U.S. & EU Pump Regulations

NAVIGATING THE DEPARTMENT OF ENERGY (DOE) ENERGY CONSERVATION STANDARD AND TEST PROCEDURE FOR PUMPS

- Motor Summit 2016, Zurich Switzerland

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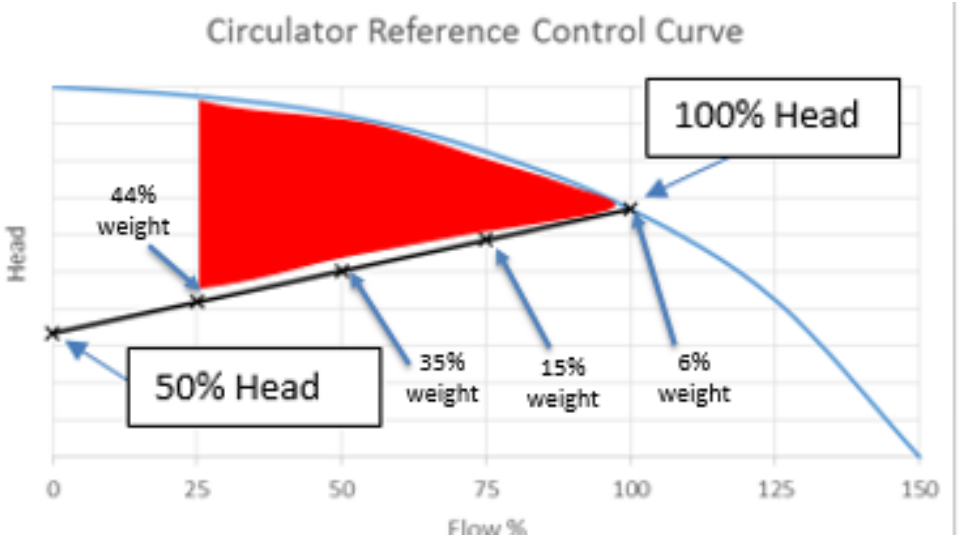
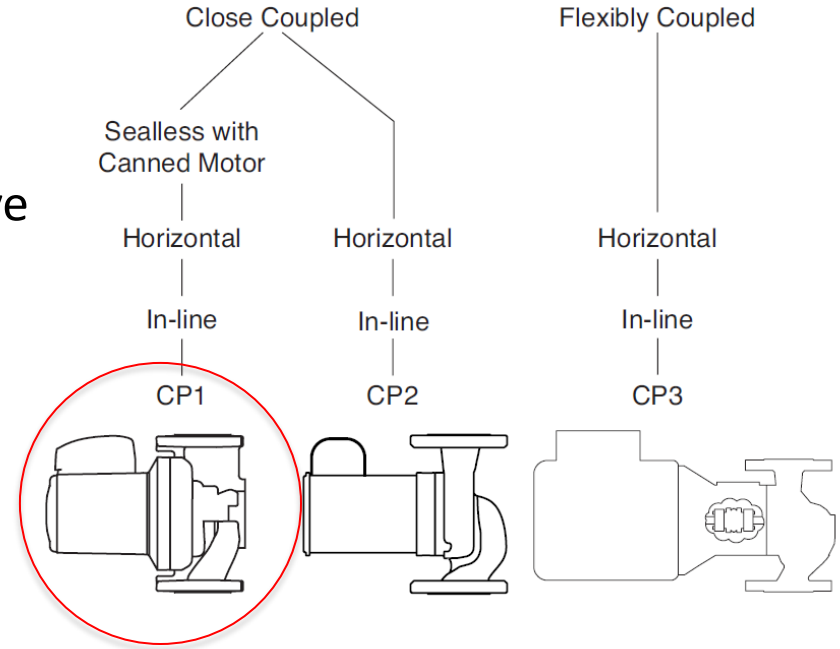
European Energy Standard Circulator Pumps

- **(EU) No 641/2009 on July 22, 2009**, regulates the energy consumption of circulator pumps. Energy Efficiency Index (EEI)

- August 2015 – Glandless circulators must have EEI ≤ 0.23



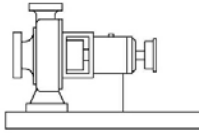
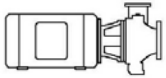
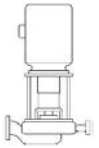
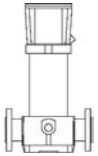
Circulator Pump Types



