ANSI/HI 6.1–6.5-2015

American National Standard for

Reciprocating Power Pumps

for Nomenclature, Definitions, Application, and Operation

ANSI/HI 6.1–6.5-2015

Hydraulic Institute

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Parsippany, New Jersey
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American National Standards Institute, Inc.

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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.

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6 Reciprocating power pumps

6.0 Scope

This standard applies to reciprocating power pumps. It includes types and nomenclature; definitions; design and application; and installation, operation, and maintenance.

6.1 Types and nomenclature

A reciprocating power pump is one driven by power from an outside source applied to the crankshaft of the pump. It consists of a liquid end and a power end. There are several variations and types of reciprocating power pumps, which are provided in horizontal and vertical configurations (see Figure 6.1).

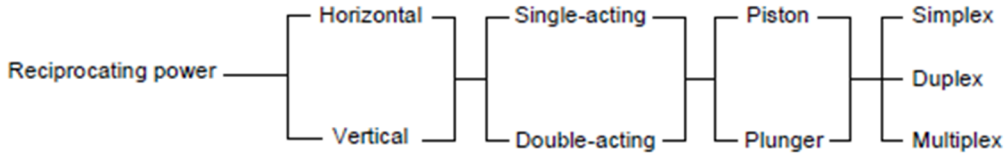


Figure 6.1 — Types of reciprocating power pumps

6.1.1 Horizontal pump

The axial centerline of the cylinder is horizontal (see Figure 6.1.1).

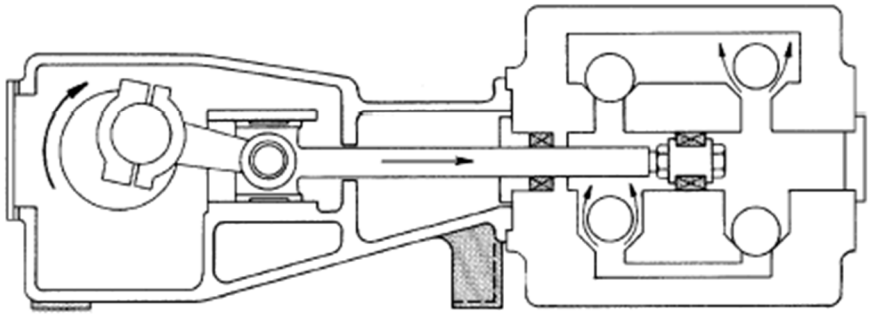


Figure 6.1.1 — Horizontal double-acting piston power pump

6.1.2 Vertical pump

The axial centerline of the cylinder is vertical (see Figure 6.1.2).

6.1.3 Piston pump

The liquid end contains pistons (see Figure 6.1.1).

6.1.4 Plunger pump

The liquid end contains plungers (see Figures 6.1.2, 6.1.4a, and 6.1.4b).

6.1.5 Single-acting pump

Liquid is discharged only during the forward stroke of the plunger or piston, that is, during one half of the revolution of the crankshaft (see Figures 6.1.2 and 6.1.4a).

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Average velocity in 6-in pipe:

$$v_6 = \frac{0.321 \times 73}{28.89} = 0.811 \text{ft/s};$$

Acceleration head in 4-in pipe:

$$h_{acc_4} = \frac{4 \times 1.84 \times 360 \times 0.066}{1.4 \times 32.2} = 3.88 \text{ ft};$$

Acceleration head in 6-in pipe:

$$h_{acc_6} = \frac{20 \times 0.811 \times 360 \times 0.066}{1.4 \times 32.2} = 8.55 \text{ ft};$$

Total acceleration head:

$$h_{acc} = 3.88 + 8.55 = 12.43 \text{ ft}$$

$$p_{acc} = \frac{h_{acc} \times s}{2.31} = \frac{12.43 \times 1.0}{2.31} = 5.38 \text{ psi}$$

6.2.7 Slurry

A mixture consisting of solid particles dispersed in a liquid.

6.2.7.1 Apparent viscosity

The viscosity of a non-Newtonian slurry at a particular rate of shear, expressed in terms applicable to Newtonian fluids.

6.2.7.2 Critical carrying velocity

The mean velocity of the specific slurry in a particular conduit, above which the solids phase remains in suspension and below which solid–liquid separation occurs.

6.2.7.3 Effective particle diameter

The single size used to represent the behavior of a mixture of various sizes of particles in a slurry. This designation is used by some engineers to calculate system requirements and pump performance.

6.2.7.4 Friction characteristic

A term used to describe the resistance to flow that is exhibited by solid–liquid mixtures at various rates of flow.

