Brussels, XXX
[…](2019) XXX draft

COMMISSION REGULATION (EU) …/…

of XXX

laying down ecodesign requirements for water pumps and water pump units pursuant to Directive 2009/125/EC of the European Parliament and of the Council,

repealing Commission Regulation (EU) No 547/2012

(Text with EEA relevance)

COMMISSION REGULATION (EU) …/…

of XXX

laying down ecodesign requirements for water pumps and water pump units pursuant to Directive 2009/125/EC of the European Parliament and of the Council,

repealing Commission Regulation (EU) No 547/2012

(Text with EEA relevance)

Article 1

Subject matter and scope

1. This Regulation establishes ecodesign requirements for the placing on the market or putting into service of rotodynamic water pumps and water pump units, for pumping clean water, including where integrated in other products.

2. This Regulation shall not apply to the following products, except with except with regard to the information requirements of Annex II, points (c), (d) and (p):

   (a) water pumps and water pump units designed specifically for pumping clean water at temperatures below – 10 °C or above 120 °C, except with regard to the information requirements of Annex II, points 2(k) to 2(m);

   (b) water pumps and water pump units designed only for fire-fighting applications;

   (c) displacement water pumps and displacement water pump units;

   (d) self-priming water pumps and self-priming water pump units.

Article 2

Definitions

For the purposes of this Regulation, the following definitions shall apply:

(1) ‘water pump’ is the hydraulic part of a device that moves clean water by physical or mechanical action and is of one of the following designs:

   — End suction own bearing (ESOB),

   — End suction close coupled (ESCC),

   — End suction close coupled inline (ESCCi),

   — Vertical Multistage (MS-V),

   — Horizontal Multistage (MS-H),

   — Submersible multistage (MSS),

   — Booster sets (BS);

(2) ‘rotodynamic water pump’ means a water pump that moves clean water by means of hydrodynamic forces;

(3) ‘water pump unit’ means a water-pump equipped or supplied with an electric motor and with or without a variable speed drive.

(4) ‘electric motor’ or ‘motor’ means a device that converts electrical input power into mechanical output power in the form of a rotation with a rotational speed and torque that depends on factors including the frequency of the supply voltage and number of poles of the motor;

(5) ‘variable speed drive’ (VSD) means an electronic power converter that continuously adapts the electrical power supplied to a single motor to control the motor’s mechanical power output according to the torque-speed characteristic of the load driven by the motor, by adjusting the power supply to a variable frequency and voltage supplied to the motor. It includes all electronics connected between the mains and the motor including extensions such as protection devices, transformers and auxiliaries;

(6) ‘End suction water pump’ means a glanded single stage end suction rotodynamic water pump designed for pressures up to 16 bar, with a specific speed ns between 6 and 80 rpm, a minimum rated flow of 6 m3/h (1,667·10–3 m3/s), a maximum shaft power of 150 kW, a maximum head of 90 m at nominal speed of 1 450 rpm and a maximum head of 140 m at nominal speed of 2 900 rpm;

(7) ‘Rated flow’ means the head and flow that the manufacturer will guarantee under normal operating conditions;

(8) ‘Glanded’ means sealed shaft connection between the impeller in the pump body and the motor. The driving motor component remains dry;

(9) ‘End suction own bearing water pump’ (ESOB) is an end suction water pump with own bearings;

(10) ‘End suction close coupled water pump’ (ESCC) is an end suction water pump of which the motor shaft is extended to become also the pump shaft;

(11) ‘End suction close coupled inline water pump’ (ESCCi) means an end suction water pump of which the water inlet of the pump is on the same axis as the water outlet of the pump;

(12) ‘Vertical multistage water pump’ (MS-V) means a glanded multi stage (i > 1) rotodynamic water pump in which the impellers are assembled on a vertical rotating shaft, which is designed for pressures up to 25 bar, and a maximum flow of 100 m^3 /h (27,78·10^{-3} m^3 /s);

(13) ‘Horizontal multistage water pump’ (MS-H) means a glanded multi stage (i > 1) rotodynamic water pump in which the impellers are assembled on a horizontally rotating shaft, which is designed for pressures up to 25 bar, and a maximum flow of 100 m^3/h (27,78·10^{-3} m^3/s);

(14) ‘Submersible multistage water pump’ (MSS) means a multi stage (i > 1) rotodynamic water pump with a nominal outer diameter from 2.5″ (63.5 mm) up to 6″ (152,4 mm) designed to be operated submersed, at operating temperatures within a range of 0 °C and 90 °C; with a nominal flow rate >1.75 m^3/h;

(15) ‘booster set’ means either a single water-pump unit or an assembly of water-pump units connected in parallel with a maximum hydraulic power of 150 kW, a minimum rated flow of 6 m^3/h (0,001667 m^3/s), to be operated with backflow prevention and

additional components influencing hydraulic performance and with components necessary to control pressure or provide flow in open loops inside buildings and which is placed on the market and/or put into service as one single product and its intended use is to pump clean water (and does not have a self-priming functionality);

(16) 'displacement water pump' means a water pump that moves clean water by enclosing a volume of clean water and forcing this volume to the outlet of the pump;

(17) 'self-priming water pump' means a water pump that moves clean water and which can start and/or operate also when only partly filled with water;

(18) 'clean water' means water with a maximum non-absorbent free solid content of 0,25 kg/m3, and with a maximum dissolved solid content of 50 kg/m3, provided that the total gas content of the water does not exceed the saturation volume. Any additives that are needed to avoid water freezing down to – 10 °C shall not be taken into account.