- $EEI = \frac{P_{L,avg}}{P_{ref}} * C_{20\%}$

European Energy Standard - Water Pumps

- **(EU) No 547/2012** on June 25, 2012 regulates efficiency of water pumps.
- Minimum Efficiency Index (MEI)
- January 2015 – Water pumps shall have a MEI ≥ 0.4

Diagram	Nomenclature (EU)
	End Suction Own Bearing (ESOB)
	End Suction Close Coupled (ESCC)
	End Suction Close Coupled In-line (ESCCi)
	Vertical Multistage (MS-V)
	Submersible Multistage (MSS)

How does MEI equate to efficiency?

$$\eta_{BEP,Min\ require} = 88.59 * \ln(n_s) + 13.46 * \ln(Q) - 11.48 * \ln(n_s)^2 - 0.85 * \ln(Q)^2 - 0.28 * \ln(n_s) * \ln(Q) - C_{pump\ type,rpm}$$

- n_s = specific speed (Metric units)
- Q = BEP flow rate (m^3/h)
- C = MEI constant for pump type and rpm
- $\eta_{75\%\ BEP,Min\ require} = 0.947 * \eta_{BEP,Min\ require}$
- $\eta_{110\%\ BEP,Min\ require} = 0.985 * \eta_{BEP,Min\ require}$

- Does not consider motor or controls (extended product)

Comparison of EEI & MEI

EU - EEI

Ratio of powers

Includes extended product

Includes speed control curve

Lower number is better

EU - MEI

Used to determine pump efficiency

Bare pump only (hydraulic end)

Does not included speed control

Higher number is better

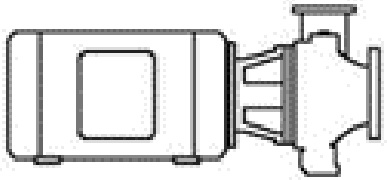
U.S. DOE PEI

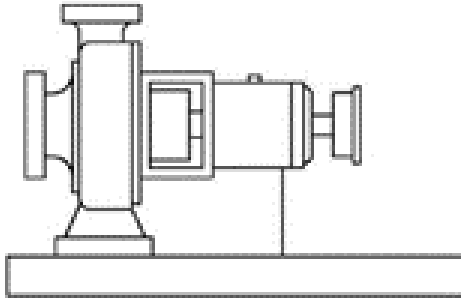
Ratio of powers (MEI based)

Bare Pump, or extended product

Includes speed control curve

Lower number is better





What is a Pump

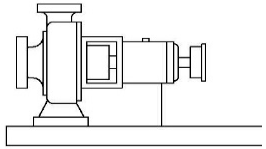
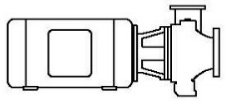
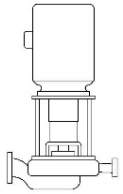
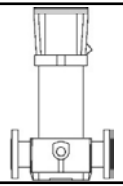
Pump means equipment that is designed to move liquids (which may include entrained gases, free solids, and totally dissolved solids) by physical or mechanical action and includes at least a **bare pump** and, if included by the manufacturer at the time of sale, **mechanical equipment, driver, and controls**.

Final Rule Scope – Included

http://www.pumps.org/DOE_Pumps.aspx

Included

- Clean Water Rotodynamic 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)

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]

