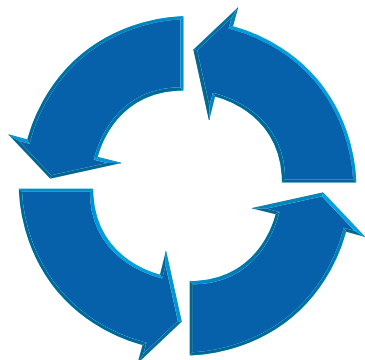




American National Standard for

Rotary Pump Tests

ANSI/HI 3.6-2010



6 Campus Drive
First Floor North
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Rotary Pump Tests

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Approved June 24, 2010
American National Standards Institute, Inc.

American National Standard

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Contents

Page

Foreword	v
3.6 Rotary pump tests	1
3.6.1 Scope	1
3.6.2 Type of performance test	1
3.6.3 Net positive inlet pressure required (NPIPR)	1
3.6.4 Terminology	2
3.6.5 Performance test	8
3.6.6 Hydrostatic test (optional)	18
3.6.7 Net positive inlet pressure required test (optional)	19
3.6.8 Rate of flow measurement	20
3.6.9 Measurement of pressure	22
3.6.10 Power measurements	23
3.6.11 Methods for rotary speed measurement	25
3.6.12 Temperature measurement	25
3.6.13 Suitable interval between calibrations for performance test instruments	25
Appendix A Index	27
Figures	
3.6.5.7.1 — Recommended test setup	11
3.6.5.9.5 — Speed correction values for pump input power for $x = 1.5$	15
3.6.5.10a — Pump performance at constant speed	16
3.6.5.10b — Pump performance at constant pressure	16
3.6.5.11.2 — Information data sheet	17
3.6.9a — Pressure tap opening with corrosion-related plug	22
3.6.9b — Welded-on pressure tap opening	22
3.6.9c — Loop manifold connecting pressure taps	22
3.6.9.1 — Use of calibrated Bourdon gauge	23
Tables	
3.6.4a — Symbols and terminology	3
3.6.4b — Subscripts	4
3.6.5.7.3 — Test tabulation	12
3.6.13 — Recommended instrument calibration interval	26

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Foreword (Not part of Standard)

Scope

The purpose and aims of the Institute are to promote the continued growth of pump knowledge for the interest of pump users and pump manufacturers and to further the interests of the public in such matters as are involved in manufacturing, engineering, distribution, safety, transportation and other problems of the industry, and to this end, among other things:

- a) To develop and publish standards for pumps;
- b) To collect and disseminate information of value to its members and to the public;
- c) To appear for its members before governmental departments and agencies and other bodies in regard to matters affecting the industry;
- d) To increase the amount and to improve the quality of pump service to the public;
- e) To support educational and research activities;
- f) To promote the business interests of its members but not to engage in business of the kind ordinarily carried on for profit or to perform particular services for its members or individual persons as distinguished from activities to improve the business conditions and lawful interests of all of its members.

Purpose of Standards

- 1) Hydraulic Institute Standards are adopted in the public interest and are designed to help eliminate misunderstandings between the manufacturer, the purchaser and/or the user and to assist the purchaser in selecting and obtaining the proper product for a particular need.
- 2) Use of Hydraulic Institute Standards is completely voluntary. Existence of Hydraulic Institute Standards does not in any respect preclude a member from manufacturing or selling products not conforming to the Standards.

Definition of a Standard of the Hydraulic Institute

Quoting from Article XV, Standards, of the By-Laws of the Institute, Section B:

"An Institute Standard defines the product, material, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing and service for which designed."

Comments from users

Comments from users of this standard will be appreciated, to help the Hydraulic Institute prepare even more useful future editions. Questions arising from the content of this standard may be sent to the Technical Director of the Hydraulic Institute. The inquiry will then be directed to the appropriate technical committee for provision of a suitable answer.

