DOE Energy Conservation Standard for Pumps

The energy efficiency of rotodynamic pumps became a focus of the U.S. Department of Energy (DOE), culminating in 10 CFR 431 Subpart Y - Energy Conservation Standard and Test Procedure for Pumps. The final Energy Conservation Standard (ECS) regulation and test procedure was published in January of 2016 and manufacturers must comply with the standard levels by January 27, 2020. This regulation is the first of its kind for pumps in the U.S. The standard level set is consistent with the least efficient 25% of pumps sold today being eliminated from the market when compliance is required. DOE estimated the benefit to be 0.27 quadrillion BTUs of energy savings over a 30 year period.

The regulation outlines the scope, standard levels and methods for testing and calculating compliance for clean water pumps of certain equipment classes in 2-pole and 4-pole nominal speed of rotation.

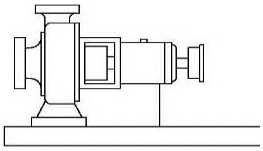
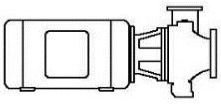
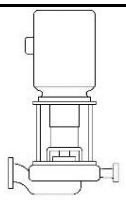
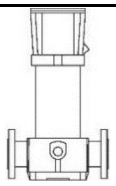
Table 1 summarizes scope refinements for clean water pumps applied to the in scope equipment classes summarized in Table 2.

Table 1 Scope Refinement

Included	Excluded
• Clean Water Pumps • BEP Pump Power Input : 1 – 200 hp (0.75 – 150 kW) • BEP rate of flow: 25 gpm (5.7 m^3/h) or greater • BEP head: 459 ft (140 m) or less • Temperature: 14 – 248 °F (-10 – 120 °C) • Nominal Speeds (RPM): 1800 (1440-2160) & 3600 (2880-4320) • Radial Flow (n_s less than 5000 U.S. units)	• Nuclear controlled • Mil Spec • Magnetic Driven • Fire Pump • Sanitary (3-A std) • Self-priming • Prime Assist • Circulator Pumps (coming soon – Rulemaking in progress) • Pool Pumps (Final rule issued December 2016) • ST [VS0] pumps with a bowl diameter > 6.0 in (15.25 cm)

6 Campus Drive | 1st Floor N. | Parsippany | NJ 07054 | 973.267.9700 | FAX 973.267.9055
www.Pumps.org

Table 2 – Scope of Clean Water Pump Equipment Classes Included

Diagram	Nomenclature (EU)	Nomenclature (DOE) / [Industry]
	End Suction Own Bearing (ESOB)	End Suction Frame Mount (ESFM) / [OH0, OH1]
	End Suction Close Coupled (ESCC)	End Suction Close Coupled (ESCC) / [OH7]
	End Suction Close Coupled In-line (ESCCi)	In-line (IL) / [OH3, OH4, OH5]
	Vertical Multistage (MS-V)	Radially Split multi-stage vertical in-line diffuser casing (RSV) / [VS8]
	Submersible Multistage (MSS)	Submersible Turbine (ST) / [VS0]

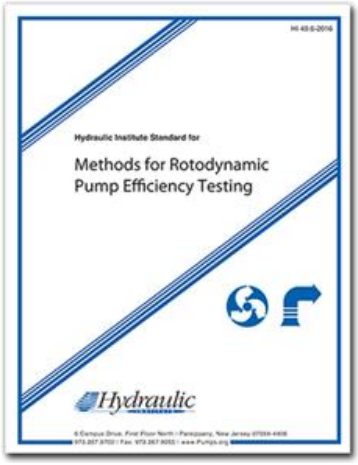
The standard created a metric called the Pump Energy Index (PEI) that is used to determine if a pump is compliant. The term "pump" defined by DOE, is inclusive of the driver and speed control when applicable. The PEI takes into account at a minimum, a test of the bare pump power at defined load points and default calculations for the driver and speed control losses; therefore, the metric is for the extended pump product. Due to covering the extended product, there are several performance metrics that are used to determine PEI and some are dependent of the load type (i.e. constant speed or variable speed) as summarized in Table 3. PEI is the representative power of the pump being rated ($PER_{CL/VL}$) over the representative power of a pump that would minimally comply (PER_{STD}) for that pump type. A PEI of 1.0 or less is required to comply with the standard.

