SLOVENSKI STANDARD
oSIST prEN 17038-3:2025

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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 rotordynamic pump units - Part 3: Testing and calculation of energy efficiency index (EEI) of booster sets

Pumpen - Methoden zur Qualifikation des Energieeffizienzindexes für Kreiselpumpen - Teil 3: Prüfung und Berechnung des Energieeffizienzindexes (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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EUROPEAN COMMITTEE FOR STANDARDIZATION
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European foreword

This document (prEN 17038-3:2024) has been prepared by Technical Committee CEN/TC 197 “Pumps”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

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.

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 m^3/h (0,001667 m^3/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 m^3/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 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 IEC 61800-2, *Adjustable speed electrical power drive systems — Part 2: General requirements — Rating specifications for low voltage adjustable speed a.c. power drive systems (IEC 61800-2)*

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 61800-9-2)*

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 m^3/h (0,001 667 m^3/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/m^3, and with a maximum dissolved solid content of 50 kg/m^3, 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: Commission Regulation EU No. 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
the height at which the water is raised vertically by the *booster set* (3.1)

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: 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 Table 1 and the indices given in Table 2 apply.

Table 1 — Symbols and units

Symbol	Designation	Unit
e	Uncertainty	- (dimensionless)
EEI	Energy efficiency index	-
η_{m}	Motor efficiency	-
η_{pump}	Pump efficiency	-
g	Gravitational acceleration	$\mathrm{m/s^2}$
H	Total differential head	m
$H_{100\ \%,\mathrm{loss}}$	Total differential head loss at 100 %-duty point	m
i	Duty point	-
m	Sample number	-
k	Pressure ratio	-
P_1	Electric power input	kW
$P_{1,\mathrm{avg}}$	Average electric power input	kW
$P_{1,\mathrm{ref}}$	Reference electric power input	kW
$P_{1,\mathrm{pd\text{-}corr}}$	Discharge-pressure-corrected electric power input	kW
$P_{1,\mathrm{ps\text{-}corr}}$	Suction-pressure-corrected electric power input	kW
$P_{1,\mathrm{Q\text{-}corr}}$	Flow-rate-corrected electric power input	kW
$P_{2,\mathrm{ref}}$	Reference pump shaft power	kW
P_{hyd}	Hydraulic power	kW
p_{d}	Discharge pressure	Pa
p_{s}	Suction pressure	Pa

Symbol	Designation	Unit
Q	Flow rate	m^3/h
z	Number of relevant booster set pumps	-
Δt / t_{tot}	Time ratio	-
ρ	Water density	kg/m^3

Table 2 — 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

5 Reference pressure control curve and reference flow-time profile

5.1 100 %-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):

$$H_{ref} = H_{100\%} \cdot \left[0.75 + 0.25 \cdot \left(\frac{Q}{Q_{100\%}} \right) \right] \quad (1)$$

where

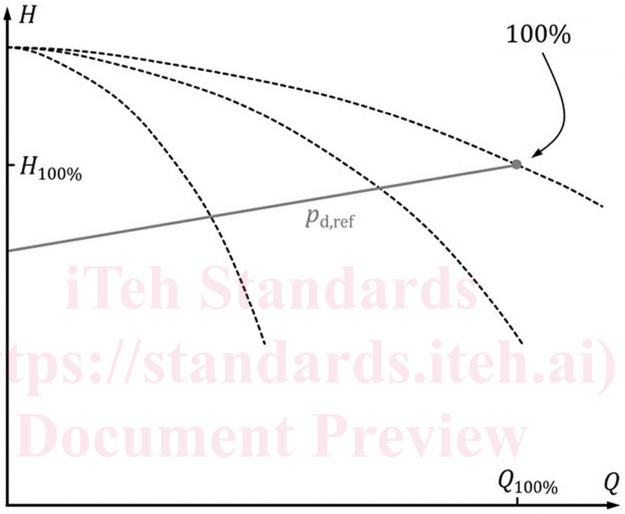
H_{ref} is the reference total differential head in m;

$H_{100\,\%}$ 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 an *Q*-*H*-curve field of an example booster set with three pumps.



Key

100 % 100 %-duty point

$p_{\text{d,ref}}$ reference discharge pressure in Pa

Figure 1 — Reference pressure control curve

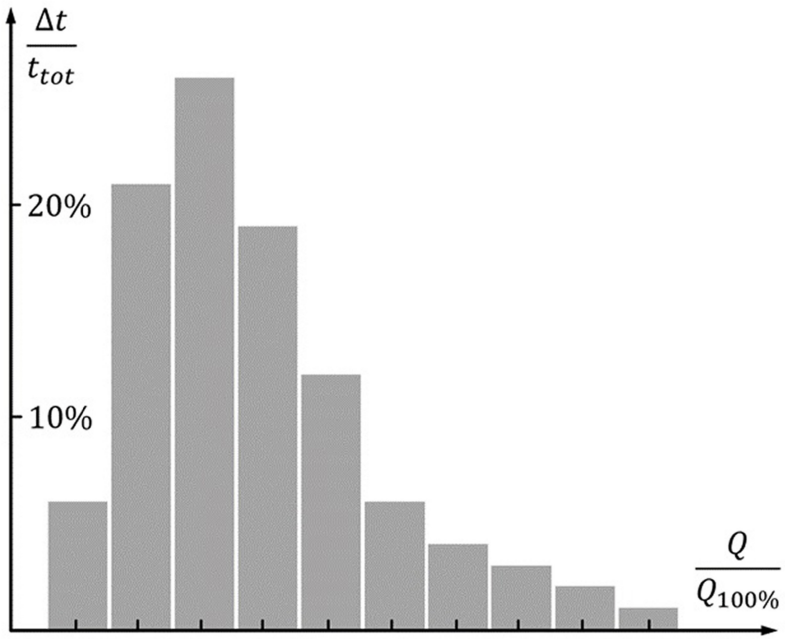
5.3 Reference flow-time profile

The reference flow-time profile for booster sets is defined in Table 3.

Table 3 — Reference flow-time profile for booster sets

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

See Figure 2 for a diagram.



Key

Δt / t_{tot}	time ratio
Q / $Q_{100\,\%}$	flow ratio

Figure 2 — Flow-time profile

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.

6 Determination of average electric power input $P_{1,avg}$ by test

6.1 General

This clause specifies performance tests and evaluations on booster sets which are carried out by a company which places the booster set on the market and/or puts it into service; Such tests shall provide the necessary information on the actual performance values of test booster sets needed for the calculation of the EEI-value according to its definition given in EN 17038-1:2019[1], Clause 4.

6.2 Test bench setup

6.2.1 General

All provisions for the test concerning the booster set (taken as “black box” and treated as a pump unit such as described in EN 17038-2) shall be in accordance with EN ISO 9906, grade 2. The exception for power of 10 kW and below (as allowed for the application of EN ISO 9906 on acceptance tests) shall not be valid.

[1] As impacted by EN 17038-1:2019/AC:2021.