}\right)\left(\frac{Q_{R,i}}{Q_{T,j}}\right)P_{T,i} \qquad \textbf{(24)}$$

Where:

$P_{R,i}$ = the rated pump shaft input power at flow point i (hp),

$H_{R,i}$ = the total system head at flow point i based on the reference system curve (ft),

$H_{T,jj}$ = the tested total system head at flow point j (ft),

[50] Council of the European Union. 2009. Commission Regulation (EC) No 641/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products. Official Journal of the European Union. L 191, 23 July 2009, pp. 35-41.

$Q_{R,i}$ = the total system head at flow point i based on the reference system curve (gpm),

$Q_{T,j}$ = the tested total system head at flow point i (gpm),

$P_{T,j}$ = the tested pump shaft input power at flow point j,

i = 25, 50, 75, and 100 percent of BEP flow as determined in accordance with the DOE test procedure, and

j= the tested flow point of the rated pump, determined in terms of percent of BEP flow.

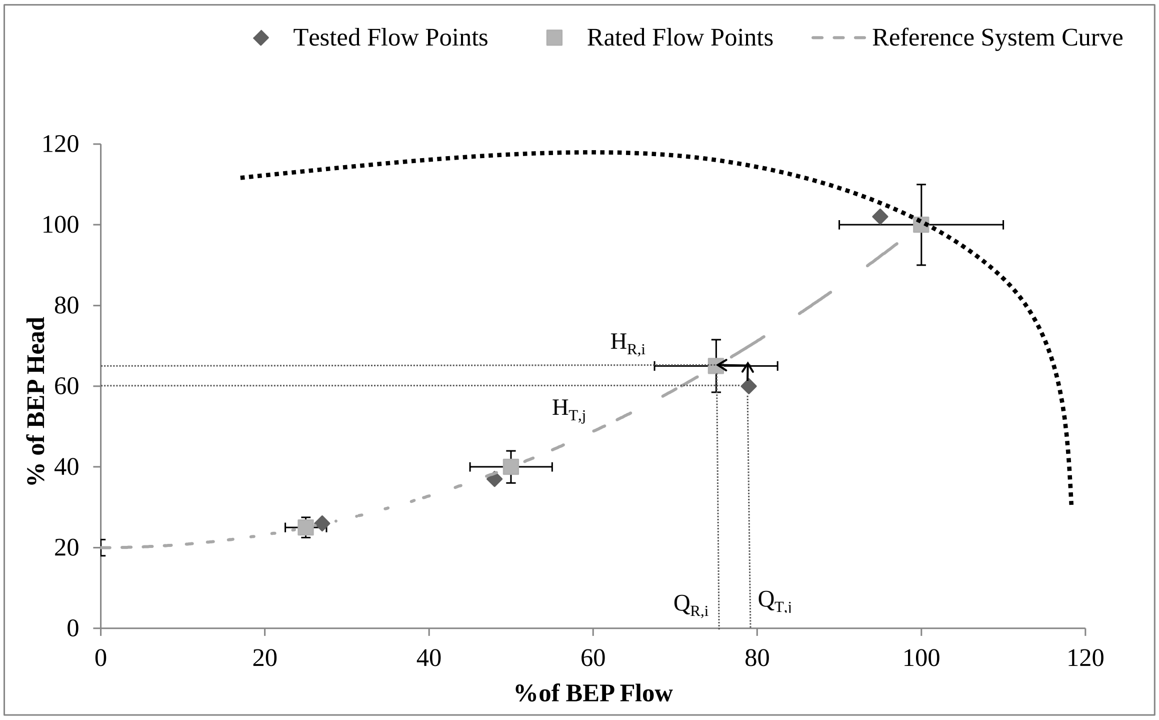

Figure III.2 Linear Extrapolation of Tested Pump Shaft Input Power Values at Tested Heat Points to Rated Pump Shaft Input Power Values at Rated Heat Points Based on the Reference System Curve.

In this case, the PER becomes an average of the measured power input to the continuous or non-continuous control at the four specified rating points based on the assumed system curve (as in Test Method C.1), as shown in equation (25):

$$PER_{VL} = \sum_{i=25\%,50\%,75\%,100\%,}(\omega_i P_i^{in}) = \omega_{25\%}(P_{25\%}^{in}) + \omega_{50\%}(P_{50\%}^{in}) + \omega_{75\%}(P_{75\%}^{in}) + \omega_{100\%}(P_{100\%}^{in}) \quad \textbf{(25)}$$

Where:

ω_i = weighting at each rating point (equal weighting or ¼ in this case),

P_i^{in} = measured or calculated input power to the continuous or non-continuous controls at rating point i, and

i = 25, 50, 75, and 100 percent of BEP flow, as determined in accordance with the DOE test procedure.

Pumps Sold with Motors and Non-Continuous Speed Controls

DOE notes that some pumps are sold with non-continuous controls, such as multi-speed motors with two or three discrete speed options. Pumps with these types of non-continuous controls are not able to use the calculation-based test method C.1 because they are not able to follow the reference system curve described in section III.E.1.c. For example, in the case of a pump sold with a two-speed motor, the pump will operate at full speed (i.e., the rated speed) for some of the flow points and reduced speed at the other flow points, as shown in Figure III.3. Which points are operated at full speed and which points are operated at reduced speed will depend on the turn-down ratio of the non-continuous control.[51]

[51] The turn-down ratio of a non-continuous control, such as a multi-speed motor, is generally defined as the ratio of the maximum speed of rotation (or speed of rotation at full speed) to the speed of rotation at the discrete lower speeds available on the control. For example, a motor with a speed of rotation at full speed of 3600 rpm and "low speed" of rotation of 1800 rpm would have a turn-down ration of 2:1.

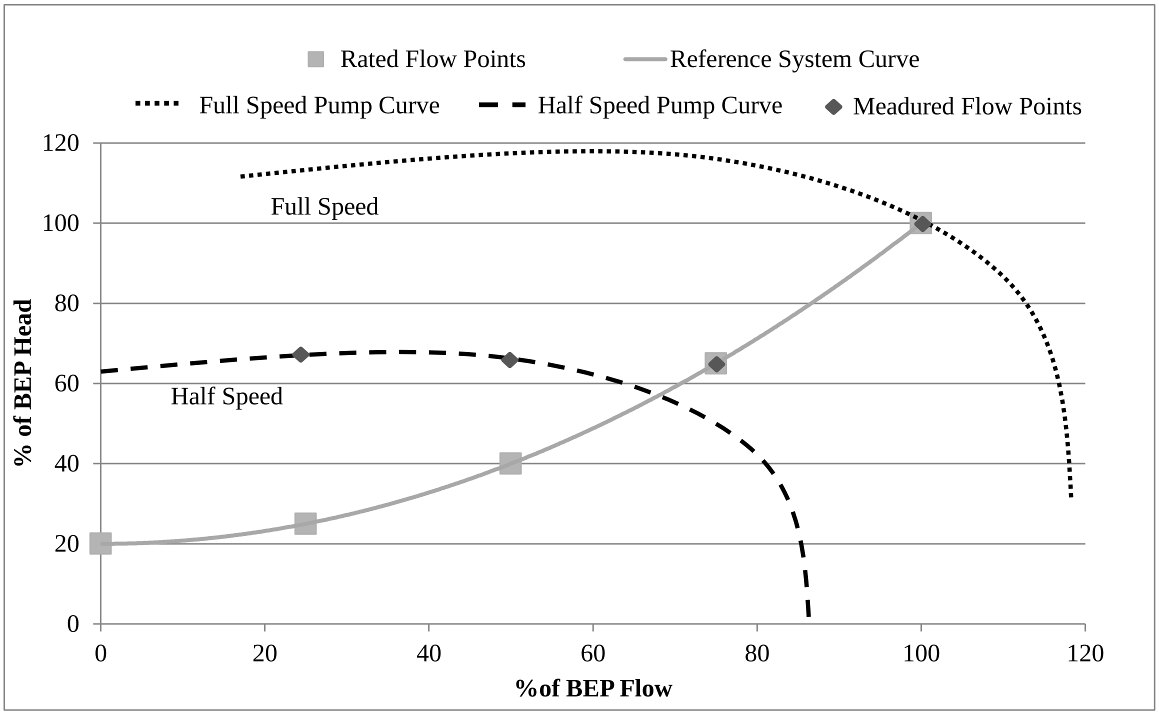

Figure III.3. Test Points Compared to Reference System Curve and Full Speed Pump Curve for a Theoretical Two-Speed Motor.

For these types of pumps sold with non-continuous controls, DOE proposes that the testing-based method found in HI 40.6–2014 be modified slightly to accommodate the operation of non-continuous controls and representatively account for their impact on pump energy performance. DOE proposes that for pumps sold with a motor and non-continuous controls, the input power to the pump at 25, 50, 75, and 100 percent of BEP flow be determined in the same manner as that for pumps sold with continuous controls described in section III.E.2.c, except that the head associated with each of the specified flow points does not have to be achieved within 10 percent of the specified head, as described by the reference system curve -- only the flow rate would need to be achieved within 10 percent of the specified value. DOE proposes to require that the measured total head corresponding to the 25, 50, 75 and 100 percent of BEP flow points be no lower than 10 percent below that defined by referenced system curve. That is, the associated total head may be anywhere in the region between the reference system curve and the full speed pump curve. In this case, the measured head and flow rate should not be corrected to the reference system curve. Instead, the measured points should be used directly in further calculations of PEI_{VL}.

The presence of continuous or non-continuous controls will positively impact the PEI_{VL} rating (i.e., it will go down) due to decreased power consumption at part load rating points, as discussed previously. The PEI_{VL} determined using this testing-based method will representatively capture the improved performance of pumps sold with motors and continuous or non-continuous controls. This proposed method can be applied to any pumps sold with continuous or non-continuous controls, but would be the only applicable method when calculation method C.1 is not applicable; namely: (1) pumps sold with motors that are not covered by DOE's energy conservation standards for electric motors (except submersible motors) and continuous controls and (2) pumps sold with any motors and non-continuous controls.

In addition, the proposed testing-based method for pumps sold with motors and continuous controls will allow for more accurate differentiation of the variable performance of different continuous control technologies that cannot be adequately captured in the calculation-based method for pumps sold with regulated motors and continuous controls.

DOE requests comment on the proposed testing-based method for pumps sold with motors and continuous or non-continuous controls.

DOE requests comment on the proposed testing-based method for determining the input power to the pump for pumps sold with motors and non-continuous controls.

DOE requests comment on any other type of non-continuous control that may be sold with a pump and for which the proposed test procedure would not apply.

3. Applicability of Calculation and Testing-Based Test Methods to Different Pump Configurations

In summary, Table III.9 outlines which test methods would apply to which pump configurations under this proposal.

Table III.9 Applicability of Calculation-Based and Testing-Based Test Procedure Options Based on Pump Configuration

Pump Configuration	Pump Sub-Configuration	Calculation-Based Test Method	Testing-Based Test Method
Bare Pump	Bare Pump	A.1: Tested Pump Efficiency of Bare Pump + Default Motor Efficiency + Default Motor Part Load Loss Curve	Not Applicable
Pump + Motor	Pump + Motor Covered by DOE's Electric Motor Energy Conservation Standards OR Pump + Submersible Motor	B.1: Tested Pump Efficiency of Bare Pump + Motor Nameplate Efficiency for Actual Motor Paired with Pump + Default Motor Part Load Loss Curve	B.2: Tested Wire-to-Water Performance
	Pump + Motor Not Covered by DOE's Electric Motor Energy Conservation Standards (Except Submersible Motors)	Not Applicable	B.2: Tested Wire-to-Water Performance
Pump + Motor + Speed Controls	Pump + Motor Covered by DOE's Electric Motor Energy Conservation Standards + Continuous Control OR Pump + Submersible Motor + Continuous Control	C.1: Tested Pump Efficiency of Bare Pump + Motor Nameplate Efficiency for Actual Motor Paired with Pump + Default Motor/Control Part Load Loss Curve + Assumed System Curve	C.2: Tested Wire-to-Water Performance
	Pump + Motor Covered by DOE's Electric Motor Energy Conservation Standards + Non-Continuous Control OR Pump + Submersible Motor + Non-Continuous Control	Not Applicable	C.2: Tested Wire-to-Water Performance
	Pump + Motor Not Covered by DOE's Electric Motor Energy Conservation Standards (Except Submersible Motors) + Continuous or Non-Continuous Controls	Not Applicable	C.2: Tested Wire-to-Water Performance

For bare pumps, DOE is proposing to establish the calculation approach as the default test procedure (method A.1, which is discussed in section III.E.1.a). Testing-based methods would not apply to bare pumps because a PEI rating (which includes the efficiency of the motor) could not be determined based on a test of the bare pump alone.

For pumps sold with motors that are either regulated by DOE's electric motor standards or are submersible motors, DOE is proposing to also allow the use of the applicable calculation-based method (B.1, discussed in section III.E.1.b) or the testing-based method (B.2, discussed in section III.E.2.b).

For pumps sold with motors that are not regulated by DOE's electric motor standards (except for submersible motors), DOE proposes to require use of the testing-based method B.2, discussed in section III.E.2.b, because the nominal full load efficiency of the motor, as determined using a specific standardized procedure, is not available for those motors.

For pumps sold with continuous control-equipped motors that are either (a) regulated by DOE's electric motor standards for electric motors or (b) submersible motors, DOE proposes to allow use of either the applicable calculation-based method (Method C.1, discussed in section III.E.1.c) or the testing-based method (Method C.2, discussed in section III.E.2.c).

For pumps sold with non-continuous control-equipped motors that are either (a) regulated by DOE's electric motor standards for electric motors or (b) submersible motors, as defined in section III.E.1.c, the calculation-based method C.1 would not be applicable because these controls are not able to follow the reference system curve described in section III.E.1.c. As such, pumps sold with non-continuous controls would also have to be tested using the testing-based method C.2 under this proposal.

For pumps sold with motors not regulated by DOE's electric motor standards (excluding submersible motors) that are equipped with either continuous or non-continuous controls, DOE notes that the proposed calculation-based methods would also not apply, just as they do not apply to pumps sold with non-continuous controls. Thus, DOE proposes that such pumps would need to be evaluated using the testing-based method C.2 discussed in section III.E.2.c.

DOE's proposed applicability of testing-based and calculation-based test methods, as shown in Table III.9, is intended to maximize the number of pumps that can be rated using the less burdensome calculation-based methods A.1, B.1, and C.1.

In the case of a pump sold with a continuous or non-continuous controlled motor that is either (a) regulated by DOE's electric motor standards or (b) a submersible motor, DOE proposes to allow use of either the calculation-based test method or the testing-based test method when determining the efficiency rating. In this case, if a manufacturer wishes to represent the improved performance of a given pump and believes that the assumptions made in the calculation method would not adequately represent the improved performance of that pump, the manufacturer may use the testing-based methods to rate the PEI_{CL} or PEI_{VL} of that pump model to capture the improved performance of the pump as tested. For example, such improved performance could be due to increased motor efficiency (decreased losses) at part load. DOE notes that this is particularly important for pumps sold with motors and continuous controls, since DOE is only assuming a single system performance curve to represent all applicable continuous controls, as described in section III.E.1.c, and the testing-based method may provide an opportunity for manufacturers to differentiate the performance of different continuous or non-continuous control technologies.

