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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Ships and marine technology — Hydraulic performance tests for waterjet propulsion system

1 Scope

This document specifies the measurement and acceptance criteria and the test report of hydraulic performance tests for waterjet propulsion system of Class A and Class B.

The test methods for the waterjet propulsion pump with and without the inlet duct are both specified. This document is applicable to the hydraulic performance test of water jet propulsion under the specified test conditions. This document specifies the precision grade of Class A for hydraulic model tests of water jet propulsion and Class B for acceptance tests of small and middle-sized or intermediate test models.

In addition, this document specifies the test conditions of Class A and Class B, and recommendations and requirements for test equipment to ensure that the test can be carried out under the conditions of corresponding accuracy.

This document does not include miscellaneous parts of waterjet unit, such as steering and reversing gear, hydraulic system and control system.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the following terms and definitions 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
waterjet unit
unit that consists of *waterjet propulsion system* (3.2), steering and reversing gear, hydraulic system and control system which is able to steer and reverse the main body

3.2
waterjet propulsion system
propulsion system that consists of *waterjet pump* (3.3), nozzle and inlet duct (generally the impeller of waterjet pump is integrated with the nozzle) and that is able to drive the main body moving

3.3
waterjet pump
pump that transfers the energy of prime mover to water by rotating impeller

Note 1 to entry: The waterjet pump obtains a counter-acting force and drives the main body moving. It consists of impeller, guide vane, shell and shaft (hereinafter referred to as "pump"). The main types are mixed-flow type and axial flow type. The axial flow waterjet pump is one in which the liquid is discharged axially from the impeller. The mixed-flow waterjet pump is one in which the liquid is discharged from impeller with an angle α ($0° < \alpha < 90°$) to the shaft line, also called the inclined waterjet pump.

3.4
flow rate
Q
volume of liquid discharged by *waterjet pump* (3.3) per unit time

3.5
pump total head
H
algebraic difference between the outlet total head, H_2, and the inlet total head, H_1

Note 1 to entry: Pump total head is given by Formula (1):

$$H = H_2 - H_1 \tag{1}$$

where

H_1 is the inlet total head, expressed in Pa;

H_2 is the outlet total head, expressed in Pa.

Note 2 to entry: Unless otherwise specified, the baseline of the head is the waterjet propulsion shaft line.

[SOURCE: ISO 9906:2012, 3.2.15, modified — notes 1 and 2 to entry have been modified.]

3.6
pump power input
P
power transmitted to the pump by its driver

[SOURCE: ISO 17769-1:2012, 2.1.11.2, modified — note 1 to entry has been deleted.]

3.7
pump efficiency
η
proportion of the *pump power input* (3.6), *P*, delivered as pump power output, P_u, at given operating conditions

Note 1 to entry: Pump efficiency is given by Formula (2):

$$\eta = \frac{P_u}{P} \tag{2}$$

where

P_u is useful mechanical power transferred to the liquid during its passage through the pump, given by Formula (3);

$$P_u = \rho g Q H \tag{3}$$

[SOURCE: ISO 17769-1:2012, 2.1.12.1, modified — Formula (3) has been added and the symbols have been explained.]

3.8
type number
K
dimensionless quantity, defined by Formula (4):

$$K = \frac{2\pi n Q'^{1/2}}{(gH')^{3/4}} = \frac{\omega Q'^{1/2}}{(y')^{3/4}} \tag{4}$$

where

Q' is volume flow rate per eye, expressed in m^3/s;

H' is head of the first stage, expressed in m;

ω is expressed in time, like s^{-1}, and n is expressed in $60 \times min^{-1}$ form.

Note 1 to entry: The type number should be taken according to the maximum diameter of the first stage impeller.

3.9
net positive suction head
NPSH
pump inlet total head above the head, equivalent to the vapour pressure per unit volume liquid, i.e. pump inlet total head adds head equivalent to atmospheric pressure and subtracts head equivalent to the vapour pressure

Note 1 to entry: Net positive suction head is calculated by Formula (5):

$$NPSH = H_1 - z_D + \frac{p_b - p_v}{\rho g} \quad (5)$$

where

p_b is (absolute) atmospheric pressure, expressed in Pa;

p_v is (absolute) vapour pressure, expressed in Pa;

z_D is height of impeller inlet, expressed in m.

