INTERNATIONAL STANDARD ISO 3555

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Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class B

Pompes centrifuges, hélico-centrifuges et hélicoïdes — Code d'essais de réception — Classe B

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3555 was developed by Technical Committee ISO/TC 115, *Pumps*, and was circulated to the member bodies in February 1975.

It has been approved by the member bodies of the following countries :

Austria	Israel	Spain
Belgium	Italy	Sweden
Bulgaria	Japan	Switzerland
Canada	Mexico	Turkey
France	Netherlands	United Kingdom
Germany	Poland	Yugoslavia
Hungary	Romania	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
U.S.A.

CONTENTS

Page

Annexes

Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class B

WARNING — Terms used in this International Standard like "guarantee" or "acceptance" shall be understood in a technical but not in a legal sense. The term "guarantee", therefore, specifies values for checking purposes determined in the contract, but does not say anything about the rights or duties arising, if these values are not reached or fulfilled. The term "acceptance" does not have any legal meaning here, either. Therefore, an acceptance test carried out successfully alone does not represent an "acceptance" in the legal sense.

0 INTRODUCTION

This International Standard is the second of a set of three dealing with acceptance tests of centrifugal, mixed flow and axial pumps[1]; they correspond to three classes of tests A, B and C[2]; class A is the most accurate and class C is the least accurate; the use of classes A and B is restricted to special cases when there is need to have the pump performance more precisely defined.

Attention is drawn to the fact that class B and A tests require more accurate apparatus and methods, which increase the cost of such tests.

The standard arrangements and procedures described are those to be employed for testing a pump individually, without reference to its final installation conditions or the effect upon it of any associated fittings, these being the usual conditions in which a pump is tested at the manufacturer's works.

Pump performance may be affected by conditions of the final site installation, and procedures are described for carrying out "standard tests" on certain types of installations of which an overall performance is required.

The conditions in which pumps are finally installed, however, often do not permit reliable tests measurements, and recommendations are made concerning the procedure to be adopted where the layout precludes tests in conformity with the standards, or where the tests cover the pump and the plant ancillary to the pump itself.

In this test code, all formulae are given in coherent units.

1 SCOPE AND FIELD OF APPLICATION

This International Standard constitutes a code for acceptance testing of pumps, defining the terms and quantities that are used, establishing the methods of testing and the ways of measuring the quantities involved according to class B so as to ascertain the performances of the pump and to compare them with the manufacturer's guarantee.

In general this code applies to any sizes of pumps tested with clean cold water and other liquids behaving as clean cold water such as defined in clause 8.

This code is not concerned with the structural details of the pump nor with the mechanical properties of their components.

1) In the rest of the text these types of pumps will be simply designated as "pumps".

2) ISO 2548.

2 SYMBOLS

2.1 List of symbols used in the test code

TABLE 1 — **Symbols**

Reference number in ISO 31[1)]	Reference number in ISO 3555	Quantity	Symbol	Dimensions[2)]	SI units
3.1.1		Mass	m	M	kg
1.3.1		Length	l	L	m
1.6.1		Time	t	T	s
4.2.1		Temperature	θ	Θ	°C
1.4.1		Area	A	L^2	m^2
1.5.1		Volume	V	L^3	m^3
1.8.1		Angular velocity	ω	T^{-1}	rad/s
1.10.1		Velocity	v	LT^{-1}	m/s
1.11.2		Acceleration of free fall	g	LT^{-2}	m/s^2
2.3.2		Speed of rotation	n	T^{-1}	s^{-1}
3.2.1		Density	ρ	ML^{-3}	kg/m^3
3.11.1		Gauge pressure	p_e	$ML^{-1}T^{-2}$	Pa
3.19.1		Viscosity (dynamic viscosity)	μ	$ML^{-1}T^{-1}$	Pa·s
3.20.1		Kinematic viscosity	ν	L^2T^{-1}	m^2/s
3.22.2		Energy	E	ML^2T^{-2}	J
3.23.1		Power (general term)	P	ML^2T^{-3}	W
12.1		Reynolds number	Re	pure number	
		Diameter	D	L	m
	3.2.1.1	Mass rate of flow	q_m	MT^{-1}	kg/s
	3.2.1.2	Volume rate of flow	q_V	L^3T^{-1}	m^3/s
	3.2.3.2	Distance to reference plane	z	L	m
	3.2.3.8	Pump total head	H	L	m
	3.2.3.6	Inlet total head	H_1	L	m
	3.2.3.7	Outlet total head	H_2	L	m
	3.2.3.9	Specific energy	y	L^2T^{-2}	J/kg
	3.2.3.10	Loss of head at inlet	H_{J1}	L	m
	3.2.3.11	Loss of head at outlet	H_{J2}	L	m
	3.2.3.12	Net positive suction head	(NPSH)[3)]	L	m
		Atmospheric pressure (absolute)	p_b	$ML^{-1}T^{-2}$	Pa
		Vapour pressure (absolute)	p_v	$ML^{-1}T^{-2}$	Pa
	3.2.4.2	Pump power input	P_a	ML^2T^{-3}	W
	3.2.4.1	Pump power output	P_u	ML^2T^{-3}	W
	3.2.4.3	Motor power input	P_{gr}	ML^2T^{-3}	W
	3.2.5.1	Pump efficiency	η	pure number	
	3.2.5.2	Transmission efficiency	η_{int}	pure number	
	3.2.5.3	Motor efficiency	η_{mot}	pure number	
	3.2.5.4	Overall efficiency	η_{gr}	pure number	
	3.2.6	Type number	K	pure number	
	6.2.1.2	Friction factor	λ	pure number	

