INTERNATIONAL STANDARD

ISO
5198

First edition
1987-07-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

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

Pompes centrifuges, hélico-centrifuges et hélices — Code d'essais de fonctionnement hydraulique — Classe de précision

Reference number
ISO 5198 : 1987 (E)

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.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5198 was prepared by Technical Committee ISO/TC 115, *Pumps.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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

0 Introduction

This International Standard is the first of a set of International Standards dealing with performance tests of centrifugal, mixed flow and axial pumps (in the rest of the text referred to as "pumps").

It specifies precision class tests (former class A). Engineering class I and class II tests (former classes B and C) will be the subject of a further International Standard.[1)]

The aims of these classes are quite different.

The precision class is mainly used for research, development and scientific purposes in laboratories, where an extremely high accuracy of measurement is important.

The engineering classes are generally applied for acceptance tests.

In most cases, engineering class II is adequate for acceptance tests. The use of engineering class I is restricted to special cases when there is a need to have the pump performance more precisely defined. However, there may be cases of high importance, in which even an engineering class I acceptance test will be judged inadequate for the precision required for defining pump performance. In these cases the use of the precision class may exceptionally be necessary for an acceptance test.

Attention must be paid to the fact that the accuracy required for a precision class test significantly increases the test costs by comparison with the costs for an engineering class test.

Precision class tests may not always be practicable, even when great effort and expense are devoted to measurements. Performance tests to precision class specifications will be required, and are possible, only in suitable circumstances. Therefore both the purchaser and the manufacturer shall carefully examine whether the accuracy required for a precision class test might be achieved either on site, on the manufacturer's test bed or in a mutually agreed laboratory. It should be noted that it may not be possible to guarantee precision class accuracy in advance of the tests.

The purpose of this International Standard is to specify how to carry out a test with extremely high precision.

This International Standard does not recommend any constructional tolerance nor any global tolerance for acceptance purposes; it is devoted to specifying and describing procedure and methods for accurately ascertaining the performance of a pump under the conditions in which it is tested. Contractual interpretation of the test results must be the subject of a special agreement between the parties concerned (see annex B).

Pump performance may be greatly affected by the installation conditions, and this must be especially considered when drawing up the contract if a precision class test is to be carried out.

1 Scope

This International Standard specifies precision class performance tests for centrifugal, mixed flow and axial pumps.

It defines the terms and quantities that are used and specifies general requirements for tests. It specifies ways of measuring the characteristic quantities of the precision class so as to ascertain the performance of the pump and thus provide a basis for comparison with the performance specified in the contract.

The structural details of pumps and the mechanical properties of their components lie outside the scope of this International Standard.

This International Standard does not specify constructional tolerances, which are purely contractual.

2 Field of application

This International Standard gives recommendations for hydraulic performance testing of centrifugal, mixed-flow and axial pumps when these tests have to meet very special requirements for research, development or acceptance of industrial high-tech. pumps, or when very accurate knowledge of performance characteristics is of prime importance.

This International Standard also applies to models and prototypes whether the pumps are tested on a test bench or on site if installation conditions so permit.

1) At present, they are dealt with in ISO 2548 and ISO 3555.

It applies

— either to the pump itself without fittings, which requires that the pump ends are accessible; or

— to the whole assembly of pump and of all or part of its upstream and downstream fittings, which is the case for pumps with inaccessible ends (submerged pumps, etc.).

NOTES

1 Attention is drawn to the fact that nearly all industrial needs are covered by the codes of acceptance testing of industrial classes I and II.

2 Acceptance tests for site and model storage pumps are dealt with in IEC Publications 198 and 497.

3 References

ISO 31, *Quantities, units and symbols.*

ISO 555, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow —*

Part 1: Constant-rate injection method.

Part 2: Integration (sudden injection) method.

Part 3: Constant-rate injection method and integration method using radioactive tracers.

ISO 1438, *Liquid flow measurement in open channels using thin-plate weirs and venturi flumes.*

ISO 1438/1, *Water flow measurement in open channels using weirs and venturi flumes — Part 1: Thin-plate weirs.*

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

ISO 2548, *Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class C.*

ISO 2975, *Measurement of water flow in closed conduits — Tracer methods —*

Part 1: General.

