ANSI/HI 10.6-2010

Approved American National Standard

ANSI

American National Standard for

Air-Operated Pump Tests

ANSI/HI 10.6-2010

Hydraulic Institute

6 Campus Drive
First Floor North
Parsippany, New Jersey
07054-4406
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Air-Operated Pump Tests

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Approved June 24, 2010

American National Standards Institute, Inc.

American National Standard

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Contents

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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 directed 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 contents 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.

Scope

This standard applies to air-operated diaphragm and bellows pumps.

Units of measurement

Metric units of measurement are used; corresponding US customary units appear in brackets. Charts, graphs, and sample calculations are also shown in both metric and US customary units. Refer to Table 10.6.3.1 for 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 air-operated pumps, were contacted prior to the approval of this standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

ekwestrel corp
Hutchinson, Frank - Consultant
John Anspach Consulting
MWH Americas Inc.
Patterson Pump Company
Pump Design, Development & Diagnostics, LLC
Taco, Inc
Weir Floway, Inc.
Weir Minerals North America
Wild, Alan - Consultant

Committee List

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:

Chair – Gary Cornell, Blacoh Fluid Controls, Inc.
Vice-chair – Gregory Duncan, Wilden Pump & Engineering LLC

Committee Members	Company
Robert Piazza	Price Pump Company
David Roseberry	Warren Rupp, Inc.
Jonathan Wiechers	ARO/Ingersoll Rand

Alternates	Company
John Armitage	Price Pump Company
Pawel Bankowski	Price Pump Company
Nick Kozumplik	ARO/Ingersoll Rand
Michael Medaska	ARO/Ingersoll Rand
Oakley Roberts	ARO/Ingersoll Rand

10.6 Air-operated pump tests

10.6.1 Scope

This standard applies to test of air-operated diaphragm and bellows pumps only. Unless otherwise stated, all tests are conducted using water at ambient temperature.

Air-operated rotodynamic and rotary pumps are not included in this test standard.

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 upon by the parties involved without sacrificing the validity of the applicable parts of the standard.

10.6.1.1 Objective

This standard provides uniform procedures for mechanical and other pump performance testing and for recording of the test results of air-operated diaphragm and bellows pumps.

10.6.2 Types of tests

This standard contains procedures for the following tests:

a) Test to demonstrate mechanical integrity while pump is in operation; see Section 10.6.4. (Required test.)

b) Performance test; see Section 10.6.5. (Optional test.)

c) Net positive suction head testing; see Section 10.6.7. (Optional test.)

d) Suction lift testing; see Section 10.6.8. (Optional test.)

e) Hydrostatic testing of pressure-retaining components; see Section 10.6.9. (Optional test.)

f) Noise measurement; see Section 10.6.10. (Optional test.)

10.6.3 Definitions

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

10.6.3.1 Symbols

See Table 10.6.3.1.

10.6.3.2 Subscripts

See Table 10.6.3.2.

10.6.3.3 Rated condition point

Rated condition point applies to the rate of flow (capacity), discharge pressure, suction pressure, NPIP/NPSH, and air consumption of the pump as specified at a specific rate of flow. Air-operated reciprocating pumps are normally purchased from a standard performance curve. There normally is no single "rated" flow rate.

Table 10.6.3.1 — Symbols

Symbol	Term	Metric unit	Abbreviation	US Customary Unit	Abbreviation	Conversion factor[a]
A	Area	square millimeters	mm^2	square inches	in^2	0.00155
D	Displacement per stroke	cubic meters	m^3	US gallons	gal	264.17
d	Diameter	millimeters	mm	inches	in	0.0394
g	Gravitational acceleration	meters/second/second	m/s^2	feet/second/second	ft/s^2	3.281
γ (gamma)	Specific weight	kilonewtons/cubic meter	kN/m^3	pounds/cubic foot	lb/ft^3	6.365
L	Stroke length	millimeters	mm	inches	in	0.0394
n	Cycle rate	cycles/minute	cpm	cycles/minute	cpm	1
NPIPA	Net positive inlet pressure available	kilopascals	kPa	pounds/square inch	psi	0.145
NPIPR	Net positive inlet pressure required	kilopascals	kPa	pounds/square inch	psi	0.145
NPSHA	Net positive suction head available	meters	m	feet	ft	3.281
NPSHR	Net positive suction head required	meters	m	feet	ft	3.281
π	pi = 3.1416	dimensionless	—	dimensionless	—	1
p	Pressure	kilopascals	kPa	pounds/square inch	psi	0.145
Q	Rate of flow (capacity)	cubic meters/hour	m^3/h	US gallons/minute	gpm	4.403
s	Specific gravity	dimensionless	—	dimensionless	—	1
t	Temperature	degrees Celsius	°C	degrees Fahrenheit	°F	$\left(°C \times \frac{9}{5}\right) + 32$
v	Velocity	meters/second	m/s	feet/second	ft/s	3.281
Z	Elevation gauge distance above or below datum	meters	m	feet	ft	3.281

[a] Conversion factor x metric units = US customary units.

