



American National Standard for
Rotary Pump Tests

ANSI/HI 3.6-1994



9 Sylvan Way
 Parsippany, New Jersey
 07054-3802

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Rotary Pump Tests

Sponsor
Hydraulic Institute

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American National Standard

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Foreword (Not part of Standard)

Purpose and aims of the Hydraulic Institute

The purpose and aims of the Institute are to promote the continued growth and well-being of pump manufacturers and 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 more useful future editions. Questions arising from the content of this Standard may be directed to the Hydraulic Institute. It will direct all such questions to the appropriate technical committee for provision of a suitable answer.

If a dispute arises regarding the contents of an Institute publication or an answer provided by the Institute to a question such as indicated above, the point in question shall be referred to the Executive Committee of the Hydraulic Institute, which then shall act as a Board of Appeals.

Revisions

The Standards of the Hydraulic Institute are subject to review, and revisions are undertaken whenever it is found necessary because of new developments and progress in the art.

Scope

This Standard applies to industrial rotary positive displacement pumps. It includes detailed procedures on the setup and conduct of hydrostatic and performance tests of such pumps.

Units of Measurement

US Customary units of measurement are predominantly used, and, where appropriate, Metric unit equivalents appear in brackets following the US units. Sample calculations are shown with US units only.

Consensus for this standard was achieved by use of the Canvass Method

The following organizations, recognized as having an interest in the standardization of rotary pumps 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.

Agrico Chemical Corporation	John Carollo Engineers
American Petroleum Institute	John Crane Inc.
Amer. Society of Heating, Refrigerating & Air-Conditioning Engineers	Malcolm Pirnie, Inc.
Amer. Society of Mechanical Engineers	Marine Spill Response Corporation
Amoco Oil Company	Min Proc Eng., Inc.
Aurora Industries	Mobil Research & Development Corp.
Black & Veatch	Monsanto Chemical Company
BP America	Montana State University
Brown & Caldwell	Montgomery Watson
Camp Dresser & McKee, Inc.	M. W. Kellogg Company
CH2M Hill	Naval Sea Systems
Chiyoda International Corporation	Naval Surface Warfare Center
Commonwealth Edison	Newport News Shipbuilding
DeWanti & Stowell	Oxy Chem
Dexter Corporation	Pacific Gas & Electric
DuPont Engineering	Raytheon Engineers & Constructors
Durametallic Corporation	Riverwood International Georgia, Inc.
Edison Electrical Institute	San Francisco Bureau of Engineering
Electric Power Research Institute	Siemens Energy & Automation
Florida Power Corporation	Simons-Eastern Consultants
Florida Power & Light	Sordoni-Skanska Construction Co.
Fluor Daniel	Star Enterprises
Freese and Nichols, Inc.	State Farm Mutual Automobile Ins. Co.
G.E. Motors	State of California Dept. of Water Res.
HDR Engineering	Stone & Webster
Holabird & Root	Summers Engineering, Inc.
Hydraulic Institute	T. Hopkins, Consultant
Institute of Paper Science & Tech.	Tennessee Eastman
J. Brunner - Consultant	Union Carbide Chemicals & Plastics Co.
	US Bureau of Reclamation

3.6 Test

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

Tests which conform to the requirements of this standard shall be designated as tests conducted in accordance with the Hydraulic Institute Test Standards.

These standards apply to tests of the pump 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, gear box, etc.), should be agreed upon in writing by all interested parties prior to 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 upon by the parties involved without sacrificing the validity of the applicable parts of the standard.

Since 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.

This test standard provides procedures for conducting and reporting various levels of tests of rotary pumps.

The objective of the standard is to establish a uniform demonstration of a pump's ability to perform satisfactorily both mechanically and hydraulically. This standard does not include vibration or acoustical testing.

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 Type of performance test

I	II	III	IV
Internal quality assurance test	RPM pressure	RPM pressure capacity	RPM pressure capacity 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 Paragraphs 3.6.4 and 3.6.5.

Optional tests: Hydrostatic Test and Net Positive Inlet Pressure Required Test are separate tests and are described in Paragraphs 3.6.10 and 3.6.11.

3.6.2 NPIPR (net positive inlet pressure required)

NPIPR (net positive inlet pressure required) 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 expressed in psi (kPa).

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) as well. The practical effect of dissolved and entrained gas is to increase the NPIPR in order to suppress the symptoms of cavitation. While true cavitation occurs if the liquid reaches its vapor pressure (bubble point) during filling of the pumping cavities, most of the cavitation symptoms will be exhibited before reaching liquid vapor pressure (bubble point). This is largely due to the entrained and dissolved gas expanding when subjected to reduced pressure. Since the level of dissolved gas is a function of the liquid and its temperature and the level of entrained gas is a function of system design and operation, NPIPR for a rotary pump is difficult to establish with precision.

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

- 1) A 5% reduction in capacity at constant differential pressure and speed;
- 2) A 5% reduction in power consumption at constant differential pressure and speed;

- 3) The inability to maintain a stable differential pressure and speed;
- 4) The onset of loud or erratic noise when this criteria is previously agreed upon by all parties.

3.6.3 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 subscripts, refer to Tables 3.3 and 3.4.

3.6.3.1 Specified condition point

Specified condition point is synonymous with rated condition point.

3.6.3.2 Rated condition point

Rated condition point applies to the capacity, pressure, viscosity, speed and power specified by the purchaser.

3.6.3.3 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 the cubic inch (mL) per revolution. A variable displacement pump shall be rated at its maximum displacement.

3.6.3.4 Slip (S)

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

Slip is determined from the following equation:

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

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

3.6.3.5 Capacity (Q)

The capacity of a rotary pump is the 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, capacity is equal to the volume displaced per unit of time, less slip.

3.6.3.6 Pump volumetric efficiency (η_v)

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

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

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

3.6.3.7 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.

3.6.3.8 Metering efficiency (η_m)

For any specified range of operating conditions, the ratio of a rotary pump's minimum volumetric efficiency to its maximum volumetric efficiency, expressed as a percent, is the metering efficiency (η_m) of the pump over the range.

$$\eta_m = \frac{\eta_{v \min}}{\eta_{v \max}} \times 100$$

3.6.3.9 Pressure (p)

Pressure is the compressive stress in a liquid at a given point. It has the units of force per unit area. The barometric pressure (p_b) shall be zero gauge pressure. Pressure measurements relative to this datum will be positive or negative. 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.