EXTENDED PRODUCT APPROACH FOR PUMPS

A Europump Guide

8 April 2013

Draft version

This working document for a future Europump guide on the Extended Product Approach is prepared by a subcommittee of the Europump Standards Commission. It has not been presented or discussed in the Europump Standards Commission or the joint working group for EuP/ErP and currently does not reflect the position of Europump.

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Foreword

This working document is prepared by a subcommittee of the Europump Standards Commission which consists of the following members:

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The working document will serve as a communication tool towards the European Commission during the legal process concerning the ecodesign requirements based on the extended product approach (EPA) for pumps. At a later stage this working document will be elaborated into a Europump guide, as an aid for pump manufacturers and users to ensure compliance with the future regulation on the extended product approach (EPA) for pumps.
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1 Introduction
Europump’s answer to the ecodesign directive for pumps is based on three pillars as shown in Figure 1. The Product Approach focuses on the efficiency of the pump alone. The Extended Product Approach is focused on the extended product (pump, PDS, controls) and the System Approach focuses on optimising the pumping system. The purpose of this guide is to describe the methodology for future implementing measures (i.e. labelling, legislation etc.) for extended pump products (EPs).

Figure 1 Europump Ecopump initiative

Figure 2 shows the difference between a Product Approach and an Extended Product Approach. Implementing measures based on a Product Approach take only the efficiency of the product into account, whereas the Extended Product Approach via the load profile and control method curve also takes the reductions in pump head into account.

1.1 Pumps in scope
The Extended Product Approach (EPA) has already been applied for circulators and forms the basis for the ecodesign requirement for these products today [1].
Figure 3 shows the road map for ecodesign requirements for pumps.

Ecodesign requirements based on extended products (EPs) are expected to be introduced during the next 5 years and the requirements will be based on an Energy Efficiency Index (EEI) as for circulators. The following pump products are expected to be targeted:

- Water pumps as defined [2]
- Booster systems (directly or indirectly)
- Wastewater pumps as defined in (to be determined)…up to 150 kW?
- Clean water pumps as defined in (to be determined)…up to 150 kW?

1.2 Energy savings
The main driver for the Extended Product Approach is the huge energy saving potential. Europump estimates that a marked transformation based on the EPA for water pumps in the scope of Commission Regulation 547/2012 only will lead to energy savings of 35 TWh per year, which is approximately ten times greater than the saving in 2020 achieved by the current regulation for water pumps.

2 Extended Product Approach for pumps
It is important to distinguish between the Extended Product Approach (EPA) and the Extended Product (EP).

- **Extended Product Approach (EPA)**: a methodology to calculate the Energy Efficiency Index (EEI) of an Extended Product (EP), which incorporates load profiles and control method.
- **Extended Product (EP)**: consists of physical components
The EPA is a methodology or procedure which can be used to qualify an extended product for a certain efficiency level, whereas the EP is the actual product. This is shown graphically in Figure 4.

Extended pump products are placed on the market as integrated units i.e. a pump, a motor with or without VSD which is supplied by one manufacturer as a complete unit. They are also placed on the market as separated units i.e. where the pump, motor and VSD are separate products supplied by one or more manufacturers. The EPA must be able to handle both integrated and separated extended pump products.

This leads to the following general definition for an extended pump product:

Extended pump product means a pump driven by an electric motor with or without a variable speed drive (VSD)

This definition is valid for all extended pump products in the scope, including circulators. The speed control is based on a system feedback which can come from sensors in the system or in the pump or from sensorless feedback transmitted by the motor.

3 Load Profiles and reference control curves
Extended pump products are used in a variety of applications with different load profiles and control methods. For the purpose of the EPA methodology these load profiles and control methods are grouped into the following:

- Closed loop systems or open loop systems
- Constant flow systems or variable flow systems

When combined they cover all applications in the scope.
3.1 Closed loop variable flow system
In a closed loop system the purpose of the pumps is to produce enough head to overcome friction losses in the system and satisfy the requirement for actuators (valves etc.). A typical closed system is a hydronic distribution system of a heating and/or air conditioning system (HVAC-system). The purpose of these pumps is to distribute energy from the energy supply (boiler, chiller etc.) to the emission systems (radiator, coils, air handling units etc.) by circulating a pumped media. The load profile for these systems is shown in Table 1.