Part 2: Constant rate injection method using non-radioactive tracers.

Part 3: Constant rate injection method using radioactive tracers.

Part 6: Transit time method using non-radioactive tracers.

Part 7: Transit time method using radioactive tracers.

ISO 3354, *Measurement of clean water flow in closed conduits — Velocity-area method using current-meters.*

ISO 3534, *Statistics — Vocabulary and symbols.*

ISO 3555, *Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class B.*

ISO 3846, *Liquid flow measurement in open channels by weirs and flumes — Free overfall weirs of finite crest width (rectangular broad-crested weirs).*

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes.*

ISO 4185, *Measurement of liquid flow in closed conduits — Weighing method.*

ISO 4359, *Liquid flow measurement in open channels — Rectangular, trapezoidal and U-shaped flumes.*

ISO 4360, *Liquid flow measurement in open channels by weirs and flumes — Triangular profile weirs.*

ISO 4373, *Measurement of liquid flow in open channels — Water level measuring devices.*

ISO 5167, *Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full.*

ISO 5168, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement.*

ISO 7194, *Measurement of fluid flow in closed conduits — Velocity-area methods of flow measurement in swirling or asymmetric flow conditions in circular ducts by means of current-meters or Pitot static tubes.*

ISO 8316, *Measurement of liquid flow in closed conduits — Method by collection of the liquid in a volumetric tank.*[1)]

IEC Publication 34-2, *Rotating electrical machines — Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles).*

IEC Publication 41, *International code for the field acceptance tests of hydraulic turbines.*

IEC Publication 193, *International code for model acceptance tests of hydraulic turbines.*

IEC Publication 198, *International code for the field acceptance tests of storage pumps.*

IEC Publication 497, *International code for model acceptance tests of storage pumps.*

1) At present at the stage of draft.

Section one: General recommendations

4 Definitions and symbols

4.1 Definitions

For the purposes of this International Standard, the following definitions apply.

4.1.1 measuring system: System composed of a measuring instrument, including a transducer which picks up physical information, and one or several elements in series transmitting or transforming the resulting signal.

Such a system has a response function which can be illustrated by a gain response or a phase response curve over a frequency range. In particular, a filtering effect appears between the picked up physical quantity and the observed signal. This filtering effect is essentially characterized by a cut frequency. In most measuring systems which are used, the continuous component of the signal can pass and the cut frequency is then strongly related to the response time of the system.

4.1.2 measuring instrument: Instrument, forming part of a measuring system, which transforms any physical quantity (pressure, speed, current, etc.) into a signal which can be directly observed (a mercury level, a point on a dial scale, a digital reading, etc.).

4.1.3 first order statistical moment: mean value of a signal: Characterization of a random process $x(t)$ by a first order statistical moment which generally is the mean μ_x calculated over a period of time T given by the equation

$$\mu_x = \frac{1}{T} \int_t^{t+T} x(t)\, dt$$

NOTE — To calculate the mean value of a signal or physical quantity, an integration period T much longer than the response time of the corresponding measuring system is usually chosen.

To determine simultaneously the mean value of several signals of several physical quantities corresponding to the same operating point, the integration period T is chosen by considering the longest response time among all the measuring systems which are used.

According to the value of the integration period T chosen to calculate the mean value of the signals, the operating conditions will be determined to be either steady or unsteady.

4.1.4 second order statistical moment: variance or autocorrelation function: Characterization of a random process $x(t)$ by a second order statistical moment calculated over a time period T and for which can be chosen either the variance σ_x^2 expressed as :

$$\sigma_x^2 = \frac{1}{T} \int_t^{t+T} [x(t) - \mu_x]^2\, dt$$

or the autocorrelation function, R_{xx}, given by the equation

$$R_{xx}(t, T) = \frac{1}{T} \int_t^{t+T} x(t)\, [x(t + T)]\, dt$$

4.1.5 steady and unsteady process: Random process $x(t)$ is said to be **slightly steady** or **steady in a general sense** when its first order statistical moment (mean μ_x) and its second order statistical moment [variance σ_x^2, or autocorrelation function $R_{xx}(t, T)$] are not dependent on time t, at which the observation begins nor on the period of time T during which the observation is made.