[SOURCE: ISO 17769-1:2012, 2.1.5.5, modified — definition has been modified; the symbols have been modified and the notes 2, 3 and 4 to entry have been deleted.]

3.10
guarantee point
operating performance of the pump which the supplier guarantees to be achieved under specified conditions

[SOURCE: ISO 17769-1:2012, 2.1.13.2, modified — note 1 to entry has been deleted.]

4 Measurement and acceptance criteria

4.1 General

The basic parameters of the waterjet hydraulic performance tests directly obtained from the measurement are flow rate, pressure, torque and speed of rotation. The derived parameters calculated from the basic parameters are head, shaft power and efficiency. All of these parameters shall meet the acceptance criteria specified in this clause.

Table 1 gives the acceptance level of pump head, flow rate, shaft power and efficiency. All acceptance criteria are expressed as percentages of guarantee values. The test equipment shall meet the measuring precision requirements. The measuring apparatus and their calibration should be confirmed. Both the purchaser and manufacturer shall be entitled to have representatives present at all tests. The date of the test shall be mutually agreed by the purchaser and manufacturer. Acceptance criteria shall meet the requirements in Table 1 and if applicable, any agreements between the purchaser and manufacturer.

Table 1 — Acceptance criteria for Class A and Class B

Quantity	Class A %	Class B %
Flow rate	±1,5	±2,0
Speed of rotation	±0,2	±0,5
Torque	±1	±1,4
Pump total head	±1	±1,5
Pump power input	±1	±1,5
Pump efficiency	±2,25	±2,9

A guarantee point may be detailed in a written contract, a customer-specific waterjet performance curve, or similar written and project specific documentation.

If not otherwise agreed upon between the purchaser and the manufacturer, the following should apply.

a) The acceptance grade should be in accordance with the grades given in Table 1.

b) Tests should be carried out on the test stand of the manufacturer's works with clean, cold water, using the methods and test arrangements specified in this document.

c) The waterjet performance should be guaranteed between the waterjet's inlet connection and outlet connection.

d) Pipe and fittings (bends, reducers, and valves) outside the waterjet are not a part of the guarantee.

The combination of manufacturing and measurement tolerances in practice necessitates the usage of tolerances on tested values. The tolerances given in Table 1 take into account both manufacturing and measurement tolerances.

The performance of a waterjet varies substantially with the nature of the liquid being pumped. Although it is not possible to give general requirements and guidelines in which clean, cold water can be used to predict performance with other liquids, it is desirable for the parties to agree on empirical rules to suit the particular circumstances.

For batch products, the number of waterjets which are tested should be agreed between the purchaser and manufacturer.

4.2 Measurement range

The flow rate is measured within the range of 80 % to 110 % of the best efficiency point or duty point at identical speed of rotation.

The variation between the measured speed of rotation and specified speed of rotation should be within ±20 % for Class A and the range from 60 % to 120 % for Class B.

4.3 Stable operating conditions of measuring systems

The test should be carried out on the test stand which meets the corresponding precision grade. The test stand may be the manufacturer's test works, or a test stand mutually agreed between the purchaser and the manufacturer. The precision grade of the test equipment is decided by the measuring system. The flow rate, inlet and outlet pressure, speed of rotation, torque, which are naturally fluctuating when measured in the tests, as well as the signals, are automatically recorded or the statistical records accumulate. The readings of delivered signals should satisfy the stable condition.

If the design or operation of the pump causes a large fluctuation in the measured value, a buffer device may be installed in the measuring instrument or its connecting pipeline, to reduce the fluctuation to the range given in Table 2 for measurement. Buffer devices should be symmetrical and linear, like capillaries, which should provide integral values that contain at least one complete fluctuation period.

