
Črpalke - Metode za opredelitev indeksa energijske učinkovitosti centrifugalnih črpalk - 3. del: Preskušanje in računanje indeksa energijske učinkovitosti (IEE) ojačevalnih agregatov

Pumps - Methods of qualification of the Energy Efficiency Index for rotodynamic pump units - Part 3: Testing and calculation of energy efficiency index (EEI) of booster sets

Pumpen - Methoden zur Qualifikation des Energieeffizienzindex für Kreiselpumpen - Teil 3: Prüfung und Berechnung des Energieeffizienzindex (EEI) von Druckerhöhungsanlagen

Pompes - Méthodes de qualification de l'indice de rendement énergétique des groupes motopompes rotodynamiques - Partie 3 : Essais et calcul de l'indice de rendement énergétique (EEI) des groupes de surpression

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23.080

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EN 17038-3

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English Version

Pumps - Methods of qualification of the Energy Efficiency
Index for rotordynamic pump units - Part 3: Testing and
calculation of energy efficiency index (EEI) of booster sets

Pompes - Méthodes de qualification de l'indice de
rendement énergétique des groupes motopompes
rotodynamiques - Partie 3 : Essais et calcul de l'indice
de rendement énergétique (EEI) des groupes de
surpression

Pumpen - Methoden zur Qualifikation des
Energieeffizienzindex für Kreiselpumpen - Teil 3:
Prüfung und Berechnung des Energieeffizienzindex
(EEI) von Druckerhöhungsanlagen

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EN 17038-3:2026 (E)**European foreword**

This document (EN 17038-3:2026) has been prepared by Technical Committee CEN/TC 197 “Pumps”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2027, and conflicting national standards shall be withdrawn at the latest by March 2027.

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Introduction

This document is the third part of a series of standards describing a methodology to evaluate energy efficiency performance of booster sets, comprising one or more pump(s), the motor(s) with or without frequency converter, and additional components influencing hydraulic performance. It is based on a non-dimensional numerical value called energy efficiency index (*EEI*). An *EEI* allows the comparison of different configurations with one common indicator. Physical influences such as number and size of the incorporated pump(s), pump unit part-load operation, motor-efficiency characteristic and frequency converter influence are implemented into this metric.

Specific requirements for testing and a calculation method for *EEI*, the so-called semi-analytical model (SAM) of a complete booster set, a specific flow-time profile and a reference control curve are given in this part of the series of standard.

EEI is an index to rate booster sets according to their energy efficiency but does not replace the need to do a life-time cost analysis regarding energy consumption over the lifetime of the booster set.

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1 Scope

This document specifies methods and procedures for testing, calculating and determining the energy efficiency index (*EEI*) of booster sets.

A booster set is either a single pump unit or an assembly of pump units connected in parallel with a maximum hydraulic power of 150 kW, a minimum rated flow of 6 m³/h (0,001 667 m³/s), 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.

A booster set with a rated flow below 6 m³/h is composed using pumps that comply with EN 17038-2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 9906:2012, *Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1, 2 and 3 (ISO 9906:2012)*

EN ISO 17769-1, *Liquid pumps and installation — General terms, definitions, quantities, letter symbols and units — Part 1: Liquid pumps (ISO 17769-1)*

EN ISO 17769-2, *Liquid pumps and installation — General terms, definitions, quantities, letter symbols and units — Part 2: Pumping System (ISO 17769-2)*

EN 60034-1, *Rotating electrical machines — Part 1: Rating and performance (IEC 60034-1)*

EN IEC 60034-2-1, *Rotating electrical machines — Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles) (IEC 60034-2-1)*

EN 60038:2011, *CENELEC standard voltages (IEC 60038:2009)*

EN 61800-9-2, *Adjustable speed electrical power drive systems — Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications — Energy efficiency indicators for power drive systems and motor starters*

EN IEC 61800-2, *Adjustable speed electrical power drive systems — Part 2: General requirements — Rating specifications for low voltage adjustable speed AC power drive systems (IEC 61800-2)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 17769-1, EN ISO 17769-2 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

booster set

single pump unit or assembly of pump units connected in parallel with a maximum hydraulic power of 150 kW, a minimum rated flow of 6 m³/h (0,001 667 m³/s), 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

Note 1 to entry: “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 considered.

[SOURCE: Regulation (EU) 547/2012]

3.2

expansion tank

tank partially filled with air, whose compressibility cushions pressure deviations under balancing small water volumes between the tank and the connected system

3.3

fixed speed pump

pump unit without an electronic power converter (e.g. frequency converter)

3.4

variable speed pump

pump unit equipped with an electronic power converter (e.g. frequency converter)

3.5

stand-by pump

pump unit which intentionally increases the number of pumps in *booster set* (3.1) compared to the installation demand for redundancy reasons

3.6

jockey pump

pump unit sized for considerably less flow than other pumps of the *booster set* (3.1) and intended only to handle leakage flows and/or small flows during cut-in of another pump

3.7

suction pressure

pressure at the inlet of a *booster set* (3.1)

Note 1 to entry: Pressures are gauge pressures (relative to the atmospheric pressure).

