SIST

SLOVENSKI STANDARD
oSIST prEN 16480:2014

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Črpalke - Minimalna zahtevana učinkovitost centrifugalnih vodnih črpalk

Pumps - Minimum required efficiency of rotodynamic water pumps

Pumpen - Geforderte Mindesteffizienz bei Kreiselpumpen für Wasser

Pompes - Rendement minimum requis des pompes à eau rotodynamiques

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23.080	Črpalke	Pumps

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Pumps - Minimum required efficiency of rotodynamic water pumps

Pompes - Rendement minimum requis des pompes à eau rotodynamiques

Pumpen - Geforderte Mindesteffizienz bei Kreiselpumpen für Wasser

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

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Foreword

This document (prEN 16480:2014) has been prepared by Technical Committee CEN/TC 197 “Pump”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive.

For relationship with EU Directive, see informative Annex ZA, which is an integral part of this document.

Introduction

Purpose and content of the standard

The water pumps within the scope of this European Standard are typically produced and sold by pump manufacturers as series of large to very large numbers. The performance characteristics of pumps of one size produced by a manufacturer show some scatter caused by manufacturing tolerances, but are described by mean values and curves which represent that size.

The total consumption of electric energy by water pumps installed in applications within the scope of this European Standard depends on the total number of installed pumps of each size and on its mean efficiency. The quality of a size in respect to its mean efficiency is quantitatively described by the Minimum Efficiency Index (MEI) which is defined and used in this standard. To achieve a certain value of the Minimum Efficiency Index (MEI), a corresponding minimum value of the mean efficiency of a size is required.

This European Standard defines – for each pump type and size within the scope of the standard - the minimum required value of efficiency depending on the value of the Minimum Efficiency Index (MEI). Also, this standard prescribes how the value of the Minimum Efficiency Index (MEI) of a pump size indicated by the manufacturer can be verified by an independent institution (e.g. in the frame of market surveillance). For the manufacturer of the pump size it is generally left free how to prove the indicated value of the Minimum Efficiency Index (MEI) of a size. Nevertheless, this standard describes also a method to prove by the manufacturer that the mean values of efficiency meet the requirements for indicating a certain value of the Minimum Efficiency Index (MEI).

Normally, the qualification of a pump size for a certain MEI value done by the manufacturer will be based on tests and evaluations on a sample of test pumps of this size. Tests and evaluations carried out for the purpose of qualifying the corresponding size must fulfill certain requirements:

- From the tests on the sample pumps, it must be possible to predict for the corresponding size the confidence intervals within which the true mean values of efficiencies which are relevant for the qualification are enclosed with a sufficiently high probability. Only in that way, the qualification of the size in respect to a required and/or indicated value of Minimum Efficiency Index (MEI) will make sure that the aspired effect of energy saving will be reached.

- If a pump size has been qualified according to the criteria described in this European Standard, every test on one or more test pump(s) of the same size (with a full impeller diameter) which is carried out in the frame of a verification procedure shall result with a very high probability in a confirmation of the qualification.

Caused by technical alignment procedures of the single pump components e.g. bearings or shaft seals the performance of the pump is gained after a certain running-in time.

Alternative ways to prove and to verify the Minimum Efficiency Index (MEI) of a pump size

This European Standard permits and describes different ways how manufacturers can achieve the qualification of a pump size for a certain value of the Minimum Efficiency Index (MEI) and how this qualification can be verified by an independent institution.

For the manufacturer it is generally left free to choose and apply appropriate methods to prove that the mean efficiency values of a size are at least equal to or higher than particular threshold values of efficiency. These particular threshold values of efficiency are related to the value of the Minimum Efficiency Index (MEI) to be indicated for the size. The way to determine these values of efficiency is described in this standard. If the way chosen by the manufacturer to prove the MEI value of a size deviates from the way mentioned in the next paragraph, the manufacturer has to document all tests, evaluations and/or calculations which are carried out and the methods which are applied to prove the justification of the indicated MEI value.

