SLOVENSKI STANDARD
SIST EN 17038-1:2019

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Črpalke - Metode za kvalifikacijo in verifikacijo indeksa energijske učinkovitosti centrifugalnih črpalk - 1. del: Splošne zahteve in postopki za preskušanje in izračun indeksa energijske učinkovitosti (EEI)

Pumps - Methods of qualification and verification of the Energy Efficiency Index for rotodynamic pumps units - Part 1: General requirements and procedures for testing and calculation of energy efficiency index (EEI)

Pumpen - Methoden zur Qualifikation und Verifikation des Energieeffizienzindexes für Kreiselpumpen - Teil 1: Allgemeine Anforderungen und Vorgehensweisen zur Prüfung und Berechnung des Energieeffizienzindexes (EEI)

Pompes - Méthodes de qualification et de vérification de l'indice de rendement énergétique des groupes motopompes rotodynamiques - Partie 1 : Exigences générales et procédures d'essai et de calcul de l'indice de rendement énergétique (EEI)

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 17038-1:2019) 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of an identical text or by endorsement, at the latest by November 2019, and conflicting national standards shall be withdrawn at the latest by November 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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Introduction

This document is the first part of a series of standards describing a methodology to evaluate energy efficiency performance of pump units, comprising the pump, the motor with or without frequency converter, based on a non-dimensional numerical value called Energy Efficiency Index (*EEI*). An *EEI* allows the comparison of different pump sizes and types with one common indicator. Physical influences such as pump size, specific speed, pump unit part-load operation, motor-efficiency characteristic and frequency converter influence are implemented into this indicator.

This standard series covers pump units which component wise can be placed on the market and assembled into a pump unit or are placed on the market as one single product. To cover these two cases a semi-analytical model has been developed in order to derive the *EEI* based on nominal data of the components only. This case happens for example when an assembler of the components builds the pump unit on site and consequently a product test cannot be done by for this assembler or when a manufacturer is quoting a pump-unit which uses a combination of components not previously built.

This particular standard gives an overview of the basic concept of *EEI* (Clause 4), basic concepts of flow-time profiles and reference pressure control curves, the qualification (Clause 5) of a pump unit type regarding an *EEI* and the verification of *EEI* values (Clause 6) given for a pump unit type either by measurement or calculation.

Specific requirements for testing, a calculation method for an *EEI*, the so called semi-analytical model of a complete pump unit, specific flow-time profiles and reference control curves are given in the subsequent parts of this standard series.

1 Scope

This document describes a methodology to evaluate energy efficiency performance of pump units based on a non-dimensional numerical value called Energy Efficiency Index (*EEI*).

This document covers pump units consisting of:

— one single or several rotodynamic water pump(s), including where integrated in other products, and driven by a motor system, consisting of an electrical motor, and either:

  — a terminal box which only enables to operate the pump unit at constant motor stator frequency and thereby (nearly) constant rotational speed, or

  — a CDM (Complete Drive Module) which enables to operate the pump unit at variable rotational speed depending on a varying demand of flow rate and/or discharge or differential pressure.

NOTE A CDM is also often called VSD (Variable Speed Drive).

Pump units as defined above are treated as extended products in respect to their energy efficiency.

2 Normative references

There are no normative references in this document.

3 Terms and definitions, symbols and subscripts

For the purpose of this document, the following terms and definitions apply.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
fixed speed
constant motor stator frequency

3.2
variable speed
varying motor stator frequency

3.3
Energy Efficiency Index
EEI
ratio between $P_{1,\,\text{avg}}$ and $P_{1,\,\text{ref}}$

3.4
reference electrical power input $P_{1,\,\text{ref}}$
calculated power input of the pump unit at the best efficiency point

3.5
average electrical power input $P_{1,\,\text{avg}}$
power input weighted by the load profile

3.6
pump unit
pump driven by a motor system

3.7
motor system
combination of an electric motor and either a terminal box or a CDM