1) ISO 31 (See annex E.)

2) M = Mass L = length T = Time Θ = Temperature

3) An optional symbol for net positive suction head is H_H.

2.2 Alphabetical lists of basic letters and subscripts

TABLE 2 — **Letters used as symbols**

Symbol	Quantity	SI units
A	Area	m^2
D	Diameter	m
E	Energy	J
g	Acceleration of free fall	m/s^2
H	Head	m
H_J	Losses in terms of head of liquid	m
K	Type number	pure number
k	Absolute roughness	m
l	Length	m
m	Mass	kg
n	Speed of rotation	s^{-1}
(NPSH)	Net positive suction head	m
p	Pressure	Pa
P	Power	W
q_m	Mass rate of flow	kg/s
q_v	Volume rate of flow	m^3/s
Re	Reynolds number	pure number
t	Time	s
v	Velocity	m/s
V	Volume	m^3
X	Tolerance	pure number
y	Specific energy	J/kg
z	Distance to reference plane	m
η	Efficiency	pure number
θ	Temperature	°C
λ	Friction factor	pure number
μ	Dynamic viscosity	Pa·s
ν	Kinematic viscosity	m^2/s
ρ	Density	kg/m^3
ω	Angular velocity	rad/s

TABLE 3 — **Letters and figures used as subscripts**

Subscript	Meaning
0	value at the specified speed
1	inlet
2	outlet
a	absorbed
av	available
b	atmospheric
e	effective
G	guaranteed
gr	unit (overall)
int	intermediate
J	loss
m	1) general case : mean 2) related to q : mass
M	manometric
mot	motor
P	pump
r	required
S	eye
sp	specified[1]
t	total
u	useful
v	1) general case : vapour 2) related to q : volume

1) This indication applies to the values of quantities relating to the guarantee point.

3 DEFINITIONS

3.1 GENERAL DEFINITIONS

In order to avoid any error of interpretation it has seemed preferable to reproduce here the definitions of quantities and units as given in ISO 31 and to supplement these definitions by some specific information on their use in this test code.

g — **acceleration of free fall.**1)

n — **speed of rotation :** The quotient of the number of rotations by the time.

ρ — **density :** Mass per unit volume.

p — **pressure :** The quotient of force by area. Unless otherwise specified, all pressures are gauge pressures, i.e. measured with respect to the atmospheric pressure.

μ — **viscosity** (dynamic viscosity, sometimes called absolute viscosity) is defined by the expression :

$$\tau = \mu \frac{u_o}{h}$$

where

u_o is the velocity of a flat plate moving in its own plane while keeping parallel to a fixed flat wall;

h is the distance from the flat plate to the fixed flat wall;

τ is the friction force of the fluid on the unit area of the flat plate during its motion.

NOTE — h should be small enough to obtain laminar flow of the fluid between the flat plate and the fixed flat wall.

ν — **kinematic viscosity :** The quotient of the viscosity (dynamic viscosity) by the density :

$$\nu = \frac{\mu}{\rho}$$

P — **power :** The quotient of the energy transferred during a time interval by the duration of this interval.