Table 10.6.3.2 — Subscripts

Subscript	Term	Subscript	Term
a	absolute	H	total head
b	barometric	i	inlet
d	discharge	max	maximum
D	diaphragm	min	minimum
DP	diaphragm plate	s	suction
EFF	effective	v	velocity
f	friction	vp	vapor pressure
g	gauge	z	elevation

10.6.3.4 Volume (standard units)

The standard unit of volume shall be as follows:

a) Metric – cubic meter.

b) US customary units – US gallon or cubic foot.

The specific weight, γ (gamma), of water at a temperature of 20 °C (68 °F) shall be taken as 9.79 kN/m^3 (62.3 lb/ft^3). For other temperatures, proper specific weight corrections shall be made, using values from the ASME steam tables.

10.6.3.5 Stroke length (*L*)

The distance traveled in one complete unidirectional motion of the diaphragm or bellows and connecting rod.

10.6.3.6 Cycle

One complete motion of the diaphragms or bellows. Two strokes equal one cycle.

10.6.3.7 Cycle rate (*n*)

The number of cycles in a given unit of time, usually one minute.

10.6.3.8 Rate of flow (capacity) (*Q*)

The volume of liquid delivered per unit of time at suction conditions. It assumes no entrained gases at the stated operating conditions.

10.6.3.9 Effective diaphragm area (A_{EFF})

A_{EFF} is an approximation of the actual working area of a diaphragm due to the flexibility of the diaphragm. It is determined by averaging the diameter at the outermost flex point of the diaphragm and the outside diameter of the outer diaphragm plate and calculating the area from resultant diameter. (See Figure 10.6.3.9.)

$$A_{EFF} = \frac{\pi\left[\frac{(d_d + d_{DP})}{2}\right]^2}{4}$$

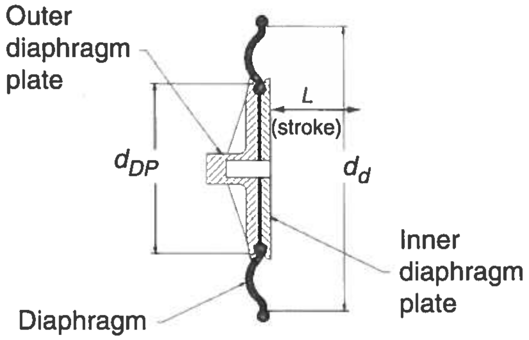

Figure 10.6.3.9 — Effective diaphragm area

10.6.3.10 Displacement per stroke (D)

The volume swept by the diaphragms or bellows in one stroke.

The displacement per stroke can by approximated with the following formula:

$$D \approx A_{EFF} \times L$$

It should be noted that the actual displacement per stroke would vary to some degree with diaphragm construction and flow rate during operation due to the flexibility of the diaphragm. The effective area A_{EFF} for a bellows pump depends on the bellows geometry. Refer to pump manufacturer for the effective bellows area.

10.6.3.11 Datum

The datum is the centerline of the pump inlet from which all elevations are measured. For example, the elevation pressure (p_z) to the datum is positive when the gauge is above datum and negative when the gauge is below datum.

10.6.3.12 Pressure (p)

Pressure is the expression of the energy content of the liquid in units of force per unit area.

10.6.3.13 Gauge pressure (p_g)

The pressure energy of the liquid determined by a pressure gauge or other pressure-measuring device, relative to the atmosphere.

10.6.3.14 Elevation pressure (p_z)

The potential energy of the liquid due to elevation of the gauge or liquid surface above or below the datum, expressed as equivalent pressure.

10.6.3.15 Maximum allowable air inlet pressure

The maximum allowable gauge pressure at the pump air inlet that will not result in damage to the pump during operation as specified by the manufacturer.

10.6.3.16 Maximum allowable discharge pressure ($p_{d\ max}$)

The maximum allowable gauge pressure at the pump discharge that will not result in damage to the pump during operation.

10.6.3.17 Maximum allowable suction pressure ($p_{s\ max}$)

The maximum allowable gauge pressure at the pump inlet that will not result in damage to the pump during operation.

10.6.3.18 Elevation head (Z)

The vertical distance from the centerline of a pressure gauge or liquid surface to the datum.

10.6.3.19 Velocity pressure (p_v)

The kinetic energy of the liquid flow expressed in equivalent pressure. It is determined as follows:

(Metric units) $$p_v = \frac{\left(\frac{v^2}{2g}\right)}{0.102} \times s$$

(US customary units) $$p_v = \frac{\left(\frac{v^2}{2g}\right)}{2.31} \times s$$

10.6.3.20 Suction lift (priming)

Pump priming is commonly referred to as *suction lift* for air-operated pumps. Suction lift is defined as the vertical elevation in meters (feet) of water that can be lifted through an air column by the pump at sea level and room temperature. There are two types of priming tests: dry suction lift and wet suction lift.