Final Rule Scope – Excluded

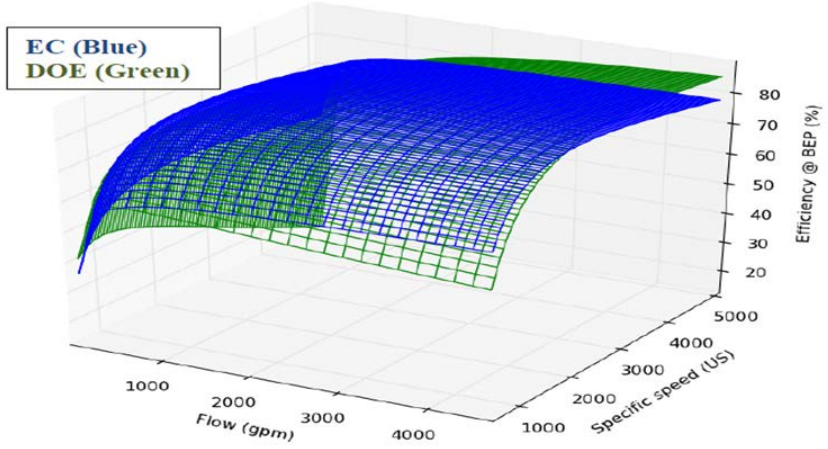
http://www.pumps.org/DOE_Pumps.aspx

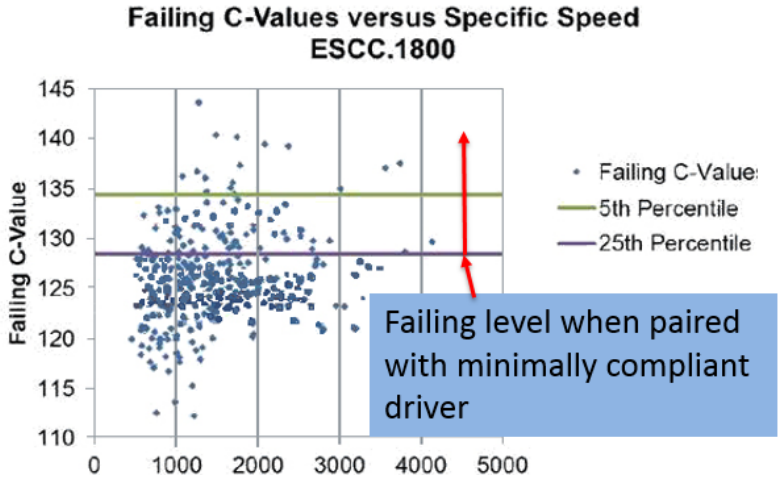
- Nuclear controlled
- Mil Spec
- Magnetic Driven
- Fire Pump
- Sanitary (3-A std)
- Self Priming
- Prime Assist
- Circulators (coming soon)
- Pool Pumps (coming soon)
- ST [VS0] pumps with a bowl diameter > 6.0 in (15.25 cm)

Performance Metric Summary

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}

Standard Efficiency Curve





DOE Evaluation of Efficiency Data
Result of Data Survey – C Factor

Equipment Class	EL0	EL1	EL2
	Baseline	10th Eff Percentile	25th Eff Percentile
ESCC 1800	134.43	131.69	128.47
ESCC 3600	135.94	134.6	130.48
ESFM 1800	134.99	132.95	128.85
ESFM 3600	136.59	134.98	130.99
IL 1800	135.92	133.95	129.3
IL 3600	141.01	138.86	133.84
RSV 1800	129.63	-	-
RSV 3600	133.2	-	-
ST 1800	138.78	-	-
ST 3600	138.78	136.92	134.85

How is Minimally Compliant Pump Determined?

$$\eta_{\text{pump},STD} = -0.8500 \times \ln(\text{Q}_{100\%})^2 - 0.3800 \times \ln(\text{Ns}) \times ln(\text{Q}_{100\%}) - 11.480 \times \ln(\text{Ns})^2 + 17.800\ln(\text{Q}_{100\%}) + 179.80 \times \ln(\text{Ns}) - (\boldsymbol{C} + 555.60)$$

Where:

$\text{Q}_{100\%} = BEP$ rate $of\ flow$ (gpm)

Ns = Specific speed calculated in U.S. Customary Units

C = Constant value determined by DOE in the final rule for each pump equipment category

Definition of Standard PER Standard

Standard PER is calculated for a minimally compliant pump. Minimally compliant motor efficiencies are used for default motor losses

