ANSI/HI 1.1–1.2-2008

Approved American National Standard

ANSI

American National Standard for

Rotodynamic (Centrifugal) Pumps

for Nomenclature and Definitions

ANSI/HI 1.1–1.2-2008

Hydraulic Institute

6 Campus Drive
First Floor North
Parsippany, New Jersey
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www.Pumps.org

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Sponsor

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Approved December 4, 2008

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 users and 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.

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. Because 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.

4B Engineering
Baldor Electric Company
Bantrel
Black & Veatch
Brown and Caldwell
Flowserve Pump Division
GIW Industries, Inc.
Grundfos Pumps Corporation
Healy Engineering
IMO Pump
ITT - Industrial Process
ITT - Water & Wastewater
J.A.S. Solutions Ltd.
John Crane Inc.
Malcolm Pirnie
National Pump Company, LLC
Patterson Pump Company
Peerless Pump Company
Pentair Water
Powell Kugler, Inc.
Sulzer Pumps (US) Inc.
TACO, Inc.
Tecsult Inc.
The Conservation Fund
Weir Floway, Inc.
Weir Minerals North America

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 – Allen J. Hobratschk, National Pump Company, LLC
Vice-chair – Michael S. Cropper, Sulzer Pumps (US) Inc.

Committee Members	Company
Charles Cappellino	ITT, Industrial Process
Randal S. Ferman	Flowserve Pump Division
Al Iseppon	Pentair Water
William Livoti	Baldor
Peter Noll	Peerless Pump Company
Greg Towsley	Grundfos Pumps Corporation
Fred Walker	Weir Floway, Inc.

Alternates	Company
Jason Davis	Pentair Water
William Ellis	Weir Floway, Inc.
Michael Mueller	Flowserve Pump Division
Roger Turley	Flowserve Pump Divsion

Preface

Symbols are used throughout this standard to identify the pump types. When originally introduced, the convention is to define the term in text, followed by the HI symbol in parenthesis (xx) and, when different, the ISO symbol is in brackets [xx].

Standard ANSI/HI 1.3 *Rotodynamic (Centrifugal) Pumps for Design and Applications* complements the nomenclature and definitions content in this document with detailed information about the design and application of rotodynamic (centrifugal) pumps.

Rotodynamic (centrifugal) pumps

1.1 Types and nomenclature

Rotodynamic pumps may be classified by such methods as impeller or casing configuration, end application of the pump, specific speed, or mechanical configuration. The method used in Figure 1.1.3a is based primarily on mechanical configuration.

1.1.1 Scope

This standard covers rotodynamic pumps with centrifugal (radial), mixed flow, and axial flow impellers, as well as regenerative turbine and pitot tube type pumps, of all industrial/commercial types except vertically suspended diffuser turbine pumps. It contains description of types, nomenclature, and definitions.

1.1.2 Definition of rotodynamic (centrifugal) pumps

Rotodynamic pumps are kinetic machines in which energy is continuously imparted to the pumped fluid by means of a rotating impeller, propeller, or rotor. The most common types of rotodynamic pumps are centrifugal (radial), mixed flow, and axial flow pumps.

Centrifugal pumps use bladed impellers with essentially radial outlet to transfer rotational mechanical energy to the fluid primarily by increasing the fluid kinetic energy (angular momentum) and also increasing potential energy (static pressure). Kinetic energy is then converted into usable pressure energy in the discharge collector.

1.1.3 Types of rotodynamic pumps

Rotodynamic pumps are most commonly typed by their general mechanical configuration (see Figures 1.1.3a, b, c, and d). The broadest characteristics, which include virtually all centrifugal pumps, are discussed in the following paragraphs:

1.1.3.1 Overhung impeller type

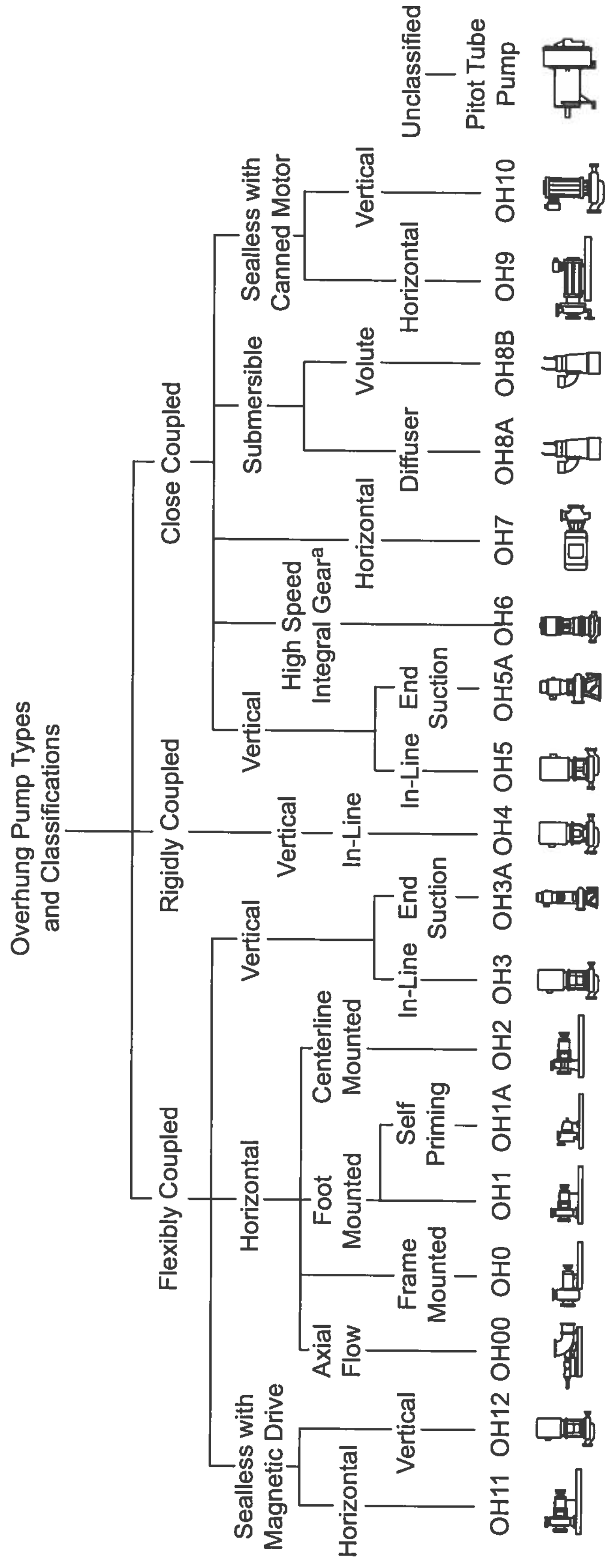
In this group, the impeller(s) is mounted on the end of a shaft that is cantilevered or "overhung" from its bearing supports.

These pumps are either close coupled, where the impeller is mounted directly on the driver shaft; or separately coupled, where the impeller is mounted on a separate pump shaft supported by its own bearings. One variation of this design is the submersible type, where a close-coupled pump/electric motor unit is designed to operate while submerged in the liquid it is pumping or another liquid.

1.1.3.1.1 Close coupled

Close-coupled pumps are commonly characterized by the following attributes:

The pump and driver share one common shaft; the driver bearings absorb all pump thrust loads (axial and radial). The driver is aligned and assembled directly to the pump unit with machined fits.



[a] Refer to Section 1.1.3.1.5 for high-speed integral gear definition.