10.6.3.21 Total head (p_H)

The measure of the pressure increase imparted to the liquid by the pump, and is, therefore, the difference between the total discharge pressure and the total suction pressure:

$$p_H = p_d - p_s$$

NOTE: Air-operated pumps will produce a maximum discharge pressure that is established by the operating air pressure. Discharge pressure, rather than differential head, is often stated on performance curves.

10.6.3.22 Net positive inlet pressure available (NPIPA)/Net positive suction head available (NPSHA)

NPIPA is the total absolute suction pressure available from the system, determined at the pump suction nozzle, less the absolute vapor pressure of the liquid at pumping temperature.

NPIPA = $p_{sa} - p_{vp}$, in kPa (psi)

Where:

p_{sa} = total suction pressure + barometric pressure = $p_s + p_b$, in kPa (psi)

p_{vp} = vapor pressure of the liquid at the temperature being pumped, in kPa (psi)

or

NPIPA = $p_s + p_b - p_{vp}$, in kPa (psi)

Where:

(Metric units) $p_s = p_{gs} + p_v + Z_s/0.102$, in kPa

(US customary units) $p_s = p_{gs} + p_v + Z_s/2.31$, in psi

NPIPA is determined at the centerline of the pump suction nozzle.

NPSHA is the same concept expressed in units of meters (feet) of process fluid.

10.6.3.23 Net positive inlet pressure required (NPIPR)/Net positive suction head required (NPSHR)

NPIPR is the amount of suction pressure required by the pump to obtain satisfactory volumetric efficiency and minimize damage from cavitation. This is usually when there is no more than 3% reduction in flow rate (capacity) from the pump at any air inlet pressure and total head condition on the pump curve. The pump manufacturer determines by test the net positive inlet pressure required by the pump at the specified operating conditions.

NPIPR is related to losses in the suction valves of the pump and frictional losses in the pump suction manifold and pumping chambers. NPIPR does not include system acceleration pressure, which is a system-related factor and can be a significant problem (see ANSI/HI 10.1-10.5, Section 10.2.3.6).

NPSHR is the same concept expressed in units of meters (feet) of process fluid.

10.6.3.24 Air consumption

The average volume of inlet air required at a specified operating condition of a pump.

10.6.3.24.1 Standard cubic feet per minute (SCFM)

A volumetric flow rate corrected to a set of "standardized" conditions of pressure, temperature, and relative humidity. The standard conditions are often defined as pressure of 14.7 psia, temperature of 60 °F, and relative humidity of 0%. But the conditions may vary depending on the "standard" used.

In countries using the metric system, the term *normal cubic meter per minute* (Nm^3/min) is very often used to denote gas volumes at a normalized or standard condition.

10.6.3.25 Cavitation

Cavitation is defined as the phenomenon of vapor bubble formation in a liquid, in a region where the pressure falls below the liquid's vapor pressure, followed by sudden collapse of bubbles due to an increase in pressure in the same region, or downstream.

10.6.4 Mechanical test

The pump is tested at the manufacturer's specified operating conditions and is monitored for abnormal noise, vibration, leakage, and proper valve operation. Test acceptance is based on visual and physical inspection to ensure that the pump meets the manufacturer's requirements.

10.6.5 Performance tests (when specified)

A pump is tested for performance to measure discharge pressure, rate of flow (capacity), and air consumption. This test is to establish conformance with the manufacturer's published performance criteria.

Pumps are to be tested with standard accessories (e.g., mufflers) unless otherwise specified. Accessories and other special equipment are to be reported with the test results.

10.6.5.1 Test setup for performance and NPIP/NPSH

This section contains general guidelines for pump test setup to ensure accurate and repeatable test results (see Figure 10.6.5.1). It must be understood that test setups that do not conform with respect to intake structure, piping, and measuring equipment, may not duplicate test facility results.

The pump test may use, but is not limited to, the following:

a) A compound pressure gauge suitable for measuring the complete range of suction pressures, whether positive or negative.

b) A discharge pipe or hose with a pressure breakdown (throttling) device.

c) A discharge pressure gauge or gauges suitable for measuring the complete range of pressures.

d) Dampening devices may be used for the suction and discharge gauges, such as needle valves or capillary tubes, to dampen out the pressure pulsations at the gauges. Hydraulic pulsation dampeners may also be used on both suction and discharge sides of the pump to reduce fluctuations of liquid flow and pressure.

e) A means for measuring air consumption to the pump shall be provided and shall be suitable for measuring the complete range of air flow.

f) A means for measuring pump speed (cycle rate).

g) Test setups intended for NPIP/NPSH testing shall be provided with a means for lowering the NPIP/NPSH to the pump (such as a suction throttle valve with optional screen or straightening vanes), variable level sump, suction tank vacuum pump, or suction tank heater.

h) A means for measuring the temperature of the test liquid at the suction.

i) The actual dimensions of the suction and discharge openings where pressure readings are to be taken shall be determined, so that proper velocity pressure calculations can be made.

