A Review of the US DOE/NRcan 2020 Energy Conservation and Test Procedures for Pumps
Presentation Overview

- DOE/NRcan - New Regulation for pump efficiency
- Scope of DOE/NRcan Regulation
- Definitions of acronyms
- Overview of PEI
- DOE defined test procedure
- DEPM PEIvl VS Induction motors PEIvl
- PEI implications on pump selection
- HI’s Energy Rating Program - Rebates
- Armstrong offering affected by DOE/NRcan regulation
- Conclusions
DOE/NRcan 2020 Regulation

- The main goal for DOE regulation is to reduce the power consumption
- 25% of pumps currently sold today are expected not to conform with the new regulation standards
- Any pump manufactured after January 27, 2020 will have to meet the new standards and be labeled with a Pump Energy Index (PEI)
DOE/NRcan 2020 Regulation

**Desired outcomes of the DOE/NRcan regulation:**

- Reduced GHG (Greenhouse gases) emissions
- Increase cost savings for businesses using regulated energy products
- Reduce unnecessary regulations differences between EU, Canada and the United States to support cross-border trade.
  - Armstrong Fluid Technology pumps have conformed to EU energy laws since 2013
- Encourage the use of variable speed controls to maximize energy savings
Scope of DOE/NRcan Regulations

- **Clean water pump** is one of the following types:
  - An end suction close-coupled pump with a specific speed not more than 5000
  - An end suction frame mounted pump with its own bearings and with a specific speed not more than 5000
  - An in-line pump
  - A radially split, multi-stage, vertical, in-line diffuser casing pump, or
  - A submersible turbine pump with a bowl diameter not greater than 152 mm (6 in)
Specific Speed vs Nominal Speed

\[
\text{Specific Speed } (N_s) = \frac{N \sqrt{Q}}{H^{3/4}}
\]

If \( Q = \text{GPM} \) and \( H = \text{Feet} \) divide \( N_s \) by 1.63

If \( Q = \text{m}^3/\text{hr} \) and \( H = \text{meters} \) divide \( N_s \) by 1.9

\( N \) = The speed of the pump in revolutions per minute (RPM) = Nominal speed

\( Q \) = The flow rate in liters per second (For either single or double suction impellers)

\( H \) = Total dynamic head in meters
Scope of DOE/NRcan Regulations

Specifications for pumps included in the regulations:

- Shaft input power between 1 - 200 Hp inclusive at (BEP)
- Flow rate > or = 25 gpm (BEP) with a full impeller diameter
- Maximum Head < 459 ft at (BEP)
- Design temperature range between 14 to 248 ºF
- Designed to operate with either 2 poles or 4 poles induction motor or non induction motor with nominal speed 3600 RPM (2880-4320) & 1800 RPM (1440-2160)
Scope of DOE/NRcan Regulations

• Does not include the following:
  • Fire pump
  • Self priming pump
  • Prime-assist pump
  • Magnet-driven pump (Not to be confused with Design Envelope Permanent magnet motors)
  • Pump designed to be used in a nuclear facility
  • Pump designed according to military specifications
  • Pool pumps and circulators (Covered under a separate regulation)
Definitions by DOE/NRcan

- **PEI** – Pump Energy Index
  - As of January 27, 2020 any pump manufactured should have a **PEI < OR = 1 and** nameplate labelled with Model Number, PEI, Impeller size to be sold in Canada & USA.
  - **PEI**<sub>CL</sub> – Pump Energy Index for **Bare pump** and **Pump + Motor**
  - **PEI**<sub>VL</sub> – Pump Energy Index for **Pump + Motor + VFD Controls**

- **PER** – Pump Efficiency Rating
  - **PER**<sub>CL</sub> – Pump Efficiency Rating for **Bare pump** and **Pump + Motor**
  - **PER**<sub>VL</sub> – Pump Efficiency Rating for **Pump + Motor + VFD Controls**
PEI – Pump Energy Index

- PEI - **Pump Energy Index** is the PER (Pump Efficiency Rating) divided by a calculated minimally compliant PER for the given pump model.

- The lower the pump Energy Index (PEI) the more efficient the pump is.

\[
PEI_{cl} = \frac{PER_{cl}}{PER_{std}} \quad PEI_{vl} = \frac{PER_{vl}}{PER_{std}}
\]

- PEI_{cl} average range is from **0.75-1.0** and PEI_{vl} average range is from **0.4-0.55**.

- PEI_{vl} is significantly better than PEI_{cl}. Armstrong Design Envelope pumps with integrated controls significantly exceed efficiency levels defined by the DOE/NRcan regulations.
PER – Pump Efficiency Rating

- The **Pump Efficiency rating** (PER) is the equally weighted average electric input power to the pump at a DOE specified load profile.