Figure 1.1.3a — Rotodynamic pump types - overhung

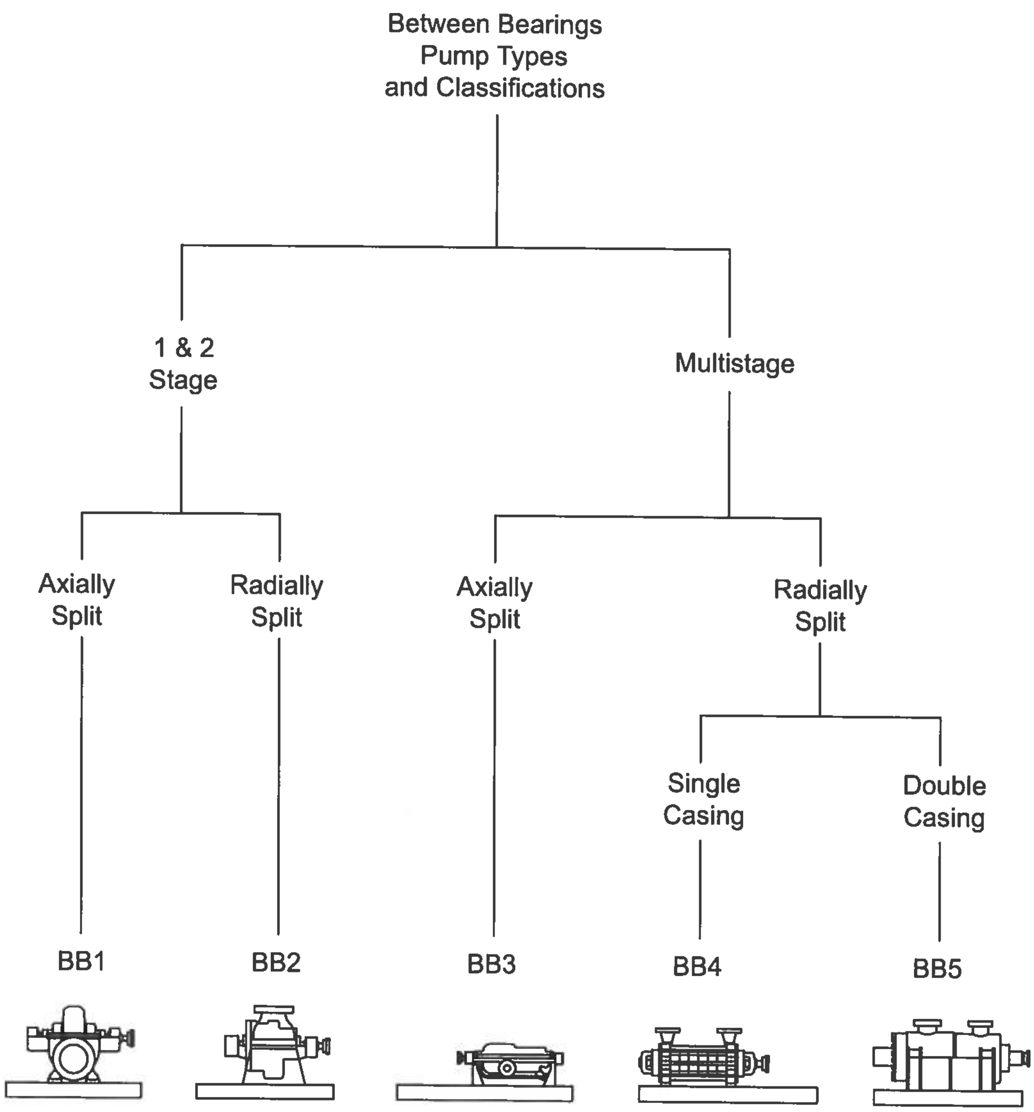


Figure 1.1.3b — Rotodynamic pump types - between bearings

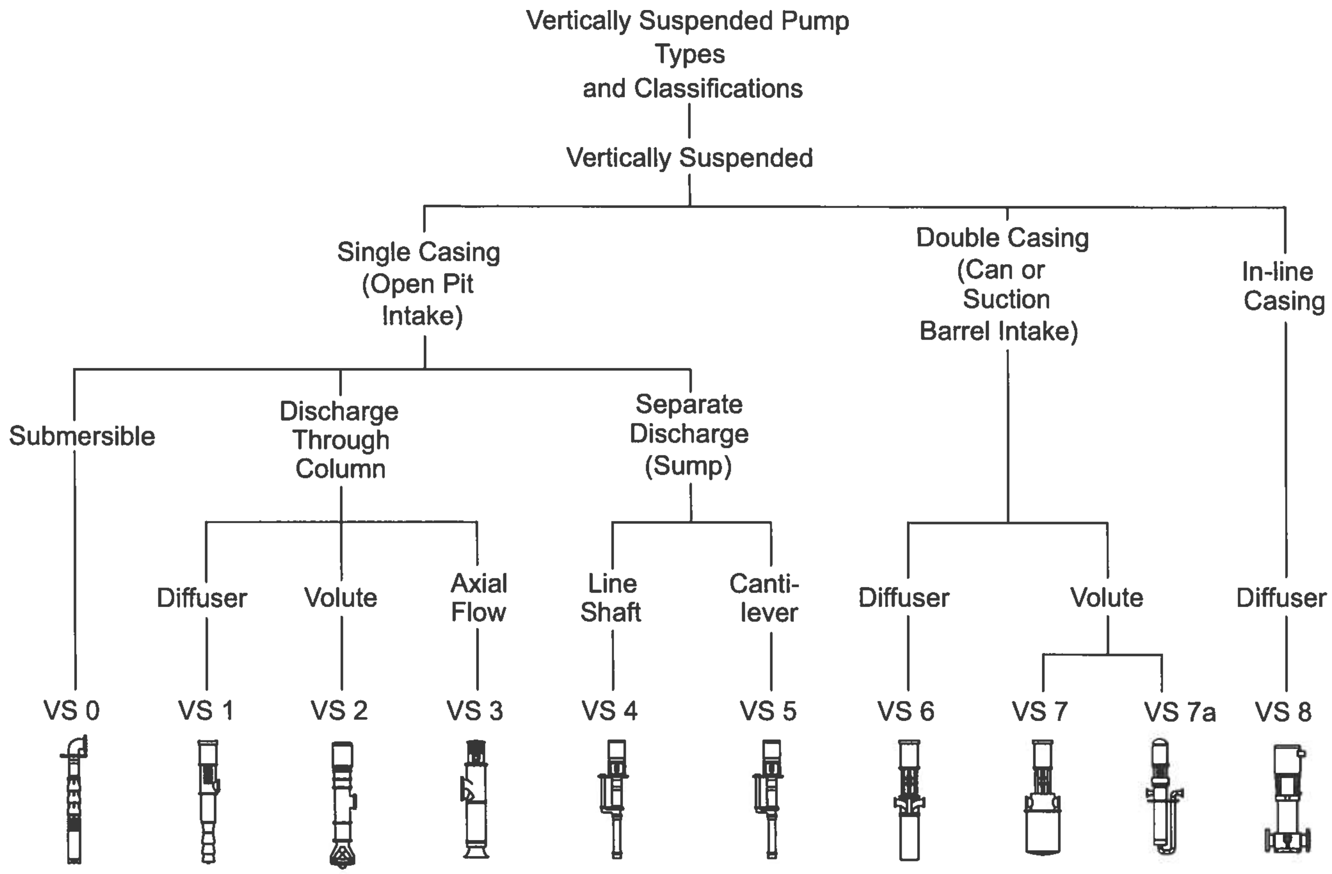


Figure 1.1.3c — Rotodynamic pump types - vertically suspended

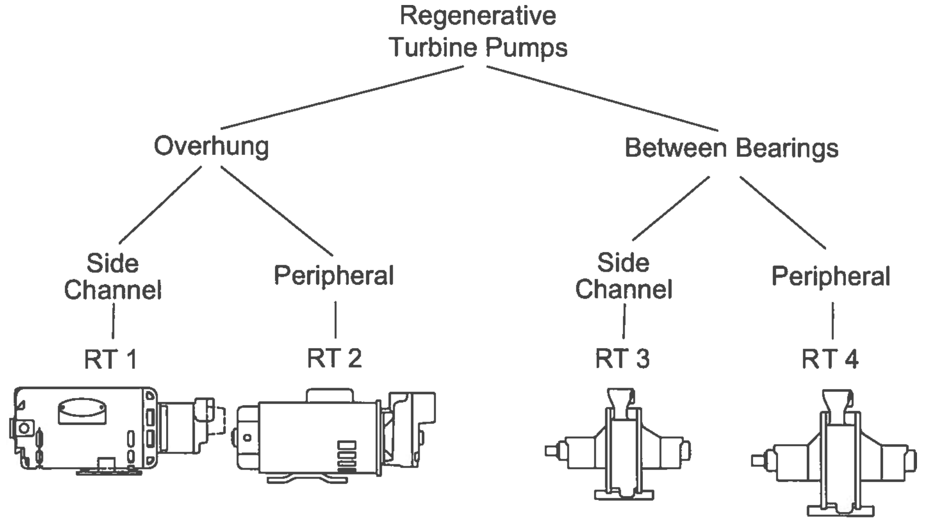


Figure 1.1.3d — Rotodynamic pump types - regenerative turbine

1.1.3.1.2 Short coupled

Pumps described as short coupled have a coupling arrangement in which the motor is supplied with a flange adaptor that mounts directly to the casing, or body of the pump, thereby permitting the use of a single or solidly coupled shaft. A variation of this design is a magnetically coupled sealless pump, which uses a series of magnets mounted directly on the motor shaft. (See also Section 1.1.6.8 Special case ASME/ANSI B73.1, C-frame adaptor.)

Short coupled pumps are commonly characterized by the following attributes:

The pump and driver have separate shafts; the pump has an integral bearing housing to absorb all pump thrust loads (axial and radial). The driver is aligned and assembled directly to the pump unit with machined fits.

1.1.3.1.3 Rigidly coupled

Pumps described as rigidly coupled have their shaft rigidly coupled to the driver shaft.

Rigidly coupled pumps are commonly characterized by the following attributes:

The pump and driver have separate shafts connected by a rigid coupling; the pump has an internal product-lubricated radial bearing. The driver is aligned and assembled directly to the pump unit with machined fits. The driver bearings absorb all pump axial thrust loads and residual radial loads.

1.1.3.1.4 Flexibly coupled

Pumps described as flexibly coupled have the pump shaft flexibly coupled to the driver shaft via a flexible element drive coupling. Usually of the spacer type.

Flexibly coupled pumps are commonly characterized by the following attributes:

Pump and driver have separate shafts; the pump has an integral bearing housing to absorb all pump thrust loads (axial and radial). With this arrangement the motor may be mounted on a support that is independent of the pump and not structurally connected to the pump frame.

1.1.3.1.5 High-speed integral gear-driven pumps

High-speed integral gear-driven single-stage overhung pumps have a speed increasing gearbox integral with the pump. The impeller is mounted directly to the gearbox output shaft. There is no coupling between the gearbox and pump; however, the gearbox is flexibly coupled to its driver. These pumps may be oriented vertically or horizontally.

Integral gear-driven single-stage overhung pumps are commonly characterized by the following attributes:

Pump, gearbox, and driver have separate shafts; the pump and gearbox have internal bearings to absorb all thrust loads (axial and radial). The gearbox shaft is flexibly coupled to the driver shaft and the motor mounts on a frame supported by the pump and gear unit.

1.1.3.2 Impeller between-bearings type

In this group, the impeller(s) is mounted on a shaft with bearings at both ends. The impeller(s) is mounted between these bearings.

These pumps may be further identified as single-stage or multistage configurations.

Table 1.1.3.1 — Overhung rotodynamic pump attributes

Attributes	Pump type				
	Close coupled	Rigidly coupled	Short coupled	Flexibly coupled	Integral gear
Pump and driver share one common shaft	x				
Pump and driver have separate shafts		x	x	x	x
Driver bearings absorb pump axial thrust loads	x	x			
Driver bearings absorb all pump axial thrust & radial loads	x				
Pump has an integral bearing housing to absorb all pump loads			x	x	x
Motor is mounted on a frame structurally attached to the pump	x	x	x		x
Motor may be mounted on a support that is independent of the pump, not structurally connected to the pump frame				x	

1.1.3.3 Pumps of other configuration

These pumps operate using the same basic kinetic principles but are configured differently than the conventional rotodynamic designs. The following examples fall within this description.