If a dispute arises regarding the content of an Institute Standard or an answer provided by the Institute to a question such as indicated above, the point in question shall be sent in writing to the Technical Director of the Hydraulic Institute, who shall initiate the Appeals Process.

Revisions

The Standards of the Hydraulic Institute are subject to constant review, and revisions are undertaken whenever it is found necessary because of new developments and progress in the art. If no revisions are made for five years, the standards are reaffirmed using the ANSI canvass procedure.

Units of measurement

Metric units of measurement are used; and corresponding US customary units appear in brackets. Charts, graphs, and sample calculations are also shown in both metric and US customary units. Since values given in metric units are not exact equivalents to values given in US customary units, it is important that the selected units of measure to be applied be stated in reference to this standard. If no such statement is provided, metric units shall govern.

Consensus

Consensus for this standard was achieved by use of the canvass method. The following organizations, recognized as having an interest in the Rotary Pump Standard, were contacted prior to the approval of this revision of the standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

A.W. Chesterton
Baldor Electric Company
Bechtel Power Corp.
Black & Veatch Corp.
Colfax Corporation
DuPont
Flowserve Corporation
FSA
GIW Industries
Healy Engineering, Inc.
J.A.S. Solutions Ltd.
Kemet, Inc.

Las Vegas Valley Water District
LyondellBasell
Malcolm Pirnie
McFarland - Tritan LLC
Moyno, Inc.
National Pump Company
Patterson Pump Company
Sulzer Pumps US Inc.
Taco, Inc.
Union Sanitary District
Weir Floway, Inc.
Weir Minerals North America

Committee Members

Although this standard was processed and approved for submittal to ANSI by the Canvass Method, a working committee met many times to facilitate its development. At the time it was developed, the committee had the following members:

Chairmen – John W. Owen, IMO Pump
Alan G. Wild, Consultant - Moyno, Inc.

Committee Members

Randolph K. Bennett
Todd E. Brown
James B. Casey
Trygve Dahl
David G. McKinstry
Michael L. Mueller
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James K. Simonelli
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Company

Leistritz Corporation
Moyno, Inc.
Milton Roy Americas
Intelliquip, LLC
IMO Pump
Flowserve Pump Division
Siemens Water Technologies
Roper Pump Company
Roper Pump Company
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formerly of Tuthill Pump Group

3.6 Rotary pump tests

This standard recognizes various performance test levels designed to permit a reasonable selection of tests, tolerances, and accuracy requirements appropriate for the application and the customer's needs.

Tests of rotary pumps that conform to the requirements of this standard shall be designated as tests conducted in accordance with the Hydraulic Institute Test Standards. Types of performance tests are defined in Section 3.6.2.

These standards apply to rotary pump tests only, unless stated otherwise. Recorded data and the final report may include information on drives and auxiliary equipment, and must be identified as such.

The type of test performed and the auxiliary equipment to be used (purchaser's driver, gearbox, etc.) should be agreed on in writing by all interested parties before the test.

It is the intent of this standard to offer testing procedures to be used by all testing facilities. It is not the intent to limit or restrict tests to only those described herein. Variations in test procedures may exist without violating the intent of this standard. Exceptions may be taken to the provisions of this standard if properly agreed on by the parties involved without sacrificing the validity of the applicable parts of the standard.

Because pumps are used to handle different liquids or liquid/solid mixtures, it is necessary to limit this standard to the testing of pumps with readily available test liquids. For other than normal test liquids, some methods and procedures not outlined herein may be required.

The objective of the standard is to establish a uniform demonstration of a pump's ability to perform satisfactorily both mechanically and hydraulically. The quantitative values observed and recorded will depend on the type of test specified. The quantitative indices are the same for a particular type of test no matter what type of pump is specified.

3.6.1 Scope

This standard recognizes four types of performance tests for rotary pumps and provides procedures for conducting and reporting test data. The test levels have been designed to permit selection of tolerances and accuracy appropriate for the application and the customer's needs. It does not include vibration or acoustical testing.

3.6.2 Type of performance test

The test types below apply to tests on liquids.