3.8
pump unit type
identical pump units of the same configuration

3.9
pressure control curve
functional dependency of the demanded head H vs. the delivered flow rate Q in the form of a non-dimensional correlation $H/H_{100\%} = f\,(Q/Q_{100\%})$

3.10
reference pressure control curve
pre-defined functional dependency $H/H_{100\%} = f\,(Q/Q_{100\%})$ for standardized measurements and calculations of average power input $P_{1,\,\text{avg}}$

3.11
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

[SOURCE: EN 61800-2]

3.12
Power Drive System
PDS
combination of CDM and motor

Table 1 — List of basic letters and subscripts

Symbol	Quantity	Unit
C	Constant	dimensionless number
D	Diameter	m
e	Measurement uncertainty, relative value	dimensionless number
E	Overall measurement uncertainty	dimensionless number
f	Frequency	s^{-1}, Hz
g	Acceleration due to gravity	m/s^2
H	Pump total head	m
k	Number of sample pumps	dimensionless number
m	Mass	kg
M	Number of pumps in a sample	dimensionless number
n	Speed of rotation	s^{-1}, min^{-1}
N	Number of instrument readings	dimensionless number
n_s	Specific speed	min−1
p	Pressure	Pa
p	Probability density	dimensionless number
P	Power	W
Q	(Volume) rate of flow	m^3/s
s	Standard deviation of a sample	according to special quantity
t	Tolerance factor, relative value	dimensionless number
t	Time	s
t	Student's factor	dimensionless number
T	Torque	Nm
u	Peripheral velocity	m/s
U	Mean velocity	m/s
U	Voltage	V
v	Local velocity	m/s
V	Volume	m^3
x	General quantity	according to specified usage
y	General quantity	according to specified usage
z	Height above reference plane	m
z	number of produced pumps	dimensionless number
η	Efficiency	dimensionless number
θ	Temperature	°C
ν	Kinematic viscosity	m^2/s
ρ	Density	kg/m^3
ω	Angular velocity	rad/s
σ	Standard deviation of normal distribution	according to special quantity

Table 2 — List of letters and figures used as subscripts

Subscript	Meaning
1	electrical
2	mechanical
abs	absolute
allowable	permitted e.g. by regulations
declared	indicated by the manufacturer
verification	permitted in verification process
individual	specific to one pump unit
amb	ambient
annual	per year
BEP	best efficiency point
dr	drive
D	datum
exp	experimentally determined
G	guaranteed
H	pump total head
I	numbering index
J	numbering index
imp	impeller
man	manufacturing
max	maximum permissible
mean	arithmetic mean value
meas	measured value
min, requ	minimum required
N	nominal
OL	overload
Pd	pre-defined
P	power
PL	part load
Q	(volume) flow rate
R	random
S	specific, systematic
sync	synchronous
tot	total, overall
true	true value
T	torque
v	vapour
x	of quantity x
y %	for probability of y %

4 Energy Efficiency Index (*EEI*) calculations

4.1 General information and explanation on *EEI*

The ratio of $P_{1,\text{ avg}}$ and $P_{1,\text{ ref}}$ is a quantitative indicator for the energy efficiency of pump units. It is called Energy Efficiency Index (*EEI*) and is defined by Formula (1):

$$EEI = \frac{P_{1,avg}}{P_{1,ref}} \tag{1}$$

In order to assess the efficiency of pump units, their actual electrical power input $P_{1,\text{ avg}}$ is compared with a reference value called $P_{1,\text{ ref}}$. It is a nominal power input of a fictitious pump unit running at nominal 100 % point.

The value of $P_{1,\text{ ref}}$ for the different pump types are defined in other parts of this standard.

The declared *EEI* value is based on the actual pump curves whether these are realized with full diameter impeller, a trimmed impeller or a power limited curve.

NOTE Contrary to the efficiency values η of the unit components, the lower the numerical value of *EEI*, the better the energy efficiency of pump units.

4.2 Weighted-average value of the electric power input

The quantification of energy efficiency of pump units should be based on the weighted average of electrical power input $P_{1,\text{ avg}}$.