(19) 'equivalent model' means a model which has the same technical characteristics relevant for the technical information to be provided, but which is placed on the market or put into service by the same manufacturer, importer or authorised representative as another model with a different model identifier;

(20) 'model identifier' means the code, usually alphanumeric, which distinguishes a specific product model from other models with the same trade mark or the same manufacturer's, importer's or authorised representative's name;

Article 3

Ecodesign requirements

The ecodesign requirements set out in Annex II shall apply from the dates indicated therein.

No ecodesign requirement is necessary regarding any other ecodesign parameter referred to in Annex I, Part 1, of Directive 2009/125/EC.

Article 4

Conformity assessment

1. The conformity assessment procedure referred to in Article 8 of Directive 2009/125/EC shall be the internal design control system set out in Annex IV of that Directive or the management system set out in Annex V of that Directive.

2. For the purposes of the conformity assessment pursuant to Article 8 of Directive 2009/125/EC, the technical documentation of water pumps shall contain a copy of the product information provided in accordance with point 2 of Annex II to this Regulation, and the details and results of calculations set out in Annex III to this Regulation.

3. Where the information included in the technical documentation for a particular model has been obtained:

   (a) from a model that has the same technical characteristics relevant for the technical information to be provided but is produced by a different manufacturer; or

   (b) by calculation on the basis of design or extrapolation from another model of the same or a different manufacturer, or both,

the technical documentation shall include the details of such calculation, the assessment undertaken by the manufacturer to verify the accuracy of the calculation and, where appropriate, the declaration of identity between the models of different manufacturers.

The technical documentation shall include a list of all equivalent models, including the model identifiers.

Article 5

Verification procedure for market surveillance purposes

Member States shall apply the verification procedure laid down in Annex IV when performing the market surveillance checks referred to in point 2 of Article 3 of Directive 2009/125/EC.

Article 6

Circumvention and software updates

The manufacturer, importer or authorised representative shall not place on the market products designed to be able to detect they are being tested (e.g. by recognising the test conditions or test cycle), and to react specifically by automatically altering their performance during the test with the aim of reaching a more favourable level for any of the parameters specified in this Regulation or declared by the manufacturer, importer or authorised representative in the technical documentation or included in any of the documentation provided.

The energy consumption of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No deterioration of performance shall occur as result of rejecting the update.

A software update shall never have the effect of changing the product's performance in a way that makes it non-compliant with the ecodesign requirements applicable for the declaration of conformity.

Article 7

Benchmarks

The benchmarks for the best-performing water pumps available at the time of adopting this Regulation are set out in Annex V.

Article 8

Review

The Commission shall review this Regulation in the light of technological progress and shall present the results of this assessment, including, if appropriate, a draft revision proposal, to the Consultation Forum no later than *[OP - please insert date – 4 years after its entry into force]*.

This review shall in particular address the appropriateness of:

(1) enabling further energy savings in the pump system;

(2) setting resource efficiency requirements in accordance with the objectives of the circular economy;

(3) including other types of pumps such as wastewater pumps and swimming pool pumps;

(4) setting stricter ecodesign requirements;

(5) the level of verification tolerances.

Article 9
Repeal

Regulation (EC) No 547/2012 is repealed as from 01/01/2022

Article 12
Entry into force and application

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union.*

It shall apply from 01/01/2022.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels,

For the Commission
The President

ANNEX I

Definitions applicable for the purposes of Annexes II to V

For the purpose of Annexes II to V, the following definitions apply:

(1) '*Impeller*' means the rotating component of a rotodynamic pump which transfers energy to the water;

(2) '*Full impeller*' means the impeller with the maximum diameter for which performance characteristics are given for a pump size in the catalogues of a water pump manufacturer;

(3) '*Specific speed*' (n_s) means a dimensional value characterising the shape of the water pump impeller by head, flow and speed (n):

$$n_s = n \cdot \frac{\sqrt{Q_{BEP}}}{(1/iH_{BEP})^{\frac{3}{4}}} \quad [min^{-1}]$$

Where

— '*Head*' (H) means the increase in the hydraulic energy of water in meters [m], produced by the water pump at the specified point of operation,

— '*Rotational speed*' (n) means the number of revolutions per minute [rpm] of the shaft,

— '*Flow*' (Q) means the volume flow rate [m^3/s] of water through the water pump,

— '*Stage*' (i) means the number of series impellers in the water pump,

— '*Best efficiency point*' (BEP) means the operating point of the water pump at which it is at the maximum hydraulic pump efficiency measured with clean cold water,

(4) '*Hydraulic pump efficiency*' (η) is the ratio between the mechanical power transferred to the liquid during its passage through the water pump and the mechanical input power transmitted to the pump at its shaft;

(5) '*Clean cold water*' means clean water to be used for pump testing, with a maximum kinematic viscosity of $1{,}5 \times 10^{-6}$ m^2/s, a maximum density of 1 050 kg/m^3 and a maximum temperature of 40 °C;

(6) '*Part load*' (PL) means the operating point of the water pump at 75 % of the flow at BEP;

(7) '*Over load*' (OL) means the operating point of the water pump at 110 % of the flow at BEP;

(8) '*Minimum Efficiency Index*' (MEI) means the dimensionless scale unit for hydraulic pump efficiency at BEP, PL and OL;

(9) '*C*' means a constant for each specific water pump type quantifying the differences in efficiency for different pump types.