I	II	III	IV
Internal quality- assurance test	Rpm Pressure Power	Rpm Pressure Rate of Flow	Rpm Pressure Rate of Flow Power

Type III and IV have two levels of acceptance for the quantitative values. The level of test is to be Level A unless otherwise specified by the user. Refer to Sections 3.6.5.4 and 3.6.5.5.

Optional tests: Hydrostatic test and net positive inlet pressure required test are separate tests and are described in Sections 3.6.6 and 3.6.7.

3.6.3 Net positive inlet pressure required (NPIPR)

NPIPR is the pressure required, above liquid vapor pressure (bubble point), to fill each pumping chamber or cavity while open to the inlet chamber. It is measured at the pump inlet and is expressed in bara (psia).

NIPIR for a rotary pump is difficult to establish with precision because of compounding external influences of fluid properties and dissolved and entrained gas, all of which affect measured NIPIR. The level of dissolved gas is a function of the fluid and its temperature. The level of dissolved gas is also a function of system design operation. Many liquids handled by rotary pumps have an unpredictable or very low vapor pressure (bubble point). Most of these liquids also have entrained and dissolved gas (frequently air). The practical effect of dissolved and entrained gas is to increase the NIPIR in order to suppress the symptoms of cavitation. While true cavitation occurs if the liquid pressure falls below its vapor pressure during filling of the pump cavities, most of the cavitation symptoms will be exhibited before reaching liquid vapor pressure. This is largely due to the entrained and dissolved gas expanding when subjected to reduced pressure.

Normal NIPIR tests are conducted in a test environment that minimizes entrained gas. NIPIR can be established at the first indication of any of the following:

- a) A 5% reduction in rate of flow at constant differential pressure and speed.
- b) A 5% reduction in power consumption at constant differential pressure and speed.
- c) The inability to maintain a stable differential pressure.
- d) The onset of loud or erratic noise when these criteria are previously agreed on by all parties.

Reports of NIPIR tests shall state the criteria used to establish NIPIR.

3.6.4 Terminology

The following terms, symbols, units, abbreviations, and definitions are used to designate test parameters or are used in connection with pump testing. For symbols and terminology, and subscripts, refer to Tables 3.6.4a and 3.6.4b, respectively.

3.6.4.1 Rated condition point

Rated condition point applies to the operating conditions, rate of flow, pressure, viscosity, speed, and power, and is to be confirmed by performance testing.

3.6.4.2 Displacement (D)

The displacement of a rotary pump is the volume displaced per revolution of the rotor(s). It may be calculated from the physical dimensions of the pumping elements, or it may be determined empirically as the volume of fluid pumped per revolution at zero differential pressure. In pumps incorporating one or more rotors operating at different speeds, it is the volume displaced per revolution of the driving rotor. The standard unit of displacement is cubic centimeter (cubic inch) per revolution. A variable displacement pump shall be rated at its maximum displacement.

3.6.4.3 Rate of flow (Q)

The rate of flow of a rotary pump is the volumetric quantity of fluid actually delivered per unit of time, including both the liquid and any dissolved or entrained gases, at stated operating conditions.

In the absence of any vapor entering or forming within the pump, rate of flow is equal to the volume displaced per unit of time, less slip.

3.6.4.4 Speed (n)

The speed of a rotary pump is the number of revolutions per minute of the rotor(s). In pumps incorporating two or more rotating elements operating at different speeds, it is the speed of the driving rotor.

3.6.4.5 Slip (S)

Slip is the quantity of fluid that leaks through internal clearances of a pump per unit of time. It is dependent on the internal clearances, the differential pressure, the characteristics of the fluid handled, and, in some rare cases, on the speed.