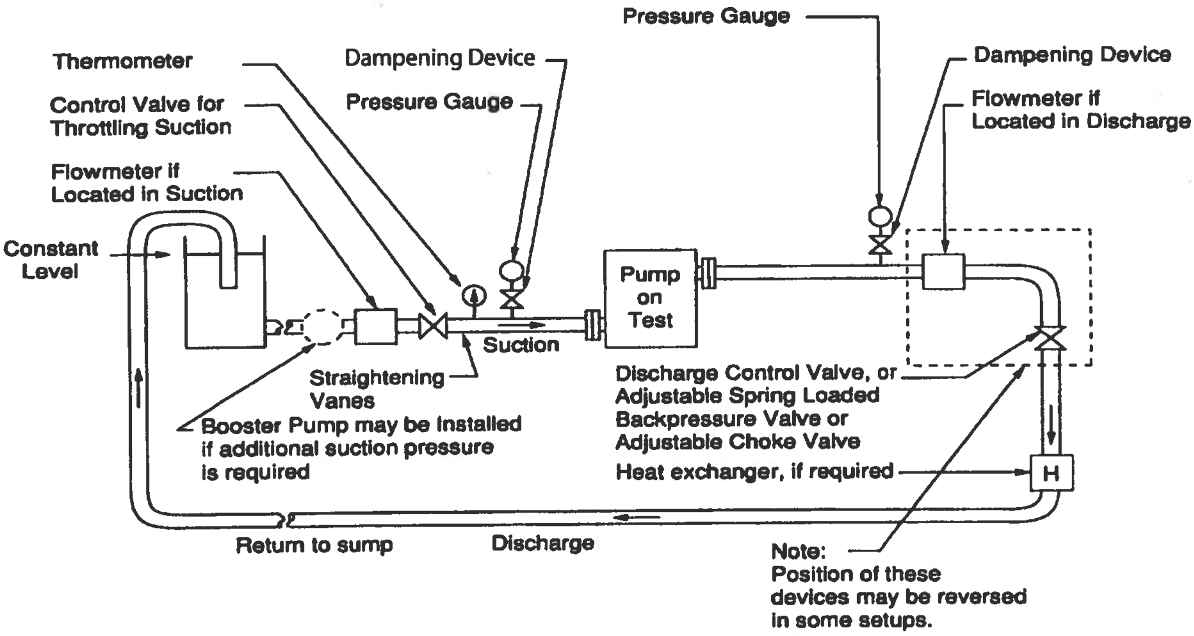

Figure 10.6.5.1 — Open or closed tank

10.6.5.2 Liquid used for performance and NPIP/NPSH testing

Water shall be used. Other test liquids may be used, but must be stated in test documentation.

Pumps intended for viscous services that are tested with water may require corrections to approximate the performance with the viscous liquid. Contact the manufacturer for the appropriate viscosity correction procedure.

10.6.6 Plotting pump performance

Performance is usually plotted as shown in Figure 10.6.6. Air consumption is normally displayed as a family of curves on the performance chart.

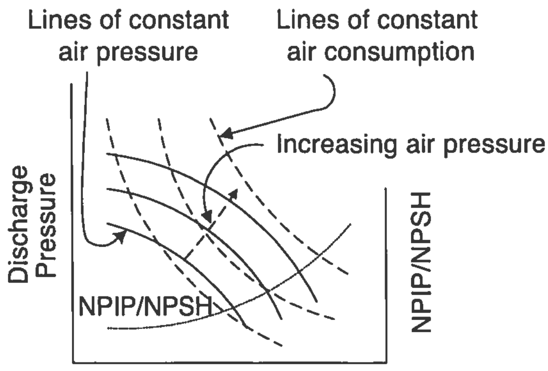

Figure 10.6.6 — Plotting test results

10.6.7 Net positive suction head required (NPIPR/NPSHR) test (when specified)

10.6.7.1 Objective

To determine the NPIP/NPSH by the pump.

10.6.7.2 Test equipment (test circuit)

Three typical arrangements are shown for determining the cavitation characteristics of pumps.

In the first arrangement, Figure 10.6.5.1, the pump is supplied from a constant level supply through a throttle valve, which is followed by a section of pipe containing straightening vanes or seven diameters of straight pipe to straighten the flow. This arrangement dissipates the turbulence produced by the throttle valve and makes possible an accurate reading of suction pressure at the pump inlet.

This simple arrangement usually is satisfactory for NPIP/NPSH greater than 34.5 kPa (5 psi), although the turbulence at the throttle valve tends to accelerate the release of dissolved air or gas from the liquid that takes place as the pressure on the liquid is reduced. A test made with this arrangement usually indicates higher NPSHR than that expected with deaerated liquid.

In the second arrangement, Figure 10.6.7.2a, the pump is supplied from a sump in which the liquid level can be varied to establish the desired NPIPR/NPSHA. This arrangement provides an actual suction lift and hence more nearly duplicates operating conditions of pumps on water service. Care should be taken to prevent vortexing as the liquid level is varied.