(10) 'Energy Efficiency Index' (EEIv) means the dimensionless scale unit for an average pump unit electric power input according to a flow-time profile and reference control curve divided by a reference power input.

(11) 'Flow-time profile' means a pattern of percentiles of time where the pump unit runs at a given flow rate.

(12) ‘Average electric power input’ ($P_{1,avg}$) is the average electric power consumption weighted by the Flow-time profile.

(13) ‘Reference electric power input’ ($P_{1,ref}$) is a nominal power input of a fictitious pump unit running at nominal 100% load point.

ANNEX II

ECODESIGN REQUIREMENTS FOR WATER PUMPS AND WATER PUMP UNITS

1. ENERGY EFFICIENCY REQUIREMENTS OF WATER PUMPS

From 01/01/2022, water pumps shall have:

— a minimum efficiency at the best efficiency point (BEP) of at least $(\eta_{BEP})_{min\ requ}$ when measured according to Annex III and calculated with the C-value for MEI = 0,4, according to Annex III,

— a minimum efficiency at part load (PL) of at least $(\eta_{PL})_{min\ requ}$ when measured according to Annex III and calculated with the C-value for MEI = 0,4, according to Annex III,

— a minimum efficiency at over load (OL) of at least $(\eta_{OL})_{min\ requ}$ when measured according to Annex III and calculated with the C-value for MEI = 0,4, according to Annex III.

2. ENERGY EFFICIENCY REQUIREMENTS OF WATER PUMPS UNITS

(a) From 1 January 2023, ESOB-, ESCC and ESCCi end suction water pump units up to 45kW shall have: an Energy Efficiency Index EEIv according to Annex III of not more than 0.62.

(b) From 1 January 2023, booster sets shall have an Energy Efficiency Index EEIv according to Annex III of not more than 0.62.

3. PRODUCT INFORMATION REQUIREMENTS OF WATER PUMPS

From 01/01/2022, the product information requirements set out in points (a) to (e) below shall be visibly displayed on:

1) the technical data sheet or user manual supplied with the water pump;
2) the technical documentation for the purposes of conformity assessment pursuant to Article 4;
3) free access websites of the manufacturer of the water pump, its authorised representative or the importer;
4) catalogues and;
5) the packaging of the water pump.

The information shall be provided in the order as presented in points (a) to (p).

a) Minimum efficiency index: MEI ≥ [x,xx];

b) Standard text: ‘The benchmark for most efficient water pumps is MEI ≥ 0,70’, or, alternatively, the indication ‘Benchmark MEI ≥ 0,70’;

c) Manufacturer’s name or trade mark, commercial registration number and address;

d) Model identifier;

e) Category (i.e. one of the designs specified in article 2: ESOB, ESCC, ESCCi, MS-V, MS-H, MSS etc.) and size identificator (rated power and nominal speed);

f) Hydraulic pump efficiency (%) with trimmed impeller [xx,x], or, alternatively, the indication [–.-];

g) Pump performance curves for the pump, including efficiency characteristics;

h) Standard text: 'The efficiency of a pump with a trimmed impeller is usually lower than that of a pump with the full impeller diameter. The trimming of the impeller will adapt the pump to a fixed duty point, leading to reduced energy consumption. The minimum efficiency index (MEI) is based on the full impeller diameter.';

i) Standard text: 'The operation of this water pump with variable duty points may be more efficient and economic when controlled, for example, by the use of a variable speed drive that matches the pump duty to the system';

j) Information relevant for disassembly, recycling or disposal at end-of-life;

k) Standard text for water pumps designed only for pumping clean water at temperatures below – 10 °C: 'Designed for use below – 10 °C only';

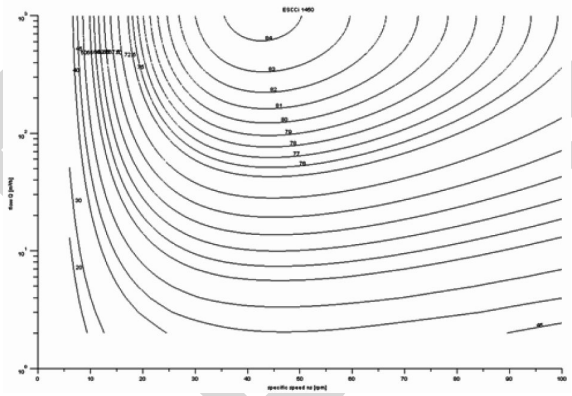
l) Standard text for water pumps designed only for pumping clean water at temperatures above 120 °C: 'Designed for use above 120 °C only';

m) For pumps designed specifically for pumping clean water at temperatures below – 10 °C or above 120 °C, manufacturer must describe the relevant technical parameters and characteristics used;

n) Standard text: 'information on benchmark efficiency is available at [www.xxxxxxxxx.xxx]';

o) Benchmark efficiency graph for MEI = 0,7 for the pump based on the model shown in the Figure. Similar efficiency graph shall be provided for MEI = 0,4.