Re — **Reynolds number** is defined by the expression :

$$Re = \frac{vD}{\nu}$$

3.2 DEFINITIONS PECULIAR TO THE TEST CODE

This sub-clause gives the definitions of concepts used in this test code, together with the associated symbols, if any have been allocated.

Concepts, even though in current use, which are not strictly necessary to the application of this code are not here defined.

3.2.1 Flow rates

3.2.1.1 q_m — In this test code, **mass rate of flow** designates the external mass rate of flow of the pump, i.e. the rate of flow discharged into the pipe from the outlet branch of the pump.

NOTE — Losses or abstractions inherent to the pump, i.e. :

a) discharge necessary for hydraulic balancing of axial thrust;

b) cooling of bearings of the pump itself;

c) water seal to the packing;

d) leakage from the fittings, internal leakage, etc.;

are not to be reckoned in the quantity delivered. On the contrary, if they are taken at a point before the flow measuring section, all derived quantities used for other purposes, such as :

e) cooling of the motor bearings;

f) cooling of a gear-box (bearings, oil cooler), etc., should be added to the measured rate of flow.

3.2.1.2 q_v — The **outlet volume rate of flow** has the following value :

$$q_v = \frac{q_m}{\rho_2}$$

In this test code, this symbol may also designate the volume rate of flow in a given section2); it is the quotient of the mass rate of flow in this section by the density. (The section may be designated by the proposed subscripts.)

3.2.2 v — Velocity of flow :

The mean velocity of flow equal to the volume rate of flow divided by the pipe cross-section 2) :

$$v = \frac{q_v}{A}$$

1) For class B tests, the local value of g should be used. Nevertheless, in most cases, a value of 9,81 m/s^2 would not involve significant error.

The local value should be calculated by the formula :

$$g = 9{,}806\ 17\ (1 - 2{,}64 \times 10^{-3} \cos 2\varphi + 7 \times 10^{-6} \cos^2 2\varphi) - 3{,}086 \times 10^{-6}\ Z$$

where φ and Z are respectively the latitude and the altitude.

2) Attention is drawn to the fact that in this case q_v may vary for different reasons across the circuit.

3.2.3 head : The energy per unit weight of fluid.

3.2.3.1 reference plane : The horizontal plane through the centre of the circle described by the external point of the entrance edges of the impeller blades; in the case of double inlet pumps the plane should be taken through the higher centre.

The manufacturer should indicate the position of this plane with respect to precise reference points on the pump.

3.2.3.2 z designates the difference between the level of the horizontal plane under consideration and the level of the reference plane. Its value is

— positive, if the plane in question is above the reference plane;

— negative, if the plane in question is below the reference plane.

3.2.3.3 p_e **— gauge pressure :** The effective pressure, relative to atmospheric pressure. The head corresponding to this pressure is

$$\frac{p_e}{\rho g}$$

Its value is

— positive if this pressure is greater than the atmospheric pressure;

— negative if this pressure is less than the atmospheric pressure.

3.2.3.4 velocity head : The kinetic energy per unit weight of the liquid in movement. It is expressed by :

$$\frac{v^2}{2g}$$

where v is the mean velocity of the liquid in the section considered.

3.2.3.5 total head : In any section, the total head is given by :

$$z + \frac{p}{\rho g} + \frac{v^2}{2g}$$

This is related to atmosphere. The absolute total head in any section is given by :

$$z + \frac{p}{\rho g} + \frac{p_b}{\rho g} + \frac{v^2}{2g}$$

3.2.3.6 H_1 **— inlet total head :** The total head in the inlet section of the pump :

$$H_1 = z_1 + \frac{p_1}{\rho_1 g} + \frac{{v_1}^2}{2g}$$

3.2.3.7 H_2 **— outlet total head :** The total head in the outlet section of the pump :

$$H_2 = z_2 + \frac{p_2}{\rho_2 g} + \frac{{v_2}^2}{2g}$$

3.2.3.8 H **— pump total head :** The algebraic difference between the outlet total head, and the inlet total head.

$$H = H_2 - H_1$$

If the variation of density of the pumped liquid is not significant,

$$H = z_2 - z_1 + \frac{p_2 - p_1}{\rho g} + \frac{{v_2}^2 - {v_1}^2}{2g}$$

If the variation of density of the pumped liquid is significant, ρ should be replaced by the mean value

$$\rho_m = \frac{\rho_1 + \rho_2}{2}$$

3.2.3.9 y **— specific energy :** The energy per unit mass of liquid. It is given by the equation

$$y = gH$$

3.2.3.10 H_{J1} **— loss of total head at inlet :** The difference between the total head of the liquid at the measuring point, or possibly of the liquid without velocity in the suction chamber, and the total head of the liquid in the inlet section of the pump.