1.1.3.3.1 Regenerative turbine type

Regenerative turbine pumps are characterized by a low rate of flow and high head. This design uses peripheral or side channel vanes or buckets that are typically manufactured integral with a rotating impeller to impart energy to the pumped liquid. The liquid travels in a helical pattern through the impeller vanes and corresponding flow passages, with the liquid pressure increasing uniformly through the passages from inlet to the discharge.

1.1.3.3.2 Pitot tube type

The pitot tube pump is a variation of a rotodynamic design and uses a pitot tube, in lieu of a volute or diffuser, to capture flow and convert velocity energy to pressure. The primary feature of a pitot tube pump that differentiates it from a conventional rotodynamic pump is that it uses a rotating casing instead of an impeller to impart velocity to the pumped liquid. The pitot tube design follows conventional pump affinity rules; however, it is capable of generating higher head than a comparable rotodynamic design at an equivalent tip speed.

1.1.3.3.3 Hydraulic power recovery turbine

A hydraulic power recovery turbine is a rotodynamic pump that operates by accepting flow in the reverse direction as normal, by virtue of the fact that a differential pressure is applied across its connections. Liquid enters the (normal) discharge connection of the pump and exits the (normal) suction connection. As such, the pump operates as a turbine, producing useable shaft power as a function of speed and differential pressure. Another name used for this type of machine is *pump as turbine* (PAT). (See ANSI/HI 1.3 *Rotodynamic (Centrifugal) Pumps for Design and Application*, Appendix A.)

1.1.3.3.4 Vortex (recessed impeller) type

A vortex or recessed impeller pump is a rotodynamic pump designed with large, uniform clearances between the open impeller vanes and the casing shroud. Radial and cup type impellers are used. The impeller is recessed from the liquid flow path, which induces a vortex action to the liquid. Correspondingly, trash and solids can pass through the pump without impinging on the impeller.

1.1.4 Impeller designs

Impeller designs are classified as radial, mixed, or axial flow, depending on their geometry. These designs are differentiated by specific speed and impeller types as described in the following paragraphs. (Refer to Sections 1.1.4.2, 1.1.4.3, and 1.1.4.4 for additional description.)

1.1.4.1 Specific speed (n_S) and suction specific speed (S)

The user is cautioned to check carefully the basis of calculation of specific speed and suction specific speed before making comparisons because there are subtle but significant differences in methods used throughout industry and in related textbooks and literature.

Preferred terms, units, and symbols to be used in the technology of pump applications are shown in Table 1.2a.

US customary units

When calculating the value for specific speed and suction specific speed, the unit of measurement used for rate of flow is defined in US gallons per minute (gpm).

Metric units

When calculating the value for specific speed and suction specific speed, the unit of measurement used within this standard for rate of flow is cubic meters per second (m^3/s).

(An alternative method of calculating this value is to use m^3/h as the unit of measurement for rate of flow, which then results in a value that is $(3600)^{0.5}$, i.e., 60 times greater.

Specific speed is an index of pump performance (developed total head). It is determined at the pump's best efficiency point (BEP) rate of flow, with the maximum diameter impeller, and at a given rotative speed. Specific speed is expressed by the following equation:

$$n_s = \frac{n(Q)^{0.5}}{(H)^{0.75}}$$

Where:

n_s = specific speed

n = rotative speed, in revolutions per minute

Q = total pump flow rate, in cubic meters per second (US gallons per minute)

H = head per stage, in meters (feet)

NOTE: When calculating specific speed using units of cubic meters per second for flow rate and meters for head per stage, 51.6 is the conversion factor for specific speed in US gallons per minute and feet (i.e., metric × 51.6 = US customary units.)

The usual symbol for specific speed in US customary units is N_S.

An alternative definition for specific speed is sometimes used based on flow rate per impeller eye rather than total flow rate. When applying this alternative method to a double suction impeller pump, the resultant value of specific speed is less by a factor of $1/(2)^{0.5}$ (i.e., 0.707 times less).

Suction specific speed is an index of pump suction operating characteristics. It is determined at the BEP rate of flow with the maximum diameter impeller. (Suction specific speed is an indicator of the net positive suction head required [NPSH3] for given values of capacity and also provides an assessment of a pump's susceptibility to internal recirculation.) Suction specific speed is expressed by the following equation:

$$S = \frac{n(Q)^{0.5}}{(NPSH3)^{0.75}}$$

Where:

S = suction specific speed

n = rotative speed, in revolutions per minute

Q = flow rate per impeller eye, in cubic meters per second (US gallons per minute)
= total flow rate for single suction impellers
= one half total flow rate for double suction impellers

$NPSH3$ = net positive suction head required in meters (feet) that will cause the total head (or first-stage head of multistage pumps) to be reduced by 3%

NOTE: When suction specific speed is derived using cubic meters per second and meters, the conversion factor to suction specific speed in US gallons per minute and feet is 51.6. The US customary symbol N_{ss} is sometimes used to designate suction specific speed.

The value S is an assessment of a pump's inlet design, including both the stationary casing and the rotating impeller design elements. Higher numerical values of S are associated with better NPSH capabilities. For pumps of typical suction inlet design, values range approximately from 120 to 250 (6000 to 13,000). In special designs, including inducers, S values can be up to 700 (35,000) or higher depending on the connected inlet piping, the pump's suction casing arrangement, the range of flow over which the pump must operate, size and power rating of the machine, and other considerations.

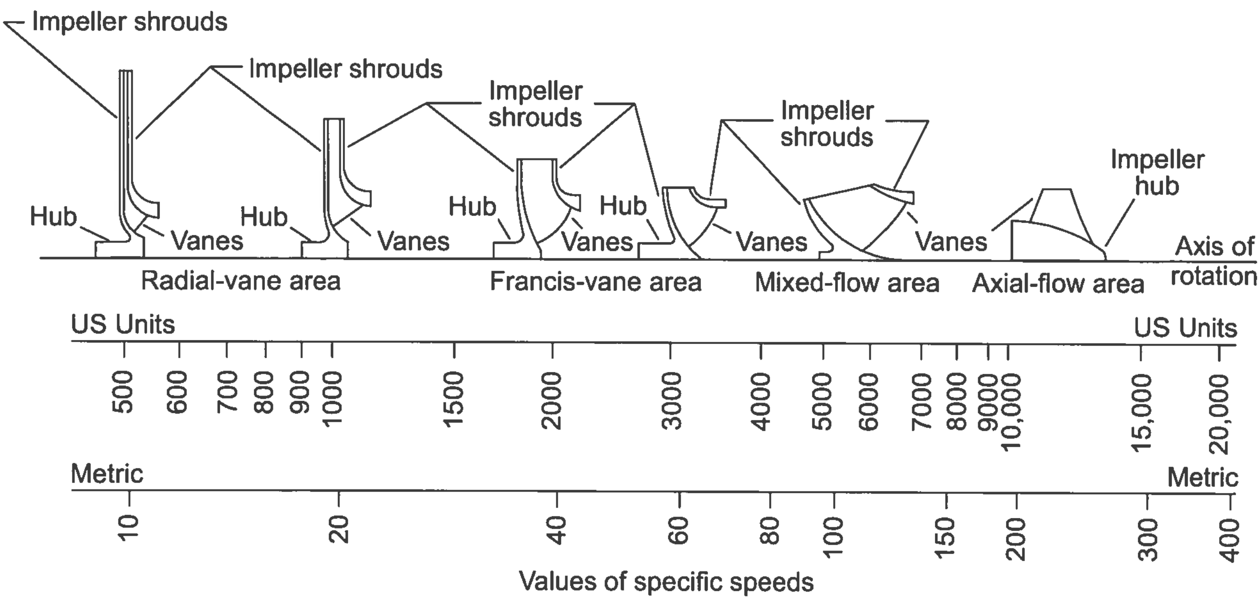


Figure 1.1.4.1 — General impeller types

1.1.4.2 Radial flow

Pumps of this type with single inlet impellers usually have a specific speed below approximately 90 (4500) and with double suction impellers, a specific speed below approximately 135 (7000). In pumps of this type, the liquid enters the impeller at the hub and flows radially to the periphery, exiting perpendicular to the rotating shaft. (See Figure 1.1.4.2.)

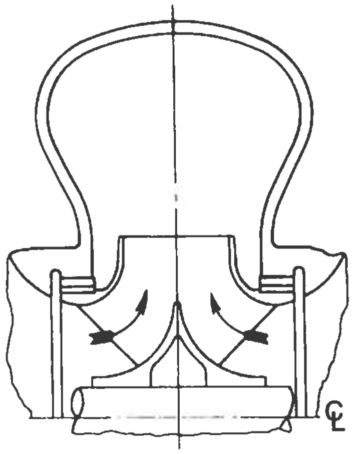


Figure 1.1.4.2 — Double suction radial flow pump

1.1.4.3 Mixed flow

This type of pump has a single inlet impeller where the flow enters axially and discharges in a mixed axial and radial direction. Pumps of this type usually have a specific speed from approximately 90 (4500) to 200 (10,000) (see Figure 1.1.4.3).

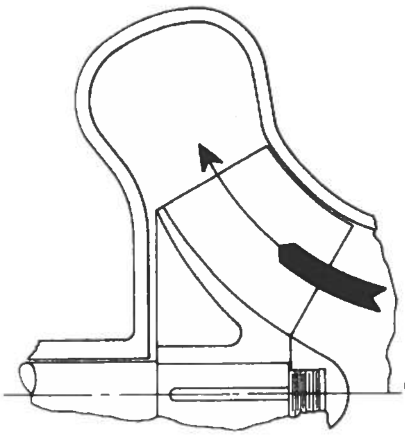


Figure 1.1.4.3 — Mixed flow impeller

1.1.4.4 Axial flow

A pump of this type, sometimes called a *propeller pump*, has a single inlet impeller with the flow entering axially and discharging nearly axially. Pumps of this type usually have a specific speed above approximately 200 (10,000) (see Figure 1.1.4.4).