Table 3 – Performance Metrics

Performance Metric		Constant Load	Variable Load
Standard Level	C-Value	Independent	
Standard Pump Efficiency	$\eta_{pump,STD}$	Independent	
Standard Pump Energy Rating	PER_{STD}	Independent	
Pump Energy Rating (Product)	PER	PER_{CL}	PER_{VL}
Pump Energy Index (Product)	PEI	PEI_{CL}	PEI_{VL}

Hydraulic Institute Test Lab Approval Program

All Energy Conservation standards have a Test Procedure that indicates how the regulated equipment must be tested to achieve uniform results in compliance with the standard. The Hydraulic Institute (HI) worked closely with the DOE throughout rulemaking process and in support, developed a new test standard, *HI 40.6 Methods for Rotodynamic Pump Efficiency Testing* to meet the needs of the regulation. HI 40.6-2014 was incorporated by reference in the regulation as the method pumps must be tested, to conform to the regulation. The standard testing methods outlined in HI 40.6 are based on the long standing *ANSI/HI 14.6 Rotodynamic Pumps for Hydraulic Performance Acceptance Tests*. HI 40.6 was developed by an HI committee with support from DOE consultants and followed HI's policies and procedures for standards development. The purpose of the committee was to develop a standard that included content required for the determination of pump efficiency and to ensure that the methods were clear and unambiguous to meet the needs of the DOE specified test procedure.



The clean water pump regulation requires that pumps be tested per HI 40.6, but does not require that the test laboratory be approved or that trained personnel conduct the testing and it should be noted that no such approval program existed. HI, understanding that regulatory requirements of pump testing is new for the industry, believed that a program should be available to the pump manufacturing and testing community, which laboratories could voluntarily go through to ensure that the laboratory has the facilities, training, qualified personnel, and procedures in place to maintain measurement equipment calibration in compliance with ISO 17025 and to test pumps in compliance with the latest version of HI 40.6. To this end HI established a committee to outline a program that specified the requirements for a laboratory to be "HI Approved". The committee develop and published *HI 40.7 Program Guide for Pump Test Laboratory Approval* and the program was launched in September of 2015. The Program Guide is freely downloadable for all that wish to learn more about the program.

The HI Pump Test Lab Approval Program (PTLAP) is open to all laboratories around the world that wish to participate. The PTLAP requires that a test laboratory location go through an onsite third party audit including procedural and hands on setup and testing of pumps to verify compliance to the applicable standards.

The HI 40.7 Program has resulted in the following benefits to the pump manufacturing industry.

- Demonstrates that participating companies are taking the initiative to engage a third party organization to audit their test laboratory to established standards.
- Supports manufacturers in preparing for the requirements of the DOE test procedure for pumps.
- Positions manufacturers to take the next step, and participate in the HI Energy Rating Program.

The HI Energy Rating Program

The ultimate goal of the Energy Conservation Standard for pumps is to reduce the power consumption. The standard estimates that 0.27 quadrillion BTUs will be saved over a 30 year implementation of the standard level. When standards levels are set there is an additional opportunity to accelerate the adoption of less power consumptive pumping solutions through third party ratings and labels. The American Council for an Energy Efficient Economy (ACEEE), utility program administrators, energy advocates and trade associations including HI have worked together on the Extended Motor Product Labeling Initiative (EMPLI). EMPLI develops a labeling brand for pumps inclusive of motors and variable speed drives or the "extended product" when applicable. As part of this initiative, an HI committee formed to develop a rating system and that could be applied too or included in marketing and submittal information of pumps within the scope of the Energy Conservation Standard. All information to participate in the program is outlined in the HI 40.5 Energy Rating Program Guide, which is available for free download.

The HI committee has developed an Energy Rating (ER) metric as shown in equation 1, which is directly calculated from the PEI, and describes the percent power savings of a pump compared to a baseline case. In addition the committee evaluated the pump efficiency data surveyed in the DOE regulation process to develop a low and high scale for each equipment class so that the HI Energy Rating can be compared to the most and least consumptive options surveyed.

$$\boldsymbol{ER = (PEI_{Baseline} - Rated\ PEI) * 100} \qquad \text{Eq. 1}$$

To illustrate the rating, if a pump has a $PEI_{Baseline}$ of 1.09 and the rated PEI value is the future DOE standard level of 1.0, the HI Energy Rating would be 9. This indicates that the rated pump uses 9% less power compared to the baseline case when evaluated per the regulatory metric assumptions, test procedure load points and load profile. The ER is depicted graphically to show where it falls with respect to other pumps of the same equipment class and load type.