Table 2 — Permissible amplitude of fluctuation as a percentage of mean value of quantities being measured

Measured quantity	Permissible amplitude of fluctuations	
	Class A %	Class B %
Flow rate	±2	±3
Differential head	±3	±4
Pressure	±2	±3
Pump power input	±2	±3
Speed of rotation	±0,5	±1
Torque	±2	±3
Temperature	0,3 °C	0,3 °C

Several sets of readings should be taken for each operating point considered. The arithmetic mean of the mean values from all sets of readings for each quantity should be taken as the actual value given by the test for the operating conditions considered. This actual value is used to ensure that the overall tolerance of the measuring system meets the uncertainty requirement of the corresponding grade. A minimum of three sets of readings should be taken at unequal intervals at the chosen point and the mean value of each quantity and the efficiency derived from each set of readings should be recorded. The variation of quantities shall meet the requirement of Table 3 (see ISO 5198).

Table 3 — Limits of variation between repeated mean values of the same quantity (based on 95 % confidence limits)

Number of sets of readings	Flow rate, pump total head, torque and pump power input	Speed of rotation
	%	%
3	0,8	0,25
5	1,6	0,5
7	2,2	0,7
9	2,8	0,9

4.4 Evaluation of flow and head

Guarantee point evaluation should be performed at the rated rotational speed. It is not necessary to recalculate the test points based on rotational speed in cases where the test rotational speed is identical to the rated rotational speed. For tests in which the test rotational speed is different from the rated rotational speed, each test point should be recalculated to the rated rotational speed, using the affinity laws.

The acceptance criteria of flow rate should be applied to its guarantee point at the guarantee head, and vice versa.

If there is no special requirement, the guarantee pump total head, H_G, is usually measured under the condition of guarantee flow rate of Q_G. It shall meet the acceptance requirements that the absolute value of the deviation between the head and the guarantee pump total head H_G is not greater than the head tolerance value. If the purchaser and the manufacturer agree, the method of determining guarantee flow rate, Q_G, under guarantee pump total head, H_G, may also be used.

4.5 Evaluation of efficiency or power

If the efficiency or power has been guaranteed, it should be evaluated against the applicable acceptance grade tolerance factor, i.e. the same as for Q / H in the following manner.

After a best-fit test curve ($Q-H$ / $Q-\eta$ / or $Q-P$ curves) is drawn and smoothly fitted through the measured test points, an additional straight line should be drawn between the origin (0 rate of flow, 0 head) and the guarantee point (rate of flow/head). If necessary, this line should be extended until it crosses the fitted test curve. The intersection between the smoothly fitted test curve and this straight line should form a new point of rate of flow/head, which is used for evaluation of efficiency or power. The measured input power or calculated efficiency at this point should be compared against the guarantee value and the applicable power or efficiency tolerance factors.

NOTE 1 The line from the origin method is used when evaluating the guarantee efficiency or power because it best retains the waterjet characteristics if the impeller diameter is changed. Additionally, this method always gives one single point of reference for evaluation.

NOTE 2 The tolerance limits for flow and head can be reduced as a result of adding a power guarantee.

5 Measurement uncertainty

5.1 General

Every measurement is inevitably subject to some uncertainty, even if the measuring procedures and the instruments, as well as the methods of analysis, fully comply with the recommendations and requirements of this document.

5.2 Statistical evaluation of overall measurement uncertainty

5.2.1 Evaluation of the random uncertainty

The random uncertainty due either to the characteristics of the measuring system or to variations of the measured quantity, or both, appears directly as a scatter of the measurements. Unlike the systematic uncertainty, the random component can be reduced by increasing the number of measurements of the same quantity under the same conditions.

A set of readings not less than three should be taken at each test point.

5.2.2 Evaluation of the systematic uncertainty

After all the known errors have been removed by zero adjustment, calibration, careful measurement of dimensions, proper installation, etc., there remains an uncertainty which never disappears. This uncertainty cannot be reduced by repeating the measurement if the same instrument and the same method of measurement are used. Permissible relative values for the systematic uncertainty in this document are given in Table 4.