Figure



Example of a benchmark efficiency graph for ESOB 2900

Further information may be added and may be complemented by graphs, figures or symbols.

if the water pump is considered exempt from efficiency requirement in accordance with Article 1(2) of this Regulation, the specific reason why it is considered exempt.

The information referred to in points (a) and (c) to (f) as well as the year of manufacture shall be durably marked on or near the rating plate of the water pump.

Manufacturers shall provide information on how to install, use and maintain the water pump in order to minimise its impact on the environment.

4. PRODUCT INFORMATION REQUIREMENTS OF WATER PUMPS UNITS

From 01/01/2022, the product information requirements set out in points (a) to (e) below shall be visibly displayed on:

1) the technical data sheet or user manual supplied with the water pump unit;
2) for water pumps units integrated in products: the technical data sheet or user manual supplied with products in which the water pump is incorporated;
3) the technical documentation for the purposes of conformity assessment pursuant to Article 4;
4) free access websites of the manufacturer of the water pump, its authorised representative or the importer;
5) catalogues and;
6) the packaging of the water pump unit.

The information shall be provided in the order as presented in points (a) to (p).

a) Minimum efficiency index of the water pump: MEI ≥ [x,xx];

b) Energy efficiency index of the water pump unit: EEIv <= [x,xx];

c) Standard text: 'The benchmark for most efficient water pumps is MEI ≥ 0,70', or, alternatively, the indication 'Benchmark MEI ≥ 0,70';

d) Manufacturer's name or trade mark, commercial registration number and address;

e) Model identifier;

f) Category (i.e. one of the designs specified in article 2: ESOB, ESCC, ESCCi, MS-V, MS-H, MSS etc.) and size identificator (rated power and nominal speed);

g) Hydraulic pump efficiency (%) with trimmed impeller [xx,x], or, alternatively, the indication [–.-];

h) Pump performance curves for the pump, including efficiency characteristics;

i) Information relevant for disassembly, recycling or disposal at end-of-life;

j) Standard text for water pumps designed only for pumping clean water at temperatures below – 10 °C: 'Designed for use below – 10 °C only';

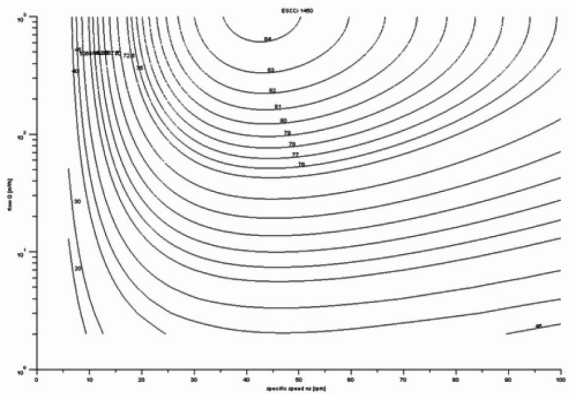
k) Standard text for water pumps designed only for pumping clean water at temperatures above 120 °C: 'Designed for use above 120 °C only';

l) For pumps designed specifically for pumping clean water at temperatures below – 10 °C or above 120 °C, manufacturer must describe the relevant technical parameters and characteristics used;

m) Standard text: 'information on benchmark efficiency is available at [www.xxxxxxxxx.xxx]';

n) Benchmark efficiency graph for MEI = 0,7 for the pump based on the model shown in the Figure. Similar efficiency graph shall be provided for MEI = 0,4.

Figure



Example of a benchmark efficiency graph for ESOB 2900

Further information may be added and may be complemented by graphs, figures or symbols.

if the water pump unit is considered exempt from efficiency requirement in accordance with Article 1(2) of this Regulation, the specific reason why it is considered exempt.

The information referred to in points (a) and (d) to (g) as well as the year of manufacture shall be durably marked on or near the rating plate of the water pump unit.

Manufacturers shall provide information on how to install, use and maintain the water pump unit in order to minimise its impact on the environment.

ANNEX III

MEASUREMENT METHODS AND CALCULATIONS

1. GENERAL PROVISIONS

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations shall be made using harmonised standards the reference numbers of which have been published for this purpose in the *Official Journal of the European Union,* or other reliable, accurate and reproducible methods, which take into account the generally recognised state-of-the-art, and in line with the following provisions:

2. DETERMINATION OF THE MEI FOR WATER PUMPS

The hydraulic pump efficiency, as defined in Annex I, is measured at the head and flow corresponding to the best efficiency point (BEP), part load (PL) and over load (OL) for full impeller diameter with clean cold water.

The formula for calculating the required minimum efficiency at best efficiency point (BEP) is as follows:

$$(\eta_{BEP})_{min\ requ} = 88{,}59\,x + 13{,}46\,y - 11{,}48\,x^2 - 0{,}85\,y^2 - 0{,}38\,x\,y - C_{Pump\ Type,rpm}$$

Where,

$x = \ln(n_s)$; $y = \ln(Q)$ and ln = natural logarithm and Q = flow in [m^3/h]; n_s = specific speed in [min^{-1}]; C = value found in Table 1.