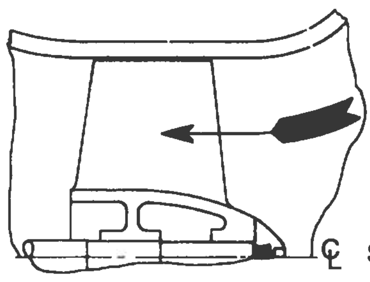


Figure 1.1.4.4 — Axial flow impeller

1.1.5 Construction drawings

The construction drawings on the following pages (Figures 1.1.5a – bb) were prepared to provide a means for identifying the various pump types covered by the HI Standards. The drawings also serve as the basis for a common language between the purchaser, manufacturer, and specification writer.

In general, the individual part names on these drawings are numbered such that rotating parts have been assigned even numbers and nonrotating parts have been assigned odd numbers. There are, however, a few exceptions.

In cases where a pump may use two or more parts that are of the same generic type but different geometries (e.g., gaskets), this difference is indicated by the addition of a letter suffix to the item number (e.g., 73A, 73B, etc.).

Hydraulic Institute pump icons represent the general class of pump design. Where available, icons are shown adjacent to the corresponding pump cross sections. Additionally, Section 1.2.9 specifically defines the icons in greater detail.

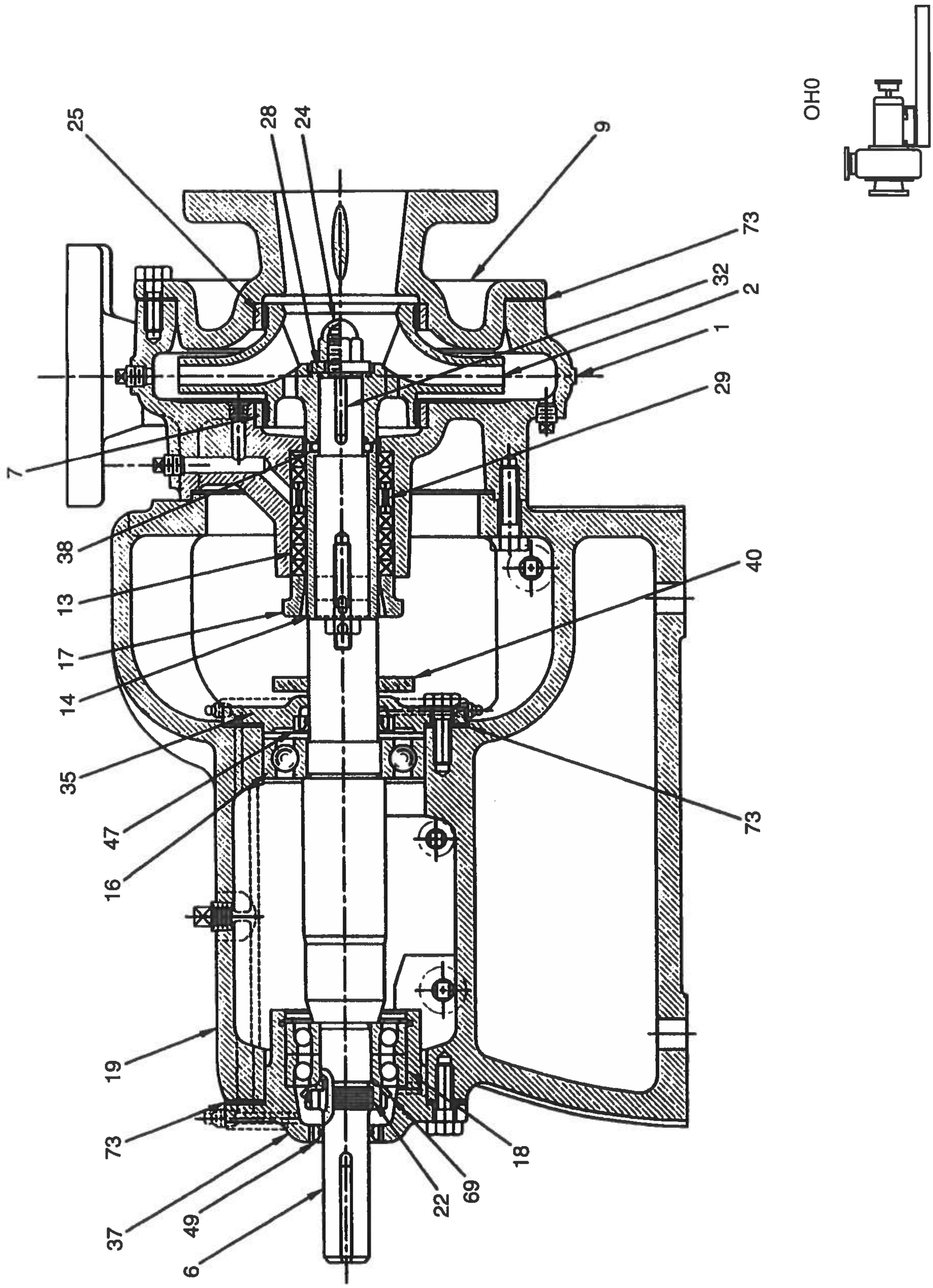


Figure 1.1.5a — Overhung impeller – flexibly coupled – single stage – frame mounted

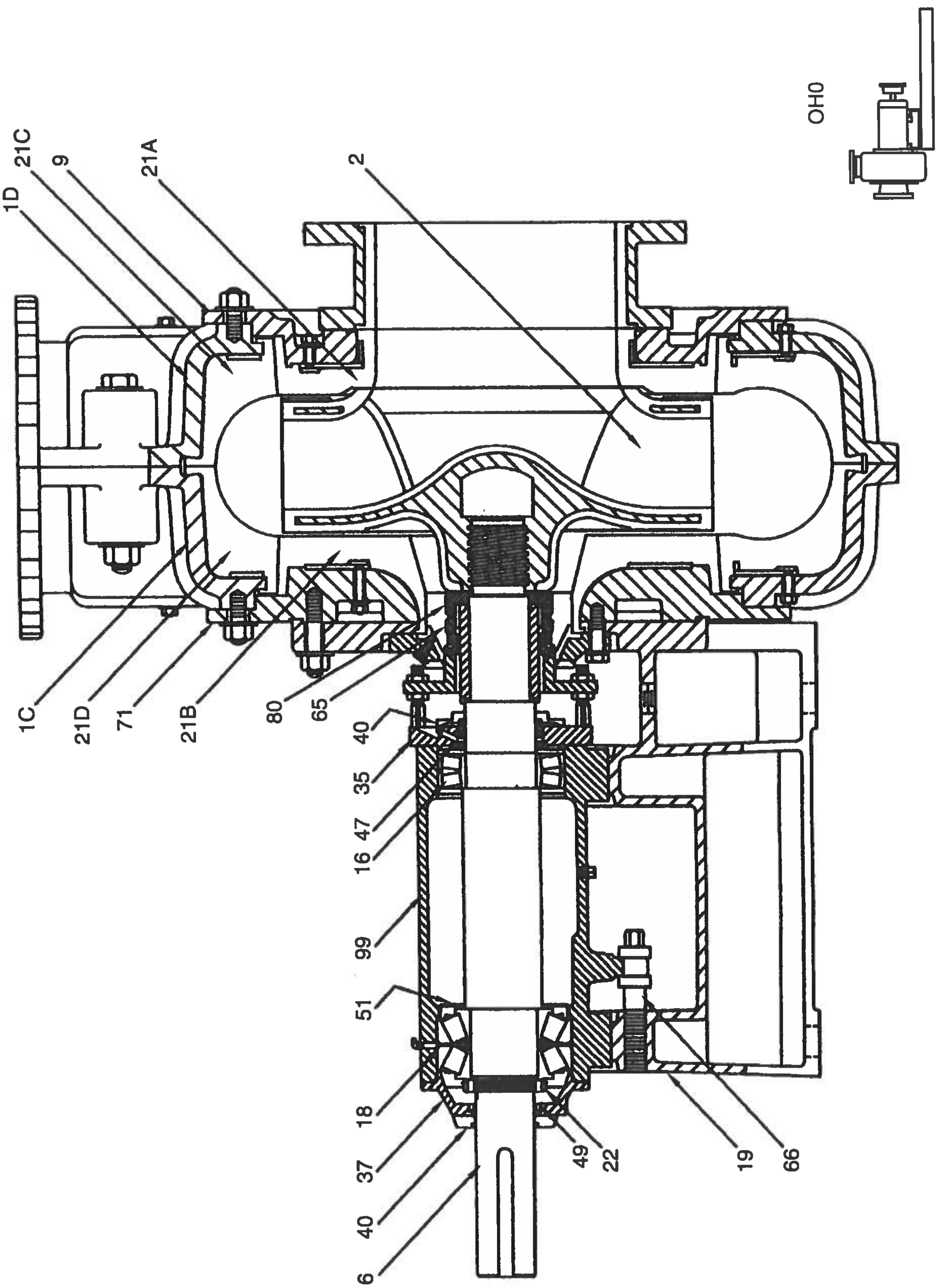


Figure 1.1.5b — Overhung impeller – flexibly coupled – single stage – frame mounted – lined pump