Slip is determined from the following equation:

$$\text{(Metric units)} \quad S = \left(\frac{Dn}{16.7 \times 10^3} \right) - Q$$

$$\text{(US customary units)} \quad S = \left(\frac{Dn}{231} \right) - Q$$

3.6.4.6 Pump volumetric efficiency (η_v)

The pump volumetric efficiency is ratio of the actual pump rate of flow to the volume displaced per unit of time. The formula for computing volumetric efficiency in percent is:

$$\text{(Metric units)} \quad \eta_v = \frac{16.7 \times 10^3 Q}{Dn} \times 100$$

$$\text{(US customary units)} \quad \eta_v = \frac{231 Q}{Dn} \times 100$$

3.6.4.7 Pressure (p)

Pressure is the compressive stress in a liquid at a given point. It has the units of force per unit area. Pressure measurements relative to atmosphere will be positive or negative.

3.6.4.8 Absolute pressure (p_a)

The absolute pressure (p_a) is the algebraic sum of gauge pressure (p_g) and barometric pressure (p_b) and may be defined as pressure above zero pressure absolute.

Table 3.6.4a — Symbols and terminology

Symbol	Term	Metric Unit	Abbr.	US Customary Unit	Abbr.	Conversion Factor ^a
A	Area	square millimeters	mm ²	square inches	in ²	645.2
D	Displacement	cubic centimeters/revolution	cm ³ /rev	cubic inches/revolution	in ³ /rev	16.39
d	Diameter	millimeters	mm	inches	in	25.4
Δ (delta)	Difference	dimensionless	—	dimensionless	—	1
η (eta)	Efficiency	percent	%	percent	%	1
F	Force	newtons	N	pounds-force	lbf	4.448
g	Gravitational acceleration	meters/second squared	m/s ²	feet/second squared	ft/s ²	0.3048
γ (gamma)	Specific weight	kilonewtons/cubic meter	kN/m ³	pounds/cubic foot	lb/ft ³	0.157
h	Head	meters	m	feet	ft	0.3048
n	Speed	revolutions/minute	rpm	revolutions/minute	rpm	1

Table 3.6.4a — Symbols and terminology (*continued*)

Symbol	Term	Metric Unit	Abbr.	US Customary Unit	Abbr.	Conversion Factor ^a
NPIPA	Net positive inlet pressure avail.	bar absolute	bara	pounds/square inch absolute	psia	0.06895
NPIPR	Net positive inlet pressure required	bar absolute	bara	pounds/square inch absolute	psia	0.06895
ν (nu)	Kinematic viscosity	millimeters squared/second (centistoke)	mm ² /s	Saybolt Seconds Universal ^b	SSU	0.216 @ 100 °F and > 70 cSt (325 SSU) ^c
π	pi = 3.1416	dimensionless	—	dimensionless	—	1
p	Pressure	bar	bar	pounds/square inch	psi	0.06895
P	Power	kilowatts	kW	horsepower	hp	0.7457
Q	Rate of flow (capacity)	cubic meters/hour	m ³ /h	US gallons/minute	gpm	0.2271
s	Specific gravity	dimensionless	—	dimensionless	—	1
S	Slip	cubic meters/hour	m ³ /h	US gallons/minute	gpm	0.2271
t	Temperature	degrees Celsius	°C	degrees Fahrenheit	°F	(°F–32) × $\frac{5}{9}$
τ (tau)	Torque	newton-meters	N•m	pound-feet	lb•ft	1.356
v	Velocity	meters/second	m/s	feet/second	ft/s	0.3048
x	Exponent	none	none	none	none	1
Z	Elevation of gauge (distance above or below datum)	meters	m	feet	ft	0.3048

^a Conversion factor × US customary units = metric units.

^b mm²/s = cSt. SSU is the common US customary unit and conversion factor instructions are given.

^c Refer to ASTM 2161 for < 70 cSt (< 325 SSU).

Table 3.6.4b — Subscripts

Subscript	Term	Subscript	Term
a	Absolute	mot	Motor
b	Barometric	OA	Overall unit
d	Outlet (discharge)	p	Pump
g	Gauge	s	Inlet (suction)
im	Intermediate mechanism	t	Theoretical
m	Metering	v	Velocity, volumetric
max	Maximum	vp	Vapor pressure
min	Minimum	w	Water