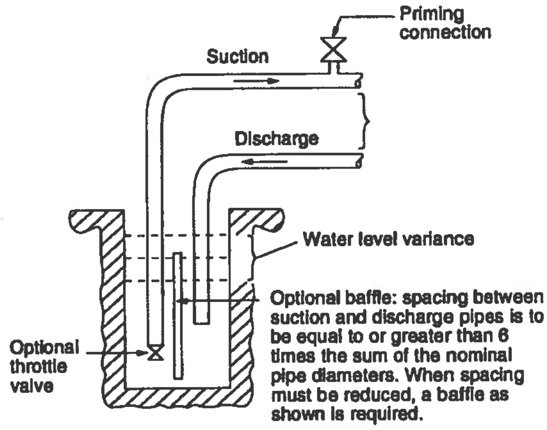

Figure 10.6.7.2a — Level control NPIPR/NPSHA test with deep sump supply

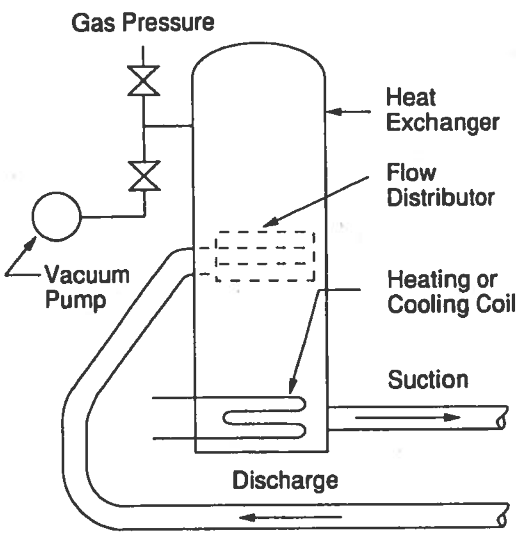

Figure 10.6.7.2b — Vacuum and/or heat control NPIPR/NPSHA test with closed loop

In the third arrangement, Figure 10.6.7.2b, the pump is supplied from a closed tank in which the level is held constant and the NPIPR/NPSHA is adjusted by varying the air or gas pressure over the liquid, the temperature of the liquid, or both.

This third arrangement tends to strip the liquid of dissolved air or gas. It gives a more accurate measurement of the pump performance uninfluenced by the release of air or gas. This arrangement more nearly duplicates service conditions where a pump takes its supply from a closed vessel with the liquid at or near its vapor pressure.

10.6.7.3 Aeration

Taking the following precautions shall minimize water aeration:

- Submerged return lines
- Reservoir sized to allow air removal achieving required pressures, positive or negative
- Inlet line properly located to prevent vortexing
- Reservoir baffles to isolate inlet from return line
- Pipe joints tightened to guard against air leakage into the system
- Use of suction stabilizer with air collection space located as close as possible to the pump suction connection

10.6.7.4 Test procedure

The NPIPR/NPSHR test should be performed at constant air inlet pressure and constant total head while measuring rate of flow (capacity) at different values of NPIPA/NPSHA. The NPIPA/NPSHA should be incrementally reduced until rate of flow loss reaches 3%.

The inlet water temperature should not vary more than 2 °C (3.6 °F) during the test (unless NPIPA/NPSHA is adjusted by varying the temperature of the liquid).

When in service, the pump must be operated above the NPSHR if noise, vibration, unstable operation, and even mechanical failure are to be avoided. The margin of operating NPIPA/NPSHA above NPIPR/NPSHR depends on the particular pump, liquid, and installation.

10.6.8 Suction lift (priming) (when specified)

10.6.8.1 Dry suction lift

With the pump in an unprimed (dry) condition, the dry suction lift is defined as the vertical elevation in meters (feet) of water that can be lifted by the pump.

10.6.8.2 Wet suction lift

With the pump and suction piping full of fluid, the wet suction lift is defined as the vertical elevation in meters (feet) of water that can be lifted by the pump.

10.6.8.3 Dry and wet suction lift (priming) test methods

Three test procedures may be used at various air pressures: the water lift method, the vacuum gauge method, and the vacuum gauge with enclosed tank method. The water lift method most accurately represents self-priming conditions in the field. The other methods may also be used, however, they usually indicate a higher value than the water lift method because they do not take into account friction loses, temperature, or other parameters. All tests are acceptable as valid methods of measuring the suction capability of the pump. All tests are performed at various air inlet pressures and the results are typically as shown as in Figure 10.6.8.3. Manufacturers typically publish suction lift at the maximum value. As the results can vary based on the test method, all published suction lift data should indicate the test method used to obtain the data.

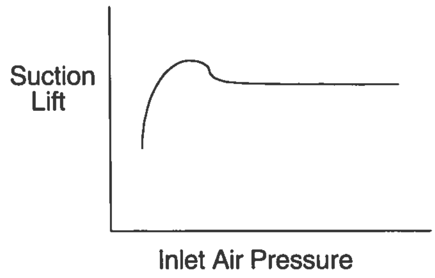

Figure 10.6.8.3 — Dry or wet suction lift test results

10.6.8.3.1 Water lift method

10.6.8.3.1.1 Dry suction lift

During the test, the pump (starting in "dry" condition) is used to lift water of varying vertical distances until it is able to prime itself (evacuate the air in the suction line and pump) and to produce flow.