Table 4 — Permissible relative values of the instrumental uncertainty, e_s

Measured quantity	Maximum permissible systematic uncertainty (at guarantee point)	
	Class A %	Class B %
Flow rate	±1,0	±1,5
Pump total head	±1,0	±1,0
Outlet pressure	±0,9	±1,0
Inlet pressure	±0,5	±1,0
Suction head for NPSH test	±0,9	±1,0
Driver power input	±0,9	±1,0
Speed of rotation	±0,35	±1,4
Torque	±0,9	±2,0

5.2.3 Overall uncertainty

The value for overall uncertainty, *e*, is given by the derived quantity of systematic uncertainty and random uncertainty. Permissible values of overall measurement uncertainty, *e*, are given in Table 5.

Table 5 — Permissible values of overall uncertainties, *e*

Quantity	Class A %	Class B %
Flow rate	±1,5	±2,0
Speed of rotation	±0,2	±0,5
Torque	±1,0	±1,4
Pump total head	±1,0	±1,5
Motor power input	±1,0	±1,5
Pump power input (derived by torque and speed of rotation)	±1,0	±1,5
Pump power input (determined from the motor power input and the efficiency of the motor)	±1,3	±2,0

5.2.4 Determination of overall uncertainty of efficiency

The overall uncertainty of efficiency is divided into the amount calculated from the torque and the speed of rotation, or the amount calculated from the pump input power.

Using the values given in Table 5, the calculations lead to the results given in Table 6.

Table 6 — Resulting greatest values of the overall uncertainties of efficiency, *e*

Quantity	Class A %	Class B %
Overall efficiency (computed from Q, H, P_{gr})	±2,0	±2,9
Pump efficiency (computed from Q, H, M, n)	±2,0	±2,9
Pump efficiency (computed from Q, H, P_{gr}, η_{mot} η_{mot})	±2,25	±3,2

5.3 Conversion

5.3.1 Conversion to the guarantee conditions

The quantities required to verify the characteristics guaranteed by the manufacturer are generally measured under conditions different from those on which the guarantee is based.

If tests have been conducted under the guarantee conditions, it is necessary to translate the quantities measured under different conditions to those guarantee conditions in order to determine whether the guarantee is fulfilled.

5.3.2 Translation of the test results

All test data obtained at the speed of rotation, n_T, in deviation from the specified speed of rotation, n_{SP}, should be translated to data based on the specified speed of rotation, n_{SP}. The variation of speed shall meet the range requirement stated in 4.2:

— flow rate Q_T, pump total head H_T, pump power input P_T, pump efficiency η_T, density ρ_T at test speed of rotation;

— Flow rate Q_{SP}, pump total head H_{SP}, pump power input P_{SP}, pump efficiency η_{SP}, density ρ_{SP} at specified speed of rotation.

The measured data of the flow rate, Q, pump total head, H, and pump power input, P, can be converted by means of Formulae (6), (7), (8) and (9):

$$Q_{SP} = Q_T \frac{n_{SP}}{n_T} \tag{6}$$

$$H_{SP} = H_T \left(\frac{n_{SP}}{n_T}\right)^2 \tag{7}$$

$$P_{SP} = P_T \left(\frac{n_{SP}}{n_T}\right)^3 \cdot \frac{\rho_{SP}}{\rho_T} \tag{8}$$

$$\eta_{SP} = \eta_T \tag{9}$$

Additionally, the results obtained for the $NPSH_R$ can be converted by means of Formula (10):

$$NPSH_{R,SP} = NPSH_{R,T} \left(\frac{n_{SP}}{n_T} \right)^x \tag{10}$$

As a first approximation for the *NPSH*, the value $x = 2$ may be used if the specified condition given in 4.2 for the speed of rotation and flow rate has been fulfilled, and if the physical state of the liquid at the impeller inlet is such that no gas separation can affect the operation of the waterjet. If the waterjet operates near its cavitation limits, or if the deviation of the test speed from the specified speed exceeds the specification given in 4.2, the phenomena can be influenced by, for instance, the thermodynamic effects, the variation of the surface tension, or the differences in dissolved or occluded air content. Values of exponent x between 1,3 and 2 have been observed and an agreement between the parties is mandatory to establish the conversion formula to be used.