Power savings over the base case or power savings over another ER can then be estimated in a simple manner as shown below in equations 2 and 3 respectively. Note that the power savings estimates are based on the load points and load profile agreed to in the Energy Conservations Standard. Some applications may dictate that a closer review of the actual operating points and load profile is required.

$$\boldsymbol{Power\ Savings} = \frac{ER}{100} * \boldsymbol{Input\ Power} \qquad \text{Eq. 2}$$

$$\boldsymbol{Power\ Savings} = \frac{ER_1 - ER_2}{100} * \boldsymbol{Input\ Power} \qquad \text{Eq. 3}$$

The Program is open to all manufacturers of pumps within scope of the Energy Conservation Standard for Pumps. However, a requirement of listing pumps in the program is that the pumps are tested in an HI approved laboratory, as an added layer of assurance and credibility. HI will manage the listing of pumps

in a database that meets the needs of public utilities that wish to incentivize the purchase of equipment that consumes less power.

A significant benefit of the HI Energy Rating program is that it is scheduled to be launched in early 2017, which is three years ahead of the regulatory compliance date. This provides a uniform method for utilities to receive the required data outlined in table 3 well ahead of DOE compliance.

For each listed product, the HI database will include all data shown in Table 3, plus $PEI_{Baseline}$ and the HI ER will be calculated and stored for public use. Utilities will have access to all the public data, but HI is still determining how that will be done. To easily allow utilities to understand how many rated products are available, HI will provide a tool that allows utilities to determine how many rated products are listed within an ER range for each load type (constant or variable) and equipment class.

Table 3 – Data that may be made public

Data Submitted that may be made public	
• Participant Company • Basic model designation • DOE equipment category • Registration number of the HI approved laboratory that performed the testing of the basic model • PEI_{CL} or PEI_{VL} as applicable - the PEI submitted shall be identical to any PEI reported to the DOE for certification of the basic model • Number of stages tested (S) • Full impeller diameter (in) • Whether the PEI_{CL} or PEI_{VL} is calculated or tested and the specific method used as outlined in the Guiding Standards (Section III, IV, V, VI, or VII of Appendix A to Subpart Y of Part 431 of the Guiding Standards) • The horsepower of the motor with which the basic model is being rated (MotorHP)	• BEP rate of flow ($Q_{100\%}$), 75% of BEP rate of flow ($Q_{75\%}$), and 110% BEP rate of flow ($Q_{110\%}$), in gallons per minute (gpm) at nominal speed of rotation • Head in feet (ft) at BEP rate of flow ($H_{100\%}$), at nominal speed of rotation • Nominal speed of rotation (n_{sp}) in revolutions per minute (rpm), as defined in the guiding standards at 1800 rpm or 3600 rpm. • For constant load ratings, power input to the driver at each required load point ($P_{75\%}^{in,M}$, $P_{100\%}^{in,M}$, $P_{110\%}^{in,M}$) corrected to nominal speed of rotation, in horsepower (hp); or • For variable load ratings, power input to the control at each required load point ($P_{25\%}^{in,C}$, $P_{50\%}^{in,C}$, $P_{75\%}^{in,C}$, $P_{100\%}^{in,C}$), corrected to the nominal speed of rotation, in horsepower (hp)

The PEI and ER metrics are a true “extended product” metrics meaning they represent the power of a bare pump inclusive of a motor at a minimum and variable speed drive when applicable. To accommodate such a metric DOE had to consider that pumps are largely not distributed with a motor or variable speed drive. Therefore, provisions are made to build on the testing of a “Bare Pump” and calculate the motor losses as a minimum requirement and drive losses when applicable and also calculate the reduced power benefits of reduced head operation with a variable speed drive.

As described, the Test procedure gives the option to:

(1) Test as a bare pump and calculate the remaining factors to get to motor or variable speed drive input power, or

(2) Test the pump inclusive of a motor and drive if it will be distributing in that configuration.

A second significant benefit of the HI Energy Rating program is that it considers that bare pumps are distributed in commerce and that motors and variable speed drives may be added down the line that otherwise would not be reported; taking full advantage of the extend product metric. To achieve this, a certificate option is available within the HI ER Program that allows calculation of a new ER when an extended product is added to listed products. HI is providing an approved calculator that can be applied to bare pumps or bare pumps + motors, which are listed in the HI database. The approved calculator requires the user to input the extended product equipment that is added, then pulls the required data from the database and outputs a single use serialized certificate that states the base ER listed product, what has been added and the new ER. Ensuring a significant opportunity is not missed, this provides a uniform way to determine the ER for extend products that would otherwise be missed due to the established commerce stream.