- It is mostly **MEASURED** for **constant load (defined as pump/motor)** or **CALCULATED** for **variable load (defined as pump/motor/drive/control)** when using a 3 phases induction motor.

- As per the DOE regulation, the following standard load profiles are to be used during the testing method.

- DOE/NRcan regulations were modelled based on EU regulation which Armstrong has conformed to for more than 5 years.

<table>
<thead>
<tr>
<th>Constant Load</th>
<th>Variable Load</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duty Point</strong></td>
<td><strong>BEP Flow RATE</strong></td>
</tr>
<tr>
<td>1</td>
<td>75%</td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>110%</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
</tr>
</tbody>
</table>
Measured Design Envelope Permanent Motors PEIvl vs calculated Induction motors PEIvl

- All published PEIvl values for Design Envelope Permanent Magnet motors (DEPM) are obtained based on the measured method as specified by the DOE regulation.

- PEIvl values for pumps using 3 phases induction motors are mostly obtained based on the DOE calculation method.

- The calculated method (Formula) specifies to use the pump best efficiency across the load profile.
Pump Energy Index – What to remember when selecting a pump?

The pump with the lowest PEI will not always reflect the best efficiency. The use of DOE/NRcan PEI ratings is valuable to determine the legal minimum Energy standard in the market place and energy incentives.
PEI – What to remember when selecting a pump?

**PUMP A: DESIGN ENVELOPE 4300 1505-005.0**

- 100 GPM @ 75 FT
- BHP 2.59 HP
- Efficiency @ The average load 65.58%
- Efficiency @ Design 73.04%
- PEIvl = .46
- 3148 RPM @ 100% flow

**PUMP B: DESIGN ENVELOPE 4300 0205-005.0**

- 100 GPM @ 75 FT
- BHP 2.72 HP
- Efficiency @ The average load 58.14%
- Efficiency @ Design 69.65%
- PEIvl = .43
- 3207 RPM @ 100% flow
Hydraulic Institute (HI) Energy Rating Program

- Voluntary energy labelling program based on DOE pump energy Index that requires a 3rd party lab certification
- Mainly used for incentive programs and rebates:
  - PG&E – Pacific Gas Electric Company
  - Xcel Energy
  - Neea – Northwest Energy Efficiency Alliance
  - CEE – Consortium of Energy Efficiency etc...
- Ratings are uploaded directly into HI database
- Allows wholesalers/Manufacturers’ representatives to provide variable load ratings using the calculator on HI website
- The higher the ER rating the more efficient the pump is. PEI is the opposite.

\[
ER_{CL,VL} = (PEI_{baseline} - PEI_{CL,VL}) \times 100
\]

\[
PEI_{baseline} = 1
\]
Hydraulic Institute (HI) Rating Program

- Example: Given a pump: PEI_{VL} = 0.43
- The corresponding ER_{VL} value will be:

Variable Load ER = (1.00 - 0.43) \times 100 = 57
Annual savings calculation based on Hydraulic Institute Energy Rating (ER)

**ESTIMATED COST SAVINGS = POWER SAVINGS × OPERATING HOURS × COST OF ELECTRICITY**

**Example:**

Calculate the annual energy savings when replacing a minimally compliant 100 hp pump (ER =0 or PEI = 1) with:

1. A 100 HP variable speed pump with ER rating of 57 or PEI = 0.43
2. A 100HP constant speed pump with ER rating of 10 or PEI = 0.9

Running 5200 Hrs at a cost of $0.15/ Kwh

**Estimated Power Savings (HP) = \( \frac{ER}{100} \times \text{Motor Horsepower} \)**

\[
\text{Estimated Power Savings} = \frac{57}{100} \times 100 = 57 \text{ HP}
\]

Convert to KW (1 HP = 0.7457 kW)

\[
\text{Estimated Power Savings (kW)} = 57 \times 0.7457 \text{kw} = 42.5 \text{ kw}
\]

**Estimated Annual Energy Savings**

\[
= 42.5 \text{ kw} \times 5200 \text{ hours} \times \frac{\$0.15}{\text{kWh}} = \$33,150
\]

**Estimated Annual Energy Savings = $5,818 for ER = 10**
Throttling is energy inefficient since the energy to the pump is not reduced. Energy is wasted by increasing the dynamic loss. 15% to 50% energy can be saved in a constant flow application.