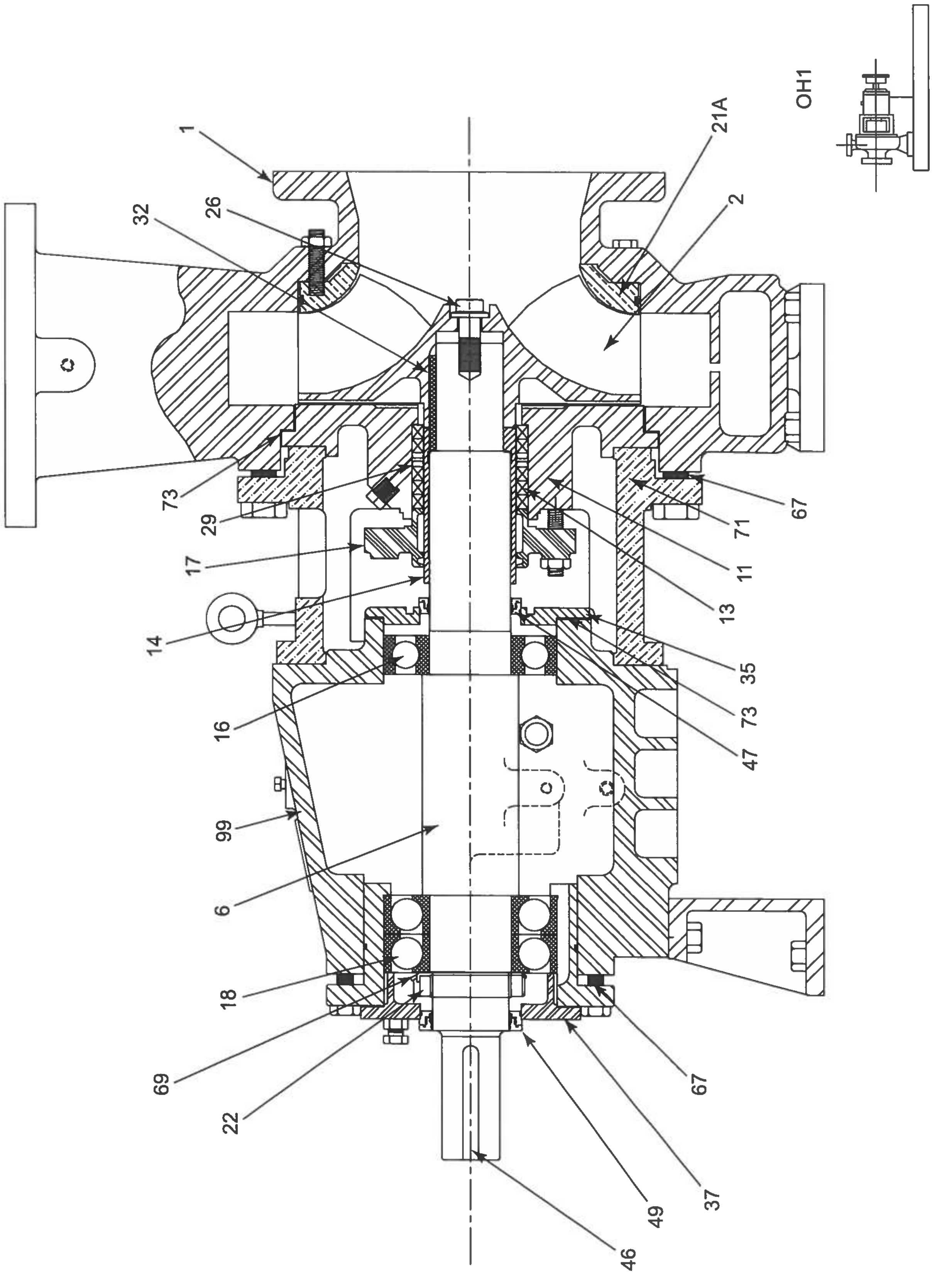


Figure 1.1.5c — Stock pump – flexibly coupled – single stage – foot mounted

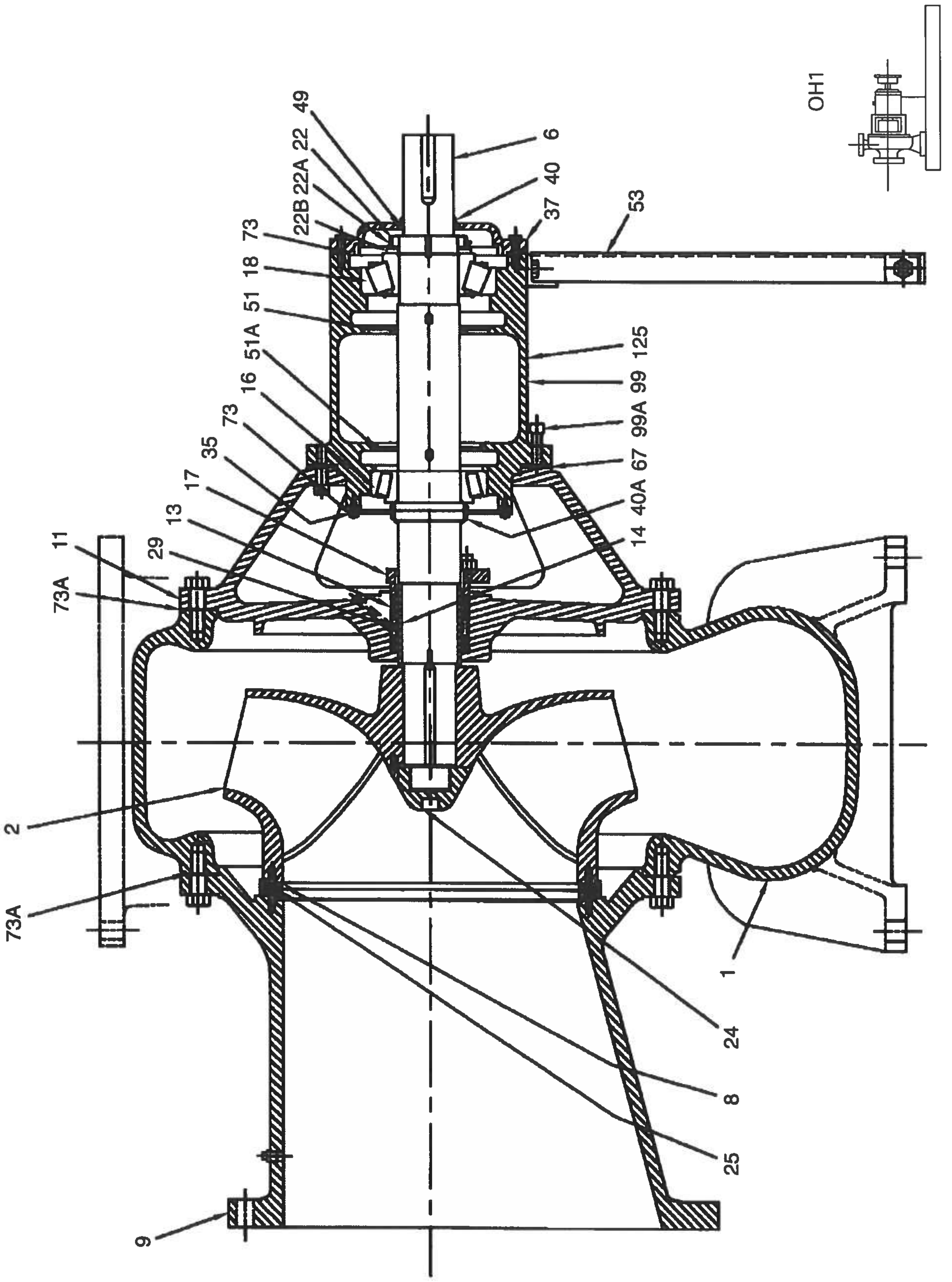


Figure 1.1.5d — Overhung impeller – flexibly coupled – single stage – foot mounted – mixed flow