DOE has designed the calculation-based approach to be conservative (through the assumed motor loss curve and assumed default motor efficiencies) to allow for comparability between the calculation-based and testing-based methods for pumps paired with continuous controls for motors that are (1) regulated by DOE's electric motor standards or (2) submersible motors. However, DOE notes that, since the actual measured efficiency of any single motor could be higher or lower than the nominal full load efficiency ratings assigned to that basic model of motor, it is possible for a given pump to be tested with a motor that is more or less efficient than its nameplate efficiency. Therefore, it is theoretically possible for the calculation-based method B.1 to generate ratings that are better or worse than the testing-based method B.2 based solely on the performance of the motor. To address this possibility, DOE proposes that, when performing enforcement testing, it would use the same test method (i.e., calculation-based or testing-based) used by the manufacturer to generate and report the rating.

DOE requests comment on its proposal to establish calculation-based test methods as the required test method for bare pumps and testing-based methods as the required test method for pumps sold with motors that are not regulated by DOE's electric motor energy conservation standards, except for submersible motors, or for pumps sold with any motors and with non-continuous controls.

DOE also requests comment on the proposal to allow either testing-based methods or calculation-based methods to be used to rate pumps sold with continuous control-equipped motors that are either (1) regulated by DOE's electric motor standards or (2) submersible motors.

DOE requests comment on the level of burden in include with any certification requirements the reporting of the test method used by a manufacturer to certify a given pump basic model as compliant with any energy conservation standards DOE may set.

F. Representations of Energy Use and Energy Efficiency

As noted previously, manufacturers of any pumps within the scope of the pump test procedure would be required to use the test procedure established through this rulemaking when making representations about the energy efficiency or energy use of their equipment. Specifically, 42 U.S.C. 6314(d) provides that "[n]o manufacturer…may make any representation…respecting the energy consumption of such equipment or cost of energy consumed by such equipment, unless such equipment has been tested in accordance with such test procedure and such representation fairly discloses the results of such testing." Manufacturers of equipment that would be addressed by this test procedure and any applicable standards that DOE may set would have 180 days after the promulgation of those standards to begin using the DOE procedure. Performing this test procedure for pumps requires a key component (C-value) that will be addressed through the standards rulemaking for pumps. (As noted earlier, DOE is working on a parallel rulemaking to set these standards.) Because of this dependency, in DOE's view, the 180-day provision prescribed by 42 U.S.C. 6314(d) would necessarily apply only when both the test procedure and standards rules have been finalized. Accordingly, under this approach, manufacturers would not be required (nor would they be able) to use the proposed procedure until standards have been set.

With respect to representations, generally, DOE understands manufacturers often make representations (graphically or in numerical form) of energy use metrics, including pump efficiency, overall (wire-to-water) efficiency, bowl efficiency, driver power input, pump power input (brake or shaft horsepower), and/or pump power output (hydraulic horsepower). Manufacturers often make these representations at multiple impeller trims, operating speeds, and number of stages for a given pump. DOE proposes to allow manufacturers to continue making these representations.

Any representations of PEI and PER must be made in accordance with the DOE test procedure, and there may only be one PEI or PER representation for each basic model. In other words, representations of PEI and PER that differ from the full impeller PEI and PER cannot be made at alternate speeds, stages, or impeller trims. Additionally, if the PEI and PER for a basic model is rated using any method other than method A.1, "bare pump with default motor efficiency and default motor part load loss curve," such a basic model may not include individual models with alternate stages or impeller trims.

If a manufacturer wishes to make unique representations of PEI or PER based on a trimmed impeller, DOE proposes that the manufacturer must certify the trimmed impeller as a separate basic model. In such a case, the "trimmed impeller" being rated would become the full impeller for the new basic model, or the maximum diameter impeller distributed in commerce for that pump model (see section III.A.1.c).

G. Sampling Plans for Pumps

DOE provides in subpart B to 10 CFR part 429 sampling plans for all covered equipment. The purpose of these sampling plans is to provide uniform statistical methods for determining compliance with prescribed energy conservation standards and when making representations of energy consumption and energy efficiency for each covered equipment type on labels and in other locations such as marketing materials. DOE proposes to adopt for pumps the same statistical sampling plans used for other commercial and industrial equipment. These requirements would be added to 10 CFR Part 429.

Under this proposal, for purposes of certification testing, the determination that a basic model complies with the applicable energy conservation standard would be based on testing conducted using the proposed DOE test procedure and sampling plan. The general sampling requirement currently applicable to all covered products and equipment provides that a sample of sufficient size must be randomly selected and tested to ensure compliance and that, unless otherwise specified, a minimum of two units must be tested to certify a basic model as compliant. 10 CFR 429.11 This minimum is implicit in the requirement to calculate a mean—an average—which requires at least two values.

DOE proposes to apply this minimum requirement to pumps. Thus, under no circumstances would a sample size of one be authorized for the purposes of determining compliance with any prescribed energy conservation standards or for making representations of energy use of covered pumps. Manufacturers may need to test a sample of more than two units depending on the variability of their sample, as provided by the statistical sampling plan.

DOE is also proposing to create a new section 10 CFR 429.59 for commercial and industrial pump certification that would include sampling procedures and certification report requirements for pumps. DOE proposes to adopt in 10 CFR 429.59 the same statistical sampling procedures that are applicable to many other types of commercial and industrial equipment. DOE believes equipment variability and measurement repeatability associated with the measurements proposed for rating pumps are similar to the variability and measurement repeatability associated with energy efficiency or consumption measurement required for other commercial equipment.

DOE is proposing to determine compliance in an enforcement matter based on the arithmetic mean of a sample not to exceed four units.

DOE requests comment on the proposed sampling plan for certification and enforcement of compliance for commercial and industrial pumps.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

The Office of Management and Budget (OMB) has determined that test procedure rulemakings do not constitute "significant regulatory actions" under section 3(f) of Executive Order 12866, "Regulatory Planning and Review," 58 FR 51735 (Oct. 4, 1993). Accordingly, this action was not subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) in the OMB.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601, et seq.) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, "Proper Consideration of Small Entities in Agency Rulemaking," 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website: http://energy.gov/gc/office-general-counsel.

DOE reviewed today's proposed rule, which would establish new test procedures for pumps, under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003. DOE tentatively concludes that the proposed rule, if adopted, would result in a significant impact on a substantial number of small entities. The factual basis is set forth below.

1. Small Business Determination

For the industrial pump manufacturing industry, the Small Business Administration (SBA) has set a size threshold, which defines those entities classified as "small businesses" for the purpose of the statute. DOE used the SBA's size standards to determine whether any small entities would be required to comply with the rule. The size standards are codified at 13 CFR part 121. The standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf. Industrial pump manufacturers are classified under NAICS 333911, "Pump and Pumping Equipment Manufacturing." The SBA sets a threshold of 500 employees or less for an entity to be considered as a small business for this category.

DOE conducted a focused inquiry into small business manufacturers of equipment covered by this rulemaking. During its market survey, DOE used available public information to identify potential small manufacturers. DOE's research involved the review individual company websites and marketing research tools (e.g., Dun and Bradstreet reports, Manta, Hoovers) to create a list of companies that manufacture pumps covered by this rulemaking. DOE also contacted the Hydraulic Institute to obtain information about pump manufacturing companies that participate in the national association. Using these sources, DOE identified 68 distinct manufacturers of pumps. DOE requests comment regarding the size of pump manufacturing entities and the number of manufacturing businesses represented by this market.

DOE then reviewed these data to determine whether the entities met the SBA's definition of a small business manufacturer of pumps and then screened out companies that do not offer equipment covered by this rulemaking, do not meet the definition of a "small business," or are foreign owned and operated. Based on this review, DOE has identified 38 companies that would be considered small manufacturers by the SBA definition, which represents approximately 33 percent of pump manufacturers with facilities in the United States, as identified by DOE. Fourteen of the 38 manufacturers that qualify as being a small business were found to be foreign owned or operated, leaving 25 small businesses in the analysis. These 25 companies represent 29 percent of pump manufacturers with facilities in the United States.

Table IV.1 groups the small businesses according to their number of employees. The majority of the small businesses affected by this rulemaking (60 percent) have fewer than 100 employees. According to DOE's analysis, annual sales associated with these small manufacturers were estimated at $1.09 billion ($43.97 million average annual sales per small manufacturer), which represents less than one percent of total industrial pump manufacturer annual sales. Although $1.09 billion in annual sales by the industry and over $43.97 million per small manufacturer are significant in many markets, many industrial and commercial pump manufacturers are large, multi-national companies, with annual sales ranging between a few million to over a trillion dollars.

Table IV.1. Small Business Size by Number of Employees with Financial Data

Number of Employees	Number of Small Businesses	Percentage of Small Businesses	Cumulative Percentage	Average Annual Sales ($M)
1–25	4	16.0%	16.0%	$4.97
26–50	5	20.0%	36.0%	$6.56
51–100	6	24.0%	60.0%	$17.90
101–200	5	20.0%	80.0%	$38.05
201–500	5	20.0%	100.0%	$104.29
Total	**25**	100.0%	100.0%	$34.74

2. Assessing the Number of Basic Models per Manufacturer

The proposed test procedure would impact manufacturers by requiring them to test the energy consumption of certain models of pumps they manufacture. As such, DOE conducted a focused inquiry into the number of basic models manufactured by large and small business in order to determine whether small business would be disproportionally impacted compared to large manufacturers. DOE used the definition of basic model and the scope of pumps proposed in section III.A as the basis for its inquiry into the number of pump models manufactured per company. Small manufacturers of pumps produce an average of 41 basic models per company covered under this scope.

DOE notes that this estimate is based on the number of different bare pump models manufactured by a specific company because often information was not available regarding the number and type of motor or control options with which a pump could be sold. As such, DOE acknowledges that this estimate of basic models may be an under estimate. However, DOE also notes that, based on its research, pumps are often distributed in commerce as a bare pump, with different motors, continuous controls, and non-continuous controls offered as add-on options. As such, based on the proposed test procedure, only physical testing of the fundamental bare pump would be required under DOE's proposed test. Subsequent ratings when the pump is sold either with a motor or with a motor and continuous or non-continuous controls could be developed based on calculations with no additional testing if the motor is covered by DOE's energy conservation standards for electric motors and the control is a continuous control.

DOE notes that the vast majority of pumps that are sold with motors are sold with motors that are covered by DOE's electric motor energy conservation standards. This understanding was confirmed by discussions of the CIP Working Group. (Docket No. EERE-2013-BT-NOC-0039, No. 09 at p. 57) Based on a review of industry literature, DOE also finds that almost all controls available to be paired with pumps are VSD controls and would meet DOE's proposed definition of continuous control and, thus, the calculation method would be applicable.

As discussed in more detail in the following, physical testing of each pump is by far the more burdensome and costly part of conducting the DOE test procedure, and any subsequent calculations should not significantly affect the burden associated with conducting DOE's proposed test procedure. Therefore, DOE acknowledges that, while different configurations of a bare pump, motor, and/or control may represent several basic models, estimating the burden associated with rating those models will be fundamentally based on the physical testing that must be performed on only the underlying bare pump, for most pumps. Therefore, DOE believes that calculating the burden of testing based on the number of bare pump models offered by a manufacturer is a reasonable and representative estimate of the burden associated with establishing a rating for the entire family, or group, or pump models that might be based on the individual bare pump. DOE notes that physical testing of the bare pump is commonly performed to describe pump performance information in manufacturer's literature. However, it is not clear that all pump manufacturers have facilities capable of performing in accordance with the DOE test procedure. As such, DOE has conservatively assumed that manufacturers would have to make a decision to incur the burden of constructing a test facility in order to perform the proposed DOE test procedure or conduct the testing a third party laboratory, as discussed further in section IV.B.3. DOE does not expect that every pump manufacturer will incur the cost as estimated in this IRFA given that many of the manufacturers are already testing and making representations of the bare pump efficiency.

DOE requests information on the percentage of pump models for which the rating of the bare pump, pump sold with a motor, and pump sold with a motor and controls cannot be based on the same fundamental physical test of the bare pump. For example, DOE is interested in the number of pump models sold with motors that are not covered by DOE's energy conservation standards for electric motors or the number of pump models sold with controls that would not meet DOE's definition of continuous control.

3. Burden of Conducting the Proposed DOE Pump Test Procedure

Pumps would be newly regulated equipment; accordingly, DOE has no test procedures or standards for this equipment. As such, this proposal would apply a uniform test procedure for those pumps that would be required to be tested and an accompanying burden on the manufacturers of those pumps. As discussed in the proposed sampling provisions in section III.F, this test procedure would require manufacturers to test at least two units of each pump basic model to develop a certified rating.

DOE notes that certification of covered pump models is not currently required because energy conservation standards do not exist for pumps. However, EPCA also requires that manufacturers use the DOE test procedure to make representations regarding energy efficiency or energy use based on the DOE test procedure for any covered pump models. For the purposes of this IRFA, DOE estimates that each manufacturer would rate each basic model of covered pump in order to make representations about a given basic model. Thus, the testing burden associated with this test procedure NOPR is similar regardless of whether standards apply. The potential difference between these cases, as discussed below, is any burden associated specifically with creating and maintaining certification reports to demonstrate compliance with any energy conservation standards for pumps.

DOE recognizes that making representations regarding the energy efficiency or energy use of covered pump models is voluntary and thus, technically, the proposed test procedure does not have any incremental burden associated with it, unless DOE establishes energy conservation standards. If necessary, a manufacturer could elect to not make representations about the energy use of covered pump models. Since certification is not currently required because there are no pump energy conservation standards, manufacturers would not be required to conduct testing in accordance with this proposed test procedure and, thus, would not incur any incremental burden associated with such testing. However, DOE realizes that manufacturers often provide information about the energy performance of the pumps they manufacture since this information is an important marketing tool to help distinguish their pumps from competitor offerings. In addition, DOE recognizes that pump energy conservation standards are currently being considered in an associated rulemaking (Docket No. EERE-2011-BT-STD-0031) and may be proposed or promulgated in the near future. Therefore, DOE is estimating the full burden of developing certified ratings for covered pump models for the purposes of making representations regarding the energy use of covered equipment or certifying compliance to DOE under any future energy conservation standards.

DOE expects that in order to determine the pump performance of any covered pump models for the purposes of making representations or certifying compliance with under any future energy conservation standards for pumps, each manufacturer would have to either (a) have the units tested in-house or (b) have the units tested at a third party testing facility. If the manufacturer elects to test pumps in-house, each manufacturer would have to undertake the following burden-inducing activities:

(1) construct and maintain a test facility that is capable of testing pumps in compliance with the test procedure, including acquisition and calibration of any necessary measurement equipment, and

(2) conduct the DOE test procedure on two units of each covered pump model.

DOE recognizes that many pump manufacturers already have pump test facilities of various types and conduct pump testing as part of an existing manufacturing quality control process, to develop pump performance information for new and existing products, and to demonstrate the performance of specific pump units for customers. However, DOE recognizes that, as such testing is not currently required or standardized, testing facilities may vary widely from one pump manufacturer to another. As such, for the purposes of estimating testing burden associated with this test procedure NOPR, DOE has estimated the burden associated with a situation where a given pump manufacturer does not have existing test facilities at all and would be required to construct such facilities to test equipment in accordance with any test procedure final rule. This is the most burdensome assumption.

DOE requests comment on the testing currently conducted by pump manufacturers and the magnitude of incremental changes necessary to transform current test facilities to conduct the DOE test procedure as proposed in this NOPR.