The value of C depends on the pump type and nominal speed, and also the MEI value.

Table 1

Minimum efficiency index (MEI) and its corresponding C-value depending on the pump type and speed

C-value for MEI $C_{PumpType,rpm}$	**MEI = 0,40**
C (ESOB, 1 450)	128,07
C (ESOB, 2 900)	130,27
C (ESCC, 1 450)	128,46
C (ESCC, 2 900)	130,77
C (ESCCi, 1 450)	132,30
C (ESCCi, 2 900)	133,69
C (MS-V, 2 900)	133,95
C (MS-H, 2 900)	133,95

C (MSS, 2 900)	128,79

The requirements for part load (PL) and over load (OL) conditions are set at slightly lower values than those for 100 % flow (η_{BEP}).

All efficiencies are based on full (untrimmed) impeller. Vertical multistage water pumps are to be tested with a 3 stage (i = 3) version. Submersible multistage water pumps are to be tested with a 9 stage (i = 9) version. If this number of stages is not offered within the specific product range the next higher number of stages within the product range is to be chosen for testing.

3. DETERMINATION OF THE EEIV FOR SINGLE STAGE ESOB, ESCC AND ESCCI WATER PUMPS UNITS

The methodology for determination of the energy efficiency index (EEI_V) for water pump units and water pumps is as follows:

1. For water pumps placed on the market without a motor the EEIv calculations shall be based on measurement of the pump combined with standardized values of a minimum compliant motor and VSD as defined in Commission regulation xxx/xxx (new electric motor regulation).

   For water pumps placed on the market with a motor and with or without a VSD the EEIv calculation shall be based on measurement of the complete unit or shall be based on the procedure for water pumps placed on the market without a motor.

   Water pumps and water pump units integrated in other products shall be dismantled from this other product and measured;

2. Where a water pump unit has more than one setting of head and flow, measure the power consumption of the water pump at the maximum setting.

   'Head' (H) means head (in meters) produced by the water pump at the specified point of operation. 'Flow' (Q) means the volume flow rate of water through the water pump (m^3/h).

3. Find the point of best efficiency of the water pump unit and define the flow and head at this point as: $Q_{100\%}$ and $H_{100\%}$.

4. Calculate the hydraulic power P_{hyd} at this point.

5. 'Hydraulic power' means an expression of the arithmetic product of the flow (Q), Head (H) and a constant.
   "P_{hyd} " means hydraulic power delivered by the water pump to the fluid pumped at the specified point of operation (in Watts). Calculate the reference power as follows:

   Calculate the reference power input $P_{1,ref}$ defined as the electric power input of a pump unit which:

   operates at a flow rate $Q_{100\%}$ and pump head $H_{100\%}$

with nominal speed $n_{100\%} = n_{N,P}$

is operated with clean cold water at its operating conditions of ($n_{N,P}$ = 2900 min^{-1}, $Q_{100\%}$, $H_{100\%}$) or ($n_{N,P}$ = 1450 min^{-1}, $Q_{100\%}$, $H_{100\%}$) whichever speed $n_{N,P}$ is closest to the actual pump speed under test,

has an efficiency according to equation below and with the C-values according to Table in Annex III,

is driven by a (fictitious) 3-phase cage-induction motor which is directly fed by an electric grid with a frequency of 50 Hz,

is of the 2-pole type for the pump nominal speed $n_{N,PU}$ = 2900 min^{-1} or is of the 4-pole type for the pump nominal speed $n_{N,PU}$ = 1450 min^{-1} according $n_{N,p}$
has a nominal power output which exactly equals the shaft power of the pump at its nominal operating conditions,

performs at exactly the motor efficiency which is required as minimum value for motors of efficiency class IE 3 according to IEC 60034-30-1.

According to the definition, the reference power $P_{1,ref}$ is calculated for an actual pump unit in the following way:
the reference hydraulic power $P_{hyd,ref}$:

$$P_{hyd,ref} = (\rho_W \cdot g \cdot \left(Q_{100\%} / 3600 \right) \cdot H_{100\%}) / 1000 \quad [kW]$$

the specific speed of the pump n_s:

$$n_s = n_{100\%} \cdot \frac{\sqrt{Q_{100\%}/3600}}{[H_{100\%}/i]^{0.75}} \quad [\text{min}^{-1}]$$

The density of clean cold water ρ_W is 1000 kg/m^3 and the gravitational constant g is 9.81 m/s^2. The units to be used are [m^3/h] for the flow rate Q_{BEP} and [m] for the pump head $H_{100\%}$. The reference hydraulic power $P_{,hyd,ref}$ results in the unit [kW].

The units to be used are:
[1/min] for the nominal rotational speed $n_{100\%}$,
[m^3/h] for the flow rate Q_{BEP} and
[m] for the pump head H_{BEP}.
i is the number of stages of multistage pumps; in the case of single stage pumps $i = 1$.