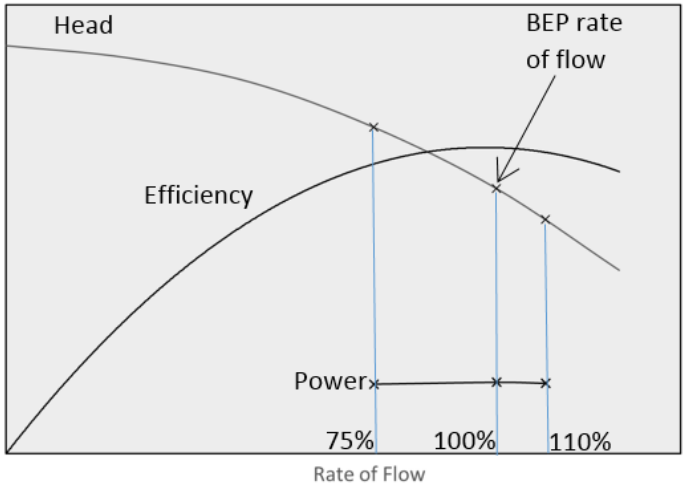
$$\mathrm{PER_{STD}} = \sum_{i} \omega_i \left(\mathrm{P_{i,}^{in,std}}\right)$$

Where:

$\mathrm{P_{i,}^{in,std}} =$ calculated input power to the motor at rating point i, for a minimally compliant pump

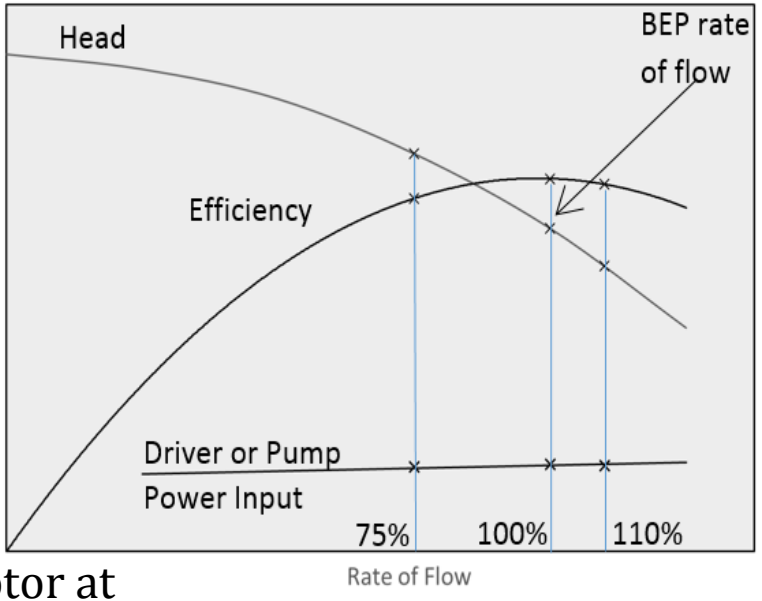
$\omega_i =$ weighting at load point, this is equal to 0.333

$i = 75\%, 100\%$ and 110% of BEP



Definition of Constant Load PER

Constant Load PER is calculated based on the pump under test that will be rated. It is applicable to pumps sold without variable speed controls.



$$\mathrm{PER_{CL}} = \sum_{i} \omega_i \left(\mathrm{P_i^{in}}\right)$$

Where:

$\mathrm{P_i^{in}} =$ measured or calculated input power to the motor at rating point i, for the rated pump

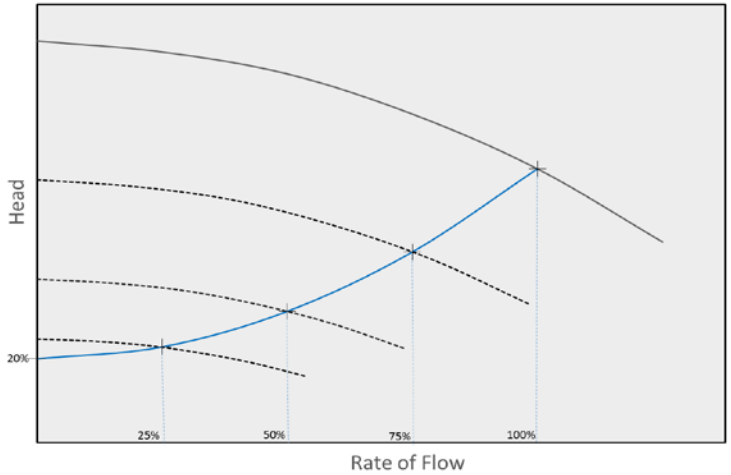
$\omega_i =$ weighting at load point, this is equal to 0.3333