Inversely, when the statistical moments are dependent on t or T, the physical phenomenon is said to be **unsteady.**

When all statistical moments of the process $x(t)$ (beyond the second order), which completely describe the statistical property of $x(t)$, are not dependent on t and T, the process is then said to be **strongly or strictly steady.**

NOTE — From a practical point of view and in this International Standard, only slightly steady processes are considered (first and second order statistical moments). It should be noted that when the considered process follows a normal or Gaussian distribution law, the first and second order statistical moments are sufficient to describe the statistical properties of the process completely and both concepts of strong or slight steadiness are then equivalent.

4.1.6 steady operating conditions: The operating conditions are said to be steady when the different signals delivered by the measuring systems and the physical quantities calculated from these signals have first order (mean μ_x) and second order [variance $\sigma_x{}^2$, or autocorrelation function $R_{xx}(t, T)$] statistical moments which do not depend on the time t at which the observation begins nor on the duration T during which the observation is made.

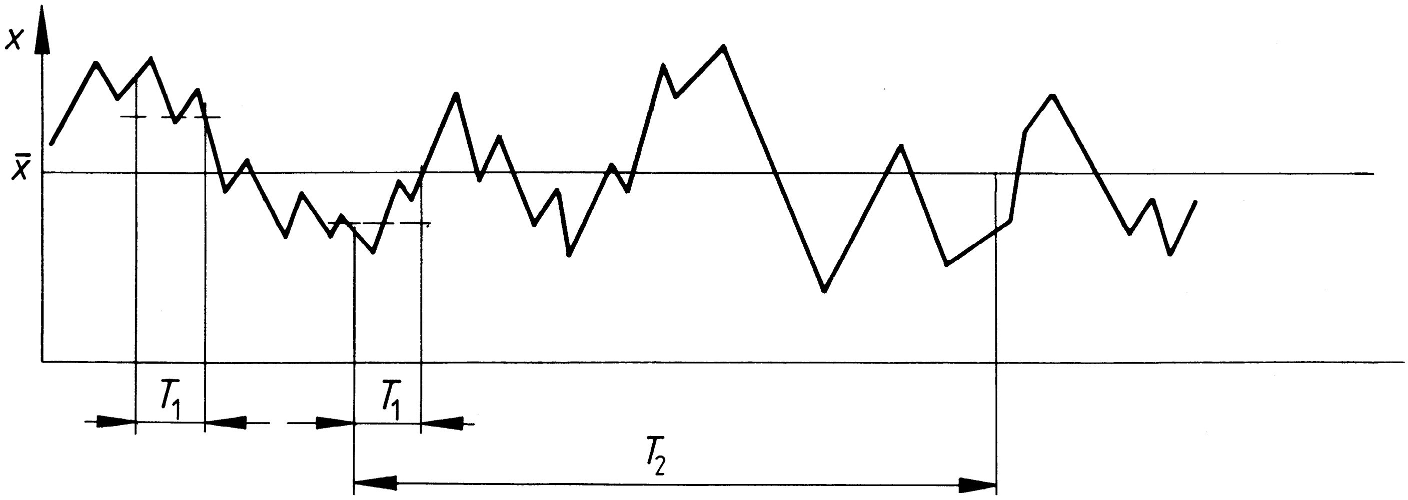
NOTE — The random signal delivered by a measuring system can be found to be steady only if the integration period T is sufficiently long. This point is difficult to check for one is never calculated for a sufficient duration; this is why, from a practical point of view, only a steadiness with a certain confidence level is defined.

4.1.7 unsteady operating conditions: The operating conditions are said to be unsteady when the different signals delivered by the measuring systems and the physical quantities calculated from these signals have a first order (mean μ_x) or second order [variance σ_x^2, or autocorrelation function $R_{xx}(t, T)$] statistical moment which depends on the time t at which the observation begins or on the period T during which the observation is made.

NOTE — The dynamic component (see figure 1) of the picked up physical quantities has different origins:

a) a random origin: turbulence, white noise of the electronic system, etc.,

b) a determinist origin: blade passing frequency, speed of rotation in connection with the electric network frequency, flow singularities, vibration modes, etc.