The proposed test procedure would require manufacturers to conduct the calculation-based method or the testing-based method, depending on the type and configuration of pump being tested. As discussed in section III.E.1, DOE is proposing the less burdensome calculation-based test methods as the required test method for bare pumps and pumps sold with motors that are covered by DOE's electric motor energy conservation standards.

In contrast, DOE is proposing to require that manufacturers use a testing-based method where pumps are sold either with motors that are not covered by DOE's electric motor energy conservation standards or with non-continuous controls. For pumps sold with motors that are covered by DOE's electric motor energy conservation standards and continuous controls, DOE is proposing to allow either testing-based methods or calculation-based methods be used to rate such equipment.

Both the calculation-based method and the testing-based method would require physical testing of pumps at some level and, as such, would utilize a similar basic testing facility. To collect information on constructing a testing facility capable of performing the proposed DOE test procedure on the proposed scope of covered equipment, DOE utilized estimates from pump testing facilities and conversations with pump testing personnel.

4. Capital Expense Associated with Constructing a Pump Testing Facility

From these sources, DOE estimates that the testing facility would need to be configured with 100 to 280 feet of stainless steel pipe of 6 to 8 inches in diameter. DOE estimates that this configuration, including its respective fittings and valves, would cost between $17,000 and $100,000 to construct, based on cost data from RS Means.[52] DOE estimates that the testing configuration would also include a double wall steel water reservoir that holds up to 6,000 gallons for smaller pipe configurations and a 30,000 gallon reservoir for larger pipe configurations, which would cost between $21,000 and $70,000 based on RS Means cost data.

The test platform of the facility could use a variety of devices to operate the bare pump. For example, a dynamometer can be used to simultaneously drive and measure the torque and rotating speed of the pump, the bare pump could be driven by a calibrated motor, or the pump could be driven by a non-calibrated motor with independent measurement of speed and torque. For testing of a pump and motor or pump, motor, and control, a separate drive system would not be necessary.

In this analysis, DOE assumed that such a facility would use a VFD and a motor to enable each pump to be analyzed for energy consumption. DOE believes that this is likely to be the most common and cost-effective approach for determining the energy consumptions of bare pumps. DOE estimates that the VFD, rated up to 250 horsepower in accordance with the scope of this rulemaking, would cost approximately $18,000 based on estimates obtained from retailers.

[52] R.S. Means Company, Inc. 2013 RS Means Electrical Cost Data. 2013. Kingston, MA.

DOE requests comment on its assumption that using a non-calibrated test motor and VFD would be the most common and least costly approach for testing bare pumps in accordance with the proposed DOE test procedure.

During testing, each pump is matched to an appropriately sized motor to drive the pump along at least seven points from 40 to 120 percent of the expected BEP flow of the pump on the pump performance curve. To test the full range of pumps covered in the scope of this standard, DOE estimates that a minimum of four motors would be necessary.

The motors would have to be sized based upon the range of pumps, which vary between 1 and 200 horsepower, to ensure that the pairing lowers the part load motor losses. These properly sized motors would be between 5 and 250 hp, and the combined cost of the motors ranges between $20,000 and $66,000.

To measure energy consumption, measurements of head, pump rotating speed, flow rate, and either electrical power or torque would be necessary. DOE estimates that the total cost of this measurement equipment would be between $15,000 and $33,000.

DOE estimates that building a testing facility capable of testing the range of pumps covered in the standard would cost approximately $91,000 to $277,000 per manufacturer.

DOE requests comment on the estimates of materials and costs to build a pump testing facility as presented.

DOE estimates that a majority of pumps are sold with motors that are covered under the current DOE motor standard or submersible motors and have been rated and, if equipped with controls, would use continuous controls. Under the proposed test procedure, DOE would not require these configurations of pumps and motors to be tested using the wire-to-water test, but would allow manufacturers the option to conduct the wire-to-water test.

All pumps sold with motors that are not covered by DOE's electric motor energy conservation standards would be required to conduct the wire-to-water test. The proposed wire-to-water test would utilize the basic test lab setup described above without the standard four test motors, but would require additional instrumentation to measure power into and out of the motor or VFD, as described in section III.C.2.e. DOE estimates the instrumentation required to measure electrical input power in a wire-to-water test or when testing with a calibrated motor would add approximately $2,000 to the cost of the test lab set up.

DOE understands that the characteristics of the power supplied to the test facility may impact the results of testing the controls in the system. However, DOE is not incorporating the testing or correction of power quality in the burden estimate presented in this NOPR because DOE could not identify reliable or consistent estimates for the cost of maintaining the proposed power supply requirements discussed in section III.C.2.a above. These factors, taken together, would result in a testing facility capable of conducting the wire-to-water test that costs between $72,000 and $213,000.

DOE requests comment on the test facility description and measurement equipment assumed in DOE's estimate of burden.

DOE requests comment and information regarding the burden associated with achieving the power quality requirements proposed in the NOPR.

DOE amortized the cost of building the testing facility based on loan interest rates and product lifetimes gathered in manufacturer surveys. The average interest rate for business loans reported by manufacturers was 11.8 percent, based on feedback obtained during preliminary analysis interviews for the standards rulemaking. DOE used a loan period of 7 years based on the assumption that the machinery qualifies for a 7-year depreciation schedule under the Modified Accelerated Cost Recovery System (MACRS).[53] The total annual payment for financing a test facility with these assumptions will be between $19,000 and $59,000 for the basic testing facility capable of conducting the calculation-based method. The total annual payment for financing for a test facility capable of conducting the alternative testing-based method would be between $15,000 and $45,000.

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[53] Department of the Treasury, Internal Revenue Service. How to Depreciate Property. IRS Pub. 926.

5. Recurring Burden Associated with Ongoing Testing Activities

In addition to the capital expenses associated with acquiring the appropriate equipment and facilities to conduct testing, manufacturers would incur recurring burden associated with maintaining the test facility and conducting each pump test. Each testing facility would need to calibrate the instrumentation used in the test loop as specified in HI 40.6–2004 appendix D. The flowmeter, torque sensor, and power quality meter all should be calibrated once a year. The pressure transducer should be calibrated every 4 months and a laser tachometer should be calibrated every 3 years. These calibrations, together, cost a testing facility about $1,241.67 per year to calibrate.

Both methods of the proposed test procedure would require test personnel to set up, conduct, and remove each pump in accordance with that procedure. Based on conversations with test engineers, DOE estimates it would take between 1 and 2 hours of an engineer's time to complete the test procedure per model tested, which would result in a cost of $53.87 to $107.74 per model based on an engineer's labor rate of $53.87 per hour. DOE estimates that setting up and removing the pumps from the test stand would require 2 to 6 hours of the engineer's time depending on the size of the pump and any other fittings that need to be configured to enable testing, resulting in a cost between $107.74 to $323.22 per model based on the labor rate of $53.87 per hour for an engineer. The total cost of testing a pump, including setup, tests, and takedown ranges between $161.61 and $430.96 per model. DOE estimates that the time required to conduct the calculation-based method of test would be the same as the time required to conduct the wire-to-water test.

As described earlier, the proposed default calculation-based method, using the basic test facility set up, would require testing each bare pump model. The test results from that rated bare pump could then be used in subsequent calculations to determine certified ratings for that pump when sold as a bare pump, with a motor that is covered by DOE's energy conservation standards for electric motors, or with a covered motor and continuous controls. However, for pumps sold with motors not certified to the DOE motor standard or with non-continuous controls, manufacturers would be required to conduct the wire-to-water test on each pump model in a test facility with additional electrical instrumentation, as described previously. Manufacturers conducting the wire-to-water tests on their equipment would need to test each pump and motor combination, which may incur a higher burden than the default calculation-based method.

As previously discussed, DOE's estimate of burden for rating pump models covered by the proposed DOE test procedure is based on the assumption that the majority of covered pump models will be able to use the calculation-based method and same fundamental bare pump test to certify a given pump in the bare pump, pump sold with a motor, or pump sold with a motor and controls configurations. DOE notes that the wire-to-water test would be available as an option for these pump models, but would not be required. DOE acknowledges that some pump models, such as pumps sold with motors that are not covered by DOE's energy conservation standards for electric motors or submersible motors and pumps sold with motors and non-continuous controls, would be required to use the wire-to-water test procedure proposed in section III.E.2. However, based on DOE's research, very few pump models will be required to use these methods.

DOE requests comment on the number of pump models per manufacturer that would be required to use the wire-to-water test method to certify pump performance.

6. Cumulative Burden

These costs, taken together, would result in an additional burden for manufacturers conducting the DOE test procedure from the construction of a testing facility and the requirement to test all pumps under the scope of the proposed test procedure. Fifteen of 25 small manufacturers identified in DOE's initial survey of manufacturers produce pumps that fall within the scope of this rulemaking and would be required to perform testing; the other 10 produce pump types that are not within the scope of pumps for which the proposed test procedure is applicable (see section III.A).

The burden of building a testing facility and testing pumps varied across small manufacturers. The lowest burden estimate is approximately $61,000 in the first year and the highest burden experienced in the first year is estimated to be around $221,000 for small manufacturers affected by the rule. Table IV.2 presents the small manufacturers stratified by employee size and shows the average burden estimated for each employee bin size as a percentage of average annual sales.

Table IV.2. Small Business Size with Pumps in Scope of Rulemaking by Number of Employees with Estimated Burden

Number of Employees	Number of Small Businesses	Average Number of Basic Models	Average Annual Sales ($M)	Average Estimated Burden (% of Sales)
1–50	8	20	6.3	2.55%
51–100	2	48	16.7	0.60%
101–500	5	78	90.9	0.36%

The burden estimates were based on annual sales data gathered in the manufacturer surveys, company websites, and marketing research tools. Total revenue for businesses was not used because data for all relevant companies were not publicly available. Annual average value added was another financial indicator investigated for the burden analysis. This indicator was not utilized because the value added pooled companies that manufacture other commodities and was not found to be representative of the pump manufacturing industry.

DOE requests comment on the use of annual sales as the financial indicator for this analysis and whether another financial indicator would be more representative to assess the burden upon the pump manufacturing industry.

As the number of employees increases, the average estimated burden, as a percentage of average annual sales, decreases. The average number of basic models is highest for small manufacturers with 51–100 employees; however, the average annual sales were a much larger factor in determining the average burden than the number of basic models per manufacturer.

For the 15 small manufacturers that produce pumps within the scope of the rulemaking, the average burden is estimated to be 1.56 percent of their average annual sales. Based on the burden estimates described herein, 3 of the 15 manufacturers would incur a burden of over 2 percent of their annual sales if the maximum burden is applied. The other 12 companies have an average estimated burden of 0.63 percent of annual sales.

Based on the estimates presented, DOE believes that the proposed test procedure amendments may have a significant economic impact on a substantial number of small entities, and the preparation of a final regulatory flexibility analysis may be required. DOE will transmit the certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the Small Business Administration for review under 5 U.S.C. 605(b).

DOE requests comment on its conclusion that the proposed rule may have a significant impact on a substantial number of small entities. DOE is particularly interested in feedback on the assumptions and estimates made in the analysis of burden associated with implementing the proposed DOE test procedure.

C. Review Under the Paperwork Reduction Act of 1995

All collections of information from the public by a Federal agency must receive prior approval from OMB. DOE has established regulations for the certification and recordkeeping requirements for covered consumer products and industrial equipment. 10

CFR Part 429, Subpart B. DOE published a notice of public meeting and availability of the framework document considering energy conservation standards for pumps on February 1, 2013. 78 FR 7304. In an application to renew the OMB information collection approval for DOE's certification and recordkeeping requirements, DOE included an estimated burden for manufacturers of pumps in case DOE ultimately sets energy conservation standards for this equipment. OMB has approved the revised information collection for DOE's certification and recordkeeping requirements. 80 FR 5099 (January 30, 2015). DOE estimated that it will take each respondent approximately 30 hours total per company per year to comply with the certification and recordkeeping requirements based on 20 hours of technician/technical work and 10 hours clerical work to actually submit the Compliance and Certification Management System templates. This rulemaking would include recordkeeping requirements on manufacturers that are associated with executing and maintaining the test data for this equipment. DOE notes that the certification requirements would be established in a final rule establishing energy conservation standards for pumps. DOE recognizes that recordkeeping burden may vary substantially based on company preferences and practices.

DOE requests comment on the burden estimate to comply with the proposed recordkeeping requirements.

DOE also generally notes that notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB control number.

D. Review Under the National Environmental Policy Act of 1969

In this proposed rule, DOE is proposing a test procedure for pumps that will be used to support the upcoming pumps energy conservation standard rulemaking. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321, et seq.) and DOE's implementing regulations at 10 CFR part 1021. Specifically, this proposed rule considers a test procedure for a pump that is largely based upon industry test procedures and methodologies resulting from a negotiated rulemaking, so it would not affect the amount, quality or distribution of energy usage, and, therefore, would not result in any environmental impacts. Thus, this rulemaking is covered by Categorical Exclusion A5 under 10 CFR part 1021, subpart D. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. Review Under Executive Order 13132

Executive Order 13132, "Federalism," 64 FR 43255 (Aug. 4, 1999) imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the equipment that is the subject of today's proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, the proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. No. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at http://energy.gov/gc/office-general-counsel. DOE examined today's proposed rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This proposed rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights" 53 FR 8859 (March 18, 1988), that this proposed regulation would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed today's proposed rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has tentatively concluded that today's regulatory action, which would prescribe the test procedure for measuring the energy efficiency of pumps, is not a significant regulatory action under Executive Order 12866 and is not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on the proposed rule.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95-91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

The proposed rule incorporates by reference the testing methods contained in HI 40.6-2014, "Methods for Rotodynamic Pump Efficiency Testing," except section 40.6.5.3, "Test report;" section A.7, "Testing at temperatures exceeding 30 °C(86 °F);" and appendix B, "Reporting of test results." In addition, the NOPR's proposed definitions incorporate by reference the following standards:

1) sections 1.1, “types and nomenclature,” and 1.2.9, “rotodynamic pump icons,” of the 2014 version of ANSI/HI Standard 1.1-1.2, “Rotodynamic (Centrifugal) Pumps For Nomenclature And Definitions;”
2) section 2.1, “types and nomenclature,” of the 2008 version of ANSI/HI Standard 2.1-2.2, “Rotodynamic (Vertical) Pumps For Nomenclature And Definitions;”

While today's proposed test procedure is not exclusively based on these industry testing standards, some components of the DOE test procedure would adopt definitions, test parameters, measurement techniques, and additional calculations from them without amendment. The Department has evaluated these industry testing standards and is unable to conclude whether they would fully comply with the requirements of section 32(b) of the FEAA, (i.e., that they were developed in a manner that fully provides for public participation, comment, and review). DOE will consult with the Attorney General and the Chairman of the FTC concerning the impact of this test procedure on competition, prior to prescribing a final rule.

M. Description of Materials Incorporated by Reference

In this NOPR, DOE proposes to incorporate by reference five industry standards related to pump nomenclature, definitions, and specifications, which DOE has referenced in its proposed definitions. These standards include ANSI/HI 1.1-1.2–2014, “Rotodynamic (Centrifugal) Pumps For Nomenclature And Definitions;” ANSI/HI 2.1-2.2–2008, “Rotodynamic (Vertical) Pumps For Nomenclature And Definitions;” FM

Class Number 1319, “Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type);” UL Standard 448-2007, “Centrifugal Stationary Pumps for Fire-Protection Service;” and NFPA Standard 20-2013, “Standard for the Installation of Stationary Pumps for Fire Protection.” These are industry-accepted standards used by pump manufacturers when designing and marketing pumps in North America. The definitions proposed in this NOPR reference specific sections of the HI standards for definitional clarity and the entirety of the NFPA, UL, and FM standards as a basis for scope exclusions. These standards are available through their organization’s websites, , , and www.pumps.org.