3.2.11 H_{J2} **— loss of total head on delivery :** The difference between the total head of the liquid in the outlet section of the pump, and the total head of the liquid at the measuring point.

3.2.3.12 (NPSH) **— net positive suction head :** The total inlet head, plus the head corresponding to the atmospheric pressure, minus the head corresponding to the vapour pressure :

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

Thus (NPSH), as well as inlet total head, is referred to the reference plane.

It is necessary to make a distinction between

— the (NPSH) *required* at given flow and speed of rotation for a given pump; it is specified by the manufacturer;

— the (NPSH) *available* for the same flow which is determined by the installation.

— the value (NPSH) determined during the cavitation-test. This value is that which causes in the first stage a drop of $(3 + K/2)$ % in total head of the first stage or in efficiency at a given rate of flow, or in a rate of flow or efficiency at a given total head.

Subscripts may be used to differentiate these quantities (for example $(NPSH)_r$ when the required value is concerned and $(NPSH)_{av}$ when the available value is concerned).

3.2.4 Power

3.2.4.1 P_u – **pump power output :** The power transferred to the liquid at its passage through the pump :

$$P_u = q_m g H = q_m y = \rho q_v g H$$

3.2.4.2 P_a – **pump power input :** The power measured at the pump coupling.

3.2.4.3 P_{gr} – **motor power input :** The power absorbed by the pump driver.

3.2.5 Efficiency

3.2.5.1 η – **pump efficiency :**

$$\eta = \frac{\text{Pump power output}}{\text{Pump power input}}$$

3.2.5.2 η_{int} – **transmission efficiency** (shafting, coupling, gears, etc.) :

$$\eta_{int} = \frac{\text{Pump power input}}{\text{Power at motor shaft}}$$

3.2.5.3 η_{mot} – **motor efficiency :**

$$\eta_{mot} = \frac{\text{Power at motor shaft}}{\text{Motor power input}}$$

3.2.5.4 η_{gr} – **overall efficiency :**

$$\eta_{gr} = \eta\, \eta_{int}\, \eta_{mot}$$

$$= \frac{\text{Pump power output}}{\text{Motor power input}}$$

3.2.6 Type number K

The type number, a dimensionless quantity, is defined by the following formula[1] :

$$K = \frac{2\pi n\,(q'_v)^{1/2}}{(gH')^{3/4}}$$

where

q'_v is the volume rate of flow per eye;

H' is the head per stage.

NOTE – Attention is drawn to the fact that, in this International Standard, the type number applies to the guaranteed flow rate, which is not in conformity with common practice where K is calculated from the flow rate corresponding to the maximum efficiency.

4 GUARANTEES

4.1 Subjects of guarantees

One or more of the following quantities may be guaranteed by the manufacturer under the specified conditions and speed of rotation :

a) total head of the pump, H_G, at the agreed flow rate q_{vG}, or flow rate of the pump q_{vG} at the agreed total head H_G (see 9.4.1);

b) power input or efficiency of the pump or combined pump-motor unit at the guaranteed $q_{vG}H_G$ point;

c) NPSH required by the pump at the agreed flow rate q_{vG};

d) other points of the q_vH curve may be indicated by guaranteeing the total head at a reduced or increased flow rate, in which case separately agreed increased tolerances will apply.

4.2 Other conditions of guarantee

Unless specifically agreed otherwise in the contract, it shall be taken that the following conditions apply to the guarantee values :

a) unless the chemical and physical properties of the liquid are stated, it shall be taken that the guarantee points apply to clean cold water;

b) the relation between the guarantee values under clean cold water conditions and the likely performance under other liquid conditions shall be agreed in the contract;

c) guarantees shall apply only to the pump as tested by the methods and in the test arrangements specified, in this International Standard;

d) the pump manufacturer shall not be responsible for the specification of the guarantee point.