If the manufacturer decides to determine the mean performance values of the size by one of the methods described in Annex D of this standard, he has to carry out tests according to the requirements given in clause 5.2 to 5.4 of this standard and evaluations as described in clause 5.5 of this standard and to prove – as described in Section 6 of this standard – that the criteria for the achievement of a certain value of the Minimum Efficiency Index (MEI) of the size are fulfilled. The test conditions, the results of test evaluation and the fulfillment of the criteria must be documented and stored for a defined time period as described in clause 5.2.

For an <u>independent institution</u>, two ways are possible and permitted by this standard to verify the value of Minimum Efficiency Index (MEI) indicated by the manufacturer:

1) If the documentation of the qualification is presented by the manufacturer to the independent institution on request, the procedure of verification executed by the independent institution is based on the documentation of tests and evaluations done and documented by the manufacturer. In this case, the documentation will be checked by the independent institution in respect to being in accordance with requirements and criteria given in this standard.

2) If no documentation is presented by the manufacturer on request or if the documentation presented by the manufacturer on request is not accepted as proof of the indicated value of MEI, the independent institution carries out tests on pumps of the size in question according to the requirements given in clauses 5.2 to 5.4 of this standard as well as evaluations as described in clause 5.5 of this standard and applies the methodology and procedure described in Section 4 of this standard.

Relevance of Sections of this standard for manufacturers or independent institutions

Section 4 describes nominal values of minimum required efficiency for a certain value of the Minimum Efficiency Index (MEI) and is generally relevant for manufacturers and independent institutions when applying this standard.

Section 5 is concerned with mean values of a pump size which are relevant for manufacturers to prove that a pump size achieves a certain value of the Minimum Efficiency Index (MEI).

Section 6 describes the methodology and procedure to be applied by an independent institution in the case that the Minimum Efficiency Index (MEI) of a size indicated by the manufacturer shall be verified by third party tests on pumps of this size.

Section 7 specifies test procedures, test conditions and evaluations and has to be applied

- by a manufacturer in the case that he decides to determine mean values of a size by tests on sample pumps of this size (e.g. by methods described in Annex E),
- by an independent institution in the case that the Minimum Efficiency Index (MEI) of a pump size shall be verified by the procedure described in Section 6.

Section 6 describes the procedure to be applied by a manufacturer in order to determine particular threshold values of efficiency for a certain value of the Minimum Efficiency Index (MEI) of a size and to prove the justification of this MEI value by the fulfillment of criteria for the mean efficiency values.

1 Scope

1.1 Pump technology

This document covers glanded water pumps for pumping clean water, including where integrated in other products. Pumps designed and produced as low duty pumps for pressures up to 16 bar for end suction pumps and up to 25 bar for multistage pumps, temperatures between -10 and +120°C, for clean water, in all kinds of materials. See Annex A for further information.

1.2 Pump types

- End suction and in-line pumps for design pressure up to 16 bar (incl. EN 733 or equivalent).
- Vertical multistage pumps with design pressures up to 25 bar.
- Submersible multistage pumps designed to operate in boreholes at operating temperatures within a range from 0°C to 90°C.
- For special design of pump types specified in this paragraph the test procedure described in section 5.5.4 shall be considered.

NOTE The pump types and sizes within the scope are typically mass produced pumps. Larger pumps at the upper end of the scope might be produced in smaller numbers.

1.3 Application of this European Standard

Figure 1 shows how this European Standard has to be applied.