DOE also proposes to incorporate by reference the test standard published by HI titled “Methods for Rotodynamic Pump Efficiency Testing,” HI 40.6–2014, with the exception of section 40.6.5.3, “Test report;” section A.7, “Testing at temperatures exceeding 30 °C(86 °F);” and appendix B, “Reporting of test results.” HI 40.6-2014 was developed to support DOE’s test procedure development and is heavily based on the industry-accepted test standard ANSI/HI 14.6. The test procedure proposed in this NOPR references nearly the entirety of ANSI/HI 14.6, in regards to test setup, instrumentation, and test conduct. HI 40.6-2014 is available through HI’s website.

V. Public Participation

A. Attendance at Public Meeting

The time, date and location of the public meeting are listed in the DATES and ADDRESSES sections at the beginning of this notice. If you plan to attend the public meeting, please notify Ms. Brenda Edwards at (202) 586-2945 or Brenda.Edwards@ee.doe.gov.

Please note that foreign nationals visiting DOE Headquarters are subject to advance security screening procedures, which require advance notice prior to attendance at the public meeting. Any foreign national wishing to participate in the meeting should advise DOE as soon as possible by contacting foreignvisit@ee.doe.gov to initiate the necessary procedures. Please also note that any person wishing to bring a laptop into the Forrestal Building will be required to obtain a property pass. Visitors should avoid bringing laptops, or allow an extra 45 minutes. Persons may also attend the public meeting via webinar.

Due to the REAL ID Act implemented by the Department of Homeland Security (DHS), there have been recent changes regarding identification (ID) requirements for individuals wishing to enter Federal buildings from specific States and U.S. territories. As a result, driver's licenses from the following States or territory will not be accepted for building entry, and instead, one of the alternate forms of ID listed below will be required.

DHS has determined that regular driver's licenses (and ID cards) from the following jurisdictions are not acceptable for entry into DOE facilities: Alaska, American Samoa, Arizona, Louisiana, Maine, Massachusetts, Minnesota, New York, Oklahoma, and Washington. Acceptable alternate forms of Photo-ID include: U.S. Passport or

Passport Card; an Enhanced Driver's License or Enhanced ID-Card issued by the States of Minnesota, New York or Washington (Enhanced licenses issued by these States are clearly marked Enhanced or Enhanced Driver's License); a military ID or other Federal government-issued Photo-ID card.

In addition, you can attend the public meeting via webinar. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's website http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/14. Participants are responsible for ensuring their systems are compatible with the webinar software.

B. Procedure for Submitting Prepared General Statements For Distribution

Any person who has plans to present a prepared general statement may request that copies of his or her statement be made available at the public meeting. Such persons may submit requests, along with an advance electronic copy of their statement in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format, to the appropriate address shown in the ADDRESSES section at the beginning of this notice. The request and advance copy of statements must be received at least 1 week before the public meeting and may be emailed, hand-delivered, or sent by mail. DOE prefers to receive requests and advance copies via email. Please include a telephone number to enable DOE staff to make a follow-up contact, if needed.

C. Conduct of Public Meeting

DOE will designate a DOE official to preside at the public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the public meeting. After the public meeting and until the end of the comment period, interested parties may submit further comments on the proceedings and any aspect of the rulemaking.

The public meeting will be conducted in an informal, conference style. DOE will present summaries of comments received before the public meeting, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will permit, as time permits, other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly and comment on statements made by others. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

A transcript of the public meeting will be included in the docket, which can be viewed as described in the Docket section at the beginning of this notice. In addition, any person may buy a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting, but no later than the date provided in the DATES section at the beginning of this proposed rule. Interested parties may submit comments using any of the methods described in the ADDRESSES section at the beginning of this notice.

Submitting comments via regulations.gov. The regulations.gov webpage will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to regulations.gov information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through regulations.gov cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through regulations.gov before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that regulations.gov provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery, or mail. Comments and documents submitted via email, hand delivery, or mail also will be posted to regulations.gov. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information on a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery, please provide all items on a CD, if feasible. It is not necessary to submit printed copies. No facsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, written in English and free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. According to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery two well-marked copies: one copy of the document marked confidential including all the information commented to be confidential, and one copy of the document marked non-confidential with the information commented to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) a description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1) DOE requests comment on its proposal to match the scopes of the pump test procedure and energy conservation standard rulemakings, as recommended by the Working Group.
2) DOE requests comment on the proposed definitions for “pump,” “bare pump,” “mechanical equipment,” “driver,” and “control.”
3) DOE requests comment on the proposed definitions for “continuous control” and “non-continuous control.”
4) DOE also requests comment and information regarding how often pumps with continuous or non-continuous controls are packaged and distributed in commerce, by manufacturers, with integrated sensors and feedback logic that would allow such pumps to automatically actuate.
5) DOE also requests comment on the likelihood of pumps with continuous and non-continuous controls being distributed in commerce, but never paired with any sensor or feedback mechanisms that would enable energy savings.
6) DOE requests comment on the proposed definition for “basic model” as applied to pumps. Specifically, DOE is interested in comments on DOE’s proposal to allow manufacturers the option of rating pumps with trimmed impellers as a single basic model or separate basic models, provided the rating

for each pump model is based on the maximum impeller diameter for that model.

7) DOE requests comment on the proposed definition for “full impeller.”

8) DOE requests comment on the proposal to require that all pump models be rated in a full impeller configuration only.

9) DOE requests comment on any other characteristics of pumps that are unique from other commercial and industrial equipment and may require modifications to the definition of “basic model,” as proposed.

10) DOE requests comment on the proposed applicability of the test procedure to the five pump equipment classes noted above, namely ESCC, ESFM, IL, RSV, and VTS pumps.

11) DOE requests comment on the proposed definitions for end suction pump, end suction frame mounted pump, end suction close-coupled pump, in-line pump, radially split multi-stage vertical in-line casing diffuser pump, rotodynamic pump, single axis flow pump, and vertical turbine submersible pump.

12) DOE requests comment on whether the references to ANSI/HI nomenclature are necessary as part of the equipment definitions in the regulatory text, are likely to cause confusion due to inconsistencies, and whether discussing the ANSI/HI nomenclature in this preamble would provide sufficient reference material for manufacturers when determining the appropriate equipment class for their pump models.

13) DOE requests comment on whether it needs to clarify the flow direction to distinguish RSV pumps from other similar pumps when determining test procedure and standards applicability.

14) DOE requests comment on whether any additional language is necessary in the proposed RSV definition to make the exclusion of immersible pumps clearer

15) DOE requests comment on its proposal to exclude circulators and pool pumps from the scope of this test procedure rulemaking.

16) DOE requests comment on the proposed definitions for circulators and dedicated-purpose pool pumps.

17) DOE requests comment on the extent to which ESCC, ESFM, IL, and RSV pumps require attachment to a rigid foundation to function as designed. Specifically, DOE is interested to know if any pumps commonly referred to as ESCC, ESFM, IL, or RSV do not require attachment to a rigid foundation.

18) DOE requests comment on its initial determination that axial/mixed flow and PD pumps are implicitly excluded from this rulemaking based on the proposed definitions and scope parameters. In cases where commenters suggest a more explicit exclusion be used, DOE requests comment on the appropriate changes to the proposed definitions or criteria that would be needed to appropriately differentiate axial/mixed flow and/or PD pumps from the specific rotodynamic pumps equipment classes proposed for coverage in this NOPR.

19) DOE requests comment on the proposed definition for "clean water pump."

20) DOE requests comment on its proposal to incorporate by reference the definition for "clear water" in HI 40.6–2014 to describe the testing fluid to be used when testing pumps in accordance with the DOE test procedure.

21) DOE requests comment on the proposed definition for "fire pump," "self-priming pump," "prime-assisted pump," and "sealless pump."

22) Regarding the proposed definition of a self-priming pump, DOE notes that such pumps typically include a liquid reservoir above or in front of the impeller to allow recirculating water within the pump during the priming cycle. DOE requests comment on any other specific design features that enable the pump to operate without manual re-priming, and whether such specificity is needed in the definition for clarity.

23) DOE requests comment on the proposed specifications and criteria to determine if a pump is designed to meet a specific Military Specification and if Military Specifications other than MIL-P-17639F should be referenced.

24) DOE requests comment on excluding the following pumps from the test procedure: fire pumps, self-priming pumps, prime-assist pumps, sealless pumps, pumps designed to be used in a nuclear facility subject to 10 CFR part 50 -- Domestic Licensing of Production and Utilization Facilities, and pumps meeting the design and construction requirements set forth in Military Specification MIL-P-17639F, "Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use" (as amended).

25) DOE requests comment on the listed design characteristics (power, flow, head, design temperature, design speed, and bowl diameter) as limitations on the scope of pumps to which the proposed test procedure would apply.

26) DOE requests comment on the proposed definition for "bowl diameter" as it would apply to VTS pumps.

27) DOE requests comment on its proposal to test pumps sold with non-electric drivers as bare pumps.

28) DOE requests comment on its proposal that any pump distributed in commerce with a single-phase induction motor be tested and rated in the bare pump configuration, using the calculation method.

29) DOE requests comment from interested party on any categories of electric motors, except submersible motors, that: (1) are used with pumps considered in this rulemaking and (2) typically have efficiencies lower than the default nominal full load motor efficiency for NEMA Design A, NEMA Design B, or IEC Design N motors....

30) DOE requests comment on the proposed load points and weighting for PEI_{CL} for bare pumps and pumps sold with motors and PEI_{VL} for pumps inclusive of motors and continuous or non-continuous controls.

31) DOE requests comments on the proposed PEI_{CL} and PEI_{VL} metric architecture.

32) DOE requests comment on its proposal to base the default motor horsepower for the minimally compliant pump on that of the pump being evaluated. That is, the motor horsepower for the minimally compliant pump would be based

on the calculated pump shaft input power of the pump when evaluated at 120 percent of BEP flow for bare pumps and the horsepower of the motor with which that pump is sold for pumps sold with motors and controls (with or without continuous or non-continuous controls).

33) DOE requests comment on using HI 40.6–2014 as the basis of the DOE test procedure for pumps.

34) DOE requests comment on its proposal to not incorporate by reference section 40.6.5.3, section A.7, and appendix B of HI 40.6–2014 as part of the DOE test procedure.

35) DOE requests comment on its proposal to require that data be collected at least every 5 seconds for all measured quantities.

36) DOE requests comment on its proposal to allow dampening devices, as described in section 40.6.3.2.2, but with the proviso noted above (i.e., permitted to integrate up to the data collection interval, or 5 seconds).

37) DOE requests comment on its proposal to require data collected at the pump speed measured during testing to be normalized to the nominal speeds of 1,800 and 3,600.

38) DOE requests comment on its proposal to adopt the requirements in HI 40.6–2014 regarding the deviation of tested speed from nominal speed and the variation of speed during the test. Specifically, DOE is interested if maintaining tested speed within ±1 percent of the nominal speed is feasible and whether this approach would produce more accurate and repeatable test results.

39) DOE requests comment on the proposed voltage, frequency, voltage unbalance, total harmonic distortion, and impedance requirements that are required when performing a wire-to-water pump test or when testing a bare pump with a calibrated motor. Specifically, DOE requests comments on whether these tolerances can be achieved in typical pump test labs, or whether specialized power supplies or power conditioning equipment would be required.

40) DOE requests comment on its proposal to test RSV and VTS pumps in their 3- and 9-stage versions, respectively, or the next closest number of stages if the pump model is not distributed in commerce with that particular number of stages.

41) DOE requests comment on its proposal to use a linear regression of the pump shaft input power with respect to flow rate at all the tested flow points greater than or equal to 60 percent of expected BEP flow to determine the pump shaft input power at the specific load points of 75, 100, and 110 percent of BEP flow. DOE is especially interested in any pump models for which such an approach would yield inaccurate measurements.

42) DOE requests comment on its proposal that for pumps with BEP at run-out, the BEP would be determined at 40, 50, 60, 70, 80, 90, and 100 percent of expected BEP flow instead of the seven data points described in section 40.6.5.5.1 of HI 40.6–2014 and that the constant load points for pumps with BEP at run-out shall be 100, 90, and 65 percent of BEP flow, instead of 110, 100, and 75 percent of BEP flow.

43) DOE requests comment on the type and accuracy of required measurement equipment, especially the equipment required for electrical power measurements for pumps sold with motors having continuous or non-continuous controls.

44) DOE requests comment on its proposal to conduct all calculations and corrections to nominal speed using raw measured values and that the PER_{CL} and PEI_{CL} or PER_{VL} and PEI_{VL}, as applicable, be reported to the nearest 0.01.

45) DOE requests comment on its proposal to determine the default motor horsepower for rating bare pumps based on the pump shaft input power at 120 percent of BEP flow. DOE is especially interested in any pumps for which the 120 percent of BEP flow load point would not be an appropriate basis to determine the default motor horsepower (e.g., pumps for which the 120 percent of BEP flow load point is a significantly lower horsepower than the BEP flow load point).

46) DOE requests comment on its proposal that would specify the default, minimally compliant nominal full load motor efficiency based on the applicable minimally allowed nominal full load motor efficiency specified in DOE's energy conservation standards for NEMA Design A, NEMA Design B, and IEC Design N motors at 10 CFR 431.25 for all pumps except pumps sold with submersible motors.

47) DOE requests comment on the proposed default minimum full load motor efficiency values for submersible motors.

48) DOE requests comment on defining the proposed default minimum motor full load efficiency values for submersible motors relative to the most current minimum efficiency standards levels for regulated electric motors, through the use of “bands” as presented in Table III.6.

49) DOE requests comment on the proposal to allow the use of the default minimum submersible motor full load efficiency values presented in Table III.6 to rate: (1) VTS bare pumps, (2) pumps sold with submersible motors, and (3) pumps sold with submersible motors and continuous or non-continuous controls as an option instead of wire-to-water testing. .

50) DOE requests comment on the development and use of the motor part load loss factor curves to describe part load performance of covered motors and submersible motors including the default motor specified in section III.D.1 for bare pumps and calculation of PER_{STD}.

51) DOE requests comment on its proposal to determine the part load losses of motors covered by DOE’s electric motor energy conservation standards at 75, 100, and 110 percent of BEP flow based on the nominal full load efficiency of the motor, as determined in accordance with DOE’s electric motor test procedure, and the same default motor part load loss curve applied to the default motor in test method A.1 for the bare pump.

52) DOE requests comment on its proposal to determine the PER_{CL} of pumps sold with submersible motors using the proposed default minimum efficiency values for submersible motors and applying the same default motor part load loss curve to the default motor in test method A.1 for the bare pump.

53) DOE also requests comment on its proposal that pumps sold with motors that are not addressed by DOE's electric motors test procedure (except submersible motors) would be rated based on a wire-to-water, testing-based approach.

54) DOE requests comment on the proposed system curve shape to use, as well as whether the curve should go through the origin instead of the statically loaded offset.