6.2.7.5 Heterogeneous mixture

A mixture of solids and a liquid in which the solids are not uniformly distributed.

6.2.7.6 Homogeneous flow (fully suspended solids)

A type of slurry flow in which the solids are thoroughly mixed in the flowing stream and a negligible amount of the solids are sliding along the conduit wall.

6.2.7.7 Homogeneous mixture

A mixture of solids and a liquid in which the solids are uniformly distributed.

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6.3.10 Piston and plunger pumps for slurry service

6.3.10.1 Typical service

Reciprocating pumps are used to handle slurries for in-plant process and pipeline applications.

As pipeline systems grow in length and rate of flow, they require higher pressures. This is advantageous for a reciprocating pump that has the desirable characteristic of maintaining high efficiency at any desired rate of flow and pressure. The type used, be it piston or plunger, single- or double-acting, depends on the particular application. Developed pressures range up to 20,000 kPa (3000 psi) with overall efficiencies of 80 to 90%.

Basic construction may or may not be the same as for clear liquid application. The differences may be in type of valves, addition of surge chambers, or liquid injection into the lower portion of the stuffing box.

Reciprocating slurry pumps are so designed that the liquid end parts that are subject to deteriorating effects of slurries can be easily and quickly replaced without dismantling any other major pump component. These parts are usually replaced in accordance with a preventive maintenance program. The scheduled replacement time is based on the user's experience with the slurry pumped. Replacement timing should be such that the part still performs adequately and does not wear to the point of causing failure of other parts of the machine.

Hydraulic passages should be sized so that the lowest velocity of the liquid will be above the critical carrying velocity of 1.2 to 1.8 m/s (4 to 6 ft/s) as an average. The highest velocity should be below that which causes excessive erosion. Typical average operating velocities through a reciprocating slurry pump's passages are 1.8 to 3.6 m/s (6 to 12 ft/s).

Lubrication and flushing of packing are extremely important. Metered, clear, external injection, which is timed to the position of the plunger during its stroke, or continuous flow injection is employed to achieve this. The mode of flushing will depend on whether or not dilution of the liquid pumped by the flushing liquid can be tolerated.

To protect the main stuffing-box packing, clear liquid is usually injected into the stuffing box between the bottom of the throat bushing and the packing. The injection lines are selected to withstand full working pressure and have a safety check valve located between the stuffing box and the injection liquid source to prevent accidental backflow of slurry into the clear liquid system.

Valves for use in slurry service are designed for velocities between 1.8 and 3.6 m/s (6 and 12 ft/s) to reduce erosion and abrasion of the valve seat and other valve components. Valve construction usually includes replaceable valve inserts made of an elastomer or polymer. Metal-to-metal ball valves may be used depending on the slurry, material, carrier liquid, and temperature.

Special considerations must be given to the slurry abrasion, attrition, particle size, and concentration. Slurry particle size has an influence on the valve lift and the ability of an elastomer valve to seat. Experience to date shows that slurry concentrations of up to 65% by weight can be handled successfully.

Suction pressure on a pump handling a slurry is usually higher than when handling clear liquid. This is to take into account the acceleration head of the solids and gases entrained with the liquid. Likewise, pulsation dampeners are usually larger on the suction and discharge side of the pump for the same reasons.

To facilitate starting and stopping a slurry pump, the pump should be fitted with adequate connections so the liquid end passages can be flushed of the slurry with clear liquid. This is especially true when there are to be extended periods during which the pump will be shut down.

Rod and plunger packing requires special considerations when dealing with abrasive materials. In a piston pump, the piston runs in a renewable metal cylinder or liner. The liners are made of abrasion and corrosion-resistant metals to resist wear for each specific slurry. Piston rods and plungers are also coated to resist wear.

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Where the abrasion of the slurry is not great and the pressures are below 14,000 kPa (2000 psi), large-volume piston pumps are more suitable. The transportation of coal slurry falls into this class of service.

6.4 Installation, operation, and maintenance

When properly installed and given good care and regular maintenance, reciprocating power pumps operate satisfactorily for a long period of time. The general principles that must be considered to ensure trouble-free operation are discussed in the following sections.

Reciprocating power pumps are built in a wide variety of designs for many different services. The manufacturer's instruction book furnished with each machine should be carefully studied and followed, as there may be specific requirements of a particular machine or application that cannot be covered in a general discussion.

6.4.1 Safety

The following precautions should be taken when working on reciprocating power pumps to ensure safety of personnel:

- Electrical power should be turned off. All valves to liquid end should be closed and the liquid end drained.

  CAUTION: Care should be taken to properly dispose of toxic or flammable liquids or vapors.

- The work area should be kept clear and any unnecessary items removed.