10.6.8.3.1.2 Wet suction lift

During the test, the pump and suction line are fully primed. With the pump running, the fluid level is lowered until the pump will no longer produce flow.

10.6.8.3.2 Vacuum gauge method

A valve and vacuum gauge are attached to the pump at the inlet. The vacuum measurement may be converted into a vertical column of fluid.

10.6.8.3.2.1 Dry suction lift

With the pump operating in a dry condition, the valve is closed and the vacuum created by the pump is recorded.

10.6.8.3.2.2 Wet suction lift

With the pump fully primed and producing flow, the valve is closed and the vacuum created by the pump is recorded.

10.6.8.3.3 Vacuum gauge with enclosed tank method

A vacuum gauge is attached to the pump at the inlet. The pump is supplied from an enclosed tank that is capable of withstanding a vacuum. Vacuum measurement may be converted into a vertical column of fluid.

10.6.8.3.3.1 Dry suction lift

With a pump and suction line in dry condition (not primed), vacuum is applied to the fluid in an enclosed tank. The vacuum level is gradually reduced until the pump is able to prime itself (evacuate the air in the suction line and pump) and to produce flow. The vacuum created by the pump is recorded when the pump is able to produce flow.

10.6.8.3.3.2 Wet suction lift

With the pump fully primed and producing flow, the vacuum is applied to the fluid in an enclosed tank. The vacuum level is gradually increased until the pump is no longer able to produce flow. The vacuum created by the pump is recorded when the pump is no longer able to produce flow.

10.6.9 Hydrostatic test of pumps or pressure-retaining components (when specified)

10.6.9.1 Objective

The objective is to demonstrate that the pump, when subjected to liquid pressure, will not leak or fail structurally.

For the purpose of this requirement, the words "will not leak," mean only prevention of escape of liquid through the external surfaces of the pump, typically to atmosphere.

10.6.9.2 Test parameters

Each part of the pump under pressure shall be capable of withstanding a hydrostatic test at not less than 150% of the maximum allowable discharge pressure.

Components or assembled pumps: The test shall be conducted on either the components or the assembled pump.

Components: The test shall be conducted on all pressure-containing components. Care must be taken not to impose pressure in excess of 150% of design on areas designed for lower pressure operation.

Assembled pump: The test shall be conducted on the entire liquid-containing area of the pump. It is important to support the air side of the diaphragms with a pressure equal to the hydrostatic pressure.

Test duration: Test pressure shall be maintained for a sufficient period of time to permit complete examination of the parts under pressure. The hydrostatic test shall be considered satisfactory when no permanent deformation, leaks, or structural failures are observed for a minimum of 5 minutes.

Test liquid: Test liquid shall be water.

Temperature: If the part tested is to operate at a temperature at which the strength of material is below the strength of the material at room temperature, then the hydrostatic test pressure should be multiplied by a factor obtained by dividing the allowable working stress for the material at room temperature by that at operating temperature. The pressure thus obtained will then be the minimum pressure at which hydrostatic pressure should be performed. The data sheet should list the actual hydrostatic test pressure.

10.6.9.3 Test procedure

This test is intended to be performed on production pumps that are subsequently provided to the customer for use. Therefore it is not desirable to introduce liquid into the air distribution system of the pump. It is important to note that pump diaphragms can be damaged if exposed to hydraulic pressure without a corresponding air pressure applied to the opposite side of the diaphragm to balance the loading.

The pump should be connected and operated with compressed air at typical operating pressure until it is fully primed. On completion of prime, the pump should be dead-headed to create a hydrostatic pressure in the liquid-containing components on one side of the pump. Subsequently, the inlet air pressure of the pump should be increased to 150% of maximum allowable air inlet pressure, resulting in the same hydrostatic test pressure in the liquid-containing components on one side of the pump. This test condition should be maintained for the test duration and the pump should be observed for any leaks or structural failures.

On successful completion of the test duration for one side of the pump, the pump pressure should be reduced to typical operating pressure and subsequently the dead-head condition should be gradually reduced until the pump shifts one time (or multiple times, such that the total number of shifts is an odd number) so that the opposite side of the pump is pressurized. On pressurization of the opposite side of the pump, the dead-head condition should be restored and the inlet air pressure should again be increased to 150% of maximum allowable air inlet pressure. This test pressure should be maintained for the test duration and the pump should be observed for any leaks or structural failures.

The test shall be considered successful if no leakage or structural failure is observed for the pump or components tested.