55) DOE requests comment on the proposed calculation approach for determining pump shaft input power for pumps sold with motors and continuous controls when rated using the calculation-based method.

56) DOE requests comment on the proposal to adopt four part load loss factor equations expressed as a function of the load on the motor (i.e., motor brake horsepower) to calculate the losses of a combined motor and continuous controls, where the four curves would correspond to different horsepower ratings of the continuous control.

57) DOE also requests comment on the accuracy of the proposed equation compared to one that accounts for multiple performance variables (speed and torque).

58) DOE requests comment on the proposed 5 percent scaling factor that was applied to the measured VSD efficiency data to generate the proposed coefficients of the four part load loss curves. Specifically, DOE seeks comment on whether another scaling factor or no scaling factor would be more appropriate in this context.

59) DOE requests comment on the variability of control horsepower ratings that might be distributed in commerce with a given pump and motor horsepower.

60) DOE requests comment and data from interested parties regarding the extent to which the assumed default part load loss curve would represent minimum efficiency motor and continuous control combinations.

61) DOE requests comment on its proposal to require testing of each individual bare pump as the basis for a certified PEI_{CL} or PEI_{VL} rating for one or more pump basic models.

62) DOE requests comment on its proposal to limit the use of calculations and algorithms in the determination of pump performance to the calculation-based methods proposed in this NOPR.

63) DOE requests comment on its proposal to determine BEP for pumps rated with a testing-based method by using the ratio of input power to the driver or continuous control, if any, over pump hydraulic output. DOE also seeks input on the degree to which this method may yield significantly different BEP points from the case where BEP is determined based on pump efficiency.

64) DOE requests comment on the proposed testing-based method for pumps sold with motors and continuous or non-continuous controls.

65) DOE requests comment on the proposed testing-based method for determining the input power to the pump for pumps sold with motors and non-continuous controls.

66) DOE requests comment on any other type of non-continuous control that may be sold with a pump and for which the proposed test procedure would not apply.

67) DOE requests comment on its proposal to establish calculation-based test methods as the required test method for bare pumps and testing-based methods as the required test method for pumps sold with motors that are not regulated by DOE's electric motor energy conservation standards, except for submersible motors, or for pumps sold with any motors and with non-continuous controls.

68) DOE also requests comment on the proposal to allow either testing-based methods or calculation-based methods to be used to rate pumps sold with continuous control-equipped motors that are either (1) regulated by DOE's electric motor standards or (2) submersible motors.

69) DOE requests comment on the level of burden to include with any certification requirements the reporting of the test method used by a manufacturer to certify a given pump basic model as compliant with any energy conservation standards DOE may set.

70) DOE requests comment on the proposed sampling plan for certification of commercial and industrial pump models.

71) DOE requests comment regarding the size of pump manufacturing entities and the number of manufacturing businesses represented by this market.

72) DOE requests comment on its assumption that, for most pump models, only physical testing of the underlying bare pump model is required, and

subsequent ratings for that bare pump sold with a motor or motor and continuous control can be based on calculations only.

73) DOE requests information on the percentage of pump models for which the rating of the bare pump, pump sold with a motor, and pump sold with a motor and controls cannot be based on the same fundamental physical test of the bare pump. For example, DOE is interested in the number of pump models sold with motors that are not covered by DOE's energy conservation standards for electric motors or the number of pump models sold with controls that would not meet DOE's definition of continuous control.

74) DOE requests comment on the testing currently conducted by pump manufacturers and the magnitude of incremental changes necessary to transform current test facilities to conduct the DOE test procedure as described in this NOPR.

75) DOE requests comment on its assumption that using a non-calibrated test motor and VFD would be the most common and least costly approach for testing bare pumps in accordance with the proposed DOE test procedure.

76) DOE requests comment on the estimates of materials and costs to build a pump testing facility as presented.

77) DOE requests comment on the test facility description and measurement equipment assumed in DOE's estimate of burden.

78) DOE requests comment and information regarding the burden associated with achieving the power quality requirements proposed in the NOPR.

79) DOE requests comment on the number of pump models per manufacturer that would be required to use the wire-to-water test method to certify pump performance.

80) DOE requests comment on the estimation of the portion of pumps that would need to be newly certified or recertified annually.

81) DOE requests comment on the use of annual sales as the financial indicator for this analysis and whether another financial indicator would be more representative to assess the burden upon the pump manufacturing industry.

82) DOE requests comment on its conclusion that the proposed rule may have a significant impact on a substantial number of small entities. DOE is particularly interested in feedback on the assumptions and estimates made in the analysis of burden associated with implementing the proposed DOE test procedure.

83) DOE requests comment on the burden estimate to comply with the proposed recordkeeping requirements.

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this proposed rule.

List of Subjects

10 CFR Part 429

Administrative practice and procedure, Confidential business information, Energy conservation, Imports, Intergovernmental relations, Small businesses.

10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on March 13, 2015.

Kathleen B. Hogan
Deputy Assistant Secretary for Energy Efficiency
Energy Efficiency and Renewable Energy

For the reasons stated in the preamble, DOE is proposing to amend parts 429 and 431 of Chapter II, subchapter D of Title 10, Code of Federal Regulations as set forth below:

PART 429 – CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

2. In §429.2 revise paragraph (a) to read as follows:

§429.2 Definitions.

(a) The definitions found in §§ 430.2, 431.2, 431.62, 431.72, 431.82, 431.92, 431.102, 431.132, 431.152, 431.172, 431.192, 431.202, 431.222, 431.242, 431.262, 431.282, 431.292, 431.302, 431.322, 431.442 and 431.462 apply for purposes of this part.

*   *   *   *   *

§429.11 [Amended]

3. Section 429.11 is amended in paragraphs (a) and (b) by removing “429.54” and adding in its place “429.62”.

4. Add §429.59 to read as follows:

§429.59 Pumps.

(a) *Determination of represented value*. Manufacturers must determine the represented value, which includes the certified rating, for each basic model by testing, in conjunction with the following sampling provisions.

(1) Units to be tested. The requirements of §429.11 are applicable to pumps; and for each basic model, a sample of sufficient size shall be randomly selected and tested to ensure that—

(i) Any value of the constant or variable load pump energy index or other measure of energy consumption of a basic model for which consumers would favor lower values shall be greater than or equal to the higher of:

(A) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the maximum of the i^{th} sample;

Or,

(B) The upper 95 percent confidence limit (UCL) of the true mean divided by 1.01, where:

$$UCL = \bar{x} + t_{0.95}\left(\frac{s}{\sqrt{n}}\right)$$

and $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95 percent one-tailed confidence interval with n-1 degrees of freedom (from appendix A of subpart B of part 429);

and

(ii) Any measure of energy consumption of a basic model for which consumers would favor higher values shall be less than or equal to the lower of:

(A) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the maximum of the i^{th} sample;

Or,

(B) The lower 95 percent confidence limit (LCL) of the true mean divided by 0.99, where:

$$LCL = \bar{x} - t_{0.95}\left(\frac{s}{\sqrt{n}}\right)$$

and $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95% one-tailed confidence interval with n-1 degrees of freedom (from appendix A of subpart B).

(b) [Reserved]

§§429.70, 429.72, and 429.102 [Amended]

5. Sections 429.70(a), 429.72(a) and 429.102(a) are amended by removing “429.54” and adding in its place “429.62”.

6. In §429.71, add paragraph (d) to read as follows:

§429.71 Maintenance of records.

*   *   *   *   *

(d) When considering if a pump is subject to energy conservation standards under part 431, DOE may need to determine if a pump was designed and constructed to the requirements set forth in MIL-P-17639F. In this case, DOE may request that a manufacturer provide DOE with copies of the original design and test data that were submitted to appropriate design review agencies, as required by MIL-P-17639F.

7. Section 429.110(e)(1), is amended by:

a. Redesignating paragraphs (e)(1)(iv) through (vi) as (e)(1)(v) through (vii), respectively;

b. Adding a new paragraph (e)(1)(iv);

c. Removing “(e)(1)(iii)”, in newly redesignated paragraph (e)(1)(v), and adding “(e)(1)(iv)” in its place;

d. Removing “(e)(1)(iv)”, in newly redesignated paragraph (e)(1)(vi), and adding “(e)(1)(v)” in its place; and

e. Removing “(e)(1)(v)”, in newly redesignated paragraph (e)(1)(vii), and adding “(e)(l)(vi)” in its place.

The addition reads as follows:

§429.110 Enforcement testing.

*   *   *   *   *

(e) * * *

(1) * * *

(iv) For pumps, DOE will use an initial sample size of not more than four units and will determine compliance based on the arithmetic mean of the sample.

* * * * *

PART 431 – ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

8. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291-6317.

9. Add subpart Y to part 431 to read as follows:

SUBPART Y – Pumps

Sec.

SUBPART Y – Pumps

§431.461 Purpose and scope.

This subpart contains definitions, test procedures, and energy conservation requirements for pumps, pursuant to Part A-1 of Title III of the Energy Policy and Conservation Act, as amended, 42 U.S.C. 6311–6317.

§431.462 Definitions.

The following definitions are applicable to this subpart, including appendix A. In cases where there is a conflict, the language of the definitions adopted in this section 462 takes precedence over any descriptions or definitions found in the 2014 version of ANSI/HI Standard 1.1-1.2, "Rotodynamic (Centrifugal) Pumps For Nomenclature And Definitions" (ANSI/HI 1.1-1.2–2014) (incorporated by reference, see §431.463), or the 2008 version of ANSI/HI Standard 2.1-2.2, "Rotodynamic (Vertical) Pumps For Nomenclature And Definitions" (ANSI/HI 2.1-2.2–2008) (incorporated by reference, see §431.463). In cases where definitions reference design intent, DOE will consider marketing materials, labels and certifications, and equipment design to determine design intent.

Bare pump means a pump excluding mechanical equipment, driver, and controls.

Basic model means all units of a given type of covered equipment (or class thereof) manufactured by one manufacturer, having the same primary energy source, and having essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency; except that:

(1) RSV and VTS pump models for which the bare pump differs in the number of stages must be considered a single basic model and

(2) Pump models for which the bare pump differs in impeller diameter, or impeller trim, may be considered a single basic model.

Best efficiency point means the pump hydraulic power operating point (consisting of both flow and head conditions) that results in the maximum efficiency.

Bowl diameter means the maximum dimension of an imaginary straight line passing through and in the plane of the circular shape of the intermediate bowl or chamber of the bare pump that is perpendicular to the pump shaft and that intersects the circular shape of the intermediate bowl or chamber of the bare pump at both of its ends, where the intermediate bowl or chamber is as defined in ANSI/HI 2.1-2.2–2008 (incorporated by reference, see §431.463).

Circulator means a pump that:

(1) Is either an end suction pump or a single-stage, single-axis flow, rotodynamic pump; and

(2) Has a pump housing that only requires the support of the supply and discharge piping to which it is connected (without attachment to a rigid foundation) to function as designed. Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature CP1, CP2, or CP3, as described in ANSI/HI 1.1-1.2–2014 (incorporated by reference, see §431.463).

Clean water pump means a pump that is designed for use in pumping water with a maximum non-absorbent free solid content of 0.25 kilograms per cubic meter, and with a maximum dissolved solid content of 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 -10 ºC.

Continuous control means a control that adjusts the speed of the pump driver continuously over the driver operating speed range in response to incremental changes in the required pump flow, head, or power output.

Control means any device that can be used to operate the driver. Examples include, but are not limited to, continuous or non-continuous speed controls, schedule-based controls, on/off switches, and float switches.

Dedicated-purpose pool pump means an end suction pump designed specifically to circulate water in a pool and that includes an integrated basket strainer.

Driver means the machine providing mechanical input to drive a bare pump directly or through the use of mechanical equipment. Examples include, but are not limited to, an electric motor, internal combustion engine, or gas/steam turbine.

End suction close-coupled (ESCC) pump means an end suction pump in which:

(1) The motor shaft also serves as the impeller shaft for the bare pump,

(2) The pump requires attachment to a rigid foundation to function as designed and cannot function as designed when supported only by the supply and discharge piping to which it is connected, and

(3) The pump does not include a basket strainer. Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature OH7, as described in ANSI/HI 1.1-1.2–2014 (incorporated by reference, see §431.463).

End suction frame mounted (ESFM) pump means an end suction pump wherein:

(1) The bare pump has its own impeller shaft and bearings and so does not rely on the motor shaft to serve as the impeller shaft,

(2) The pump requires attachment to a rigid foundation to function as designed and cannot function as designed when supported only by the supply and discharge piping to which it is connected, and

(3) The pump does not include a basket strainer. Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature OH0 and OH1, as described in ANSI/HI 1.1-1.2–2014 (incorporated by reference, see §431.463).

End suction pump means a single-stage, rotodynamic pump in which the liquid enters the bare pump in a direction parallel to the impeller shaft and on the side opposite the bare pump's driver-end. The liquid is discharged through a volute in a plane perpendicular to the shaft.

Fire pump means a pump that is compliant with NFPA Standard 20-2013 (incorporated by reference, see §431.463), "Standard for the Installation of Stationary Pumps for Fire Protection," and is either:

(1) Underwriters Laboratory (UL) listed under UL Standard 448-2007 (incorporated by reference, see §431.463), "Centrifugal Stationary Pumps for Fire-Protection Service," or

(2) Factory Mutual (FM) approved under the October 2008 edition of FM Class Number 1319, "Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type)," (incorporated by reference, see §431.463).

Full impeller diameter means the maximum diameter impeller used with a given pump basic model distributed in commerce or the maximum diameter impeller referenced in the manufacturer's literature for that pump basic model, whichever is larger.

In-line (IL) pump means a single-stage, single axis flow, rotodynamic pump in which:

(1) Liquid is discharged through a volute in a plane perpendicular to the impeller shaft, and

(2) The pump requires attachment to a rigid foundation to function as designed and cannot function as designed when supported only by the supply and discharge piping to which it is connected. Examples include, but are not limited to, pumps complying with

ANSI/HI nomenclature OH3, OH4, or OH5, as described in ANSI/HI 1.1-1.2–2014 (incorporated by reference, see §431.463).

Mechanical equipment means any component of a pump that transfers energy from the driver to the bare pump.

Non-continuous control means a control that adjusts the speed of a driver to one of a discrete number of non-continuous preset operating speeds, and does not respond to incremental reductions in the required pump flow, head, or power output.

Prime-assist pump means a pump designed to lift liquid that originates below the center line of the pump impeller. Such a pump requires no manual intervention to prime or re-prime from a dry-start condition. Such a pump includes a vacuum pump or air compressor to remove air from the suction line to automatically perform the prime or re-prime function.

Pump means equipment designed to move liquids (which may include entrained gases, free solids, and totally dissolved solids) by physical or mechanical action and includes a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, driver, and controls.

Radially split, multi-stage, vertical, in-line diffuser casing (RSV) pump means a vertically suspended, multi-stage, single axis flow, rotodynamic pump in which:

(1) Liquid is discharged in a place perpendicular to the impeller shaft,

(2) Each stage (or bowl) consists of an impeller and diffuser, and

(3) No external part of such a pump is designed to be submerged in the pumped liquid. Examples include, but are not limited to, pumps complying with ANSI/HI nomenclature VS8, as described in ANSI/HI 2.1-2.2–2008 (incorporated by reference, see §431.463).

Rotodynamic pump means a pump in which energy is continuously imparted to the pumped fluid by means of a rotating impeller, propeller, or rotor.