In the case of combined motor waterjet units or if the guarantees are with respect to agreed frequency and voltage instead of an agreed speed of rotation, flow rate, pump total head, pump power input and pump efficiency data are subject to the abovementioned conversion requirements, i.e. Formulae (6), (7), (8) and (9), provided n_{SP} is replaced with the frequency, f_{SP}, and n_T with frequency, f_T. Such conversion, however, should be restricted to cases where the selected frequency during the test varies by no more than 1 %. If the voltage used in the test is no more than 5 % above or below the voltage on which the guarantee characteristics are based, the other operational data require no change.

If the abovementioned deviations, i.e. ±1 % for frequency and ±5 % for voltage, are exceeded, it is necessary for the purchaser and the manufacturer to reach an agreement.

6 Test method

6.1 Test condition

6.1.1 Test location

This document is suitable for the test rig of laboratory or pump manufacturer.

6.1.2 Test personnel

The test personnel should have enough test ability or have a relevant test qualification.

6.1.3 Test date

The test date should be agreed by the manufacturer and the purchaser for the witness test.

6.1.4 Test outline

The test outline and method to be followed should be submitted to the purchaser for the witness test. The manufacturer is required to submit the information specified in 6.1.1 to 6.1.3 to the purchaser so that the purchaser has enough time to consider and negotiate. The unguaranteed test date obtained from the test only plays a referential role.

6.1.5 Environment and water quality

The environment near the test device should be considered. This includes the temperature, humidity, geographical position and local gravity. Particular attention should be paid to the effects of temperature on the medium density, especially for the cavitation test. Generally, the medium is fresh water. However, the medium may be replaced if the medium of the full-scale pump working environment is sea water or other mediums. These properties should be recorded as shown in Table 7.

Table 7 — Properties of fresh water

Characteristic	Unit	Range
Temperature	°C	from 5 to 40
Kinematic viscosity	m^2/s	from 0,659 to 1,5 × 10^{-6}
Density	kg/m^3	from 992,2 to 1 000

6.2 Test device

The test instrument and apparatuses in the test should be recorded and provided for the purchaser if necessary. Periodic calibration of the instrument and equipment is required. For information regarding the working section forms of test device, see Annex B.

Some measures should be taken to simulate the ship speed at the pump inlet to keep the same flow energy as real application condition. It can also avoid the appearance of cavitation.

6.3 Test items

6.3.1 General

Test items should also be recorded in Table 8.

Table 8 — Test items

Test item	Class A	Class B
Performance test	√	√
Cavitation test	√	optional

6.3.2 Performance test

6.3.2.1 General

By measuring the inlet and outlet pressure, it is possible to obtain the rotational speed of the propulsion pump and the power of the shaft at the design operating point at several flow points before and after the working point, the head, pump efficiency and other derived quantities. The measured values of each flow point are plotted into curves, and performance curves of the tested model or real waterjet propulsion are obtained.

6.3.2.2 Test procedure

The test device should work 1 h at least and the inspector should exhaust the system. During the period, the system should be exhausted every 20 min.

During the period of operation, the flow rate of the test pump should be adjusted to the rated flow rate.

After operation is stable, the performance test begins with a fully open valve. The flow rate should be reduced gradually. The head, rotational speed and pump shaft power should be measured every 5 min at the desired flow rate. Testing points should be uniformly distributed over the performance curve.

The test time should be long enough to attain the reproducible results.

All the measurements are expected to be done under the stable operation condition (see 4.3 and Table 3). The test should be done without the effect of pump cavitation, unless otherwise specified.

The number of test points can be determined according to test requirements or contract agreements. At least 5 test points should be taken, as shown in Table 9. The flow rate of one test point is expected to be within a range of 95 % to 100 % of the design flow rate, and another one should be within a range of 100 % to 105 %. The flow rates of the three remaining testing points shall be distributed within the allowable operating range of the pump performance curve. It is recommended to take the testing point near the maximum allowable head and flow rate.