4.3 Fulfilment of guarantee

The nominated guarantee for any quantity shall be deemed to have been met if, when tested according to this International Standard, the measured performance falls within the tolerance specified in clause 9 for the particular quantity. Other points on the q_vH curve shall not be guaranteed unless the points and tolerances for fulfilment of guarantee are agreed in the contract.

5 TESTS

5.1 Organization of tests

5.1.1 *Place of testing*

Acceptance tests shall be carried out at the manufacturer's works, or alternatively at a place to be mutually agreed between the manufacturer and the purchaser.

1) This formula is the same as the basic formula $K = \frac{\omega\, q'_v{}^{1/2}}{y'^{3/4}}$

5.1.2 *Time of testing*

The time of testing shall be mutually agreed by the manufacturer and the purchaser.

When tests are not carried out in the manufacturer's works, time shall be allowed for preliminary adjustments by both the manufacturer and the installer.

5.1.3 *Staff*

Accurate measurements depend not only on the quality of the measuring instruments used but also on the ability and skill of the persons operating and reading the measuring devices during the tests. The staff entrusted with effecting the measurements must be selected just as carefully as the instruments to be used in the test.

Specialists with adequate experience in measuring operations in general shall be charged with operating and reading complicated measuring apparatus. Reading simple measuring devices may be entrusted to such helpers who — upon short prior instruction — can be assumed to effect the readings with proper care and the accuracy required.

A chief of tests shall be appointed, possessing adequate experience in measuring operations. Normally, when the test is carried out at the manufacturer's works, the chief of tests is a staff member of the manufacturing firm.

All persons charged with effecting the measurements are subordinated during the tests to the chief of tests, who conducts and supervises the measurements, reports on test conditions and the results of the tests and then drafts the test report. All questions arising in connection with the measurements and their execution are subject to his decision.

The parties concerned shall provide all assistance that the chief of tests considers necessary.

5.1.4 *Test programme*

Only the guaranteed operational data shall form the basis of the test; other data determined by measurement during the tests shall have merely an indicative (informative) function and it shall be so stated if they are included in the programme.

5.1.5 *Testing equipment*

The chief of tests shall be responsible for the selection and operation of measuring equipment. All of the measuring equipment shall be covered by reports showing, by calibration or by comparison with other International Standards, that it complies with the requirements of 5.4. These reports shall be presented if required.

5.1.6 *Test reports*

All test records and record charts shall be initialled by the chief of tests and by the representatives of both the purchaser and the manufacturer, each of whom shall be provided with a copy of all records and charts.

The evaluation of the test results, including graphical plotting of the pump performance curve, shall be made as far as possible while the tests are in progress and, in any case, before the installation and instrumentation are dismantled in order that suspect measurements can be repeated without delay.

5.2 Test arrangements

5.2.1 *Standard test arrangements*

All practical steps shall be taken to ensure that flow through the measuring section shall result in

a) an axially symmetric velocity distribution;

b) a uniform static pressure distribution;

c) freedom from swirl induced by the installation.

Some methods for ensuring these conditions for standard test arrangements are suggested below.

Acceptance tests may be carried out under standard test conditions for pumps where the type number is less than or equal to 1,5.

When the type number is greater than 1,5, it must be agreed contractually that the results of such tests will be held to apply only to specified conditions. The purpose of such tests will be to provide an assurance that the pump will, if suitably installed, perform the specified duty.

It is recommended that for standard test circuits leading from reservoirs with a free surface, or from large stilling vessels in a closed cicuit, the inlet straight length L shall be determined by the expression :

$$\frac{L}{D} = K + 5$$

where D is the pipe diameter.

This expression is also valid for an arrangement that includes, at a distance L upstream, a simple medium-radius right angle bend that is not fitted with guide vanes. Under these conditions, flow straighteners are not necessary in the pipe between the bend and the pump.

However, in a closed circuit where there is neither a reservoir nor a stilling vessel immediately upstream of the pump, it is necessary to ensure that the flow into the pump is free from swirl induced by the installation and has a normal symmetrical velocity distribution.

Significant swirl can be avoided by :

— careful design of the test circuit upstream of the measurement section;

— judicious use of a flow straightener;

— suitable arrangement of the pressure tappings to minimize their influence on the measurement.