Sealless pump means either:

(1) A pump that transmits torque from the motor to the bare pump using a magnetic coupling, or

(2) A pump in which the motor shaft also serves as the impeller shaft for the bare pump, and the motor rotor is immersed in the pumped fluid.

Self-priming pump means a pump designed to lift liquid that originates below the center line of the pump impeller. Such a pump requires initial manual priming from a dry start condition, but requires no subsequent manual re-priming.

Single axis flow pump means a pump in which the liquid inlet of the bare pump is on the same axis as the liquid discharge of the bare pump.

Vertical turbine submersible (VTS) pump means a single-stage or multi-stage rotodynamic pump that is designed to be operated with the motor and stage(s) (or bowl(s)) fully submerged in the pumped liquid, and in which:

(1) Each stage of this pump consists of an impeller and diffuser, and

(2) Liquid enters and exits each stage of the bare pump in a direction parallel to the impeller shaft. Examples include, but are not limited to, a pumps complying with ANSI/HI nomenclature VS0, as described in ANSI/HI 2.1-2.2–2008 (incorporated by reference, see §431.463).

§431.463 Materials incorporated by reference.

(a) *General*. DOE incorporates by reference the following standards into subpart Y of part 431. The material listed has been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Any subsequent amendment to a standard by the standard-setting organization will not affect the DOE test procedures unless and until amended by DOE. Material is incorporated as it exists on the date of the approval and a notice of any change in the material will be published in the Federal Register. All approved material is available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html. Also, this material is available for inspection at U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586-2945, or go tohttp://www1.eere.energy.gov/buildings/appliance_standards/. These standards can be obtained from the sources below.

(b) FM. Factory Mutual. 270 Central Avenue Johnston, RI 02919, 401-275-3000. www.fmglobal.com/

(1) FM Class Number 1319, “Approval Standard for Centrifugal Fire Pumps (Horizontal, End Suction Type),” approved October 2008, IBR approved for §431.462.

(2) [Reserved]

(c) HI. Hydraulic Institute, 6 Campus Drive, First Floor North, Parsippany, NJ, 07054-4406, 973-267-9700. www.pumps.org

(1) ANSI/HI Standard 1.1-1.2, (“ANSI/HI 1.1-1.2–2014”), “Rotodynamic (Centrifugal) Pumps For Nomenclature And Definitions;” approved 2014, section 1.1, “Types and nomenclature,” and section 1.2.9, “Rotodynamic pump icons,” IBR approved for §431.462.

(2) ANSI/HI Standard 2.1-2.2, (“ANSI/HI 2.1-2.2–2008”), “Rotodynamic (Vertical) Pumps For Nomenclature And Definitions,” approved 2008, section 2.1, “Types and nomenclature,” IBR approved for §431.462.

(3) HI 40.6-2014, (“HI 40.6-2014”), “Methods for Rotodynamic Pump Efficiency Testing,” except section 40.6.5.3, “Test report;” section A.7, “Testing at temperatures exceeding 30 °C(86 °F);” and appendix B, “Reporting of test results;” approved 2014, IBR approved for §431.464, and appendix A to subpart Y of part 431.

(h) NFPA. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169, 617-770-3000. www.nfpa.org.

(1) NFPA Standard 20-2013, "Standard for the Installation of Stationary Pumps for Fire Protection," approved 2013, IBR approved for §431.462.

(2) [Reserved]

(i) UL. Underwriters Laboratory, 333 Pfingsten Road, Northbrook, IL 60062. http://ul.com/

(1) UL Standard 448-2007, "Centrifugal Stationary Pumps for Fire-Protection Service," approved 2007, IBR approved for §431.462.

(2) [Reserved]

§431.464 Test procedure for measuring and determining energy consumption of pumps.

(a) Scope.

(1) This section provides the test procedures for determining the constant and variable load pump energy index for:

(i) The following categories of clean water pumps:

A. End suction close-coupled (ESCC);

B. End suction frame mounted (ESFM);

C. In-line (IL);

D. Radially split, multi-stage, vertical, in-line casing diffuser (RSV); and

E. Vertical turbine submersible (VTS) pumps

(ii) With the following characteristics:

A. Shaft power of at least 1 hp but no greater than 200 hp at the best efficiency point (BEP) at full impeller diameter for the number of stages required for testing (see section 1.2.2 of this appendix),

B. Flow rate of 25 gpm or greater at BEP and full impeller diameter,

C. Maximum head of 459 feet at BEP and full impeller diameter,

D. Design temperature range from -10 to 120 °C,

E. Designed to operate with either: (1) a 2- or 4-pole induction motor, or (2) a non-induction motor with a speed of rotation operating range that includes speeds of rotation between 2,880 and 4,320 revolutions per minute and/or 1,440 and 2,160 revolutions per minute..., and

F. For VTS pumps, a 6-inch or smaller bowl diameter.

(iii) Except for the following pumps:

A. Fire pumps

B. Self-priming pumps

C. Prime-assist pumps

D. Sealless pumps

E. Pumps designed to be used in a nuclear facility subject to 10 CFR part 50, “Domestic Licensing of Production and Utilization Facilities”

F. Pumps meeting the design and construction requirements set forth in Military Specification MIL-P-17639F, “Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use” (as amended).

(b) Testing and Calculations. Determine the applicable constant load pump energy index (PEI_{CL}) or variable load pump energy index (PEI_{VL}) using the test procedure set forth in appendix A of this subpart Y.

APPENDIX A TO SUBPART Y OF PART 431 – UNIFORM TEST METHOD FOR THE MEASUREMENT OF ENERGY CONSUMPTION OF PUMPS.

I. Test Procedure for Pumps.

A. General. To determine the constant load pump energy index (PEI_{CL}), for bare pumps and pumps sold with electric motors or the variable load pump energy index (PEI_{VL}) for pumps sold with electric motors and continuous or non-continuous controls, testing shall be performed in accordance with HI 40.6-2014, except section 40.6.5.3, "Test report;" section A.7, "Testing at temperatures exceeding 30 °C (86 °F);" and appendix B, "Reporting of test results;" (incorporated by reference, see §431.463) with the modifications and additions as noted throughout the provisions below. Where HI 40.6-2014 refers to "pump," the term should be interpreted to refer to the "bare pump," as defined in §431.462. Also, for the purposes of applying this appendix, the term "volume per unit time," as defined in section 40.6.2, "Terms and definitions," of HI 40.6-2014 shall be deemed to be synonymous with the term "flow rate" used throughout that standard and this appendix A.

A.1 Scope. Section II of this appendix is applicable to all pumps and describes how to calculate the Pump Energy Index (section II.A) based on the PER_{STD} (section

II.B) and the PER_{CL} or PER_{VL} determined in accordance with one of sections III through VII, based on the testing method and configuration in which the pump is distributed in commerce. Sections III through VII describe different test methods that apply depending on the configuration of the pump being rated, as described in Table 1 of this appendix.

Table 1. Applicability of Calculation-Based and Testing-Based Test Procedure Options Based on Pump Configuration

Pump Configuration	**Pump Sub-Configuration**	**Applicable Test Methods**
Bare Pump	Bare Pump.	Section III: Test Procedure for Bare Pumps
Pump + Motor	Pump + Motor Covered by DOE's Electric Motor Energy Conservation Standards OR Pump + Submersible Motor	Section IV: Testing-Based Approach for Pumps Sold with Motors OR Section V: Calculation-Based Approach for Pumps Sold with Motors
	Pump + Motor Not Covered by DOE's Electric Motor Energy Conservation Standards (Except Submersible Motors)	Section IV: Testing-Based Approach for Pumps Sold with Motors
Pump + Motor + Controls	Pump + Motor Covered by DOE's Electric Motor Energy Conservation Standards + Continuous Control OR Pump + Submersible Motor + Continuous Control	Section VI: Testing-Based Approach for Pumps Sold with Motors and Controls OR Section VII: Calculation-Based Approach for Pumps Sold with Motors Controls
	Pump + Motor Covered by DOE's Electric Motor Energy Conservation Standards + Non-Continuous Control OR Pump + Submersible Motor + Non-Continuous Control	Section VI: Testing-Based Approach for Pumps Sold with Motors and Controls
	Pump + Motor Not Covered by DOE's Electric Motor Energy Conservation Standards (Except Submersible Motors) + Continuous or Non-Continuous Controls	Section VI: Testing-Based Approach for Pumps Sold with Motors and Controls

Section III of this appendix addresses the test procedure applicable to bare pumps. This test procedure also applies to pumps sold with drivers other than motors and pumps sold with single-phase induction motors.

Section IV of this appendix addresses the testing-based approach for pumps sold with motors, which is applicable to all pumps sold with electric motors, other than single-phase induction motors.

Section V of this appendix addressed the calculation-based approach for pumps sold with motors, which applies to:

(1) Pumps sold with electric motors regulated by DOE’s energy conservation standards for electric motors at §431.25, other than single-phase induction motors, and

(2) Pumps sold with submersible motors.

Section VI of this appendix addresses the testing-based approach for pumps sold with motors and controls, which is applicable to all pumps sold with electric motors, other than single-phase induction motors, and continuous or non-continuous controls.

Section VII of this appendix discusses the calculation-based approach for pumps sold with motors and controls, which applies to:

(1) Pumps sold with electric motors regulated by DOE’s energy conservation standards for electric motors at §431.25, other than single-phase induction motors, and continuous controls and

(2) Pumps sold with submersible motors and continuous controls.

B. <u>Measurement Equipment</u>. For the purposes of measuring pump power input, driver power input, and pump power output, the equipment specified in HI 40.6-2014 Appendix C (incorporated by reference, see §431.463) necessary to measure head, speed of rotation, flow rate, temperature, torque, and electrical power shall be used and shall comply with the stated accuracy requirements in HI 40.6-2014 Table 40.6.3.2.3 except as noted in section VI.B of this appendix.

C. Test Conditions. Testing shall be conducted in accordance with the test conditions, stabilization requirements, and specifications of HI 40.6-2014 (incorporated by reference, see §431.463) section 40.6.3, "Pump efficiency testing;" section 40.6.4, "Considerations when determining the efficiency of a pump;" section 40.6.5.4 (including appendix A), "Test arrangements;" and section 40.6.5.5, "Test conditions;" and at full impeller diameter.

C.1 The nominal speed of rotation shall be determined based on the range of speeds of rotation at which the pump is designed to operate, in accordance with sections I.C.1.1, I.C.1.2, I.C.1.3, I.C.1.4, or I.C.1.5 of this appendix, as applicable. When determining the range of speeds at which the pump is designed to operate, DOE will refer to published data, marketing literature, and other publically-available information about the pump model and motor, as applicable.

C.1.1 For pumps sold without motors, the nominal rating speed will be selected based on the speed for which the pump is designed. For bare pumps designed for speeds of rotation including 2,880 to 4,320 revolutions per minute n(rpm), the nominal speed of rotation shall be 3,600 rpm. For bare pumps designed for speeds of rotation including 1,440 to 2,160 rpm, the nominal speed of rotation shall be 1,800 rpm.

C.1.2 For pumps sold with 4-pole induction motors, the nominal speed of rotation shall be 1,800. rpm

C.1.3 For pumps sold with 2-pole induction motors, the nominal speed of rotation shall be 3,600 rpm.

C.1.4 For pumps sold with non-induction motors where the operating range of the pump and motor includes speeds of rotation between 2,880 and 4,320 rpm, the nominal speed of rotation shall be 3,600 rpm.

C.1.5 For pumps sold with non-induction motors where the operating range of the pump and motor includes speeds of rotation between 1,440 and 2,160 rpm, the nominal speed of rotation shall be 1,800 rpm.

C.2 For RSV and VTS pumps, testing shall be performed on the pump with three stages for RSV pumps and nine stages for VTS pumps. If the basic model of pump being tested is only available with fewer than the required number of stages, the pump shall be tested with the maximum number of stages with which the basic model is distributed in commerce in the United States. If the basic model of pump being tested is only available with greater than the required number of stages, the pump shall be tested with the lowest number of stages with which the basic model is distributed in commerce in the United States. If the basic model of pump being tested is available with both fewer and greater than the required number of stages, but not the required number of stages, the pump shall be tested with the number of stages closest to the required number of stages. If both the next lower and next higher number of stages are equivalently close to the required number of stages, the pump shall be tested with the next higher number of stages.

D. Data Collection and Analysis.

D.1 Data Sampling Frequency. Data shall be collected every three seconds for all measured quantities.

D.2 Dampening Devices. Use of dampening devices, as described in section 40.6.3.2.2, shall only be permitted to integrate up to 5 seconds.

D.3 Stabilization. Data recording at any test point shall be taken under stabilized conditions, as defined in HI 40.6-2014 section 40.6.5.5.1 (incorporated by reference, see §431.463).

D.4 Calculations and Rounding. All measured data shall be normalized to the nominal speed of rotation of 3,600 or 1,800 rpm based on the nominal speed of rotation selected for the pump in section I.C.1 of this appendix, in accordance with the procedures specified in section 40.6.6.1.1 of HI 40.6-2014 (incorporated by reference, see §431.463). Except for the "expected BEP flow rate," all terms and quantities refer to values determined in accordance with the procedures set forth in this appendix for the rated pump. All calculations shall be performed using their raw measured values with PER_{CL}, PER_{VL}, PEI_{CL}, and PEI_{VL} values, as applicable, rounded to the hundredths place (i.e., 0.01).

D.5 Pumps with BEP at Run Out. Pumps for which the expected maximum efficiency corresponds to the maximum flow rate at which the pump is designed to operate continuously or safely (i.e., pumps with BEP at run-out), the seven flow points for determination of BEP in sections III.C, IV.C, V.C, VI.D, and VII. C of this appendix shall be as follows: 40, 50, 60, 70, 80, 90, and 100 percent of the maximum flow rate of the pump instead of those specified. In addition, all references to 75, 100, and 110 percent of the BEP flow rate for determination of PER_{CL} and PER_{STD} shall instead be 65, 90, and 100 percent of the BEP flow rate determined with the modified flow points specified in this section I.D.5 of this appendix.

II. Calculation of the Pump Energy Index.

A. Determine the PEI of each tested pump based on the configuration in which it sold as follows:

A.1. For bare pumps and pumps sold with motors, determine the PEI_{CL} using the following equation:

$$PEI_{CL} = \frac{PER_{CL}}{PER_{STD}}$$

Where:

PEI_{CL} = the pump energy index for a constant load (hp),

PER_{CL} = the pump energy rating for a constant load determined in accordance with either section III (for bare pumps, pumps sold with single-phase induction motors, and pumps sold with drivers other than electric motors), section IV (for pumps sold with motors rated using the testing-based approach), or section V (for pumps sold with motors rated using the calculation-based approach) of this appendix (hp), and

PER_{STD} = the PER_{CL} for a pump of the same equipment class that is minimally compliant with DOE's energy conservation standards with the same flow and specific speed characteristics as the tested pump, as determined in accordance with section II.B of this appendix (hp).

A.2 For pumps sold with motors and continuous controls or non-continuous controls, determine the PEI_{VL} using the following equation:

$$PEI_{VL} = \frac{PER_{VL}}{PER_{STD}}$$

Where:

PEI_{VL} = the pump energy index for a variable load,

PER_{VL} = the pump energy rating for a variable load determined in accordance with section VI (for pumps sold with motors and continuous or non-continuous controls rated using the testing-based approach) or section VII of this appendix (for pumps sold with motors and continuous controls rated using the calculation-based approach) (hp), and

PER_{STD} = the PER_{CL} for a pump of the same equipment class that is minimally compliant with DOE's energy conservation standards with the same flow and specific speed characteristics as the tested pump, as determined in accordance with section II.B of this appendix (hp).