Based on 6” (150mm) 40 hp (30kw) pumping unit

<table>
<thead>
<tr>
<th></th>
<th>Hp (Kw)</th>
<th>Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incremental</td>
<td>Cumulative</td>
</tr>
<tr>
<td>A</td>
<td>Constant Speed - Unthrottled</td>
<td>31.38 (23.40)</td>
</tr>
<tr>
<td>B</td>
<td>Constant Speed - Throttled</td>
<td>30.44 (22.70)</td>
</tr>
<tr>
<td>C</td>
<td>Variable Speed - Unthrottled Constant Flow</td>
<td>21.97 (16.38)</td>
</tr>
</tbody>
</table>

Design Envelope (VL rated) Saves Energy in Constant Flow Systems
# Additional Energy Savings with Design Envelope

<table>
<thead>
<tr>
<th>Drive on Wall</th>
<th>Design Envelope Pump</th>
<th>Design Envelope Energy saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>Sensorless</td>
<td>73%</td>
</tr>
<tr>
<td>Sensor broken / not calibrated / not set up / pumps on bypass</td>
<td>Sensorless</td>
<td>55%</td>
</tr>
<tr>
<td>Sensor in Mechanical room</td>
<td></td>
<td>49%</td>
</tr>
<tr>
<td>Sensor Not at end of system</td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>Components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inefficient motor / drive pairing</td>
<td>Automatic motor adaption</td>
<td>5%</td>
</tr>
<tr>
<td>Traditional sized motor</td>
<td>Smaller motor 20% of time</td>
<td>1.5%</td>
</tr>
<tr>
<td>Traditional pump impeller trim</td>
<td>Optimized trim</td>
<td>5%</td>
</tr>
<tr>
<td>Traditional motor</td>
<td><strong>DE Permanent Magnet Motor to 10 hp</strong></td>
<td>10%</td>
</tr>
<tr>
<td>Multiple Pump Staging</td>
<td>Capacity based - BMS</td>
<td>30%</td>
</tr>
<tr>
<td>Pump selection</td>
<td>Traditional design point</td>
<td>9%</td>
</tr>
<tr>
<td>Flow Balancing</td>
<td>Throttle</td>
<td>15%</td>
</tr>
<tr>
<td>Redundancy</td>
<td>Duty standby 100%</td>
<td><strong>Parallel Sensorless 85%</strong></td>
</tr>
<tr>
<td>Boiler or Chilled water system savings</td>
<td>Flow control not optimized and is generally too high</td>
<td>3 to 6% of heating or cooling source</td>
</tr>
<tr>
<td>Active Performance management</td>
<td>none</td>
<td><strong>Connected to cloud and APM system preventing drift</strong></td>
</tr>
</tbody>
</table>
Sensorless Control Savings
Knowing Where We Need to Operate

Minimum Head equates to sensor setting at remote cooling coil in traditional system
Efficiency Improvements with Design Envelope Permanent Magnet motors

Less drop off in efficiency at lower speeds
Ideal for HVAC pumps!

![Graph showing efficiency and energy savings vs speed for DEPM, NEMA Premium IM, and energy savings.]

- **DEPM**
- **NEMA Premium IM**
- **Energy Savings**

**X-axis**: Speed
**Y-axis**: Efficiency (%) and Energy Savings (%)
Parallel Sensorless Pump Control
Staging Methodology

Armstrong Best Efficiency Staging

Speed Based Staging
Active Performance Management

Offerings provide the platform and embedded software

Enable the Connectivity and Diagnostic Analytics

LEARNs.
PREDICTs.
OPTIMIZES
Pump Manager: A Performance Management Service for pumps

A cloud based Performance Management service.

Industry leading analytics and pump specific insights.

Enhanced reliability and sustained optimal performance
Armstrong offerings and DOE/NRcan compliance

- Vertical Inline Twin Design Envelope: 4312, 4392
- Vertical Inline Design Envelope: 4300, 4380
- Vertical Inline Tango, DualArm Design Envelope: 4322, 4372, 4302, 4382
- Horizontal End Section Design Envelope: 4200H, 4280
- Vertical Inline Constant speed: 4300, 4380, 4360
- Horizontal End suction constant speed: 4030, 4270, 4280
- Horizontal Split case constant speed: 4600 (Exempt from the regulation)
- Vertical Multistage: 4700

All Armstrong pumps are compliant to the DOE/NRcan. ADEPT, nameplates and submittals will be updated with PEI and ER values before January 27, 2020.
In summary

- ALL Armstrong pumps **meet or exceed** the DOE/NRcan regulation
- ALL Design Envelope pumps **significantly exceed** the minimum DOE/NRcan standards
  - All pumps used in HVAC should be Design Envelope (VL rated) pumps
  - Design Envelope (VL rated) pumps save between 15 to 50% of energy in **constant flow applications**
  - Design Envelope pump complete value (**Sensorless control, Parallel Sensorless pump control, appropriate redundancy and active performance management**) is not taken in consideration by the DOE/NRcan ratings and remains the best for customer solutions
- ADEPT remains the best tool for pump selection
- Armstrong recommends Design Engineers to specify a **PEI of .57 / ER of 43 or better on the nameplate and directly from the manufacturer**.
Information

http://er.pumps.org/ratings/home

For any additional questions regarding the DOE & Nrcan regulations, please email Cressent Callimaque - ccallimaque@armstrongfluidtechnology.com