The reference pump efficiency $\eta_{ref,PU} = \eta_{100\%}$ is given by the equation:

$$\eta_{100\%} = -11{,}48(\ln(n_s))^2 - 0{,}85 \cdot (\ln(Q_{100\%}))^2 - 0{,}38 \cdot \ln(n_s) \cdot \ln(Q_{100\%}) + 88{,}59 \ln(n_s) + 13{,}46 \cdot \ln(Q_{100\%}) - C$$

'Reference power' means a relation between hydraulic power and power consumption of a water pump unit, based on a fictitious water pump with MEI =0.4 and a fictitious motor with efficiency level IE3.

The reference shaft power $P_{2,ref}$ in the pump unit [kW] is calculated:

$$P_{2,ref} = \frac{P_{hyd,ref}}{\frac{1}{100} \cdot \eta_{ref,PU} - \Delta\eta} \left[kW\right]$$

The reference motor efficiency $\eta_{ref,Mot}$ is given by

$$\eta_{ref,M} = a\left[log_{10}\left(\frac{P_{2,ref}}{1kW}\right)\right]^3 + b \cdot \left[log_{10}\left(\frac{P_{2,ref}}{1kW}\right)\right]^2 + c \cdot log_{10}\left(\frac{P_{2,ref}}{1kW}\right) + d\left[\%\right]$$

with

	Case 1: motor ($P_{2,ref}$ > 0,75kW)		**Case 2: motor ($P_{2,ref}$ < 0,55kW)**	
Coefficient	**2-pole**	**4-pole**	**2-pole**	**4-pole**
'*a*'	0,356 9	0,077 3	6,853 2	7,635 6
'*b*'	- 3,307 6	- 1,895 1	6,200 6	4,823 6
'*c*'	11,610 8	9,298 4	25,131 7	21,090 3
'*d*'	82,250 3	83,702 5	84,039 2	86,099 8

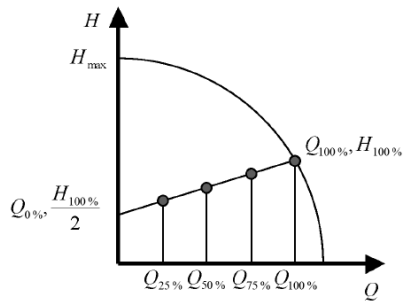
values for motors with 0,55kW < $P_{2,ref}$ < 0,75kW have to be linearly interpolated between the resulting values of Case 1 at 0,75kW and of Case 2 at 0,55kW.

The reference electric power input is

$$P_{1,ref} = \frac{P_{2,ref}}{\frac{1}{100} \cdot \eta_{ref,M}} \left[kW\right]$$

Define the reference control curve as the straight line between the points:

$(Q_{100\,\%}, H_{100\,\%})$ and $(Q_{0\,\%}, \frac{H_{100\,\%}}{2})$



$$H_i / H_{100\%} = \left[0,5 + 0,5 \cdot \left(Q_i / Q_{100\%} \right) \right]$$

6. Select a setting of the water pump unit so that the water pump unit runs at the best efficiency point on the pump curve.

   'System curve' means a relationship between flow and head (H = f(Q)) resulting from friction in the pumping system.

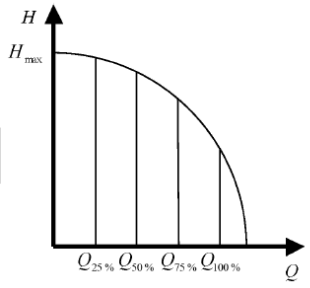
7. For a pump unit with a VSD adjust the water pump unit to load points inside a tolerance band according to the technical state of the art. Measure the electric power consumption of the water pump unit P_1 resulting from the load points :

   $[Q_{100\%} ; H_{100\%}]$,
   $[0,75 \cdot Q_{100\%} ; 0,875 \cdot H_{100\%}]$,
   $[0,5 \cdot Q_{100\,\%}, 0,75 \cdot H_{100\%}]$,
   $[0,25 \cdot Q_{100\,\%}; 0,625 \cdot H_{100\%}]$

   'P_1' means the electrical power consumption (in Watts) by the water pump unit at the specified point of operation.

   For a pump unit without a VSD measure the electric power consumption of the water pump unit P_1 and H resulting from the following flows:

   $Q_{100\%} ; 0,75 \cdot Q_{100\%} ; 0,5 \cdot Q_{100\,\%} ; 0,25 \cdot Q_{100\,\%}$



8. Calculate $P_{1,avg}$ as follows:

   The measured electric power $P1$,meas at the flow rate Qi at the given head of Hi shall be corrected (except for mode of operation M2) by

$$P_{1,corr} = \left(\frac{H_i}{H_{measured}} \right) \cdot P_{1,measured}$$

9. Using the measured values of $P_{1,corr}$ and the reference flow-time profile:

Flow Q in % of $Q_{100\%}$	25	50	75	100

Time Δt in % of total operating time	44	35	15	6

10. Calculate the weighted average power $P_{1,avg}$ as:

$$P_{1,avg,v} = \sum_{i=1}^{i=4}\left[\left(\frac{\Delta t}{100}\right)_i \cdot P_{1,corr,i}\right]$$

$$P_{1,avg,v} = 0{,}06 \cdot P_{1,avg,\,100\,\%} + 0{,}15 \cdot P_{1,avg\,75\,\%} + 0{,}35 \cdot P_{1,avg\,50\,\%} + 0{,}44 \cdot P_{1,avg\ 25\,\%}$$

11. Calculate the energy efficiency index EEI_V as:

$$EEI_v = \frac{P_{1,avg,v}}{P_{1,ref}}$$

4. DETERMINATION OF THE EEIV FOR BOOSTER SETS (BS)

1. For booster sets placed on the market in single components the EEIv calculation shall be based on state of the art calculation methods.