3.8

discharge pressure

pressure at the outlet of a *booster set* (3.1)

Note 1 to entry: Pressures are gauge pressures (relative to the atmospheric pressure).

3.9

total differential head

height at which the water is raised vertically by the *booster set* (3.1)

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3.10**hydraulic power**

power of the pumped water transferred by a pump, defined mainly by flow rate and *total differential head* (3.9)

3.11**nominal booster set flow rate**

design operation flow rate of the *booster set* (3.1), typically defined by *nominal booster set speed* (3.12) and high booster set efficiency, e.g. the best efficiency point of the booster set (resp. the best efficiency point of one pump multiplied by the pump number)

3.12**nominal booster set speed**

maximum speed that the *booster set* (3.1) is designed to run continuously

3.13**best efficiency point****BEP**

pump or *booster set* (3.1) duty point with highest total efficiency “wire to water”

3.14**100% duty point**

duty point of maximum value of the *hydraulic power* (3.10) at *nominal booster set speed* (3.12)

Note 1 to entry: It is to be expected more or less close to the nominal booster set duty point.

3.15**control curve**

adjusted *discharge pressure* (3.8) dependent on flow rate of a *booster set* (3.1)

Note 1 to entry: See also A.2.1.

3.16**reference control curve**

representative pressure control curve defined relatively by the *100%-duty point* (3.14)

3.17**reference total differential head**

total differential head (3.9) defined by the *reference control curve* (3.16) and the *reference flow rate* (3.18)

3.18**reference flow rate**

flow rate defined by the *100%-duty point* (3.14) and the *flow-time profile* (3.19)

3.19**flow-time profile**

relation between defined flow rate intervals and relative operation time

3.20**complete drive module****CDM**

electronic power converter connected between the electric supply and a motor as well as extensions such as protection devices, transformers and auxiliaries

Note 1 to entry: The complete drive module shall be according to EN IEC 61800-2.

3.21**power drive system****PDS**

combination of a *CDM* (3.20) and an electric motor

4 Symbols and abbreviations

The symbols and units given in Tables 1 and 2 and the indices given in Tables 3 and 4 apply.

Table 1 — Symbols and units

Symbol	Designation	Unit
E	Uncertainty	- (dimensionless)
EEI	Energy efficiency index	-
EEI_{base}	Base value of EEI	-
H_m	Motor efficiency	-
H_{pump}	Pump efficiency	-
g	Gravitational acceleration	m/s ²
H	Total differential head	m
$H_{100\%,\text{loss}}$	Total differential head loss at 100 %-duty point	m
I	Duty point	-
M	Sample number	-
n_s	Pump specific speed	1/min
K	Pressure ratio	-
P_1	Electric power input	kW
$P_{1,\text{avg}}$	Average electric power input	kW
$P_{1,\text{ref}}$	Reference electric power input	kW
$P_{1,\text{pd-corr}}$	Discharge-pressure-corrected electric power input	kW
$P_{1,\text{ps-corr}}$	Suction-pressure-corrected electric power input	kW
$P_{1,\text{Q-corr}}$	Flow-rate-corrected electric power input	kW
$P_{2,\text{ref}}$	Reference pump shaft power	kW
P_{hyd}	Hydraulic power	kW
p_d	Discharge pressure	Pa
p_s	Suction pressure	Pa

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Symbol	Designation	Unit
Q	Flow rate	m ³ /h
z	Number of relevant booster set pumps	-
$\Delta t / t_{\text{tot}}$	Time ratio	-
ρ	Water density	kg/m ³
U	Voltage	V
I	Current	A
$T_{63\%}$	Time constant	s
$A_p B_p C_p D_p$	Polynomial parameters hydraulic power	-
$A_{pd} B_{pd} C_{pd} D_{pd}$	Polynomial parameters measured discharge pressure	-
$A_{ps} B_{ps} C_{ps} D_{ps}$	Polynomial parameters measured suction pressure	-

Table 2 — Additional symbols and units for Clause 7 (SAM)

Symbol	Designation	Unit
$p_{\min}$	Minimum pressure	Pa
$p_{\max}$	Maximum pressure	Pa
$Q_{II \rightarrow I}$	Hysteresis of flow switching from pump II to pump I	m ³ /h
Q_{off}	Threshold flow when a pump is triggered to switched off	m ³ /h
Q_{tr}	Steady-state flow after pump switching off	m ³ /h
n	Rotational pump speed	1/min
$j p (1p, 2p, 3p)$	Booster set characteristic for j running pump	-
$H_{L,\text{tot}}$	Total, internal hydraulic loss	m
P_2	Pump shaft power	kW
$P_{\text{el,aux}}$	Auxiliary electric losses	kW
$\zeta_{\text{n.r.v}}$	Loss coefficient of the non-return valves	-
$\zeta_{\text{c.o.v}}$	Loss coefficient of cut-off valves	-
$\zeta_{\text{piping element } i}$	Loss coefficient of piping element i	-
$A_{N,\text{PU}}$	Nominal suction and discharge cross sections	m ²
A_i	Inner cross section of a pipe element i	m ²
$Q_{\text{piping element } i}$	Flow rate of piping element i	m ³ /h
Q_{PU}	Flow rate of the pump unit	m ³ /h
H_{PU}	Total differential head of the pump unit	m
$A_{\text{hyd}}, B_{\text{hyd}}, C_{\text{hyd}}, D_{\text{hyd}}$	Polynomial parameters of relative hydraulic power	-
$a_{\text{H}}, b_{\text{H}}, c_{\text{H}}, d_{\text{H}}$	Polynomial parameters of relative total differential head	-
s	Relative flow factor of running pumps	-

