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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Hydraulic Institute
European Energy Standard Circulator Pumps


- August 2015 – Glandless circulators must have EEI ≤ 0.23

\[ EEI = \frac{P_{L,avg}}{P_{ref}} \times C_{20\%} \]
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
How does MEI equate to efficiency?

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

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

- 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 include 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 m³/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)
<table>
<thead>
<tr>
<th>Diagram</th>
<th>Nomenclature (EU)</th>
<th>Nomenclature (DOE) / [Industry]</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td>End Suction Own Bearing (ESOB)</td>
<td>End Suction Frame Mount (ESFM) / [OH0, OH1]</td>
</tr>
<tr>
<td><img src="image2.png" alt="Diagram" /></td>
<td>End Suction Close Coupled (ESCC)</td>
<td>End Suction Close Coupled (ESCC) / [OH7]</td>
</tr>
<tr>
<td><img src="image3.png" alt="Diagram" /></td>
<td>End Suction Close Coupled In-line (ESCCi)</td>
<td>In-line (IL) / [OH3, OH4, OH5]</td>
</tr>
<tr>
<td><img src="image4.png" alt="Diagram" /></td>
<td>Vertical Multistage (MS-V)</td>
<td>Radially Split multi-stage vertical in-line diffuser casing (RSV) / [VS8]</td>
</tr>
<tr>
<td><img src="image5.png" alt="Diagram" /></td>
<td>Submersible Multistage (MSS)</td>
<td>Submersible Turbine (ST) / [VS0]</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Performance Metric</th>
<th>Constant Load</th>
<th>Variable Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Level</td>
<td>C-Value</td>
<td>Independent</td>
</tr>
<tr>
<td>Standard Pump Efficiency</td>
<td>$\eta_{\text{pump,STD}}$</td>
<td>Independent</td>
</tr>
<tr>
<td>Standard Pump Energy Rating</td>
<td>( \text{PER}_{\text{STD}} )</td>
<td>Independent</td>
</tr>
<tr>
<td>Pump Energy Rating (Product)</td>
<td>( \text{PER} )</td>
<td>( \text{PER}<em>{\text{CL}} ) ( \text{PER}</em>{\text{VL}} )</td>
</tr>
<tr>
<td>Pump Energy Index (Product)</td>
<td>( \text{PEI} )</td>
<td>( \text{PEI}<em>{\text{CL}} ) ( \text{PEI}</em>{\text{VL}} )</td>
</tr>
</tbody>
</table>
Standard Efficiency Curve

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

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

Failing C-Values versus Specific Speed ESCC.1800

Failing level when paired with minimally compliant driver
How is Minimally Compliant Pump Determined?

\[ \eta_{pump, STD} = -0.8500 \times \ln(Q_{100\%})^2 - 0.3800 \times \ln(Ns) \times \ln(Q_{100\%}) - 11.480 \times \ln(Ns)^2 + 17.800 \ln(Q_{100\%}) + 179.80 \times \ln(Ns) - (C + 555.60) \]

Where:

- \( Q_{100\%} = BEP \) 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

\[ \text{PER}_{\text{STD}} = \sum_i \omega_i (P_i^{\text{in,std}}) \]

Where:

- \( P_i^{\text{in,std}} \) = 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.

\[ \text{PER}_{\text{CL}} = \sum_i \omega_i (p_{i}^{\text{in}}) \]

Where:

- \( p_{i}^{\text{in}} \) = 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

\[ \text{PER}_{VL} = \sum_{i} \omega_i (P_{in,c}^i) \]

Where:

\[ P_{in,c}^i = \]
measured or calculated input power to the control at rating point \( i \), for the rated pump

\[ \omega_i = \]
weighting at load point, this is equal to 0.25

\( i = 25\%, 50\%, 75\%, \) & 100\% of BEP
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 \( \text{PER}_{\text{CL/VL}} \) over the power of a minimally compliant pump \( \text{PER}_{\text{STD}} \).

\[
\text{PEI}_{\text{CL/VL}} = \frac{\text{PER}_{\text{CL/VL}}}{\text{PER}_{\text{STD}}} \leq 1.00
\]
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

2014 – DOE Test Procedure

2015 – Test Lab Audit Approval

2017 – Energy Rating Program

HI Labeled

HI Approved

HI Tested

Data Trust Enforcement Markets

Utility Partners

$8 Billion Incentives to reduce energy consumption

Performance Metrics + Reporting = Compliance
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
### Average PEI and ER by equipment

\[ ER = (PEI_{Baseline} - \text{Rated PEI}) \times 100 \]

<table>
<thead>
<tr>
<th>DOE Type</th>
<th>Average PEI Constant Load</th>
<th>Average ER Constant Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Standard Level</td>
</tr>
<tr>
<td>ESCC 1800</td>
<td>1.09</td>
<td>1.00</td>
</tr>
<tr>
<td>ESCC 3600</td>
<td>1.09</td>
<td>1.00</td>
</tr>
<tr>
<td>ESFM 1800</td>
<td>1.10</td>
<td>1.00</td>
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<tr>
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<td>1.00</td>
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<tr>
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<td>RSV 1800</td>
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<tr>
<td>RSV 3600</td>
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<td>1.00</td>
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<tr>
<td>ST 1800</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>ST 3600</td>
<td>1.06</td>
<td>1.00</td>
</tr>
</tbody>
</table>
\[
\text{Power Savings} = \frac{ER}{100} \times \text{Average Motor Power}
\]

\[
\text{Power Savings} = \frac{ER_1 - ER_2}{100} \times \text{Average Motor Power}
\]
Reference Links

[DOE Energy Conservation Standard]
[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]
[Commission Regulation (EU) No 547/2012]
pumps@ee.doe.gov  [email DOE for more information]
Thank you!

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• Motor Summit 2016, Zurich Switzerland