T_1 is an insufficiently long integration period. The mean value, $\bar{x}$, of x as estimated from T_1 will vary.

T_2 is a sufficiently long period.

Figure 1 — Graph of the evolution of a phenomenon (supposed to be known)

It is supposed that the possible unsteadiness of the operating conditions has a frequency lower than that corresponding to these phenomena (less than half the lowest encountered frequency); as a consequence, the integration period T will not be less than twice the period T corresponding to the lowest frequency mentioned above.

4.1.8 fluctuations: Periodic or random evolutions of a phenomenon $x(t)$ as a function of time, varying around a mean value and describing a physical quantity or a signal delivered by a measuring system.

All evolutions having a period or a pseudo-period less than twice the integration period chosen to calculate the mean values are considered as fluctuations. Then the fluctuations can be considered as being "rapid" compared to the variations of the mean value (see 4.1.9).

NOTE — Only fluctuations having a period or a pseudo-period higher than twice the response time of the corresponding measuring system can be detected.

4.1.9 variations of the mean value (in unsteady operating conditions): Evolution of the mean value of a physical quantity or of signal delivered by a measuring system, between one reading and the next, in unsteady operating conditions.

The variations of the mean values should show a period or a pseudo-period higher than twice the integration period T chosen to calculate the mean value.

Then the variations of the mean value can be considered as being "slow" compared to fluctuations (see 4.1.8).

4.1.10 readings: Visual observations allowing the recording of the value of the signal delivered by a measuring system.

Two types of readings should be considered:

a) the "quasi-instantaneous" reading of the signal, which is made during as short a time as possible (but not shorter than the response time of the measuring system considered);

NOTE — The group of "quasi-instantaneous" readings made during the integration period T allows the calculation of statistical moments (see 4.1.3 and 4.1.4).

b) the "averaging reading" of the signal which is made over or at the end of the integration period T depending on the measuring system, this "averaging reading" leads directly to the mean value of the signal.

4.1.11 set of readings: Group of "quasi-instantaneous" readings leading to the determination of the values of the different signal or physical quantities characterizing an operating point.

4.1.12 response time of a measuring instrument: Time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits of its final steady value.

4.1.13 Prandtl number, *Pr*:

$$Pr = \frac{\mu c_p}{\lambda}$$

where

μ is the dynamic viscosity of the fluid;

λ is its thermal conductivity.

(Definition taken from ISO 31/12.)

4.2 Quantities, symbols and units

Table 1 gives concepts and some of their uses in this International Standard, together with any associated symbols which have been allocated; it is based on ISO 31.

The definitions, particularly those given for kinetic energy coefficient, specific energy and NPSH may not be appropriate for completely general use in hydrodynamics, and are for the purposes of this International Standard only.

Table 2 gives an alphabetical list of symbols used, and table 3 gives a list of subscripts.

Table 1 — List of quantities (based on ISO 31)[1)]

Quantity	Definition[2)]	Symbol	Dimension[3)]	Unit
Mass		m	M	kg
Length		l	L	m
Time		t	T	s
Temperature		θ	Θ	°C
Area		A	L^2	m^2
Volume		V	L^3	m^3
Angular velocity		ω	T^{-1}	rad/s
Velocity		v	LT^{-1}	m/s
Acceleration due to gravity[4)]		g	LT^{-2}	m/s^2
Speed of rotation	Number of rotations per unit time	n	T^{-1}	s^{-1}
Density	Mass per unit volume	ϱ	ML^{-3}	kg/m^3
Pressure	Force per unit area. Unless otherwise specified all pressures are gauge pressures, i.e. measured with respect to atmospheric pressure.	p	$ML^{-1}T^{-2}$	Pa (1 bar = 10^5 Pa)
Kinematic viscosity		ν	L^2T^{-1}	m^2/s
Specific energy	Energy per unit mass	E	L^2T^{-2}	J/kg
Power (general term)		P	ML^2T^{-3}	W
Reynolds number		Re	dimensionless	
Diameter		D	L	m
Flow rates				
Mass rate of flow	The 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.	$q_m(q)$	MT^{-1}	kg/s

Table 1 — List of quantities (based on ISO 31)[1] (*continued*)