The weighting factor when averaging the electrical power input P_1 is the fraction of operating time at the respective flow rate. Generally, for any application there is a continuous function describing the dependency of (differential) time fraction $\mathrm{d}t/t_{\text{tot}}$ on the relative flow rate $Q/Q_{100\ \%}$ where t_{tot} is the total operating time and $Q_{100\ \%}$ is defined in the specific parts of this standard.

For the assessment of the energy efficiency of pump units, common and standardized “flow-time profiles” are needed as basis for indicating their energy efficiency. The flow-time profile is defined for each pump type in other parts of this standard.

In order to simplify further the determination of a value which characterizes the energy efficiency of pump units, in this document the different flow-time profiles are described by a limited number of points, not by a continuous curve or function. These discrete points are pairs of values of $Q/Q_{100\ \%}$ and $\Delta t/t_{\text{tot}}$. These values define the discretised flow-time profiles. They are given as reference flow-time profiles in the specific parts of this standard. (In this case, Δt is a finite fraction of operating time and $Q/Q_{100\ \%}$ is the average value of relative flow rate demanded within this time fraction.)

NOTE 1 The reference flow-time profiles defined in this document for variable flow operation reflect the typical ranges and variations of demanded flow rate in these types of applications and are based on experimental field studies, see [1], [2].

For a given reference flow-time profile, the weighted average of the electric power input $P_{1,\,avg}$ is calculated by Formula (2):

$$P_{1,avg} = \sum_{i=1}^{N}\left[\left(\frac{\Delta t}{t_{tot}}\right)_i \cdot P_{1,i}\right] \quad (2)$$

where

i is the consecutive number of the points of the flow-time profile and N is the total number of the points of the flow-time profile.

For calculating $P_{1,\,avg}$, the electric power input P_1 shall be known for each value $Q/Q_{100\,\%}$ of the reference flow-time profile.

But as for the flow-time profiles, common and standardized correlations $H/H_{100\,\%} = f\,(Q/Q_{100\,\%})$ are needed as basis for indicating and comparing the energy efficiency of pump units placed on the market and/or put into service as extended products. These standardized correlations $H/H_{100\,\%} = f\,(Q/Q_{100\,\%})$ are called reference pressure control curves in this document and are defined in subsequent parts of this standard.

For calculating $P_{1,\,avg}$ in the case of variable speed operation, the electric power input P_1 shall be determined at the relative flow rate values $Q/Q_{100\,\%}$ of the relevant reference load-flow profile and for the corresponding rotational speed n.

NOTE 2 Especially at low values of $Q/Q_{100\,\%}$ the electric power input P_1 is considerably higher for pump units operated at constant motor stator frequency than for speed controlled pump units. This holds true independently of the actual pressure control curve.

4.3 The reference electric power input $P_{1,ref}$

For assessing the energy efficiency of pump units within the scope of this document, a non-dimensional value is needed which directly reflects the energy efficiency of pump units. The numerical magnitude of this value shall be independent of parameters which influence the unit component's efficiency such as, for example, their geometrical size and nominal power. For this purpose, the actual electrical power input $P_{1,\,avg}$ averaged according to Formula (1) is divided by an appropriate reference value $P_{1,\,ref}$. This reference value shall:

— have a physical basis;

— consider relevant influences on the electrical power input of pump units;

— be independent from the efficiency related quality of individual components of the pump unit.

The chosen definitions of $P_{1,\,ref}$ which fulfil these requirements are given in other parts of this standard.

5 Qualification of pump unit types in respect to their Energy Efficiency Index

5.1 General remarks

The qualification of a pump unit type in respect to the Energy Efficiency Index (*EEI*) is the responsibility of the company which places it on the market and/or puts it into service.

Product information on *EEI* of a pump unit type can either state the (legally) required *EEI* in the format "*EEI* ≤ 0.XX" or can indicate a lower value "*EEI* ≤ 0.YY" if the pump unit type is qualified for that and the manufacturer decides so. *EEI* values shall be rounded to two decimal places.