Table 9 — Performance test

	Class A	Class B	
Test points	from 12 to 15	Performance test	Acceptance test
		from 12 to 15	5

6.3.3 NPSH test

6.3.3.1 General

The purpose of net positive suction head (NPSH) test is to testify the agreed, guaranteed, required net positive suction head. This test is only aimed at the net positive suction head related to pump hydrodynamic performance (change of head, flow rate, power) and does not study effects (noise, vibration, cavitation erosion, etc.) caused by the cavitation.

Cavitation inception can be detected by the head or power drop for given flow rate. For the lower head pump, a drop of $\left(2+\dfrac{K}{2}\right)\%$ in head can be attained by agreement.

6.3.3.2 Test procedure

In most cases, clean cold water is used for the cavitation test. Therefore, the cavitation test conducted with clean cold water cannot precisely forecast the cavitation performance of pump conveying unclean cold water.

The air content in water has important effects on the measurement of NPSH, which should be taken into account.

Once the test device has been started, it should run for about 1 h to exhaust. During this period, the inspector should make the test system exhaust about every 20 min. A closed test device is recommended and the vacuum equipment can be used to reduce NPSH at a given flow rate point until the pump head is reduced by $\left(2+\dfrac{K}{2}\right)\%$. In the cavitation test, the critical cavitation allowance at three or more flow rate points should be measured separately, and the value at 100 % rated flow rate should be taken as the assessment value. Thus, a cavitation performance curve can be obtained.

7 Test report

A complete set of paper or electrical records are available for at least five years. For the witness test, all the test records should be signed by all parties who witnessed the test, and copies of all records should be provided to representatives of all parties. The evaluation of the test results should be completed as much as possible during the test. The test device, instruments and apparatuses should not be dismantled before getting the precise data, so that questionable measurement data can be reassessed. If necessary, the test results may be summarized to form a report. Annex A contains information on the contents of a test report and a pump test recording table.

Annex A
(informative)

Test report

A.1 Recommendations for the test report

The report should include all details of the tested pump and relevant device. It is recommended that all original data of measuring points are included in the report. It is recommended to draw a graph with the measuring points after conversion, and a fitting curve of all measuring points in the graph should be drawn. The guarantee point should be marked out with the acceptance standard. The acceptance standard is expected to be indicated by a vertical line for head tolerance (at the rate of flow guarantee point). However, a horizontal line indicates rate of flow tolerance (at the head guarantee point), as illustrated in ISO 9906:2012, Figures 2 and 3. The two ends of the vertical line represent the upper and lower limits of head respectively. The two ends of horizontal line represent upper and lower limits of rate of flow respectively. Besides, these lines should start from the guarantee points.

The test report should include the information below (if in use):

— test date;

— the International Standard used;

— test device and measuring system;

— test model;

— test condition and method;

— any deviations from the procedure;

— any unusual features observed;

— test data;

— test conclusion.

A.2 Pump test sheet

The pump test sheets illustrated in Tables A.1, A.2, A.3 and A.4 are given for guidance for presenting pump test results and assisting in their interpretation. The pump test sheet does not include all the information required from a pump test, and modifications can be necessary depending on the type of the pump, its application, and the mode of calculation.

The manufacturer should provide performance curves showing relations of pump total head (H), pump power input (P), pump efficiency (η) and *NPSH* with flow rate (Q). The form of the figure is not restricted, whether it is dimensional or dimensionless.

Table A.1 — Sensor sheet

Sensor name	Brand			Range	
	Specification model			Precision	
	Metrological number			Note	

Table A.2 — Tested item performance parameters

Item	Design parameter	Design value
flow rate		
Pump total head		
Rotating speed		
Pump power input		
Pump efficiency		
Cavitation specification speed		
Mode number		