Quantity	Definition[2]	Symbol	Dimension[3]	Unit
Volume rate of flow	The outlet volume rate of flow is given by the equation $q_V = \frac{q_m}{\varrho}$ For the purposes of this International Standard, this symbol may also designate the volume rate of flow in a given section[5] of the pump outlet; it is the quotient of the mass rate of flow in this section by the density. (The section may be designated by subscripts.)	q_V (Q)	L^3T^{-1}	m^3/s
Mean velocity	The mean velocity of flow equal to the volume rate of flow divided by the pipe cross-section[5] $U = \frac{q_V}{A}$	U	LT^{-1}	m/s
Local velocity	Velocity of flow at any point	v	LT^{-1}	m/s
Gauge pressure	Any pressure used in this International Standard except atmospheric and vapour pressure; the effective pressure, relative to the atmospheric pressure. Its value is — positive if this pressure is greater than the atmospheric pressure; — negative if this pressure is less than the atmospheric pressure.	p_e	$ML^{-1}T^{-2}$	Pa
Atmospheric pressure (absolute)		p_b	$ML^{-1}T^{-2}$	Pa
Vapour pressure (absolute)		p_v	$ML^{-1}T^{-2}$	Pa
Head	The energy per unit mass of fluid divided by gravitational acceleration.		L	m
Height	Elevation of a point above a reference plane. If the point is below the reference plane, z is negative.	z	L	m
Reference plane	Any horizontal plane to be used as a datum for height measurement. A materialized reference plane may be more practical than an imaginary one for measurement purposes.	—	—	—
Inlet impeller height (or eye height)	The height of the centre of the circle described by the external point of the entrance edges of the first impeller blades. In case of double inlet pumps, z_s is the higher impeller height. The manufacturer should indicate the position of this point with respect to precise reference points on the pump.	z_s	L	m
Velocity head	Height of fluid corresponding to the kinetic energy per unit mass of fluid divided by gravitational acceleration. Its value is given by the formula $\alpha U^2/2g$		L	m
Velocity head coefficient	A coefficient relating velocity head in the section with the mean velocity in that section. It is defined by the equation $\alpha = \frac{\int_A v^3 \, dA}{U^3 A}$ If v is constant, $\alpha = 1$	α	dimensionless	
Available velocity head	The part of the velocity head contributing to the total head. Its value is given by the formula $\alpha_a U^2/2g$ where $1 < \alpha_a < \alpha$ See 8.1.1.3		L	m
Available velocity head coefficient	A coefficient relating available velocity head in a section to the mean velocity in that section. See 8.1.1.3	α_a	dimensionless	

Table 1 — List of quantities (based on ISO 31)[1] (*continued*)

Quantity	Definition[2]	Symbol	Dimension[3]	Unit
Total head (in section *i*)	Total head in a given section, *i*, is usually calculated as: $H_i = z_i + \frac{p_{ei}}{\varrho_i g} + \alpha_{ai} \frac{U_i^2}{2g}$ This equation assumes that pressure varies hydrostatically in the section and that compressibility of the liquid pumped may be neglected. See 8.1.1.2 concerning the correctness of this last assumption.	H_i	L	m
Inlet total head	Total head at inlet section 1	H_1	L	m
Outlet total head	Total head at outlet section 2	H_2	L	m
Pump total head	Algebraic difference between outlet total head H_2 and inlet total head H_1: $H = H_2 - H_1$ Separate evaluation of H_1 and H_2 is not always necessary. Other methods may even be recommended if compressibility is to be accounted for. See 8.1.1.2.	H	L	m
Loss of 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.	H_{J1}	L	m
Loss of head at outlet	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.	H_{J2}	L	m
Net positive suction head; NPSH	Inlet total head increased by the head (in flowing liquid) corresponding to the atmospheric pressure at the test location and decreased by the sum of the head corresponding to the vapour pressure of the pump liquid at the inlet temperature and of the inlet impeller height. $(NPSH) = H_1 + \frac{p_b}{\varrho_1 g} - \frac{p_v}{\varrho_1 g} - z_1$ NOTES 1 To maintain consistency between precision class and engineering classes I and II, the arbitrary definition of (NPSH) is the same. Therefore, in calculating (NPSH) values, the value of α_{a1} is taken to be equal to unity (see velocity head coefficient). 2 Local velocity distribution may influence (NPSH) performance of the pump. Limitation of local velocity variation is given in clause 12. 3 It is necessary to make a distinction between — the (NPSH) required at given flow and speed of rotation for a given pump — this is specified by the manufacturer; — the (NPSH) available for the same flow, which is inferred from the installation; — the cavitation test (NPSH). Subscripts may be used to differentiate these quantities [for example $(NPSH)_r$ when the value required by the pump is concerned, $(NPSH)_a$ when the available value is concerned and $(NPSH)_c$ when cavitation test (NPSH) is concerned].	(NPSH)	L	m
Critical net positive suction head	Net positive suction head associated with [2 + (*K*/2)] % either of head drop in the first stage or of the efficiency drop.	$(NPSH)_c$	L	m