<table>
<thead>
<tr>
<th>Load Profile</th>
<th>Flow [%]</th>
<th>Time [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁</td>
<td>100</td>
<td>6</td>
</tr>
<tr>
<td>L₂</td>
<td>75</td>
<td>15</td>
</tr>
<tr>
<td>L₃</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>L₄</td>
<td>25</td>
<td>44</td>
</tr>
</tbody>
</table>

At part load the pump head can be reduced due to reduction in friction losses in the system. The control method must take that into account. Figure 5 shows the load points from and the reference control curve as defined for these systems (green line).
The EEI calculation of all pumps (fixed speed or variable speed) used in closed loop variable flow systems will be evaluated according to this reference control curve and load profile.

3.2 Open loop variable flow system
Pumps in open loop variable flow systems must deliver a certain static pressure and, in addition, enough head to overcome friction losses in the system. A typical open loop variable flow system is a water distribution system in cities and buildings. A load profile for these systems is shown in Table 2.
Table 2 Load profile for open loop variable flow systems

<table>
<thead>
<tr>
<th>Flow [%]</th>
<th>Time [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁</td>
<td>100</td>
</tr>
<tr>
<td>L₂</td>
<td>90</td>
</tr>
<tr>
<td>L₃</td>
<td>80</td>
</tr>
<tr>
<td>L₄</td>
<td>70</td>
</tr>
<tr>
<td>L₅</td>
<td>60</td>
</tr>
<tr>
<td>L₆</td>
<td>50</td>
</tr>
<tr>
<td>L₇</td>
<td>40</td>
</tr>
<tr>
<td>L₈</td>
<td>30</td>
</tr>
<tr>
<td>L₉</td>
<td>20</td>
</tr>
<tr>
<td>L₁₀</td>
<td>10</td>
</tr>
</tbody>
</table>

At part load the pump head can also be reduced in these systems due to reduction in friction losses and the control method must take that into account. Figure 6 shows the load points from Table 2 and the reference control curve as defined for these systems (green line).
The EEI calculation of all pumps (fixed speed or variable speed) used in open loop variable flow systems will be evaluated according to this reference control curve and load profile.

3.3 **Constant flow system (open and closed loop)**

In a constant flow system the pump must overcome a certain static pressure in an open loop system or overcome a certain friction loss in a closed system which is designed to give a certain constant flow. A typical application of an open loop constant flow system is where the purpose of the pump is to move liquid from one reservoir to another. A typical example of a closed loop system could be a boiler feed pump. In a real system the flow is very seldom constant. For example it will vary due to the level of the reservoirs etc. Therefore it makes sense to define a load profile with a load point around the best efficiency point. Such a load profile is shown in Table 3.
Table 3 Load profile for constant flow systems (open and closed loop)

<table>
<thead>
<tr>
<th></th>
<th>Flow [%]</th>
<th>Time [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁</td>
<td>110</td>
<td>25</td>
</tr>
<tr>
<td>L₂</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>L₃</td>
<td>75</td>
<td>25</td>
</tr>
</tbody>
</table>

These are the same load points as those used for MEI calculation for water pumps, where a time profile has been added.

Figure 7 Load points constant flow systems (open and closed loop) listed in Table 2. In these systems variable speed is not a benefit and no reference control curve is defined.

The EEI calculation of all pumps (fixed speed or variable speed) used in constant flow systems (open loop and closed loop) will be evaluated according to this load profile.