B. Determine the pump energy rating for the minimally compliant reference pump (PER_{STD}), according to the following equation:

$$PER_{STD} = \sum \omega_i \left(P_i^{in}\right)$$

Where:

PER_{STD} = the PER_{CL} for a pump that is minimally compliant with DOE's energy conservation standards with the same flow and specific speed characteristics as the tested pump (hp),

ω_i = 0.3333,

P_i^{in} = calculated driver power input at rating point i for the minimally compliant pump calculated in accordance with section II.B.1of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

B.1. Determine the driver power input at each rating point as the pump power input power plus the motor load losses at each rating point as follows:

$$P_i^{in} = P_i + L_i$$

Where:

P_i^{in} = driver power input at each rating point i (hp),

P_i = pump power input to the bare pump at each rating point i calculated in accordance with section II.B.1.1 of this appendix (hp),

L_i = the part load motor losses at each rating point i calculated in accordance with section II.B.1.2 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

B.1.1. Determine the pump power input to the minimally compliant pump at each rating point i based on a ratio of the pump power output for the tested pump and the calculated efficiency of a minimally compliant pump with the same flow rate and specific speed characteristics as the tested pump:

$$P_i = \frac{P_{Hydro,i}}{\alpha_i \times \left[{}^{\eta_{pump,STD}}/_{100} \right]}$$

Where:

P_i = pump power input to the bare pump at each rating point i (hp),

α_i = 0.947 for 75 percent of the BEP flow rate, 1.0 for 100 percent of the BEP flow rate, and 0.985 for 110 percent of the BEP flow rate;

$P_{Hydro,i}$ = the pump power output at rating point i of the tested pump determined in accordance with section II.B.1.1.2 of this appendix (hp);

$\eta_{pump,STD}$ = the minimally compliant pump efficiency calculated in accordance with section II.B.1.1.1 of this appendix (%); and

i = 75, 100, and 110 percent of the measured BEP flow rate of the tested pump.

B.1.1.1 Calculate the minimally compliant pump efficiency based on the following equation:

$$\eta_{pump,STD} = -0.85 \times \ln(Q_{100\%})^2 - 0.38 \times \ln(Ns) \times \ln(Q_{100\%}) - 11.48 \times \ln(Ns)^2 + 13.46 \times \ln(Q_{100\%}) + 179.80 \times \ln(Ns) - (C - 555.6)$$

Where:

$\eta_{pump,STD}$ = minimally compliant pump efficiency (%),

Q100% = the BEP flow rate of the tested pump (gpm),

Ns = specific speed of the tested pump determined in accordance with section II.B.1.1.1.1 of this appendix, and

C = the appropriate C-value for the type and rated speed of rotation of the tested pump, as listed at §431.466.

B.1.1.1.1 Determine the specific speed of the rated pump using the following equation:

$$N_s = \frac{n \times \sqrt{Q_{100\%}}}{(H_{100\%})^{0.75}}$$

Where:

Ns = specific speed,

n = the nominal speed of rotation (rpm),

$Q_{100\%}$ = the measured BEP flow rate of the tested pump (gpm), and

$H_{100\%}$ = total head at 100 percent of the BEP flow rate of the tested pump (ft).

B.1.1.2 Determine the pump power output at each rating point, i, of the tested pump using the following equation:

$$P_{Hydro,i} = \frac{Q_i \times H_i \times SG}{3956}$$

Where:

$P_{Hydro,i}$ = the measured pump power output at rating point i of the tested pump (hp),

Q_i = the measured flow rate at each rating point i of the tested pump (gpm),

H_i = pump total head at each rating point i of the tested pump (ft), and

SG = the specific gravity of water at specified test conditions.

B.1.2 Determine the motor part load losses at each rating point i by multiplying the motor full load losses by the part load loss factor calculated at each rating point (y_i), as follows:

$$L_i = L_{full,default} \times y_i$$

Where:

L_i = default part load motor losses at rating point i (hp),

$L_{full,default}$ = default motor losses at full load determined in accordance with section II.B.1.2.1 of this appendix (hp),

y_i = part loss factor at rating point i determined in accordance with section II.B.1.2.2 of this appendix, and

i = load points corresponding to 75, 100, and 110 percent of the measured BEP flow rate of the tested pump.

B.1.2.1 Determine the full load motor losses using the appropriate motor efficiency value and horsepower as shown in the following equation:

$$L_{full,default} = \frac{MotorHP}{\left[\eta_{motor,full}/_{100}\right]} - MotorHP$$

Where:

$L_{full,default}$ = default motor losses at full load (hp),

MotorHP = the motor horsepower as determined in accordance with section II.B.1.2.1.1 of this appendix (hp), and

$\eta_{motor,full}$ = the default nominal full load motor efficiency as determined in accordance with section II.B.1.2.1.2 of this appendix (%).

B.1.2.1.1 Determine the motor horsepower as follows:

- For bare pumps, the motor horsepower is determined as the horsepower rating listed in Table 2 of this appendix that is either:

  (i) Equivalent to or

  (ii) The next highest horsepower greater than, the pump power input to the bare pump at 120 percent of the BEP flow rate of the tested pump.

- For pumps sold with motors, pumps sold with motors and continuous controls, or pumps sold with motors and non-continuous controls, the motor horsepower is that of the motor with which the pump is being sold.

B.1.2.1.2 Determine the default nominal full load motor efficiency as follows:

- For pumps other than VTS pumps, the default nominal full load motor efficiency is the minimum of the nominal motor full load efficiency from the appropriate table for NEMA Design B motors at 10 CFR 431.25 for open or enclosed motors, with the number of poles relevant to the speed at which the pump is being rated and the motor horsepower determined in section II.B.1.2.1.1 of this appendix.
- For VTS pumps, the default nominal full load motor efficiency is the default nominal efficiency listed in Table 2 of this appendix with the number of poles relevant to the speed at which the pump is being tested and the motor horsepower determined in section II.B.1.2.1.1 of this appendix.

B.1.2.2 The part load loss factor at each rating point i (y_i) is determined as follows:

$$y_i = \left(-0.4508 \times \left(\frac{P_i}{MotorHP}\right)^3 + 1.2399 \times \left(\frac{P_i}{MotorHP}\right)^2 - 0.4301 \times \left(\frac{P_i}{MotorHP}\right) + 0.6410\right)$$

Where:

y_i = the part load loss factor at load point i,

P_i = pump power input to the bare pump at each rating point i (hp),

MotorHP = the motor horsepower as determined in accordance with section II.B.1.2.1.1 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the measured BEP flow rate of the tested pump.

III. Test Procedure for Bare Pumps.

A. Scope. This section III applies only to:

(1) Bare pumps,

(2) Pumps sold with drivers other than electric motors, and

(3) Pumps sold with only single-phase induction motors.

B. Test Conditions. The requirements regarding test conditions presented in section I.C of this appendix apply to this section III. When testing pumps using a calibrated motor:

(1) The voltage, frequency, and voltage unbalance of the power supply shall be maintained within ±0.5 percent of the rated values of the motor and

(2) Total harmonic distortion shall be maintained below 5 percent throughout the test.

C. Testing BEP for the Pump. Determine the best efficiency point (BEP) of the pump as follows:

C.1. Adjust the flow by throttling the pump without changing the speed of rotation of the pump to a minimum of seven data points: 40, 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate of the pump at the nominal speed of rotation, as specified in HI 40.6-2014, except section 40.6.5.3, section A.7, and appendix B (incorporated by reference, see §431.463).

C.2. Determine the BEP flow rate as the flow rate at the point of maximum pump efficiency on the pump efficiency curve, as determined in accordance with section 40.6.6.3 of HI 40.6-2014 (incorporated by reference, see §431.463), where the pump efficiency is the ratio of the pump power output divided by the pump power input.

D. Calculating the Constant Load Pump Energy Rating. Determine the PER_{CL} of each tested pump using the following equation:

$$PER_{CL} = \sum \omega_i \left({P^{in}}_i \right)$$

Where:

PER_{CL} = the pump energy rating for a constant load (hp),

ω_i = 0.3333,

P_i^{in} = calculated driver power input at rating point i as determined in accordance with section III.D.1 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

D.1 Determine the driver power input at each rating point as the pump power input power plus the motor load losses at each rating point as follows:

$$= P_i + L_i$$

Where:

P_i^{in} = driver power input at each rating point i (hp),

P_i = pump power input to the bare pump at each rating point i, as determined in section III.D.1.1 of this appendix (hp),

L_i = the part load motor losses at each rating point i as determined in accordance with section III.D.1.2 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

D.1.1 Determine the pump power input at 75, 100, 110, and 120 percent of the BEP flow rate by employing a least squares regression to determine a linear relationship between the pump power input at the nominal speed of rotation of the pump and the measured flow rate at the following load points: 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate. Use the linear relationship to define the pump power input at the nominal speed of rotation for the load points of 75, 100, 110, and 120 percent of the BEP flow rate.

D.1.2 Determine the motor part load losses at each rating point i by multiplying the motor full load losses by the part load loss factor calculated at each rating point (y_i), as follows:

$$L_i = L_{full,default} \times y_i$$

Where:

L_i = default motor losses at rating point i (hp),

$L_{full,default}$ = default motor losses at full load as determined in accordance with section III.D.1.2.1 of this appendix (hp),

y_i = loss factor at rating point i as determined in accordance with section III.D.1.2.2 of this appendix, and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

D.1.2.1 Determine the full load motor losses using the appropriate motor efficiency value and horsepower as shown in the following equation:

$$L_{full,default} = \frac{MotorHP}{\left[\eta_{motor,full}/_{100}\right]} - MotorH$$

Where:

$L_{full,default}$ = default motor losses at full load (hp);

MotorHP = the motor horsepower, determined as the horsepower rating listed in Table 2 of this appendix that is either:

(i) Equivalent to or

(ii) The next highest horsepower greater than, the pump power input to the bare pump at 120 percent of the BEP flow rate of the tested pump (hp); and

$\eta_{motor,full}$ = the nominal full load motor efficiency as determined in accordance with section III.D.1.2.1.1 of this appendix (%).

D.1.2.1.1 Determine the nominal full load motor efficiency as follows:

- For pumps other than VTS pumps, the nominal full load motor efficiency is the minimum of the standard motor full load efficiency from the appropriate table for NEMA design B motors at 10 CFR 431.25 for open or enclosed motors, with the number of poles relevant to the nominal speed of rotation at which the pump is being rated and the appropriate motor horsepower as specified in section III.D.1.2.1 of this appendix.

- For VTS pumps, the nominal full load motor efficiency is the default nominal efficiency listed in Table 2 of this appendix with the number of poles relevant to the nominal speed of rotation at which the pump is being tested and the appropriate motor horsepower as specified in section III.D.1.2.1 of this appendix.

D.1.2.2 The loss factor at each rating point i (y_i) is determined as follows:

$$y_i = \left(-0.4508 \times \left(\frac{P_i}{MotorHP}\right)^3 + 1.2399 \times \left(\frac{P_i}{MotorHP}\right)^2 - 0.4301 \times \left(\frac{P_i}{MotorHP}\right) + 0.6410\right)$$

Where:

y_i = the part load loss factor at load point i,

P_i = pump power input to the bare pump at each rating point i as determined in accordance with section III.D.1.1 of this appendix (hp),

MotorHP = the motor horsepower, determined as that equivalent to, or the next highest horsepower-level greater than, the pump power input to the bare pump at 120 percent of the BEP flow rate of the tested pump (hp)determined in accordance with section III.D.1.2.1 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

IV. Testing-Based Approach for Pumps Sold with Motors.

A. Scope. This section IV applies only to pumps sold with electric motors, other than single-phase induction motors.

B. Test Conditions. The requirements regarding test conditions presented in section I.C of this appendix apply to this section IV. The following conditions also apply:

(1) The voltage, frequency, and voltage unbalance of the power supply shall be maintained within ±0.5 percent of the rated values of the motor, and

(2) Total harmonic distortion shall be maintained below 5 percent throughout the test.

C. Testing BEP for the Pump. Determine the BEP of the pump as follows:

C.1 Adjust the flow by throttling the pump without changing the speed of rotation of the pump to a minimum of seven data points: 40, 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate of the pump at the nominal speed of rotation, as specified in HI 40.6-2014, except section 40.6.5.3, section A.7, and appendix B (incorporated by reference, see §431.463).

C.2. Determine the BEP flow rate as the flow rate at the point of maximum overall efficiency on the pump efficiency curve, as determined in accordance with section 40.6.6.3 of HI 40.6-2014 (incorporated by reference, see §431.463), where the overall efficiency is the ratio of the pump power output divided by the driver power input.

D. Calculating the Constant Load Pump Energy Rating. Determine the PER_{CL} of each tested pump using the following equation:

$$PER_{CL} = \sum \omega_i \left(P_i^{in} \right)$$

Where:

PER_{CL} = the pump energy rating for a constant load (hp),

ω_i = 0.3333,

P_i^{in} = measured driver power input to the motor at rating point i for the tested pump as determined in accordance with section IV.D.1 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

D.1 Determine the driver power input at 75, 100, and 110 percent of the BEP flow rate by employing a least squares regression to determine a linear relationship between the driver power input at the nominal speed of rotation of the pump and the measured flow rate at the following load points: 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate. Use the linear relationship to define the driver power input at the nominal speed of rotation for the load points of 75, 100, and 110 percent of the BEP flow rate.

V. Calculation-Based Approach for Pumps Sold with Motors

A. Scope. This section V can only be used in lieu of the test method in section IV of this appendix to calculate the index for:

(1) Pumps sold with motors subject to DOE's energy conservation standards for electric motors at §431.25 (except for single-phase induction motors), and

(2) VTS pumps sold with submersible motors. Pumps sold with any other motors cannot use this section and must apply the test method in section IV of this appendix.

B. Test Conditions. The requirements regarding test conditions presented in section II.B of this appendix apply to this section V. When testing using a calibrated motor:

(1) The voltage, frequency, and voltage unbalance of the power supply shall be maintained within ±0.5 percent of the rated values of the motor, and

(2) Total harmonic distortion shall be maintained below 5 percent throughout the test.

C. Testing BEP for the Bare Pump. Determine the best efficiency point (BEP) of the pump as follows:

C.1 Adjust the flow by throttling the pump without changing the speed of rotation of the pump to a minimum of seven data points: 40, 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate of the pump at the nominal speed of rotation, as specified in HI 40.6-2014, except section 40.6.5.3, section A.7, and appendix B (incorporated by reference, see §431.463).

C.2. Determine the BEP flow rate as the flow rate at the point of maximum pump efficiency on the pump efficiency curve, as determined in accordance with section 40.6.6.3 of HI 40.6-2014 (incorporated by reference, see §431.463), where pump efficiency is the ratio of the pump power output divided by the pump power input.