   For booster sets placed on the market with a motor and with or without a VSD the EEI_v calculation shall be based on measurement of the complete unit or shall be based on the procedure for booster sets placed on the market in single components.

2. If in the booster set an expansion tank and/or a "jockey pump" is integrated they shall not affect the EEI value and therefore shall be deactivated during tests to determine EEI_v except a tank of a volume $V_{tank} \leq 10\,l + (Q_{100\%}/1m^3/h)$.
   Expansion tank and/or "jockey pump" shall be neglected if the booster set is placed on the market in components.

3. Find the point of maximum hydraulic output power of the booster set and define the flow and head at this point as: $Q_{100\%}$ and $H_{100\%}$.

4. The reference flow-time profile for booster sets is

Flow Q in % of $Q_{100\%}$	10	20	30	40	50	60	70	80	90	100
Time Δt in % of total operating time	6	21	26	19	12	6	4	3	2	1

5. The reference control curve for booster sets is defined by:

$$H_{ref} / H_{100\%} = 100 \cdot [0.75 + 0.25 \cdot (Q / Q_{100\%})] \quad [\%]$$

6. For the case that the given head from the reference control curve at a load point from the flow-time profile is not reached, the following penalty has to be applied:

$$P_{1,pen}(Q_i) = 2 \cdot \frac{H_{ref}(Q_i) - H_{meas}(Q_i)}{H_{meas}(Q_i)} \cdot P_{1.meas}(Q_i)$$

with

$$H_{ref}(Q_i) = \frac{p_{ref}(Q_i) - p_s(Q_i)}{\rho \cdot g}$$

and

$$H_{meas}(Q_i) = \frac{p_{meas}(Q_i) - p_s(Q_i)}{\rho \cdot g}.$$

7. To determine the weighted average electric power input $P_{1,\text{avg}}$ perform the following steps:

Measure the electric power input P_1 as described in Sub-section 8.2 for all values of the relative flow rate $Q/Q_{100\%}$ defined by the reference flow-time profile (see table 5.1 in Sub-section 5.1). Perform the measurements for increasing flow rate as well as for decreasing flow rate according to the reference flow-time profile.

Calculate the weighted average of the electric power $P_{1,\text{avg}}$ by the equation

$$P_{1,avg} = \sum_{i=1}^{i=10} \left[\left(\frac{\Delta t}{100} \right)_i \cdot P_{1,i} \right]$$

The final value to be used for the determination of EEI is the arithmetic mean of the two values $P_{1,avg,inc}$ and $P_{1,avg,dec}$

$$P_{1,avg} = \frac{P_{1,avg,inc} + P_{1,avg,dec}}{2}$$

$P_{1,ref}$ is a theoretical value which serves to refer the actual averaged electric power input $P_{1,avg}$ of a real booster set to this value and to lead to a dimensionless value for the energy efficiency.

For booster sets the reference electric power $P_{1,ref}$ is defined as the electric power input of a (virtual) reference booster set which

- is equipped with two (virtual) fixed speed pumps of the vertical multistage type (MS-V),

- is operated with clean cold water at the flow rate Q100% and at the booster head H100% of the actual booster set, determined by test as described in Sub-clause 8.2.2 or determined by the means of a SAM as described in Sub-clause 9.7,

- has at this operating point a total internal hydraulic loss (caused by piping and valves) of 2 m,

- has no auxiliary electric losses.

The (virtual) pumps have a specific speed of ns = 45 min-1 and an efficiency equal to the minimum value according to this specific speed and to a Minimum Efficiency Index (see EN 16480) of MEI = 0.4.
Each pump is driven by a fictitious 3-phase cage-induction motor which

- is of the 2-pole type and is directly fed by an electric grid with a frequency of 50 Hz,

- has a nominal power output which exactly equals the shaft power of the driven pump at its defined operating condition,

- performs at exactly the motor efficiency which is required as minimum value for motors of efficiency class IE 3 according to IEC 60034-30-1.

According to its definition, the reference power $P_{1,ref}$ is calculated for an actual booster set in the following way:

The reference hydraulic power $P_{hyd,ref}$ of each of the 2 pumps is

$$\left(P_{hyd,ref}\right)_{per\ pump} = \left[\rho \cdot g \cdot \left(\frac{1}{2} \cdot \frac{Q_{100\%}}{3600}\right) \cdot \left(H_{100\%} + 2m\right)\right] / 1000 \quad [kW]$$

with ρ = 998,2 kg/m³, g = 9.81 m/s² and $Q_{100\%}$ in [m³/h],

In correspondence to EN 16480, the reference pump efficiency $\eta_{ref,PU}$ is given by the equation

$$\eta_{ref,PU} = -11.48\left(ln\left(n_s\right)\right)^2 - 0.85 \cdot \left(ln\left(Q_{100\%}/2\right)\right)^2 - 0.38 \cdot ln\left(n_s\right) \cdot ln\left(Q_{100\%}/2\right) + 88.59 ln\left(n_s\right) + 13.46 \cdot ln\left(Q_{100\%}/2\right) - C$$

with n_s = 45 min^{-1}, C = 133.95 and MEI = 0.4 the reference pump efficiency $\eta_{ref,PU}$ is defined as

$$\eta_{ref,PU} = -0.85 \cdot \left(ln\left(Q_{100\%}/2\right)\right)^2 - 1.45 \cdot ln\left(Q_{100\%}/2\right) + 13,46 \cdot ln\left(Q_{100\%}/2\right) + 36.93$$