$i = 75\%, 100\%$ and 110% of BEP

Definition of Variable Load PER

Calculated based on the pump under test that will be rated, applicable to pumps sold with variable speed controls

$$\mathbf{PER_{VL}} = \sum_{i} \boldsymbol{\omega_i}\left(\boldsymbol{P_i^{in,c}}\right)$$



Where:

$P_i^{in,c}$ = measured or calculated input power to the control at rating point i, for the rated pump

ω_i = weighting at load point, this is equal to 0.25

$i = 25\%, 50\%, 75\%, \ \& 100\%\ of\ BEP$

DOE Rulemakings Summary

Published January 27, 2016, the Energy Conservation Standard (ECS) sets standard levels such that 25% of most power consumptive pump sold today will not comply. Compliance is required four years after publication in Federal Register – January 27, 2020

The Pump Energy Index (PEI) metric consists of a ratio of the Pump Energy Rating power of the pump being rated ($PER_{CL/VL}$) over the power of a minimally compliant pump (PER_{STD}) .

$$PEI_{CL/VL} = \frac{PER_{CL/VL}}{PER_{STD}} \leq 1.00$$

Voluntary Industry Labeling
Extended Motor Product Labeling Initiative (EMPLI)

EMPLI

- Joint effort between the American Council for an Energy Efficient Economy (ACEEE), energy advocates and trade associations that represent Fans, compressors, pumps and motors & drives.

Goal

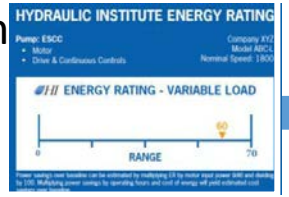
- Implemented prior to DOE compliance date (Q1-2017 Pumps)
- Common themed third party (trade association) ratings/labels
- Provide energy savings verification & Meet the needs of public service commissions
- Applied to motor driven system
- Can be added after initial distribution

Hydraulic Institute (HI) Program Alignment

2017 – Energy Rating Program

2015 – Test Lab Audit Approval

2014 – DOE Test Procedure



HI Labeled

HI Approved

HI Tested

Utility Partners

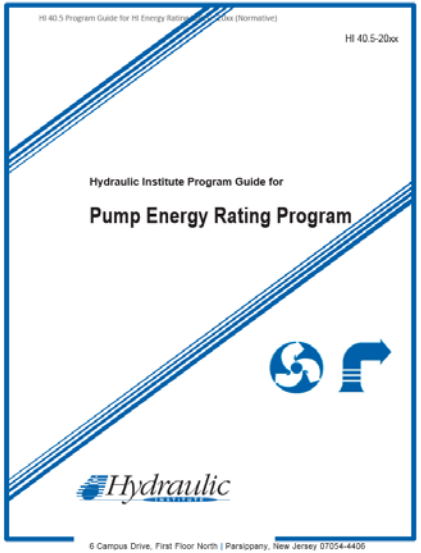
$8 Billion Incentives to reduce energy consumption

Performance Metrics + Reporting = Compliance

Data | Trust | Enforcement | Markets | Incentives

HI Energy Rating Program

- HI committee has developed a program guide for voluntary label (Q1-2017 Launch)
- Sets requirements to participate (Globally)
- Defines Energy Rating (ER) Metric & Label
- Pumps tested in HI Approved Laboratory
- HI maintains database for utility incentive program use