- All lifting devices should be checked for condition and capacity limits before using.

- Before dismantling, assembling, or performing maintenance on the pump, the proper tools, correct parts, and manufacturer's instruction book should be available.

- All safety precautions should be followed, as directed by the safety engineer.

6.4.2 Storage

All reciprocating power pumps are tested, inspected, and protected against corrosion for the period of shipment and installation only.

If the pump is not to be installed at once, the pump and parts such as packing, special wrenches, etc., should be stored in a clean, dry location, free from temperature extremes, in an approximately level position and without distortion. Coat all machined surfaces with heavy, noncorrosive oil. Inspect frequently to see that the surfaces are free of corrosion. Renew oil coating when necessary. Before putting the unit into operation, clean it thoroughly with a high-grade rust remover.

If a pump will be in storage or taken out of service, such as a relocation, plant shutdown, etc., for more than three months, it is good insurance to completely fill the power and liquid ends with high-grade noncorrosive lubricating liquid. Inspect periodically for possible leakage.

6.4.3 Location of pump

Locate the pump as close to the liquid supply as possible in a clean, dry, and accessible place, so it can be inspected at regular intervals during operation. Provide ample room for maintenance.

6.4.4 Protection against seepage or flood

If it is necessary to place the pump in a pit or other low area, then provision should be made to protect the pump from seepage or flood.

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6.4.5 Provision for servicing space

Whether mounted on the floor, on a foundation above the floor level, or in a pit, sufficient room should be allowed for removal of plungers, pistons, rods, crankshafts, etc., and/or inspection of wearing parts as recommended in the instruction book.

6.4.6 Foundation

Small pumps can be located on the floor or supporting surface, provided that the supporting installation area is sufficiently strong to support at least 150% of the total unit weight, including the driver.

Large and medium-size pump foundations should be reinforced concrete, resting on firm soil or piling, and about 300 mm (12 in) above the surrounding floor level. It should be entirely independent of walls or footings, building supports, or floor structures. Proper concrete mixture, correct reinforcements, sufficient mass, and satisfactory footing are essential to give rigid, permanent support to prevent vibration. The bearing pressures allowed on soil vary widely depending on the underlying nature of the soil, local building laws, etc. These data, available in engineering handbooks and manuals, should be carefully investigated.

6.4.6.1 Foundation bolts

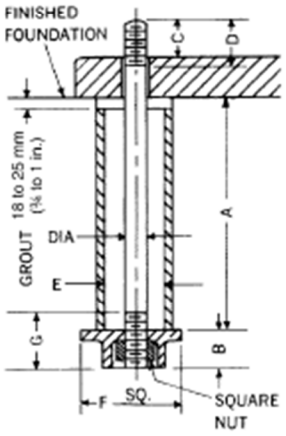
Locate the foundation bolts according to the elevation drawing. Set bolts in sleeves two to three times the bolt diameter to allow for variation in pump parts, skids, or baseplates (see Figure 6.4.6.1). The sleeves should be held rigidly, yet allow the bolts to be moved. Do not fill the sleeves with grout until the entire unit has been accurately aligned, supported, and leveled.

The frame or baseplate when so designed should be completely filled with grout, utilizing the openings provided as filling and vent holes. Do not leave leveling pieces, shims, or wedges in place.

If leveling screws are used, back off after grout has hardened. The machine must not finally rest only on leveling pieces or shims of questionable area, wedges with line contact, or screws with point contact. Foundation bolts should not be tightened until the grout has fully hardened, usually about 48 hours after pouring.

6.4.7 Installation

Most pumps are aligned with the driver before leaving the factory.



Dia	A	B	C	D	E	F	G	Dia	A	B	C	D	E	F	G
Metric (millimeters)								US customary units (inches)							
12	300	50	18	25	50	125	50	½	12	2	⅞	1⅛	2	5	2
16	280	50	24	32	50	125	50	⅝	15	2	1	1½	2	5	2
19	460	50	30	40	80	125	50	¾	18	2	1¼	1¾	3	5	2
22	535	50	35	45	80	125	50	⅞	21	2	1⅜	2	3	5	2
25	610	65	38	50	80	150	65	1	24	2½	1½	2¼	3	6	2½
29	685	65	45	60	100	150	65	1⅛	27	2½	1⅝	2⅜	4	6	2½
31	760	65	45	60	100	150	65	1¼	30	2½	1¾	2⅝	4	6	2½
38	915	100	55	70	100	225	100	1½	36	3½	2	3⅛	4	9	3½
45	1065	100	65	90	125	225	100	1¾	42	3½	2¼	3½	5	9	3½

Figure 6.4.6.1 — Foundation bolt data

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