5.2.2 *Simulated test arrangements*

When pumps are tested under simulated site conditions flow straighteners shall not be installed immediately before the pump. It is important that the characteristics of flow to the simulated circuit should be controlled; that the flow should, as far as possible, be free from significant swirl induced by the installation and have a symmetrical velocity distribution. If necessary, the velocity distribution of the flow into the simulated circuit shall be determined by careful pitot tube traverses, in order to establish that the required flow characteristics exist. If not the required characteristics can be obtained by the installation of suitable means, such as the Zanker flow straightener (see figure 1); but care must be taken to ensure that the conditions of test will not be affected by the high, irrecoverable pressure losses associated with efficient straightening devices.

5.2.3 *Pumps tested with fittings*

If specified in the contract, standard tests can be carried out on a combination of a pump and :

1) associated fittings at the final site installation; or

2) an exact reproduction thereof; or

3) fittings introduced for testing purposes and taken as forming part of the pump itself (see for example 5.2.4, 5.2.5, etc.).

Connection on the inlet and outlet sides of the whole combination shall be made in accordance with 6.2.2.

Measurements shall then be taken in accordance with 5.3.2.2 and 5.3.2.3.

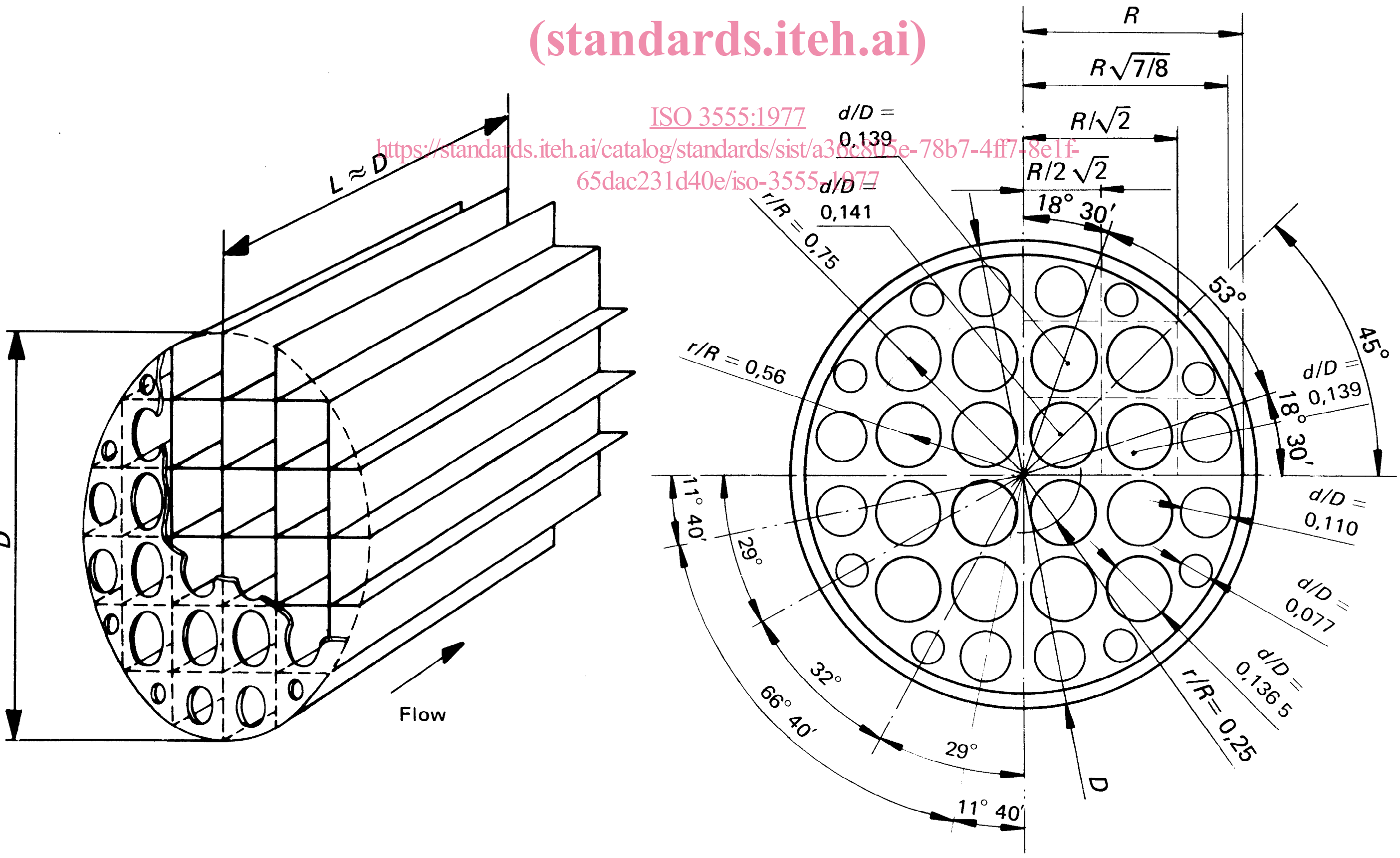

FIGURE 1 — **Zanker flow straightener**

5.2.4 *Pumping installation under submerged conditions*

Where a pump, or a combination of a pump and its fittings, is tested or installed in conditions where the standard pipe connection on either inlet or outlet as described in 6.2.2, cannot be made owing to inaccessibility or submergence, measurements shall be taken in accordance with 6.2.1.6.

5.2.5 *Borehole and deep-well pumps*

Borehole and deep-well pumps cannot usually be tested with their complete lengths of delivery main and, consequently, the loss of head in the portions omitted, and the power absorbed by any shafting therein, cannot be measured. Any thrust bearing, would also be more lightly loaded during the test than it would be in the final installation. (See 6.2.1.6.)

5.2.6 *Self-priming pumps*

In principle the priming ability of self-priming pumps shall always be verified at the contractual static suction head with the attached inlet piping equivalent to that in the final installation. When the test cannot be carried out in the described manner, the test arrangement to be used shall be specified in the contract.

5.3 Test conditions

5.3.1 *Execution of tests*

The duration of the test shall be sufficient to obtain consistent results having regard to the degree of accuracy to be achieved.

Where multiple readings are taken to reduce the error margin (see 5.3.2), they shall be taken at unequal intervals of time.