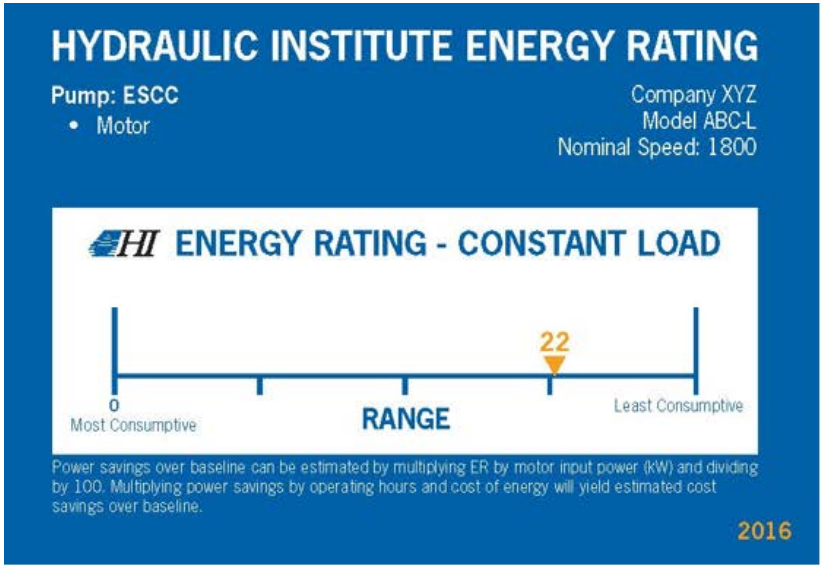
HI Approved
PUMP TEST LAB

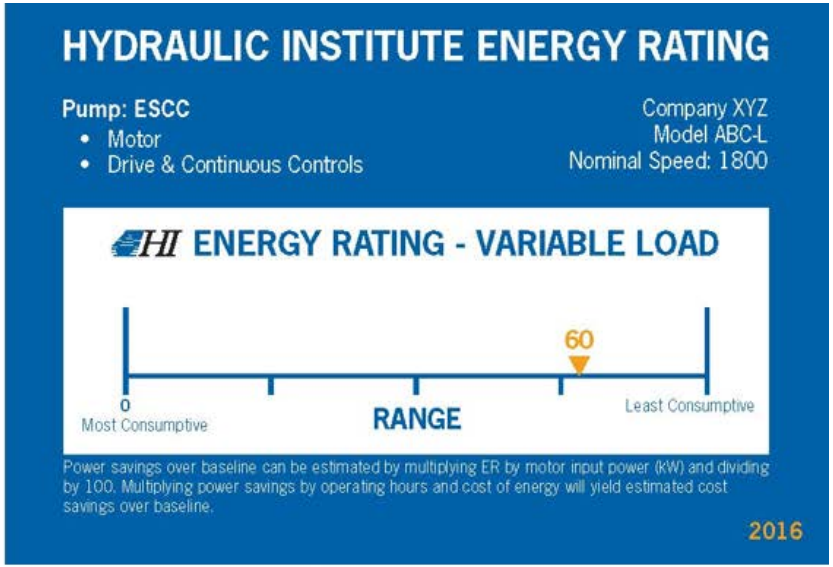
Average PEI and ER by equipment

Average PEI Constant Load		
DOE Type	Baseline	Standard Level
ESCC 1800	1.09	1.00
ESCC 3600	1.09	1.00
ESFM 1800	1.10	1.00
ESFM 3600	1.09	1.00
IL 1800	1.11	1.00
IL 3600	1.12	1.00
RSV 1800	1.00	1.00
RSV 3600	1.00	1.00
ST 1800	1.00	1.00
ST 3600	1.06	1.00

Average ER Constant Load		
DOE Type	Baseline	Standard Level
ESCC 1800	0	9
ESCC 3600	0	9
ESFM 1800	0	10
ESFM 3600	0	9
IL 1800	0	11
IL 3600	0	12
RSV 1800	0	0
RSV 3600	0	0
ST 1800	0	0
ST 3600	0	6

$$ER = (PEI_{Baseline} - Rated\ PEI) * 100$$





$$\boldsymbol{Power\ Savings} = \frac{ER}{100} * \boldsymbol{Average\ Motor\ Power}$$

$$\boldsymbol{Power\ Savings} = \frac{ER_1 - ER_2}{100} * \boldsymbol{Average\ Motor\ Power}$$

Reference Links

https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/14

[DOE Energy Conservation Standard]

https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=111

[DOE Test Procedure]

http://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=10:3.0.1.4.17

[Title 10 chapter II subchapter d part 429 – Certification, Compliance & Enforcement]

http://www.ecfr.gov/cgi-bin/text-idx?SID=e1731bec52be347851839569e4399728&mc=true&node=pt10.3.431&rgn=div5

[Title 10 Chapter II subchapter d part 431 – Energy efficiency program]

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:191:0035:0041:EN:PDF

[Commission Regulation (EC) No 641/2009]

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:165:0028:0036:en:PDF

[Commission Regulation (EU) No 547/2012]

pumps@ee.doe.gov [email DOE for more information]

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- Motor Summit 2016, Zurich Switzerland

Thank you!

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