Table 1 — List of quantities (based on ISO 31)[1] (*concluded*)

Quantity	Definition[2]	Symbol	Dimension[3]	Unit
Type number	A number defined by the equation $$K = \frac{2\pi\, n\, (q'_V)^{1/2}}{(gH')^{3/4}} = \frac{\omega\, q'_V{}^{1/2}}{E'^{3/4}}$$ where q'_V is the volume rate of flow per eye and H' is the head of the first stage. This quantity shall be calculated at the best efficiency point.	K	dimensionless	
Pump power input	Mechanical power transmitted to the pump shaft.	P	ML^2T^{-3}	W
Driver power input	Power input to driving unit.	P_{gr}	ML^2T^{-3}	W
Pump power output	The power transferred to the liquid at its passage through the pump $$P_u = \varrho q_V\, g\, H = \varrho q_V\, E$$	P_u	ML^2T^{-3}	W
Pump efficiency	$$\eta = \frac{P_u}{P}$$	η	dimensionless	
Overall efficiency	$$\eta_{gr} = \frac{P_u}{P_{gr}}$$	η_{gr}	dimensionless	

1) Further symbols used in the thermodynamic method are given in table 9.

2) In order to avoid any error of interpretation, it is deemed desirable to reproduce 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 International Standard.

3) M = mass, L = length, T = time, Θ = temperature.

4) For precision class tests, the local values of g should be used. Nevertheless, in most cases, a value of 9,81 m/s² would not involve significant error. The local value should be calculated by the equation

$$g = 9{,}780\,3\,(1 + 0{,}005\,3\,\sin^2\varphi) - 3 \times 10^{-6}\, z$$

where φ and z are respectively the latitude, in degrees, and the altitude, in metres.

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

Table 2 — Alphabetical list of symbols

Symbol	Quantity	Units
A	Area	m^2
D	Diameter	m
e	Relative value of uncertainty	—
E	Specific energy	J/kg
f	Frequency	Hz
g	Acceleration due to gravity	m/s^2
H	Pump total head	m
H_J	Losses in terms of head of liquid	m
k	Equivalent uniform roughness	m
K	Type number	dimensionless
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	dimensionless
t	Time	s
U	Mean velocity	m/s
v	Local velocity	m/s
V	Volume	m^3
z	Height above reference plane	m
α	Velocity head coefficient	dimensionless
η	Efficiency	dimensionless
θ	Temperature	°C
λ	Universal coefficient for head loss	dimensionless
ν	Kinematic viscosity	m^2/s
ϱ	Density	kg/m^3
ω	Angular velocity	rad/s

NOTE — See also clause 11.

Table 3 — List of letters and figures used as subscripts

Subscript	Designation
1	inlet
2	outlet
a	available
ac	acoustic
b	atmospheric
c	critical
d	drop
e	effective (gauge)
f	fully developed
gr	unit (overall)
H	pump total head
int	intermediate
M	manometric
m	mass
mot	motor
P	pump power input
p	pump
r	required
s	eye
sp	specified
t	total
T	translated
u	useful
V	volume
v	vapour (pressure)
vis	visible
η	efficiency

5 Specified duty

5.1 Main specification

One or more of the following quantities may be specified under the conditions and speed or rotation stated in the contract:

a) pump total head, H_{sp}, at the agreed flow rate, q_{Vsp}, or flow rate of the pump, q_{Vsp}, at the agreed total head, H_{sp}.

b) power input or efficiency of the pump or combined pump-motor unit at the specified q_{Vsp}, H_{sp} point.

c) net positive suction head, (NPSH), required by the pump at the agreed flow rate q_{Vsp} for a specified cavitation effect as defined, for example, in 12.1.3.2 at the agreed flow rate.

d) other points of the $H(q_V)$ curve may be indicated by specifying either the total head at a reduced or increased flow rate, or the flow rate at a reduced or increased total head.

