

Nederlandse praktijkrichtlijn

# **NPR-ISO/TR 19688**

(en)

Rotodynamische pompen - Hydraulische prestatie-acceptatietest met behulp van een modelpomp (ISO/TR 19688:2019,IDT)

Rotodynamic pumps - Hydraulic performance acceptance test using a model pump (ISO/TR 19688:2019,IDT)

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**Rotodynamic pumps — Hydraulic performance acceptance test using a model pump**

*Pompes rotodynamiques — Modèle réduit de pompe utilisé pour les essais de performance hydraulique*



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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations/governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by ISO/TC 115, *Pumps*, SC 2, *Methods of measurement and testing*.

## Introduction

Wherever the capacity of a manufacturer's test facility is not appropriate to realise the necessary physical preconditions for testing a pump at realistic flow/head conditions the alternative of a model pump is taken. By means of the similitude theory, a model pump is used to assess and calculate the ability of the real pump to be built. The option using such model pump or prototype pump is chosen

- when the capacity of the pump, namely its flow rate and/or its power input (e.g. flow rate  $\geq 35,000 \text{ m}^3/\text{h}$ , and  $P_2 \geq 5,000 \text{ kW}$ ), exceeds the limitations of the test facility, or
- one part or parts of the pump should be constructed by concrete walls and reproduction of the whole assembly is impractical.

In consideration of these given facts the application of a model pump for the hydraulic performance acceptance test is an efficient and effective alternative. The advantages using a model pump may also include:

- a higher precision due to the difference in measurement uncertainties;
- minimising costs in respect to material and other resources;
- and shorter delivery period(s) of the prototype pump(s).

For many years, manufacturers have developed and specified independent calculation approaches and collected experiences to handle the similitude theory for pumps and their specifics. Several calculation models are described in the pertinent literature. This document describes testing methods using model pumps for hydraulic performance acceptance tests in addition to other testing methods given in ISO 9906 as hydraulic performance acceptance tests for prototype pumps.

This document has been initially established based on prior standards such as the Japanese Industrial Standard JIS B 8327. This document combined with ISO 9906 presents new testing methods for hydraulic acceptance tests of pumps.



# Rotodynamic pumps — Hydraulic performance acceptance test using a model pump

## 1 Scope

This document describes hydraulic performance tests (including cavitation tests) using a small size pump (centrifugal, mixed flow or axial pump, hereinafter referred to as a “model pump”).

This document is used for pump acceptance tests with a geometrically similar model pump to guarantee the performance of a large size pump manufactured for practical use (hereinafter, a “prototype pump”). This document, however does not preclude a temporary assembly inspection or other tests on the prototype pump. Moreover, it is preferable to conduct the tests with prototype pumps unless

- the capacity of the pump, namely its flow rate and/or its power input, is beyond the limitations of the test facility, though it is difficult to set a criterion for carrying out a model pump test instead of the prototype pump test in terms of the volume rate of flow or the power input,
- a part of the pump is to be constructed by concrete walls and reproduction of the whole assembly is impractical,
- model tests are specified by the purchaser, or
- it is difficult to carry out the prototype pump test due to any other reasons.

This document applies to performance tests under steady operating conditions corresponding to the prototype pump.

## 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.

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

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

## 3 Terms and definitions

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

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

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

### 3.1 General terms

#### 3.1.1 performance test

test to examine the performance of a pump in a state free from the influence of cavitation

**ISO/TR 19688:2019(E)****3.1.2****cavitation test**

test to examine whether pump total head changes happen due to the occurrence of cavitation under operating conditions of a model pump corresponding to the working conditions of a prototype pump

Note 1 to entry: Cavitation test corresponds to NPSH Type III test in ISO 9906:2012.

**3.1.3****NPSH3 test**

test to reduce the *NPSH* of a model pump and determine the *NPSH* value at which the pump total head of a model pump is reduced by 3 % due to the occurrence of cavitation compared with the pump total head measured without the occurrence of cavitation

Note 1 to entry: NPSH 3 test corresponds to NPSH Type I or II test in ISO 9906:2012.

Note 2 to entry: NPSH is an abbreviation for “net positive suction head”.

**3.1.4****four quadrant characteristic test**

test to examine the characteristics of a model pump regarding its pump range, pump brake range, water turbine range, water turbine brake range and reverse pump range

Note 1 to entry: The purpose is to obtain the characteristics necessary for the calculation of pump transient phenomena.

**3.1.5****specified speed of rotation**

speed of rotation of a model pump selected to indicate the performance of the model pump corresponding to the requirements on a prototype pump determined by the agreement between the purchaser and manufacturer

**3.1.6****test speed of rotation**

measured speed of rotation of a model pump in a performance test or cavitation test on the pump

**3.1.7****specified volume rate of flow**

volume rate of flow at the specified speed of rotation of a model pump corresponding to the requirements on a prototype pump determined by the agreement between the purchaser and manufacturer

**3.1.8****specified pump total head**

pump total head at the specified speed of rotation and volume rate of flow of a model pump corresponding to the requirements on a prototype pump determined by the agreement between the purchaser and manufacturer

**3.2 Terms and definitions relating to performance****3.2.1****acceleration of gravity**

*g*

acceleration due to gravity

local value used, the local value of the acceleration of gravity is calculated by the following formula:

$$g = 9,7803 \times (1 + 0,0053 \times \sin^2 \varphi) - 3,0 \times 10^{-6} \cdot Z$$

where

$Z$  is the altitude, expressed in metres (m);

$\varphi$  is the latitude, expressed in degrees [°].