Table A.3 — Test condition

Date condition	Sheet number		Test date	
	Ambient temperature	°C	Barometric pressure	kPa
	Test start time		Test stop time	
	Switch on water temperature	°C	Switch off water temperature	°C
Tested model	Model code		Model number	
Motor/Inverter	Tested pump motor matched power	kW	Inverter power	kW
	Auxiliary pump motor power	kW	Auxiliary pump motor rotating speed	r/min
Apparatus/ Instrument	Flow metre diameter	mm	Cavitation bucket static pressure	MPa
	Flow metre range	m^3/s	Flow meter error	%
	Inlet pressure sensor range	kPa ~ kPa	Inlet pressure sensor error	%
	Outlet pressure sensor range	kPa ~ kPa	Outlet pressure sensor error	%
	Torque metre range	N·m	Torque metre error	%
Installation and debugging	Impeller maximum clearance	mm	Maximum clearance installation position	
	Impeller minimum clearance	mm	Minimum clearance installation position	
	Spacing between impeller and guide vane	mm		
Inspector	Inspector		Sheet maker	
	Proof reader			
	Test personnel			
Note				

Table A.4 — Test data

<table>
<tr><td colspan="2">Name and number</td><td colspan="2"></td><td colspan="2">Product number</td><td colspan="2"></td><td colspan="2">Test date</td><td></td></tr>
<tr><td colspan="2">Manufacturer</td><td colspan="2"></td><td colspan="2">Ambient temperature</td><td colspan="2">°C</td><td colspan="2">Water temperature</td><td>°C</td></tr>
<tr><td colspan="2">Inlet and outlet area</td><td colspan="2">m^2</td><td colspan="2">Barometric pressure</td><td colspan="2">kPa</td><td colspan="2">Potential difference</td><td>m</td></tr>
<tr><td colspan="7">Test data</td><td colspan="4">Value converted to rated speed</td></tr>
<tr><td rowspan="2">Item</td><td>Rate of flow</td><td>Power</td><td>Head</td><td>Rotating speed</td><td>Inlet pressure</td><td>Outlet pressure</td><td>Rate of flow</td><td>Head</td><td>Shaft power</td><td>Efficiency</td></tr>
<tr><td>m^3/s</td><td>kW</td><td>m</td><td>r/min</td><td>MPa</td><td>MPa</td><td>m^3/s</td><td>m</td><td>kW</td><td>%</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Annex B
(informative)

Working section of the test device

B.1 General

The temperature rise of the test device in operation should be within the allowable range and shall not affect the characteristics of the medium.

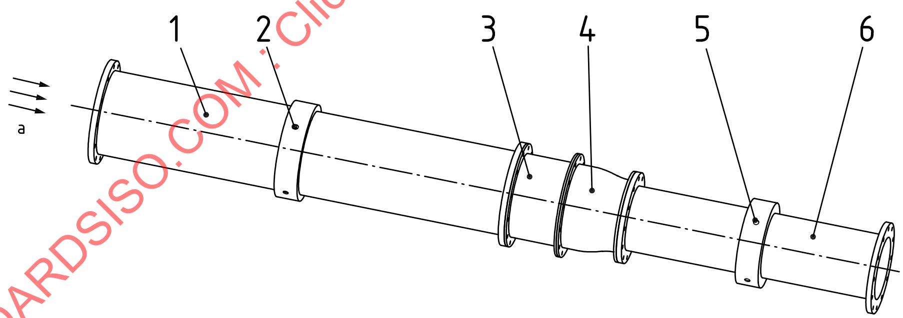
B.2 Model test device with uniform inflow

The section between the uniform chamber in front of the model pump rotor and the pressure measuring section after the guide vane (nozzle) includes inlet uniform chamber, test model, outlet uniform chamber and the test shaft, as shown in Figure B.1.

The uniform chamber should be installed before the rotor inlet, and the pressure measuring holes are required to be set. The distance between the position of the pressure measuring hole and the rotor inlet should be double the inlet pipe diameter.

The pressure measuring section shall be installed after the guide vane (nozzle). The pressure measuring holes shall also be set in the section. The distance between the position of the pressure measuring hole and the nozzle should be double the outlet pipe diameter.

The model pump installation method is the same as the prototype pump. The pressure measuring point of inlet and outlet uniform chamber should be at the same level.



Key

1 inlet uniform chamber

2 pressure measuring point 1

3 propeller house

4 guide vane

5 outlet uniform chamber

6 pressure measuring point 2

a Inflow.

Figure B.1 — Working section of model test device with uniform inflow