D. Calculating the Constant Load Pump Energy Rating. Determine the PER_{CL} of each tested pump using the following equation:

$$PER_{CL} = \sum \omega_i \left(P_i^{in} \right)$$

Where:

PER_{CL} = the pump energy rating for a constant load (hp),

ω_i = 0.3333,

P_i^{in} = calculated driver power input to the motor at rating point i for the tested pump as determined in accordance with section V.D.1 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

D.1 Determine the driver power input at each rating point as the pump power input power plus the motor load losses at each rating point as follows:

$$P_i^{in} = P_i + L_i$$

Where:

P_i^{in} = driver power input at each rating point i (hp),

P_i = pump power input to the bare pump at each rating point i, as determined in section V.D.1.1 of this appendix (hp),

L_i = the part load motor losses at each rating point i as determined in accordance with section V.D.1.2 of this appendix (hp), and

i = load points corresponding to 75, 100, and 110 percent of the BEP flow rate.

D.1.1 Determine the pump power input at 75, 100, 110, and 120 percent of the BEP flow rate by employing a least squares regression to determine a linear relationship between the pump power input at the nominal speed of rotation of the pump and the measured flow rate at the following load points: 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate. Use the linear relationship to define the pump power input at the nominal speed of rotation for the load points of 75, 100, 110, and 120 percent of the BEP flow rate.

D.1.2 Determine the motor part load losses at each rating point i by multiplying the motor full load losses by the part load loss factor calculated at each rating point (y_i), as follows:

$$L_i = L_{full,default} \times y_i$$

Where:

L_i = motor losses at each load point i (hp),

$L_{full,default}$ = motor losses at full load as determine in accordance with section V.D.1.2.1 of this appendix (hp),

y_i = part load loss factor at rating point i as determined in accordance with section V.D.1.2.2 of this appendix, and

i = load points corresponding to 75, 100, and 110 percent of the measured BEP flow rate of the tested pump.

D.1.2.1 Determine the full load motor losses using the appropriate motor efficiency value and horsepower as shown in the following equation:

$$L_{full,default} = \frac{MotorHP}{\left[\eta_{motor,full}/100\right]} - MotorHPMotorH$$

Where:

$L_{full,default}$ = default motor losses at full load (hp), MotorHP = the horsepower of the motor with which the pump model is being rated (hp), and

$\eta_{motor,full}$ = the nominal full load motor efficiency as determined in accordance with section V.D.1.2.1.1 of this appendix (%).

D.1.2.1.1 Determine the nominal full load motor efficiency as follows:

- For pumps other than VTS pumps, the nominal full load motor efficiency is that of the motor with which the given pump model is being rated, as determined in accordance with the DOE test procedure for electric motors at §431.16.
- For VTS pumps, the nominal full load motor efficiency is the default nominal efficiency listed in Table 2 of this appendix with the number of poles relevant to the nominal speed of rotation at which the pump is being tested and the horsepower of the motor with which the pump is being rated.

D.1.2.2 The loss factor at each rating point i (y_i) is determined as follows:

$$y_i = \left(-0.4508 \times \left(\frac{P_i}{MotorHP}\right)^3 + 1.2399 \times \left(\frac{P_i}{MotorHP}\right)^2 - 0.4301 \times \left(\frac{P_i}{MotorHP}\right) + 0.6410\right)$$

Where:

y_i = the part load loss factor at load point i,

P_i = the pump power input to the bare pump as determined in accordance with section V.D.1.1 of this appendix (hp),

MotorHP = the horsepower of the motor with which the pump model is being rated (hp), and

i = load points corresponding to 75, 100, and 110 percent of the measured BEP flow rate of the tested pump.

VI. Testing-Based Approach for Pumps Sold with Motors and Controls.

A. Scope. This section VI applies only to pumps sold with electric motors, other than single-phase induction motors, and continuous or non-continuous controls. For the purposes of this section VI, all references to “driver input power” in HI 40.6-2014 (incorporated by reference, see §431.463) shall refer to the input power to the continuous or non-continuous controls.

B. Measurement Equipment. The requirements regarding measurement equipment presented in section I.B of this appendix apply to this section VI, and in addition electrical measurement equipment shall be:

(1) Capable of measuring current, voltage, and real power up to the 40^{th} harmonic of fundamental supply source frequency, and

(2) Have an accuracy of ±0.2 percent at the full scale at the fundamental supply source frequency.

C. Test Conditions. The requirements regarding test conditions presented in section I.C of this appendix apply to this section VI and, in addition:

(1) The voltage, frequency, and voltage unbalance of the power supply shall be maintained within ±0.5 percent of the rated values of the motor, and

(2) Total harmonic distortion shall be maintained below 5 percent throughout the test.

D. Testing BEP for the Pump. Determine the BEP of the pump as follows:

D.1. Adjust the flow by throttling the pump without changing the speed of rotation of the pump to a minimum of seven data points: 40, 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate of the pump at the nominal speed of rotation, as specified in HI 40.6-2014, except section 40.6.5.3, section A.7, and appendix B (incorporated by reference, see §431.463).

D.2. Determine the BEP flow rate as the flow rate at the point of maximum overall efficiency on the pump efficiency curve, as determined in accordance with section 40.6.6.3 of HI 40.6-2014 (incorporated by reference, see §431.463), where overall efficiency is the ratio of the pump power output divided by the driver power input.

E. Calculating the Variable Load Pump Energy Rating. Determine the PER_{VL} of each tested pump using the following equation:

$$PER_{VL} = \sum \omega_i \left(P_i^{in} \right)$$

Where:

PER_{VL} = the pump energy rating for a variable load (hp);

ω_i = 0.25;

P_i^{in} = the measured driver power input to the motor and controls at rating point i for the tested pump as determined in accordance with section VI.E.1 of this appendix; and

i = load points corresponding 25, 50, 75, and 100 percent of the measured BEP flow rate of the tested pump.

E.1. Determine the driver power input at 100 percent of the measured BEP flow rate of the tested pump by employing a least squares regression to determine a linear relationship between the measured driver power input at the nominal speed of rotation of the pump and the measured flow rate, using the following load points: 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate. Use the linear relationship to define the driver power input at the nominal speed of rotation for the load point of 100 percent of the measured BEP flow rate of the tested pump.

E.2 Determine the driver power input at 25, 50, and 75 percent of the BEP flow rate by measuring the driver power input at the load points defined by:

(1) Those flow rates, and

(2) The associated head points calculated according to the following reference system curve equation:

$$H_i = 0.8 \frac{H_{100\%}}{(Q_{100\%})^2} \times {Q_i}^2 + 0.2 \times H_{100\%}$$

Where:

H_i = pump total head at rating point i (ft),

H_{BEP} = pump total head at 100 percent of the BEP flow rate and nominal speed of rotation (ft),

Q_i = flow rate at rating point i (gpm),

$Q_{100\%}$ = flow rate at 100 percent of the BEP flow rate (gpm), and

i = 25, 50, and 75 percent of the measured BEP flow rate of the tested pump.

E.2.1. For pumps sold with motors and continuous controls, the specific head and flow points must be achieved within 10 percent of the calculated values and the measured driver power input must be corrected to the exact intended head and flow conditions using the following equation:

$$P_{R,i} = \left(\frac{H_{R,i}}{H_{T,j}}\right)\left(\frac{Q_{R,i}}{Q_{T,j}}\right)P_{T,j}$$

Where:

$P_{R,i}$ = the tested pump shaft input power at flow point i (hp),

$H_{R,i}$ = the intended total system head at flow point i based on the reference system curve (ft),

$H_{T,j}$ = the tested total system head at flow point j (ft),

$Q_{R,i}$ = the intended total system head at flow point i based on the reference system curve (ft),

$Q_{T,i}$ = the tested total system head at flow point i (ft),

$P_{T,j}$ = the tested pump shaft input power at flow point j (hp),

j = the tested flow point of the pump being rated (stated in terms of percent of BEP flow), and

i = 25, 50, and 75 percent of the BEP flow rate.

E.2.2. For pumps sold with motors and non-continuous controls, the head associated with each of the specified flow points shall be no lower than 10 percent below that defined by the reference system curve equation in section VI.E.2 of this appendix. Only the measured flow points must be achieved within 10 percent of the calculated values. Correct for flow and head as described in section VI.E.2.1, except do not correct measured head values that are higher than the reference system curve at the same flow rate; only flow rate and head values lower than the reference system curve at the same flow rate should be corrected. Instead, use the measured head points directly to calculate PEI_{VL}.

VII. Calculation-Based Approach for Pumps Sold with Motors and Controls.

A. Scope. This section VII can only be used in lieu of the test method in section VI of this appendix to calculate the index for:

(1) Pumps sold with motors regulated by DOE's energy conservation standards for electric motors at §431.25 (except for single-phase induction motors) and continuous controls, and

(2) Pumps sold with submersible motors and continuous controls. This approach does not apply to:

(i) Pumps sold with motors that are not regulated by DOE's energy conservation standards for electric motors at 10 CFR 431.25, except for VTS pumps, or

(ii) Pumps that are sold with electric motors and non-continuous controls; these pumps must apply the test method in section VI of this appendix.

B. Test Conditions. The requirements regarding test conditions presented in section II.B of this appendix apply to this section VII. When testing using a calibrated motor:

(1) The voltage, frequency, and voltage unbalance of the power supply shall be maintained within ±0.5 percent of the rated values of the motor, and

(2) Total harmonic distortion shall be maintained below 5 percent throughout the test.

C. Testing BEP for the Bare Pump. Determine the BEP of the pump as follows:

C.1. Adjust the flow by throttling the pump without changing the speed of rotation of the pump to a minimum of seven data points: 40, 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate of the pump at the nominal speed of rotation, as specified in HI 40.6-2014, except section 40.6.5.3, section A.7, and appendix B (incorporated by reference, see §431.463).

C.2. Determine the BEP flow rate as the flow rate at the point of maximum pump efficiency on the pump efficiency curve, as determined in accordance with section 40.6.6.3 of HI 40.6-2014 (incorporated by reference, see §431.463), where pump efficiency is the ratio of the pump power output divided by the pump power input.

D. Calculating the Variable Load Pump Energy Rating. Determine the PER_{VL} of each tested pump using the following equation:

$$PER_{VL} = \sum \omega_i (\mathrm{P}_i^{in})$$

Where:

PER_{VL} = the pump energy rating for a variable load (hp);

ω_i = 0.25;

P_i^{in} = the calculated driver power input to the motor and controls at rating point i for the tested pump as determined in accordance with section VII.D.1 of this appendix; and

i = load points corresponding 25, 50, 75, and 100 percent of the measured BEP flow rate of the tested pump.

D.1 Determine the driver power input at each rating point as the pump power input plus the motor load losses at each rating point as follows:

$$P_i^{in} = P_i + L_i$$

Where:

P_i^{in} = driver power input at each rating point i (hp),

P_i = pump input power to the bare pump at each rating point i as determined in accordance with section VII.D.1.1 of this appendix (hp),

L_i = the part load motor and control losses at each rating point i as determined in accordance with section VII.D.1.2 of this appendix (hp), and

i = load points corresponding to 25, 50, 75, and 100 percent of the measured BEP flow rate of the tested pump.

D.1.1 Determine the pump power input at 100 percent of the measured BEP flow rate of the tested pump by employing a least squares regression to determine a linear relationship between the measured pump input power at the nominal speed of rotation and the measured flow rate at the following load points: 60, 75, 90, 100, 110, and 120 percent of the expected BEP flow rate. Use the linear relationship to define the pump power input at the nominal speed of rotation for the load point of 100 percent of the BEP flow rate.

D.1.1.1 Determine the pump input power at 25, 50, and 75 percent of the BEP flow rate based on the measured pump input power at 100 percent of the BEP flow rate and using with the following equation:

$$P_i = \left(0.8\frac{{Q_i}^3}{{Q_{100\%}}^3} + 0.2\frac{Q_i}{Q_{100\%}}\right) \times P_{100\%}$$

Where:

P_i = pump input power at rating point i (hp);

$P_{100\%}$ = pump input power at 100 percent of the BEP flow rate (hp);

Q_i = flow rate at rating point i (gpm);

$Q_{100\%}$ = flow rate at 100 percent of the BEP flow rate (gpm); and

i = 25, 50, and 75 percent of the measured BEP flow rate of the tested pump.

D.1.2 Calculate the motor and control part load losses at each rating point i by multiplying the motor full load losses by the part load loss factor calculated at each rating point (z_i), as follows:

$$L_i = L_{full,default} \times z_i$$

Where:

L_i = motor and control losses at rating point i (hp),

$L_{full,default}$ = motor losses at full load as determined in accordance with section VII.D.1.2.1 of this appendix (hp),

z_i = part load loss factor at rating point i as determined in accordance with section VII.D.1.2.2 of this appendix, and

i = load points corresponding to 25, 50, 75, and 100 percent of the measured BEP flow rate of the tested pump.

D.1.2.1 Determine the full load motor losses using the appropriate motor efficiency value and horsepower:

$$L_{full,default} = \frac{MotorHP}{\left[\eta_{motor,full}/100\right]} - MotorHP$$

Where:

$L_{full,default}$ = default motor losses at full load (hp),

MotorHP = the horsepower of the motor with which the pump model is being rated (hp), and

$\eta_{motor,full}$ = the nominal full load motor efficiency as determined in accordance with section VII.D.1.2.1.1 of this appendix (%).

D.1.2.1.1 Determine the nominal full load motor efficiency as follows:

- For all pumps, except VTS pumps, sold with motors and continuous controls, the nominal full load motor efficiency is that of the motor with which the given pump model is being rated, as determined in accordance with the DOE test procedure for electric motors at §431.16.
- For VTS pumps sold with submersible motors and continuous controls, the nominal full load motor efficiency is the default nominal efficiency

listed in Table 2 of this appendix with the number of poles relevant to the nominal speed of rotation at which the pump is being tested and the horsepower of the motor with which the pump is being rated.

D.1.2.2 The part load loss factor at each rating point i (z_i) is determined at each load point follows:

$$z_i = \left(\mathrm{a} \times \left(\frac{P_i}{MotorHP} \right)^2 + \mathrm{b} \times \left(\frac{P_i}{MotorHP} \right) + \mathrm{c} \right)$$

Where:

z_i = the motor and control part load loss factor,

a,b,c = coefficients listed in Table 3 of this appendix based on the horsepower of the motor with which the pump is being rated,

P_i = the pump power input to the bare pump as determined in accordance with section VII.D.1.1 of this appendix (hp),

MotorHP = the horsepower of the motor with which the pump is being rated (hp), and

i = load points corresponding to 25, 50, 75, and 100 percent of the measured BEP flow rate of the tested pump.

Table 2. Default Submersible Motor Full Load Efficiency by Motor Horsepower

Default Submersible Motor Full Load Nominal Efficiency		
Motor Horsepower	Pole configurations	
	2	4
1	55	68
1.5	66	70
2	68	70
3	70	75.5
5	74	75.5
7.5	68	74
10	70	74
15	72	75.5
20	72	77
25	74	78.5
30	78.5	82.5
40	80	84
50	81.5	85.5
60	82.5	86.5
75	82.5	87.5
100	81.5	85.5
125	84	85.5
150	84	86.5
200	85.5	87.5
250	86.5	87.5

Table 3. Motor and Control Part Load Loss Factor Equation Coefficients for Section VII.D.1.2.2 of this Appendix A

Motor Horsepower (hp)	Coefficients for Motor and Control Part Load Loss Factor (z_i)		
	a	B	c
≤5	-0.4658	1.4965	0.5303
>5 and ≤20	-1.3198	2.9551	0.1052
>20 and ≤50	-1.5122	3.0777	0.1847
>50	-0.8914	2.8846	0.2625