Symbol	Designation	Unit
j	Number of actually running pumps	-
k_{corr}	Correction factor	-
a_p, b_p, c_p, d_p	Polynomial parameters of shaft power	-
$P_{N,M}$	Nominal motor shaft power	kW
T	Shaft torque	Nm
D_{imp}	Impeller diameter	m
$\Delta t/100$	Time ratio	-
CD_{corr}	Correction factor for control deviation	-
F	Sensitivity factor	-
t_{EEI}	Manufacturing tolerance	-

Table 3 — Indices

Indices	Designation
0 %	At zero flow rate
10 %	At 10 %-duty point
...	...
100 %	At 100 %-duty point
adj	Adjusted
BEP	Best efficiency point
calc	Calculated
dec	Decreasing flow measurement
exp	Expected
i	At duty point i
$i+10$ %	At duty point $i+10$ %
inc	Increasing flow measurement
meas	Measured
rate	Rated
ref	Reference

Table 4 — Additional indices for Clause 7 (SAM)

Indices	Designation
N_PU	Nominal pump unit
tot	Total
L	Loss
PU	Pump unit

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Indices	Designation
hyd	Hydraulic
inc	Referring to increasing quantities
dec	Referring to decreasing quantities
var	Variable speed pump
fix	Fixed speed pump

5 Reference pressure control curve and reference flow-time profile**5.1 The 100 %-duty point**

The 100 %-duty point is defined as duty point of maximum hydraulic power at nominal booster set speed, see 3.11.

The flow rate at 100 %-duty point $Q_{100\%}$ is defined as flow rate of that duty point.

The total differential head at 100 %-duty point $H_{100\%}$ is defined as total differential head of the that same duty point.

For details of determination see Clause 6.

5.2 Reference pressure control curve

The reference control curve for booster sets is defined by Formula (1):

$$H_{\text{ref}} = H_{100\%} \cdot \left[0,75 + 0,25 \cdot \left(\frac{Q}{Q_{100\%}} \right) \right] \quad (1)$$

where

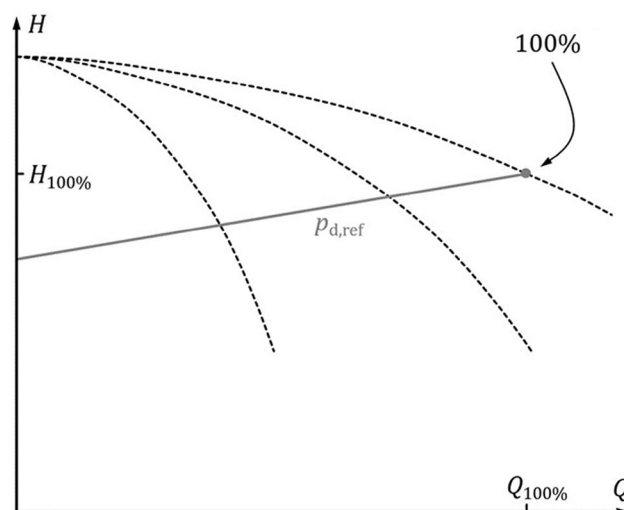
H_{ref} is the reference total differential head in m;

$H_{100\%}$ is the total differential head at 100 %-duty point in m;

Q is the flow rate in m³/h;

$Q_{100\%}$ is the flow rate at 100 %-duty point in m³/h.

See Figure 1 for illustration of a Q - H -curve field of an example booster set with three pumps.

**Key**

100 % 100 % duty point

 $p_{d,ref}$ reference discharge pressure in Pa**Figure 1 — Reference pressure control curve**

NOTE Annex A and Annex C describe the different control methods for booster sets. Sets with only fixed speed pumps will follow a curve of higher pressure based on the Q - H -curve of the pumps and the constant (minimum) pressure setting of the control. Sets which can follow the reference pressure control curve will show a better energy efficiency index (EEI). Sets with fixed speed pumps programmed to follow the reference pressure control (as best they can) will have a better energy efficiency index (EEI) than if programmed for constant pressure.

5.3 Reference flow-time profile

The reference flow-time profile for booster sets is defined in Table 5.

Table 5 — Reference flow-time profile for booster sets

Duty point	i	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
Flow ratio	$Q / Q_{100\%}$	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
Time ratio	$\Delta t / t_{tot}$	6 %	21 %	26 %	19 %	12 %	6 %	4 %	3 %	2 %	1 %

See Figure 2 for a diagram showing the flow-time profile.