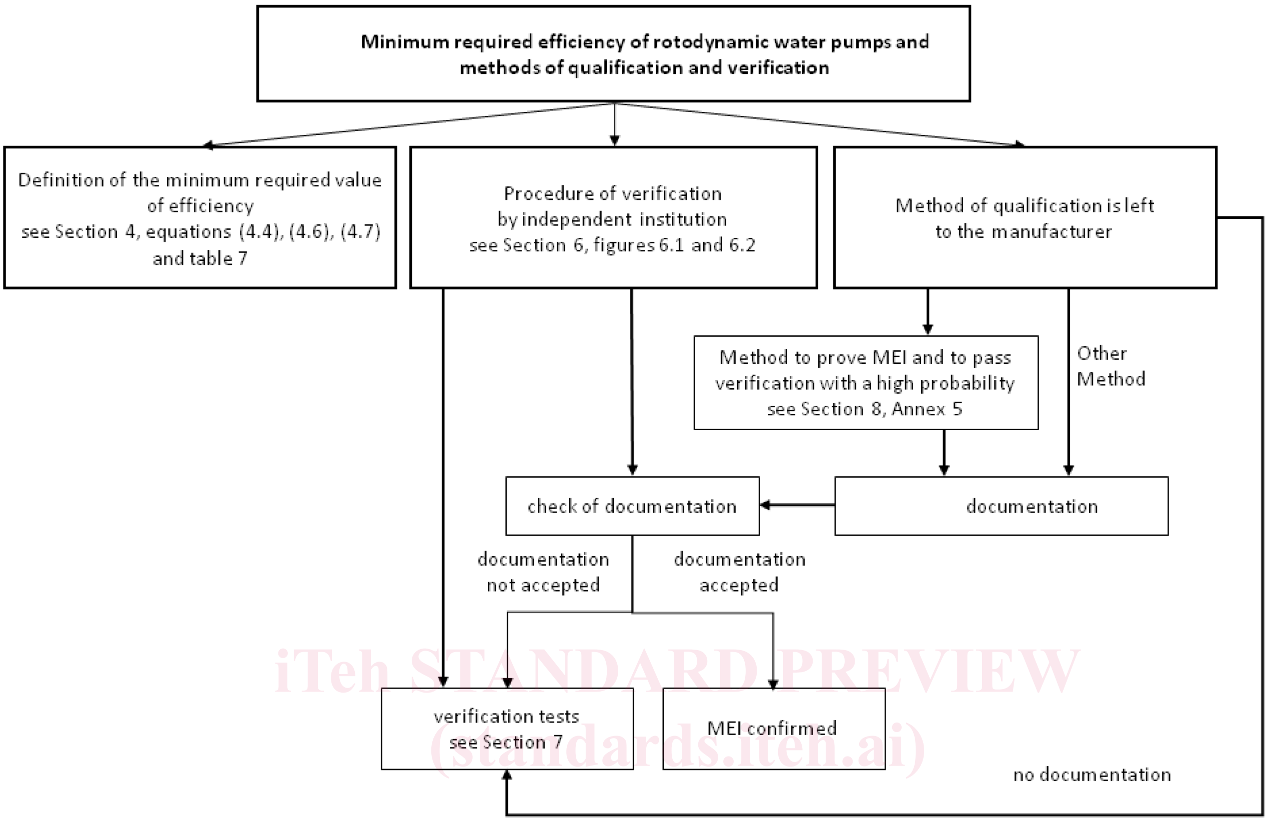

Figure 1 — Scheme of application of this standard

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 31, *General principles concerning quantities, units and symbols*

ISO 2186, *Fluid flow in closed conduits — Connections for pressure signal transmissions between primary and secondary elements*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices — Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross section conduits running full*

ISO 5198, *Centrifugal, mixed flow and axial pumps — Code for hydraulic performance tests — Precision class*

ISO 9104, *Methods of evaluating the performance of electromagnetic flowmeters for liquids in closed conduits*

ISO 9906, *Rotodynamic pumps – Hydraulic performance acceptance test – Classes 1, 2 and 3*

ISO 2854: *Statistical interpretation of data – Techniques of estimation and tests relating to means and variances*

ISO 2602: *Statistical interpretation of test results - Estimation of the mean – Confidence interval*

3 Terms and definitions

3.1 General

For the purposes of this European Standard, the quantities, definitions, symbols and units given in ISO 9906 and in section 3.2 apply. Section 3.2 gives specific definitions of terms - in deviation of ISO 9906 - used in this European Standard, together with any associated symbols which have been allocated and is based on ISO 31.

Table 1 gives an alphabetical list of symbols used and table 2 gives a list of subscripts. As far as possible, the quantities, definitions and symbols used in this standard comply with those used in ISO 9906. Quantities, definitions and symbols used in ISO 9006, but not needed in this standard are not contained section 3.2 and tables 1, 2 while these tables contain some quantities, definitions and symbols which are not used in ISO 9906.