Note 1 to entry: In many cases, however, no notable error occurs when 9,80 m/s<sup>2</sup> is used.

### 3.2.2

#### Reynolds number

$Re$

ratio of inertial force to viscous force

The Reynolds numbers used for hydraulic efficiency conversion for a model pump and a prototype pump are given by the following formulae:

$$Re_{hP} = \frac{u_{1P} \cdot D_{1P}}{\nu_P}$$

for the prototype pump

$$Re_{hM} = \frac{u_{1M} \cdot D_{1M}}{\nu_M}$$

for the model pump

where

$Re_{hM}$  is the Reynolds number of the model pump, dimensionless (—);

$Re_{hP}$  is the Reynolds number of the prototype pump, dimensionless (—);

$u_{1M}$  is the peripheral velocity at the impeller inlet diameter of the model pump, expressed in metres per second (m/s),  $u_{1M} = \pi \cdot D_{1M} \cdot n_M$ ;

$u_{1P}$  is the peripheral velocity at the impeller inlet diameter of the prototype pump, expressed in metres per second (m/s),  $u_{1P} = \pi \cdot D_{1P} \cdot n_P$ ;

$D_{1M}$  is the inlet diameter of the impeller of the model pump, expressed in metres(m);

$D_{1P}$  is the inlet diameter of the impeller of the prototype pump, expressed in metres(m);

$\nu_M$  is the kinematic viscosity of liquid in the model pump, expressed in square metres per second (m<sup>2</sup>/s);

$\nu_P$  is the kinematic viscosity of liquid in the prototype pump, expressed in square metres per second (m<sup>2</sup>/s);

$n_M$  is the speed of rotation of the model pump, expressed in reciprocal seconds (s<sup>-1</sup>);

$n_P$  is the speed of rotation of the prototype pump, expressed in reciprocal seconds (s<sup>-1</sup>).

### 3.2.3

#### peripheral velocity

$u$

speed of a rotor in the tangential direction

### 3.2.4

#### pipe friction loss coefficient

$\lambda$

coefficient used for calculating the loss of head due to friction in a pipe

**ISO/TR 19688:2019(E)****3.2.5****equivalent diameter**

$D_e$   
the cross-sectional area divided by the wetted perimeter of a hydraulic passageway and multiplied by 4

**3.2.6****hydraulic efficiency**

$\eta_h$   
proportion of the pump total head to the theoretical head (impeller head when there is no loss of head)

Note 1 to entry: It should be noted that the definition of hydraulic efficiency in this document is different from that in ISO 17769-1. In ISO 17769-1, where hydraulic efficiency involves all hydraulic losses such as those resulting from friction due to the relative motion of internal surfaces and internal leakage. In this Document, on the other hand, disc friction losses at impellers and internal leakage losses are classified into the factor for mechanical efficiency and volumetric efficiency, respectively, and out of scope of hydraulic efficiency.

**3.2.7****hydraulic efficiency ratio**

$F_h$   
ratio between the hydraulic efficiency of a prototype pump and the hydraulic efficiency of a model pump at a mutually corresponding operating point

**3.2.8****mechanical efficiency**

$\eta_m$   
proportion of the power that an impeller transmits to a liquid to the pump power input

Note 1 to entry: It should be noted that the definition of mechanical efficiency in this document is different from that in ISO 17769-1. Here, the loss of power at the seals and bearings is out of scope (it should be dealt with separately) and the loss of power due to disc friction is considered as the factor, while loss of power at seals and bearings is taken as factor as in ISO 17769-1.

**3.2.9****mechanical efficiency ratio**

$F_m$   
ratio between the mechanical efficiency of a prototype pump and the mechanical efficiency of a model pump at a mutually corresponding operating point

**3.2.10****volumetric efficiency**

$\eta_v$   
proportion of the volume rate of flow of a pump and the volume rate of flow passing through the impeller

Note 1 to entry: It should be noted that the definition of volumetric efficiency in this document is different from that in ISO 17769-1. The definition given in ISO 17769-1 seems applicable only for positive displacement pumps, while the definition in this Technical Report is for rotodynamic pumps.

**3.2.11****volumetric efficiency ratio**

$F_v$   
ratio between the volumetric efficiency of a prototype pump and the volumetric efficiency of a model pump at a mutually corresponding operating point

**3.2.12****scale effect coefficient**

$V$   
proportion of the loss due to the scale effect to the combination of scalable and non-scalable losses

Note 1 to entry: The loss due to the scale effect is equal to a loss due to friction of wall surface of flow passage.



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