All measurements shall be made under steady conditions of operation but a decision to make measurements when such conditions cannot be obtained shall be a matter of agreement between the parties concerned.

Verification of the guaranteed point shall be obtained by recording at least five points of measurements closely and evenly grouped around the guaranteed point, for example between 0,9 and 1,1 q_{vG}.

Where, for special reasons, it is necessary to determine performance over a range of operating conditions, a sufficient number of measurements points shall be taken to establish the performance within the limits of error stated in 5.4.

5.3.2 *Stability of operation*

5.3.2.1 Definitions

For the purpose of this International Standard the following definitions apply :

oscillations : Short-period fluctuations about a mean value during the time that a single reading is being made.

variations : Those changes in value which take place between one reading and the next.

5.3.2.2 Permissible oscillations in readings and use of damping

Where the construction or operation of a pump is such that oscillations of great amplitude are present, measurements may be carried out by means of an instrument capable of providing an integration over at least one complete cycle of oscillation. The calibration of such an instrument shall comply with the provisions of the appropriate clauses.

Restricted damping may be introduced in measuring instruments and their connecting lines where necessary to reduce the amplitude of oscillations to within the values given in table 4.

TABLE 4 — **Maximum permissible amplitude of oscillations as a percentage of mean value of quantity being measured**

Measured quantity	Maximum permissible amplitude of oscillations %
Rate of flow Head Torque Power	± 3
Speed of rotation	± 1

NOTES

1 When using a differential pressure device to measure flow rate, the maximum permissible amplitude of the oscillations of the observed differential head may be ± 6 %.

2 In the case of inlet total pressure head and outlet total pressure head measurement, the maximum permissible amplitude oscillation is to be calculated individually on the pump total head.

Where it is possible that damping will significantly affect the accuracy of the readings, the tests shall be repeated using a symmetrical and linear damping device, for example a capillary tube.

5.3.2.3 Number of sets of observations

5.3.2.3.1 Steady conditions

In steady and well controlled test conditions, only one set of readings of individual quantities will be recorded for the specified test condition. This set shall be recorded only after the observers have been satisfied that the oscillations have settled down within the limits specified in tables 4 and 5.

5.3.2.3.2 Unsteady conditions

In such cases where the unsteadiness of test conditions gives rise to doubts concerning the accuracy of the tests, the following procedure shall be followed :

Repeated readings of the measurements shall be made at the guaranteed point, only speed and temperature being