In this European Standard all equations are given in coherent SI-units.

3.2 List of quantities with definitions

Terms and definitions from ISO 9906 + additions like MEI

3.2.1
Reynolds number
Dimension less number that gives a measure of the ratio of inertial forces to viscous forces and consequently quantifies the relative importance of these two types of forces for given flow conditions. In this standard, it is defined by the relation:

$$\mathrm{Re} = \frac{D_{imp} \cdot u}{\nu}$$

where u is the peripheral velocity at the outer impeller diameter D_{imp}

3.2.2
(Volume) rate of flow
The rate of flow designates the external rate of flow of the pump, i.e. the rate of flow discharged into the pipe from the outlet branch of the pump.

Note 1 to entry: Losses or abstractions inherent to the pump, i.e.:

- discharge necessary for hydraulic balancing of axial thrust;
- cooling of bearings of the pump itself;
- water seal to the packing;

Note 2 to entry: Leakage from the fittings, internal leakage, etc., is not to be reckoned in the rate of flow. On the contrary, all derived flows for other purposes, such as cooling of the motor bearings; cooling of a gear box (bearings, oil cooler), etc. are to be reckoned in the rate of flow.

Note 3 to entry: Whether and how these flows must be taken into account depends on the location of their derivation and of the section of flow-measurement respectively.

3.2.3
Driver power input
The power absorbed by the pump driver

3.2.4
Pump efficiency

$$\eta = \frac{P_{\mathrm{u}}}{P} = \frac{Pump\ \ power\ output}{Pump\ \ power\ input}$$

3.2.5
Driver efficiency

$$\eta_{\mathrm{dr}} = \frac{P}{P_{gr}} = \frac{Pump\ power\ input}{Driver\ power\ input}$$

3.2.6
Overall efficiency

$$\eta_{\mathrm{gr}} = \frac{P_{\mathrm{u}}}{P_{gr}} = \frac{Pump\ power\ output}{Driver\ power\ input}$$

3.2.7
Specific speed
Dimensional number characterising the impeller type (radial, semi-axial, axial) of rotodynamic pumps

$$n_s = n_N \cdot \frac{\sqrt{Q_{BEP}}}{H_{BEP}^{0.75}}$$

Note 1 to entry: For multistage pumps, H_{BEP} is the head per stage which results from dividing the total pump head at the point of best efficiency by the number of stages i

3.2.8
Minimum efficiency index (MEI)
Value which determines the minimum required efficiency for the qualification criteria and, thereby, is a measure of the quality of a pump size in respect to efficiency.

3.3 Lists of basic letters and subscripts

3.4

Table 1 — Alphabetical list of basic letters used as symbols

Symbol	Quantity	Unit
A	Area	m^2
C	Constant	pure number
D	Diameter	m
e	Measurement uncertainty, relative value	pure number
f	Frequency	s^{-1}, Hz
g	Acceleration due to gravity	m/s^2
H	Pump total head	m
k	number of instrument readings or sample pumps	pure number
m	Mass	kg
M	number of pumps of a sample	pure number
n	Speed of rotation	s^{-1}, min^{-1}
N	Number of instrument readings	pure number
n_s	Specific speed	min^{-1}
p	Pressure	Pa
p	Probability	pure 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	pure number
t	Time	s
t	Student´s factor	pure 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 special quantity
y	General quantity	according to special quantity
z	Height above reference plane	m
z	number of produced pumps	pure number
η	Efficiency	pure 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

For a list of concise designations (short term description) of pump types in scope see Annex B.