3.4 Relation between system types and pump types
There is no one-to-one mapping between system types and pump types. Some pump types are used in different systems. Table 4 show the relation between system types and pump types.
Table 4 System type vs. pump type

<table>
<thead>
<tr>
<th>Pump type</th>
<th>Relation to EuP/ErP</th>
<th>System type</th>
<th>Variable flow</th>
<th>Constant flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Closed loop</td>
<td>Open Loop</td>
</tr>
<tr>
<td>Circulators</td>
<td>Lot 11</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESCCI</td>
<td>Lot 11</td>
<td>X</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>ESOB</td>
<td>Lot 11</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ESCC</td>
<td>Lot 11</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>Lot 11</td>
<td>O</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>MSS</td>
<td>Lot 11</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Wastewater pumps</td>
<td>Lot 28</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Clean water pumps</td>
<td>Lot 29 (except Lot 11 pump types)</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
</tbody>
</table>

For pump types used in more than one system type, more than one EEI value will be calculated. The product information requirements must ensure that the EEI is calculated and documented for all the entries in the table marked with an ‘X’. Calculation and documentation of an EEI are optional for the entries marked with an ‘O’ in the table.

The energy efficiency requirements must specify that when putting an extended product into service, the energy efficiency requirements (in terms of EEI) for a particular pump type used in a particular system type must be met.

4 Methodology for calculation of EEI for extended products

The Energy Efficiency Index (EEI) is based on the same methodology as for circulators. Basically it consists of an average power input calculated on a load-time profile divided by a reference power input.

Figure 8 shows how the power in an extended product is defined. $P_1$ is the electrical power input from the grid. $P_2$ is the mechanical power from the motor shaft. $P_{\text{hydr}}$ is the hydraulic power produced by the pump.

![Figure 8 Definition of Powers in an extended pump product. The combined motor and CDM (VSD) is referred to as a Power Drive System (PDS)]]

A graphical presentation of the EEI calculation is shown in Figure 9. The left side shows the calculation of average power input i.e. the numerator of the EEI index. The right side shows how to calculate the reference power i.e. the denominator of the EEI index.
The power input values $P_{1,i}$ in Figure 9 can be measured, but this is not possible in most cases especially not for separated units. The $P_{1,i}$ values will then be calculated from Semi Analytical Models as described in the next section.

The reference power input based on actual efficiency of the pump as defined in the EC regulation for water pumps [2] and later on for the other pump types in the scope in Lot 28 and Lot 29. Based on actual measurements of the pump, the head and the flow, the best efficiency point (H100%, Q100%) is determined and from that the specific speed ($n_s$) is calculated. Based on the hydraulic power and the efficiency, the reference shaft power $P_{2,ref}$ is calculated, which can via the IEC 600034-30 for motors be converted onto a reference power input. The reference efficiency of the VSD is set to 100% by definition. The actual efficiency of the specific VSD is captured by the power input values $P_{1,i}$ as is the case for pump and motor.

4.1 Semi Analytical Models (SAMs)
A methodology for an extended pump product cannot be based on measurement only although this is an option, which can be applied in some cases.

Separated extended pump products are in many cases built on site, which makes a determination of EEI based on measurements of the extended product impossible. Therefore a methodology based on Semi Analytical Models (SAMs) has been developed to overcome this problem [3].

A SAM is a model which is based on measurement combined with physical and empirical knowledge of the product. Based on SAMs of the pump, motor and VSD it is possible to calculate the EEI of the extended product based on a few measurement points (supporting points) of the individual products (pump, motor and VSD).
Based on the SAM for the pumps, the torque and rotational speed at the part load point is calculated.

Based on SAMs of the Power Drive System (PDS) the power losses at these part load point can be calculated and used to determine the power input to the extended product.

The SAM for the PDS is described in [4]. Figure 11 shows the eight load points which are defined in this standard. These eight points are chosen to cover all PDS applications.

![Figure 11 Related losses of a PDS at different part load points (Source: [4])](image)

**Error! Reference source not found.** shows the three supporting points for pump applications. All pump applications in the scope will be within the green shaded area.
The actual losses will be based on interpolation based on these supporting points. Part One of the PDS standard [5] will cover the generic application of the standard for extended products. A specific measurements standard must be written for all products. A draft standard for pumps is already under development.

Bibliography

[5] prEN 50589-1 Procedure for determining the energy efficiency indicators or motor driven applications by using the extended product approach and semi analytical model, CENELEC, 20xx.