10.6.10 Noise (when specified)

Manufacturers shall test per one of the following established sound pressure or sound power standards:

- ANSI S 1.13 *Measurement of Sound Pressure Levels in Air Pumps General Guidelines for Types, Definitions, Applications, Sound Measurement and Decontamination*
- ANSI/HI 9.1–9.5 *Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination*
- Other standards as agreed to by manufacturer and customer

The manufacturer will report pump noise levels as either sound pressure or sound power. The manufacturer shall also report:

- The standard under which the test was completed
- Air inlet pressure and rate of flow or discharge pressure at the test condition

The manufacturer shall test at 4.8 bar (70 psig) and in the mid-flow range for the subject pump with a standard exhaust silencer, unless otherwise stated.

Note that the materials of construction and operating conditions, such as air inlet pressure and pump rate of flow, can affect noise levels.

10.6.11 Instrumentation

Test instrumentation shall be selected so that it can provide measurements with the accuracy as indicated herein at rated conditions. Instruments need not be calibrated specifically for each test, but are to be periodically calibrated by the instrument manufacturer or other suitable party. Refer to Table 10.6.11 for suitable period between calibrations for performance test instruments.

Table 10.6.11 — Recommended instrument calibration interval

Rate of flow	
Venturi	Note 1
Nozzle	Note 1
Orifice plate	Note 1
Turbine	1 yr
Magnetic flow	1 yr
Rotameter	5 yr
Ultrasonic	5 yr
Pressure	
Bourdon tube (pressure gauge)	4 mo
Manometers	Not req'd
Dead weight tester	1 yr
Transducers	4 mo
Digital indicator	1 yr

Speed	
Pulse counters	
Electronic	1 yr
Mechanical	1 yr
Temperature	
Electric	2 yr
Mercury	5 yr

NOTES:
1) Initial calibration required. Further calibration is not required unless it is suspected there are critical dimensional changes.
2) Use instrument manufacturer's recommendation if less than listed above.

10.6.11.1 Fluctuation and accuracy

Acceptable fluctuation of test readings during test and accuracy of instruments is as shown in Table 10.6.11.1.

Table 10.6.11.1 — Actual measurement

	Acceptable fluctuation of test reading %	Accuracy of the instrument as a % of the values
Rate of flow (capacity)	5	1.5
Discharge pressure	2.5	1.5
Suction pressure	2.5	1.5
Air consumption	5	2
Pump speed	3	2

To avoid erroneous results due to inherent pulsing flows:

- Instrumentation with sensitivity to frequency response less than the pumping stroke frequency shall be employed

- Time-weighted averaging is normally used in reported data

10.6.11.2 Pressure measurement

The units of pressure and the definition of total head and its component parts are covered in the definitions section.

10.6.11.2.1 Pressure tap location

A minimum of two diameters of straight pipe of unvarying cross section before the suction stabilizer and after the discharge dampener following an elbow, valve, or other obstruction is necessary to ensure representative flow conditions. If a stabilizer and/or a dampener are not employed, then the gauge must be dampened sufficiently to prevent pulsations from affecting the gauge readings.

The opening in the pipe shall be flush with, and normal to, the wall of the water passage.

The wall of the water passage shall be smooth and of unvarying cross section. For a distance of at least 305 mm (12 in) preceding the opening, all tubercles and roughness shall be removed with a file or emery cloth, if necessary.

The opening shall be of a diameter from 3.175 to 6.350 mm (0.125 to 0.25 in) and a length equal to twice the diameter.

The edge of the opening shall be provided with a suitable radius tangential to the wall of the water passage, and shall be free from burrs or irregularities.

Where more than one tap or orifice is required at a given measuring section, a separate connection, properly valved, shall be made. As an alternative, separate instruments shall be provided.

Multiple pressure taps shall not be connected to a head-measuring instrument unless there will be not more than 1% pressure variation between pressures at each opening.

10.6.11.2.2 Complete measurement of pressure by means of gauges

The pressure definitions as stated in the definitions section are applicable. The quantities (Z_d and Z_s) are negative if the gauge center is below the datum elevation. See Figure 10.6.11.2.2.

10.6.11.2.3 Measurement of pressure by means of calibrated gauges

Some applicable types of pressure indicators are:

- Pressure transducers – strain gauge and magnetic type
- Diaphragm-activated magnetic linkage type
- Bellows-activated torque to transfer type
- Bourdon-tube-actuated gear type

10.6.11.2.4 Other methods of pressure measurement

When the methods of quantity measurement described above are not applicable, there are other methods not included in this standard that may be used, provided the accuracy of the instrument can be demonstrated.

10.6.11.3 Air consumption measurement

Any technically sound flow-measuring system can be used for measuring air consumption.

Some applicable types of flow-measuring instruments are:

- Hot wire anemometers
- Calibrated orifice piping runs
- Rotameters

Other methods of air consumption measurements may be used, provided the accuracy of the instrument as described in this standard can be demonstrated.

10.6.11.4 Speed (cycle rate) measurement

Any technically sound cycle-counting device can be used to measure pump speed. The cycle rate can also be measured manually (count number of strokes over a given period of time). Speeds for pumps may exceed several hundred cycles per minute, so manually measuring cycle rates can be difficult. Measurements should only be taken under steady state conditions, with the maximum permissible short-term speed fluctuations being no more than ±3%.

