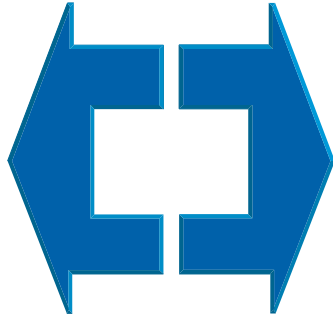




American National Standard for

# Reciprocating Pump Tests

ANSI/HI 6.6-2015



6 Campus Drive  
First Floor North  
Parsippany, New Jersey  
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American National Standard for  
**Reciprocating Pump Tests**

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Approved March 5, 2015  
**American National Standards Institute, Inc.**

# 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 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; corresponding US customary units appear in parentheses. 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 for this standard was achieved by use of the canvass method**

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

A.W. Chesterton Company  
Kemet Inc.  
LVVWD - Las Vegas Valley Water District

Weir Floway, Inc.  
Weir Group

### **Standard reviewers**

The following individuals helped to review this standard in preparation for balloting and to address the comments and suggestions received with the ballots.

Scott Baker, Pentair - Berkeley  
Rick Hammond, ClydeUnion Pumps, an SPX Brand

Tom Newman, ClydeUnion Pumps, an SPX Brand  
Herb Tackett, Hydro, Inc.

## 6.6 Reciprocating pump tests

### 6.6.1 Scope

This standard is for reciprocating power pumps, which are driven by power from an outside source applied to the crankshaft. It includes procedures for testing such pumps.

These standards apply to test of the pump only, unless stated otherwise.

The type of test performed and the auxiliary equipment to be used should be agreed on by the purchaser and manufacturer prior to the test.

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 if agreed on by the parties involved without sacrificing the validity of the applicable parts of the standard.

#### 6.6.1.1 Objective

This standard provides uniform procedures for hydrostatic, hydraulic, and mechanical pump performance testing and for recording of the test results of reciprocating pumps.

Vibration and acoustical testing methods are not included in this standard. Refer to ANSI/HI 9.1–9.5 *Pumps - General Guidelines*, for acoustical testing procedures.

### 6.6.2 Types of tests

This standard contains procedures for the following types of tests:

- a) Performance test to demonstrate one of the following:
  - 1) Mechanical integrity at speed and pressure specified.
  - 2) Rate of flow and mechanical integrity at speed and pressure specified.
  - 3) Rate of flow, power, and mechanical integrity at speed and pressure specified.

Optional tests as follows when specified:

- b) Hydrostatic testing of pressure-retaining components is described in Section 6.6.5.
- c) Net positive suction head testing is described in Section 6.6.6.

#### 6.6.2.1 Performance test

Unless otherwise specified, the rate of flow, pressure, and efficiency are based on shop tests using water corrected to 20 °C (68 °F).

If the facility cannot test at rated speed because of limitations in power, electrical frequency, or available speed changers, the pump may be tested at between 50% and 200% of rated speed.

### 6.6.3 Terminology

The following terms and symbols are used to designate test parameters used in connection with pump tests.

#### 6.6.3.1 Symbols

See Table 6.6.3.1 on page 3.

#### 6.6.3.2 Subscripts

See Table 6.6.3.2 on page 4.

#### 6.6.3.3 Rated condition point

Rated condition point applies to the rate of flow, discharge pressure, suction pressure, net positive suction head required (NPSHR), speed, and power of the pump as specified by the order.

#### 6.6.3.4 Normal condition point

Normal condition point applies to the point at which the pump will normally operate. It may be the same as the rated condition point.

#### 6.6.3.5 Volume (standard units)

The standard unit of volume shall be as follows:

- a) Metric unit – cubic meter.
- b) US customary unit – US gallon or cubic foot.

The specific weight ( $\gamma$ ) of water at a temperature of 20 °C (68 °F) shall be taken as 396 kilonewtons per cubic meter ( $\text{kN/m}^3$ ) (62.3 pounds per cubic foot [ $\text{lb/ft}^3$ ]). For other temperatures, proper specific weight corrections shall be made, using values from the American Society of Mechanical Engineers (ASME) steam tables.

##### 6.6.3.5.1 Stroke ( $L$ )

The traverse of one complete unidirectional motion of the piston or plunger.

##### 6.6.3.5.2 Pump displacement ( $D$ )

The displacement of a reciprocating pump is the volume swept by all pistons or plungers per unit of time with no volumetric losses (slip). Deduction for piston rod volume is made on double-acting piston type pumps when calculating displacement. Some texts normalize displacement by speed (rpm), making it the theoretical displacement per revolution of the shaft; however, for the purposes of this standard, the operating speed is included making it theoretical displacement per unit time.

For single-acting pumps, plunger or piston:

$$\text{(metric units)} \quad D = \frac{ALnM}{16.7 \times 10^6}$$

$$\text{(US customary units)} \quad D = \frac{ALnM}{231}$$

For double piston pumps without tail rods:

$$\text{(metric units)} \quad D = \frac{(2A - a)LnM}{16.7 \times 10^6}$$

Table 6.6.3.1 — Symbols

| Symbol    | Term                                          | Metric unit               | Abbreviation       | US customary unit        | Abbreviation        | Conversion factor <sup>a</sup>        |
|-----------|-----------------------------------------------|---------------------------|--------------------|--------------------------|---------------------|---------------------------------------|
| A         | Area                                          | square millimeter         | mm <sup>2</sup>    | square inch              | in <sup>2</sup>     | 645.2                                 |
| a         | Area of piston rod                            | square millimeter         | mm <sup>2</sup>    | square inch              | in <sup>2</sup>     | 645.2                                 |
| β (beta)  | Meter or orifice ratio                        | dimensionless             | —                  | dimensionless            | —                   | 1                                     |
| C         | Coefficient for acceleration head             | dimensionless             | —                  | dimensionless            | —                   | 1                                     |
| D         | Displacement                                  | cubic meter per hour      | m <sup>3</sup> /h  | US gallon/minute         | gpm                 | 0.2271                                |
| d         | Diameter                                      | millimeter                | mm                 | inch                     | in                  | 25.4                                  |
| Δ (delta) | Difference                                    | dimensionless             | —                  | dimensionless            | —                   | 1                                     |
| η (eta)   | Efficiency                                    | percent                   | %                  | percent                  | %                   | 1                                     |
| g         | Gravitational acceleration                    | meter/second squared      | m/s <sup>2</sup>   | foot/second squared      | ft/s <sup>2</sup>   | 0.3048                                |
| γ (gamma) | Specific weight                               | kilonewton/cubic meter    | kN/m <sup>3</sup>  | pound/cubic foot         | lb/ft <sup>3</sup>  | 0.1571                                |
| h         | Head                                          | meter                     | m                  | foot                     | ft                  | 0.3048                                |
| L         | Stroke length                                 | millimeter                | mm                 | inch                     | in                  | 25.4                                  |
| M         | Number of pistons                             | dimensionless             | —                  | dimensionless            | —                   | 1                                     |
| n         | Speed                                         | revolution/minute         | rpm                | revolution/minute        | rpm                 | 1                                     |
| NPIPA     | Net positive inlet pressure available         | kilopascal                | kPa                | pound/square inch        | psi                 | 6.895                                 |
| NPIPR     | Net positive inlet pressure required          | kilopascal                | kPa                | pound/square inch        | psi                 | 6.895                                 |
| NPSHA     | Net positive suction head available           | kilopascal                | kPa                | pound/square inch        | psi                 | 6.895                                 |
| NPSHR     | Net positive suction head required            | kilopascal                | kPa                | pound/square inch        | psi                 | 6.895                                 |
| ν (nu)    | Kinematic viscosity                           | millimeter squared/second | mm <sup>2</sup> /s | second Saybolt Universal | SSU                 | 0.22 <sup>b</sup>                     |
| π         | pi = 3.1416                                   | dimensionless             | —                  | dimensionless            | —                   | 1                                     |
| p         | Pressure                                      | kilopascal                | kPa                | pound/square inch        | psi                 | 6.895                                 |
| P         | Power                                         | kilowatt                  | kW                 | horsepower               | hp                  | 0.7457                                |
| q         | Rate of flow (capacity)                       | cubic meter/hour          | m <sup>3</sup> /h  | cubic foot/second        | ft <sup>3</sup> /s  | 101.94                                |
| Q         | Rate of flow (capacity)                       | cubic meter/hour          | m <sup>3</sup> /h  | US gallon/minute         | gpm                 | 0.2271                                |
| ρ (rho)   | Density                                       | kilogram/cubic meter      | kg/m <sup>3</sup>  | pound mass/cubic foot    | lbm/ft <sup>3</sup> | 16.02                                 |
| s         | Specific gravity                              | dimensionless             | —                  | dimensionless            | —                   | 1                                     |
| S         | Slip                                          | percent                   | %                  | percent                  | %                   | 1                                     |
| t         | Temperature                                   | degree Celsius            | °C                 | degree Fahrenheit        | °F                  | (°F–32) × <sup>5</sup> / <sub>9</sub> |
| τ (tau)   | Torque                                        | newton-meter              | N·m                | pound-foot               | lb-ft               | 1.356                                 |
| v         | Velocity                                      | meter/second              | m/s                | foot/second              | ft/s                | 0.3048                                |
| V         | Specific volume                               | cubic meter/kilowatt      | m <sup>3</sup> /kW | cubic foot/pound         | ft <sup>3</sup> /lb | 6.365                                 |
| x         | Exponent                                      | none                      | none               | none                     | none                | 1                                     |
| Z         | Elevation gauge distance above or below datum | meter                     | m                  | foot                     | ft                  | 0.3048                                |

<sup>a</sup> Conversion factor × US customary units = metric units.

<sup>b</sup> Conversion is valid at 38 °C (100 °F) and above 70 mm<sup>2</sup>/s (325 SSU).

(US customary units)  $D = \frac{(2A - a)LnM}{231}$

For double piston pumps with tail rods:

(metric units)  $D = \frac{2(A - a)LnM}{16.7 \times 10^6}$

(US customary units)  $D = \frac{2(A - a)LnM}{231}$

Where:

$M$  = number of pistons or plungers

$D$  = pump displacement

$A$  = area of piston/plunger

$a$  = area of piston rod

$n$  = speed, in rpm

$L$  = stroke length

**Table 6.6.3.2 — Subscripts**

| Subscript | Term              | Subscript | Term               |
|-----------|-------------------|-----------|--------------------|
| a         | Absolute          | oa        | Overall            |
| b         | Barometric        | p         | Pump               |
| c         | Piston or plunger | r         | Tail rod           |
| d         | Discharge         | s         | Suction            |
| dvr       | Driver input      | t         | Theoretical        |
| g         | Gauge             | Δ (delta) | Differential       |
| H         | Total head        | v         | Velocity           |
| i         | Inlet             | V         | Volume             |
| max       | Maximum           | vp        | Vapor pressure     |
| min       | Minimum           | w         | Hydraulic or water |
| mot       | Motor             | x         | Exponent           |
| ni        | Net inlet         | 1         | Test condition     |
| o         | Outlet            | 2         | Specific condition |