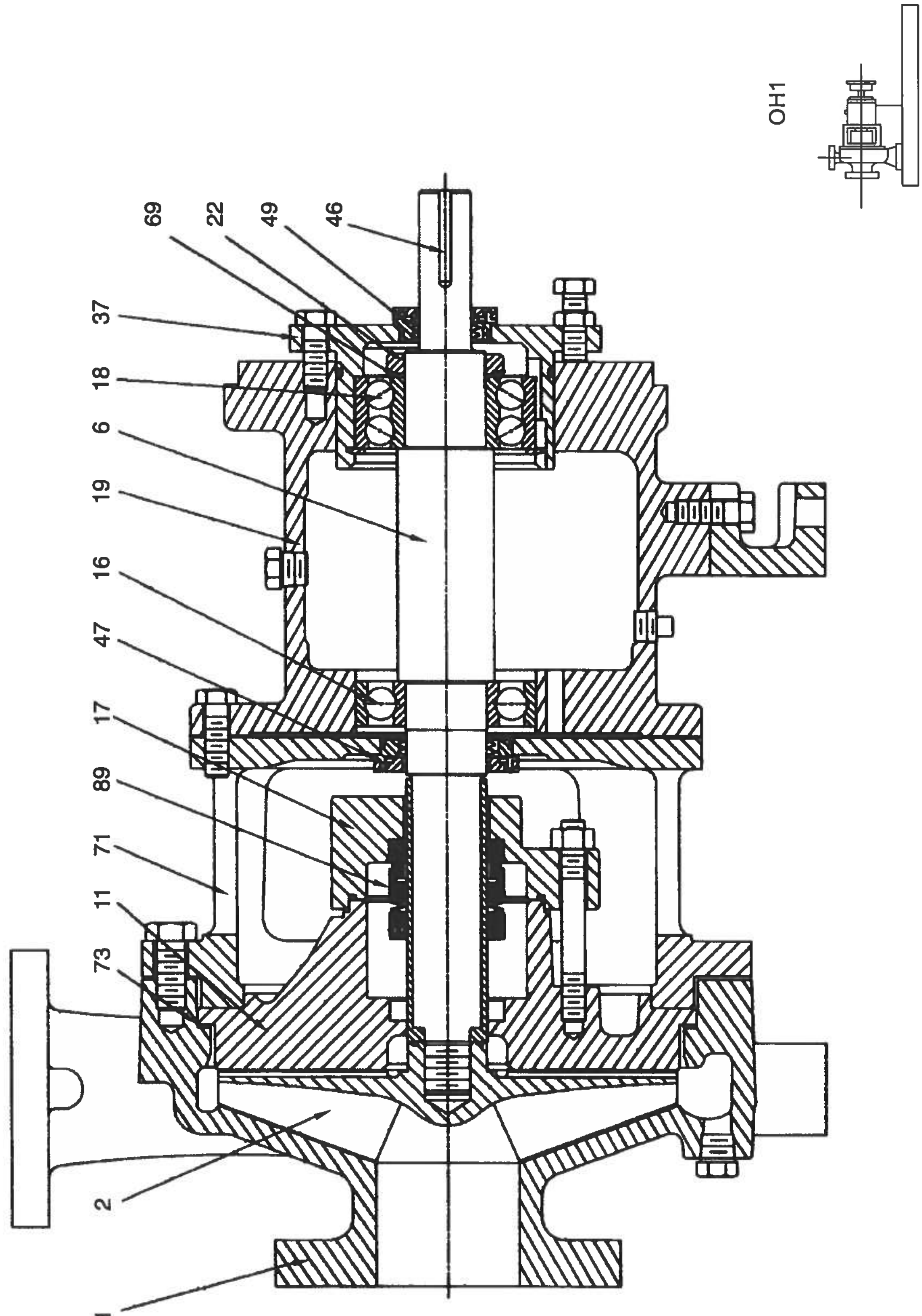


Figure 1.1.5e — Overhung impeller – flexibly coupled – single stage – foot mounted – ANSI B73.1

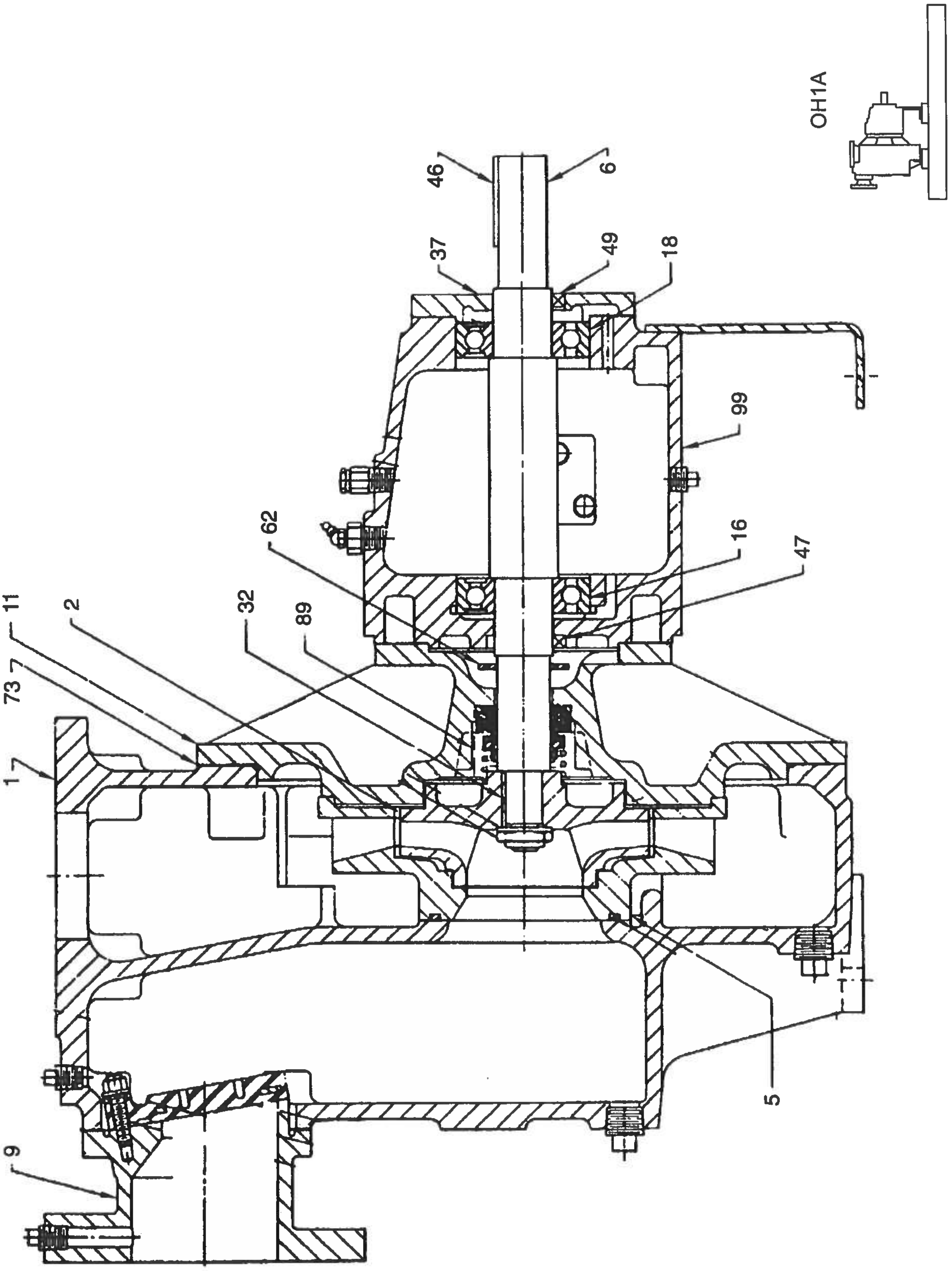


Figure 1.1.5f — Overhung impeller – flexibly coupled – single stage – foot mounted – self-priming

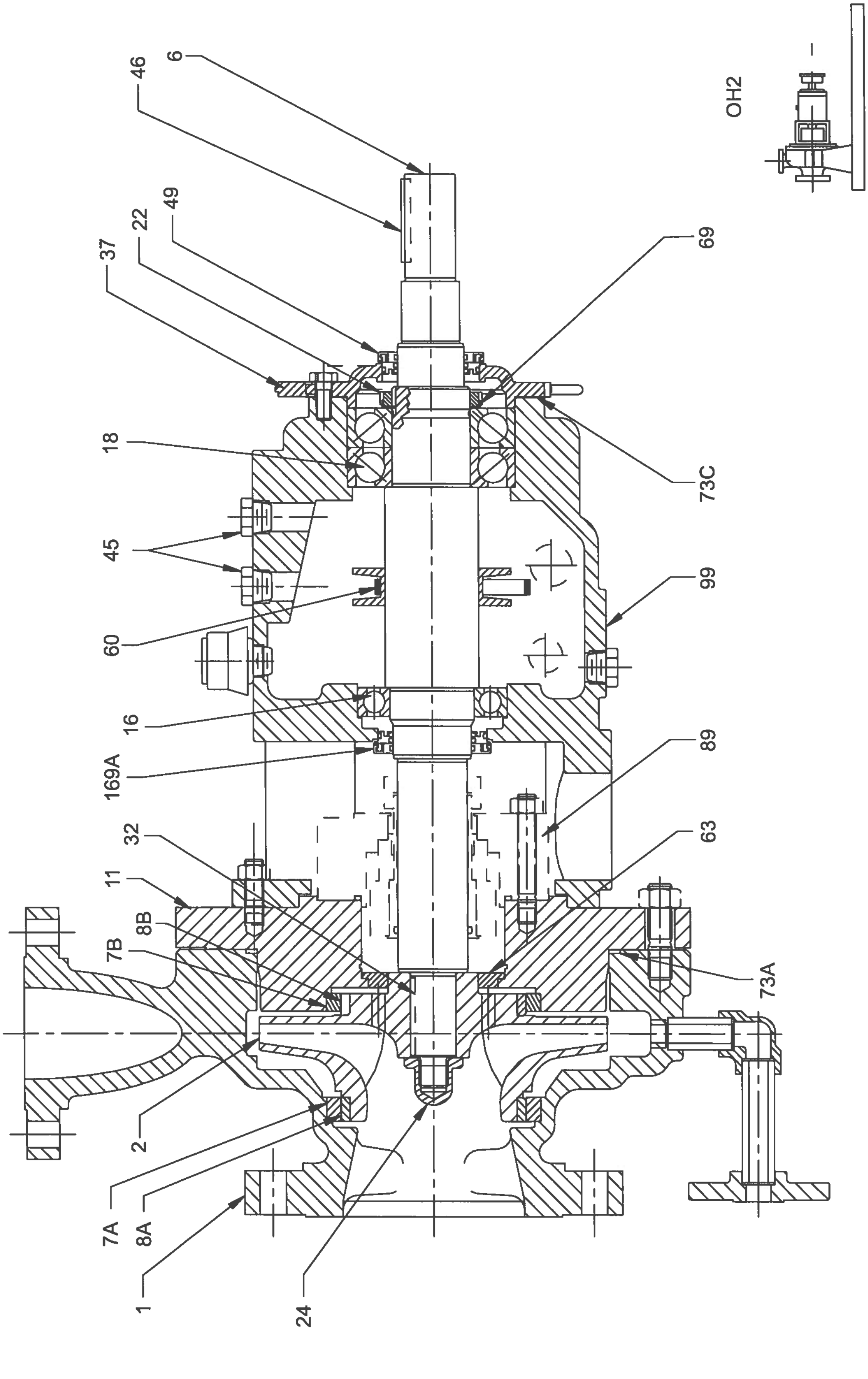
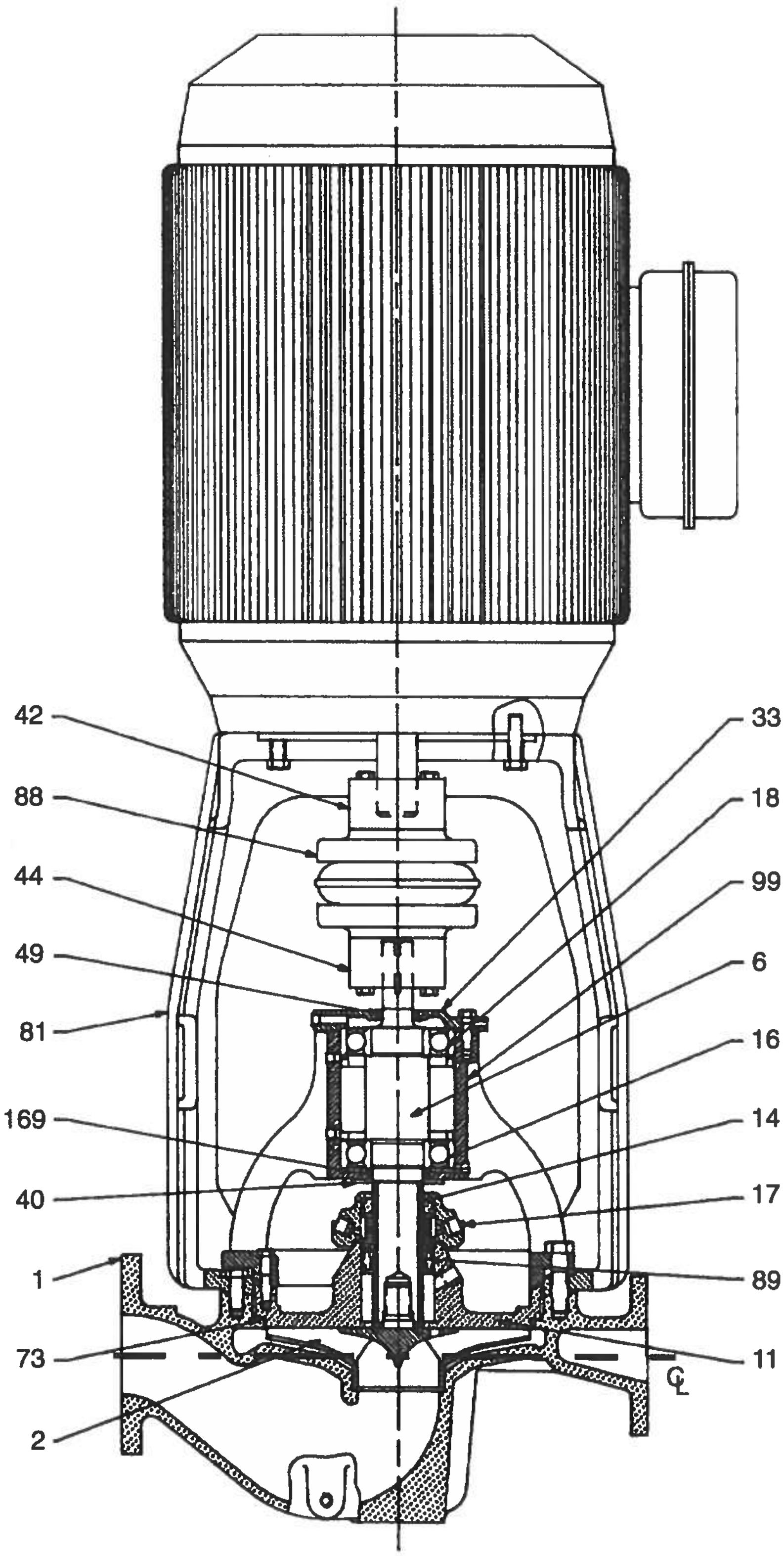