5.2 Other specifications

Unless specifically agreed otherwise in the contract, the specified values are valid in the following conditions :

a) unless the chemical and physical properties of the liquid are stated, it shall be taken that the points specified apply to clean cold water (see table 4);

Table 4 — Specification of "clean cold water"

Characteristic	Unit	max.
Temperature	°C	40
Kinematic viscosity	m^2/s	$1{,}5 \times 10^{-6}$
Density	kg/m^3	1050
Non-absorbent free solid content	kg/m^3	2,5
Dissolved solid content	kg/m^3	50

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

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

6 General requirements for tests

6.1 Organization of tests

6.1.1 Place of testing

Performance 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.

Both purchaser and manufacturer shall be entitled to have representatives present at all tests and calibrations in order to verify that they are performed in accordance with this International Standard and any prior written agreements.

6.1.2 Time of testing

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

6.1.3 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 shall be selected just as carefully as the instruments to be used in the test.

A chief of tests possessing adequate experience in measuring operations shall be appointed. 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.

6.1.4 State of pump

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

6.1.5 Test programme

Only the specified 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 this shall be stated if they are included in the programme.

6.1.6 Test equipment

When deciding on the measuring procedure, the measuring and recording apparatus required shall be specified at the same time.

The chief of tests shall be responsible for checking the correct installation of the apparatus and its perfect functioning.

All measuring apparatus shall be covered by reports showing, by calibration or by comparison with other International Standards, that it complies with the requirements of 6.4. These reports shall be presented if required.

The measuring devices used shall have valid calibration. Periodic calibration shall be performed by an entitled body. During the pump tests, the indications of the various instruments shall be cross-compared to check that their calibration is maintained. Generally after site testing or in case of dispute, new calibration shall be performed as soon as possible.

6.1.7 Test report

After actual scrutiny, the test results shall be summarized in a report signed either by the chief of tests alone, or by him and representatives of the manufacturer and of the purchaser.

All parties to the contract shall receive a copy of the report as an essential condition for the completion of the contract.

The test report shall contain the following information :

a) place and date of the performance test;

b) manufacturer's name, type of pump, serial number, and if possible year of construction;

c) specified characteristics, operational conditions during the performance test;

d) specification of the pump's drive;

e) description of the test procedure and the measuring apparatus used including calibration data;

f) observed readings;

g) evaluation and analysis of test results with calculation of measuring uncertainties according to 6.4, 6.5 and annex A;

h) conclusion : comparison of the test results with the specified duties (see annex B).

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 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 measurements regarded as suspect can be repeated without delay.

6.2 Test arrangements

The performance of a pump in a given test arrangement, however accurately measured, cannot be assumed to be a correspondingly accurate indication of its performance in another arrangement.

Moreover, the conditions which permit the most accurate measurements to be taken are not necessarily those under which the pump may perform most satisfactorily nor those under which the user may ultimately require it to perform.

This International Standard therefore defines the conditions necessary to measure performance most accurately and discusses the errors which may be caused by failing to meet those conditions, in order that the interested parties may define the test arrangement most suited to the circumstances.

Recommendations and general guidance about suitable pipe arrangements upstream of a measuring device are given in clauses 7 and 8; if necessary, they can be used in conjunction with International Standards on flow measurement in closed conduits concerning the different flow measurement methods.

6.2.1 Standard test arrangements

The most accurate measurement of head is possible when the flow at the measuring section has:

a) an axially symmetrical velocity distribution;

b) a uniform static pressure distribution;

c) freedom from swirl induced by the installation.

The complete flow patterns at both inlet and outlet measuring sections may be influenced by both the pump and by the geometry of the installations.