Table 2 — List of letters and figures used as subscripts

Subscript	Meaning
1	inlet
2	outlet
abs	absolute
amb	ambient
annual	per year
curve	on fitting curve
BEP	at best efficiency point
dr	driver
D	datum
exp	experimentally determined
gr	combined motor/pump unit (overall)
G	guaranteed
H	pump total head
i	numbering index
j	numbering index
imp	impeller
man	manufacturing
max	maximum permissible
mean	mean value of pump series
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
t	translated
u	useful
v	vapour
x	of quantity x
y %	for probability of y %
η	efficiency

3.5 General definitions

3.4.1
Qualification
In this European Standard, the criteria are described which have to be fulfilled to qualify a pump size in respect to a certain value of the Minimum Efficiency Index (MEI). For the purpose of qualification, the manufacturer of the pump size has to prove by appropriate methods the fulfillment of the efficiency criteria defined in this standard. Generally, the qualification criteria refer to the mean values of the size which are valid for the full impeller diameter and which will be determined by tests and evaluations on pumps of the respective size. These mean efficiency values and their confidence intervals have to be compared to nominal values of minimum required efficiency. Also these values depend on parameters (see Section 4) the values of which partly result from the tests and can only be determined with some uncertainty or tolerance. Therefore, so-called particular threshold values of efficiency are determined and used in the frame of the qualification procedure for comparison with the mean values.

3.4.2
Verification of the qualification
After a pump size has been qualified by the manufacturer and placed on the market, an independent institution may check the result of the qualification procedure. In this case, the tests and the evaluation of the test data have to be carried out according to Section 5 of this European Standard. The decision has to be taken according to the procedure described in Section 7 of this European Standard.

3.4.3
Independent institution
Based on European directives and/or national legislation, some institutions may be authorized – in the frame of market surveillance - to check the justification of MEI values indicated by manufacturers. These institutions are generally called independent institutions whatever the special type of the institution (non-governmental organisation (NGO), neutral institute, market surveillance authorities or similar) may be.

3.4.4
Minimum Efficiency Index (MEI)
The Minimum Efficiency Index (MEI) is a measure for the quality of a pump size in respect to efficiency. The higher the value of the MEI is, the better the pump size is in respect to efficiency and as lower is the yearly energy consumption if pumps of this size are installed. The upper limit of values of the Minimum Efficiency Index (MEI) is principally open and depends only on physical and technological constraints. (For more details, see Section 4.4 and Annex C).

3.4.5
Nominal value of minimum required efficiency
In this European Standard, criteria are defined which have to be fulfilled by a pump size if this size shall achieve the qualification in respect to a certain value of the Minimum Efficiency Index (MEI). The criteria are based on nominal values of the minimum required efficiency which are defined in Section 4 of this standard. These nominal values of minimum required efficiency refer to the mean efficiency of the size and depend, themselves, on certain mean properties of the pump size (pump type, nominal speed of rotation, flow rate at best efficiency point and specific speed) and on the Minimum Efficiency Index (MEI). For one size, different nominal values of minimum required efficiency are relevant at best efficiency point, at specified part load and overload operating points, respectively.

3.4.6
Particular threshold values of efficiency $\eta_{threshhold}$
These values are calculated from the minimum required efficiency by subtracting a total tolerance.

3.4.7
Pump size
Mass produced pumps of the same type manufactured and sold by a pump manufacturer are mostly subdivided in a number of sizes. Each size is characterized by certain dimensions (e.g. nominal diameter of discharge flange and nominal impeller diameter for end-suction and multistage pumps, nominal outer casing diameter in the case of submersible multistage pumps). In a Q-H-chart given in his catalogues by the manufacturer, each size within the chart covers a certain range of Q- and H-values. Within this range each duty point can be served by a pump of the corresponding size by adapting its Q-H-curve by impeller trimming, i.e. by cutting down the outer impeller diameter to an appropriate value. The upper limit of the Q-H-range covered by one pump size is determined by the full diameter of the impeller corresponding to this size.

3.4.8
Full impeller diameter of a pump size
The maximum outer impeller diameter for which performance characteristics are given for a pump size in the required documentation of a manufacturer is called full impeller diameter in this European Standard. In the case of an impeller with the blade outlet edge not being parallel to the axis of rotation, the full diameter refers to the arithmetical mean of the maximum outer diameters at the front and hub shrouds of the impeller. The Q-H-curve for the full diameter determines the upper limit of the Q-H-range covered by the corresponding pump size. Mean performance values of a pump size are generally to be understood and used as being valid for the full diameter of the corresponding pump size. Also the test pumps taken as a sample out of the whole number of pumps of a size have to be tested with the full diameter corresponding to this size when applying this European Standard.