Figure 1.1.5g — Overhung impeller – flexibly coupled – single stage – centerline mounted – API 610



OH3

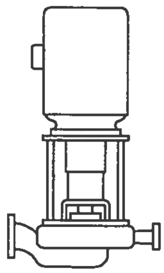


Figure 1.1.5h — Overhung impeller – integral bearing frame – single stage – in-line – flexible coupling

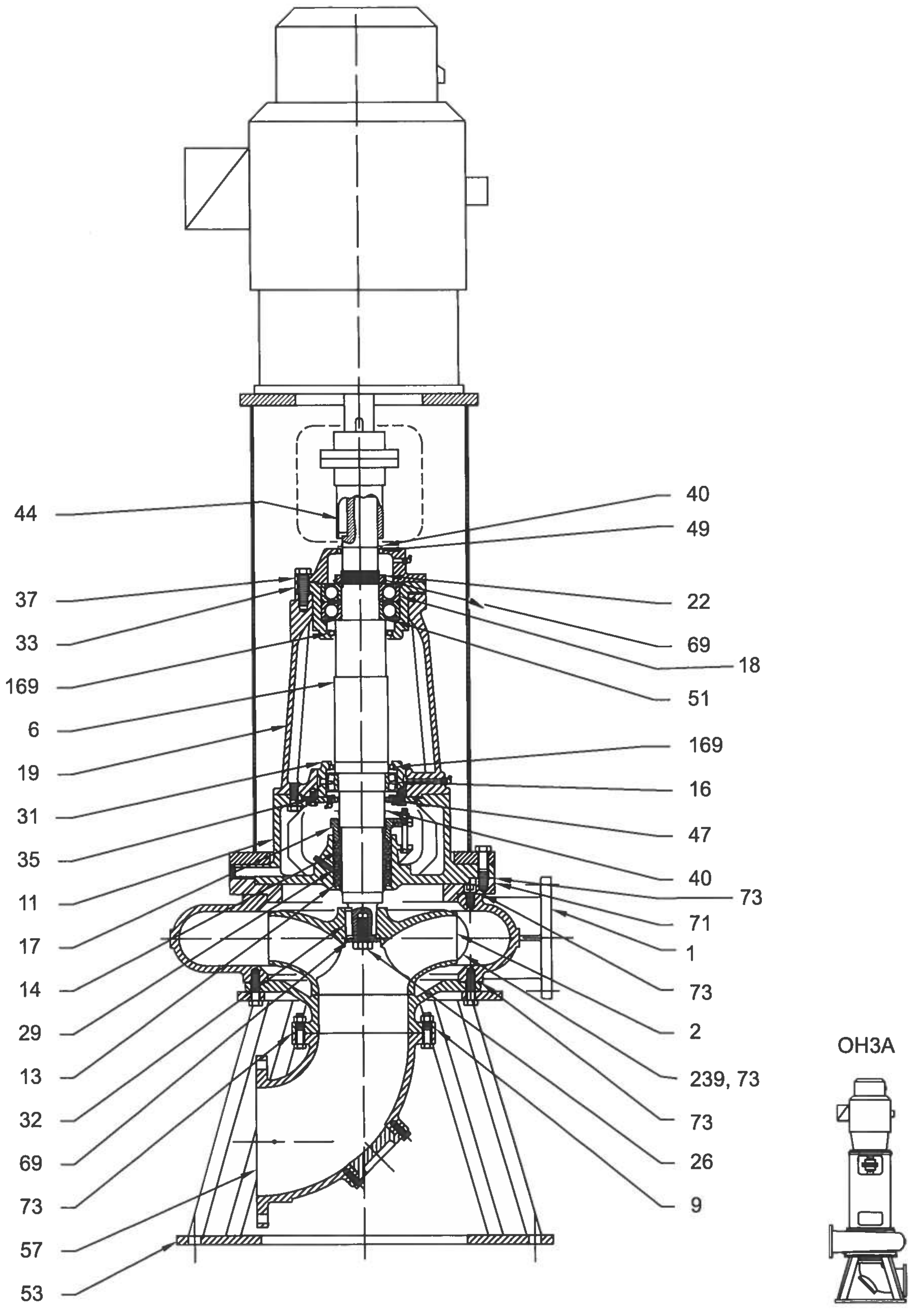
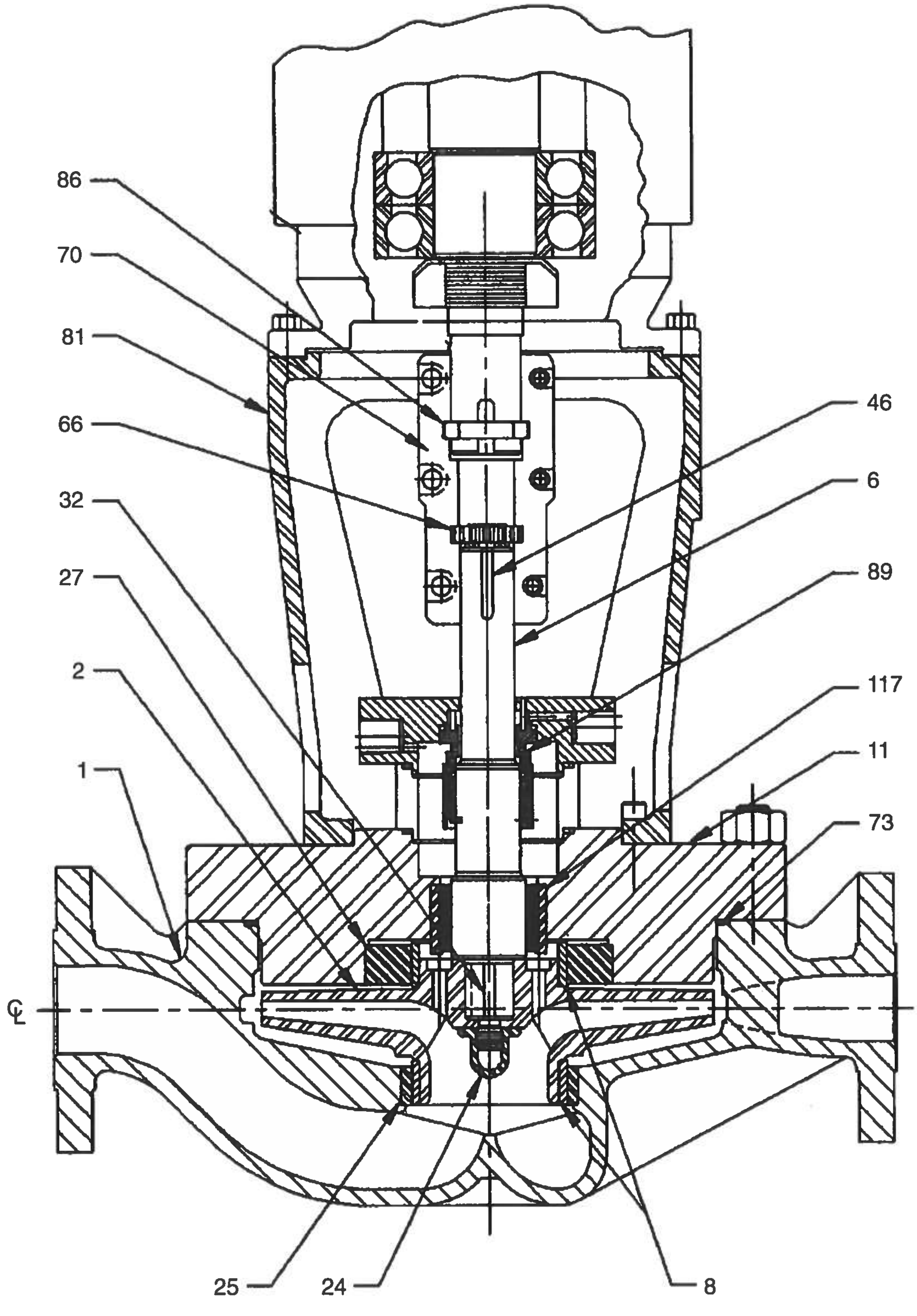