Calculate with the reference hydraulic power $P_{hyd,ref}$ per pump and with the reference pump efficiency $\eta_{ref,PU}$ the reference shaft power $P_{2,ref}$ of each of the (virtual) pumps in [kW]:

$$\left(P_{2,ref}\right)_{per\ pump} = 100 \cdot \frac{P_{hyd,ref}}{\eta_{ref,PU}} \quad [kW]$$

The reference motor efficiency is defined in Annex IV 2 5.

Calculate $P_{1,ref}$ as:

$$P_{1,ref} = 100 \cdot \frac{2 \cdot \left(P_{2,ref}\right)_{per\ pump}}{\eta_{ref,M}} \ [kW]$$

8. Calculate the energy efficiency index EEI_v for booster sets with:

$$EEI_{v,booster\ sets} = \frac{P_{1,avg,v}}{P_{1,ref}}$$

ANNEX IV

VERIFICATION PROCEDURE FOR MARKET SURVEILLANCE PURPOSES

The verification tolerances defined in this Annex relate only to the verification of the measured parameters by Member State authorities and shall not be used by the manufacturer, importer or authorised representative as an allowed tolerance to establish the values in the technical documentation or in interpreting these values with a view to achieving compliance or to communicate better performance by any means.

Where a model has been designed to be able to detect it is being tested (e.g. by recognizing the test conditions or test cycle), and to react specifically by automatically altering its performance during the test with the objective of reaching a more favourable level for any of the parameters specified in this Regulation or included in the technical documentation or included in any of the documentation provided, the model and all equivalent models shall be considered not compliant.

When verifying that a product model complies with the requirements laid down in this Regulation pursuant to Article 3(2) of Directive 2009/125/EC the authorities of the Member States shall apply the following procedure for the requirements referred to in Annex II.

(1) The Member State authorities shall verify one single unit of the model.

(2) The model shall be considered to comply with the applicable requirements if:

(a) the values given in the technical documentation pursuant to point 2 of Annex IV to Directive 2009/125/EC (declared values) and where applicable the values used to calculate these values are not more favourable for the manufacturer, importer or authorised representative than the results of the corresponding measurements carried out pursuant to point (g) thereof; and

(b) the declared values meet any requirements laid down in this Regulation and any required product information published by the manufacturer, importer or authorised representative does not contain values that are more favourable for the manufacturer, importer or authorised representative than the declared values; and

(c) when the Member State authorities test the unit of the model, the determined values (the values of the relevant parameters as measured in testing and the values calculated from these measurements) comply with the respective verification tolerances as set out in Table 2.

(3) If the results referred to in points (2)(a) or (2)(b) are not achieved the model and all equivalent models shall be considered not to comply with this Regulation.

(4) If the result referred to in point (2)(c) is not achieved;

(a) for models that are produced in quantities of less than five per year including equivalent models, the model and all equivalent models shall be considered not to comply with this Regulation;

(b) for models that are produced in quantities of five or more per year including equivalent models, the Member State authorities shall select three additional units of the same model for testing. As an alternative, the three additional units selected may be one or more of equivalent models.

(5) The model shall be considered to comply with the applicable requirements if for these three units the arithmetical mean of the determined values complies with the respective verification tolerances given in Table 2.

(6) If the result referred to in point (5) is not achieved the model and all equivalent models shall be considered not to comply with this Regulation.

(7) The Member State authorities shall provide all relevant information to the authorities of the other Member States and to the Commission without delay after a decision is taken on the non-compliance of the model according to points (3) or (6).

The Member State authorities shall use the measurement and calculation methods set out in Annex III.

The Member State authorities shall only apply the tolerances set out in Table 2 and shall only use the procedure described in points (1) to (7) for the requirements referred to in this Annex. For the parameters in Table 2, no other tolerances such as those set out in harmonised standards or in any other measurement method shall be applied.

Table 2

Verification tolerances

Parameters	**Verification tolerances**
Efficiency at BEP (η_{BEP})	The determined value* shall not be lower than the declared value by more than 5 %.
Efficiency at PL (η_{PL})	The determined value* shall not be lower than the declared value by more than 5 %.
Efficiency at OL (η_{OL})	The determined value* shall not be lower than the declared value by more than 5 %.

* In the case of three additional units tested as prescribed in point 4 (b), the determined value means the arithmetical mean of the values determined for these three additional units.

ANNEX V

INDICATIVE BENCHMARKS

At the time of adoption of this Regulation the best available technology on the market for the environmental aspects that were considered significant and are quantifiable is efficiency index (MEI) ≥ 0,70.