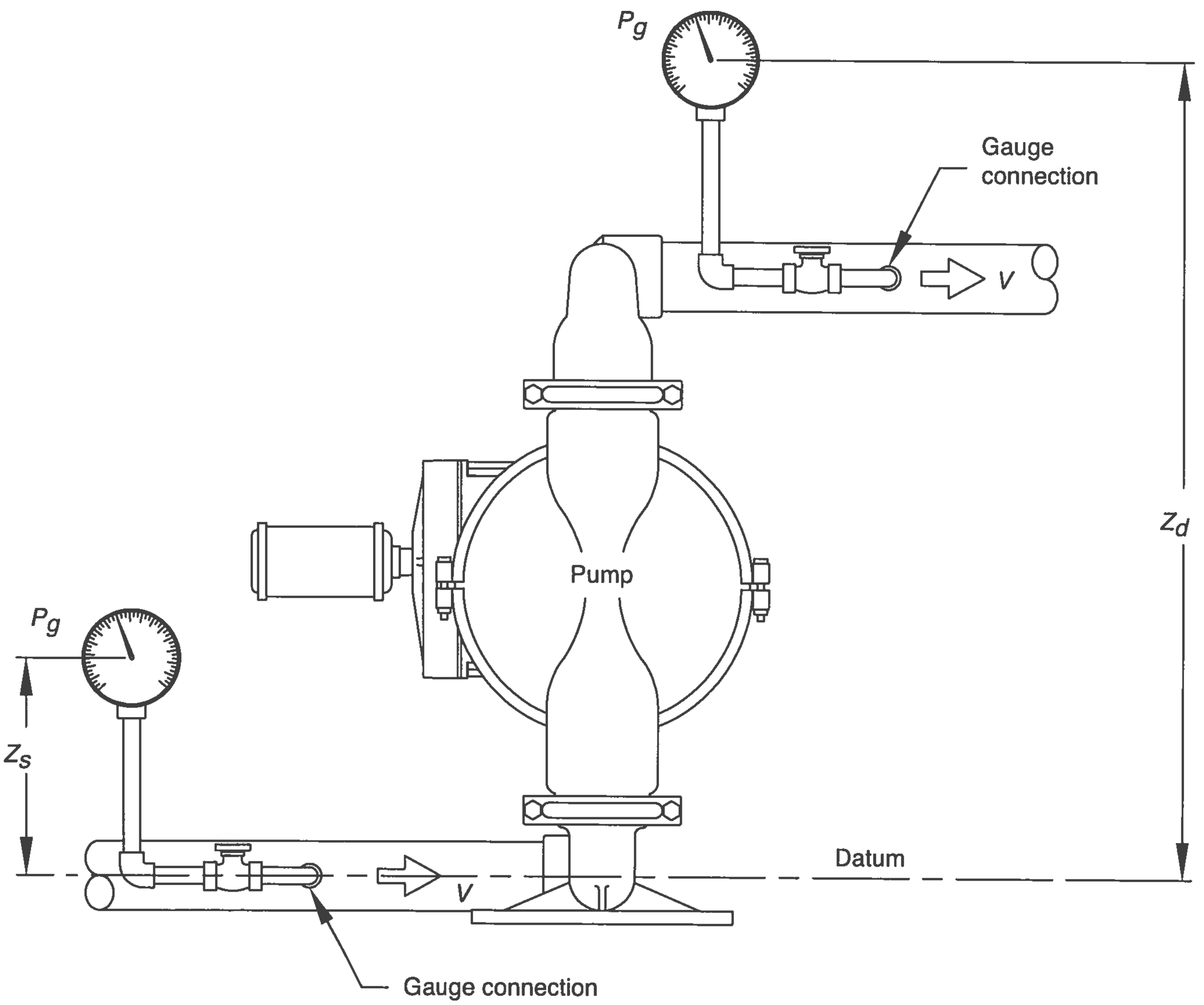

Figure 10.6.11.2.2 — Gauge connections

10.6.11.5 Temperature measurement

Any technically sound temperature-measuring device can be used to measure fluid temperature. The temperature-measuring device shall have no effect on the measurements of pressure and flow rate. Temperature should be measured as close to the pump inlet and/or outlet as possible.

10.6.12 Rate of flow (capacity) measurement

Any technically sound flow-measuring system can be used for measuring pump rate of flow. However, it must be installed so that the entire flow is passing through the instrument section.

Some applicable types of flow-measuring instruments are:

- Turbine flowmeters
- Magnetic flowmeters
- Piston meters, wobble plate meters, rotary vane meters, and the like
- Venturi meters, nozzles, and orifice plates
- Pitot tubes
- Volume collection tank

Other methods of flow rate measurement may be used, provided the accuracy of the instrument as described in this standard can be demonstrated.

Appendix A

Index

This appendix is not part of this standard, but is presented to help the user in considering factors beyond this standard.

Note: an f. indicates a figure, and a t. indicates a table.

B125