Figure 1.1.5i — Vertical end suction OH3A



OH4

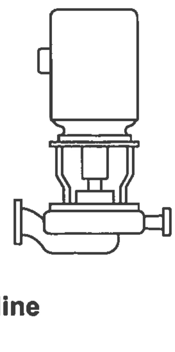


Figure 1.1.5j — Overhung impeller – rigidly coupled – single stage – vertical in-line

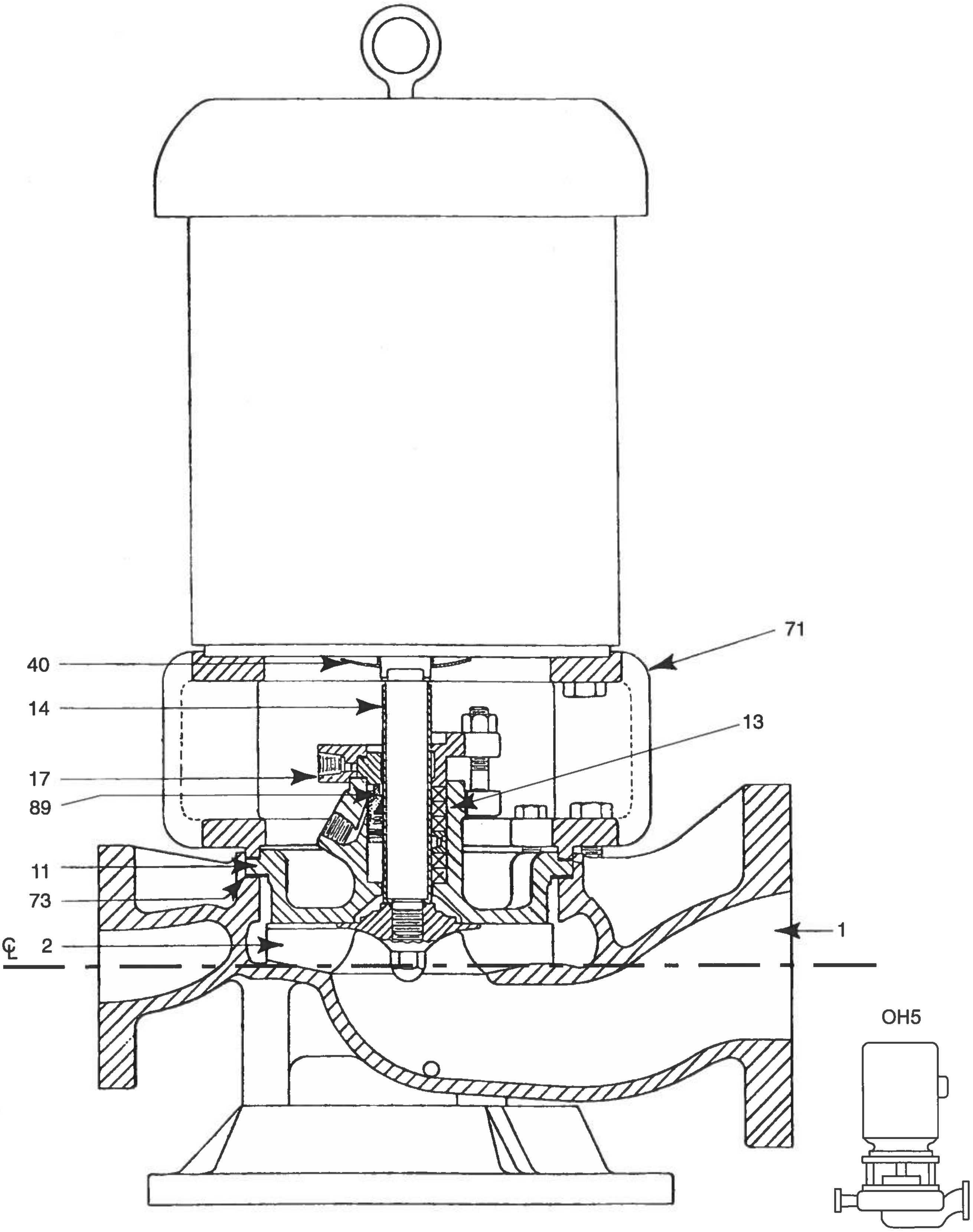


Figure 1.1.5k — Overhung impeller – close coupled – single stage – in-line (showing seal and packing)

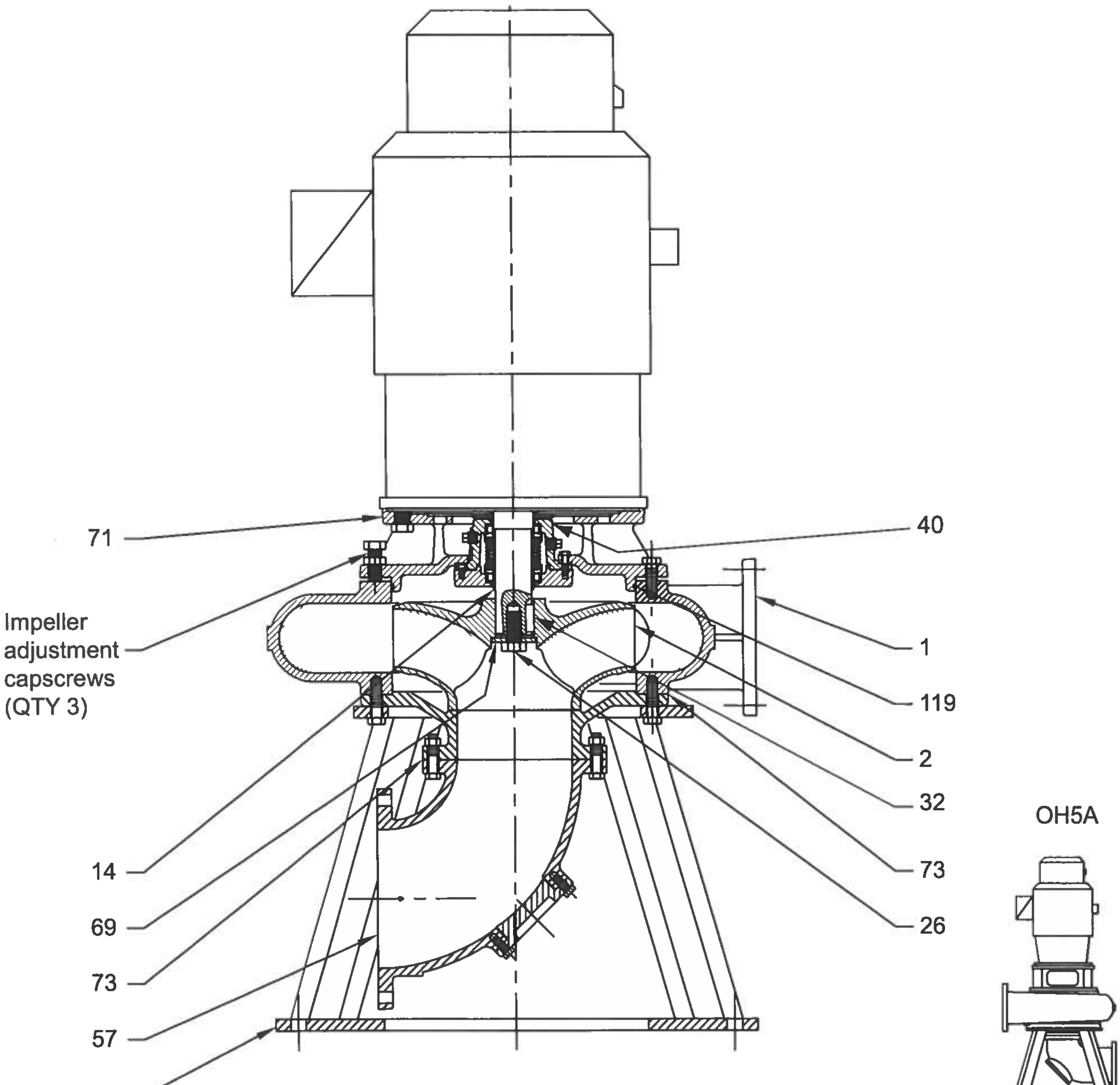
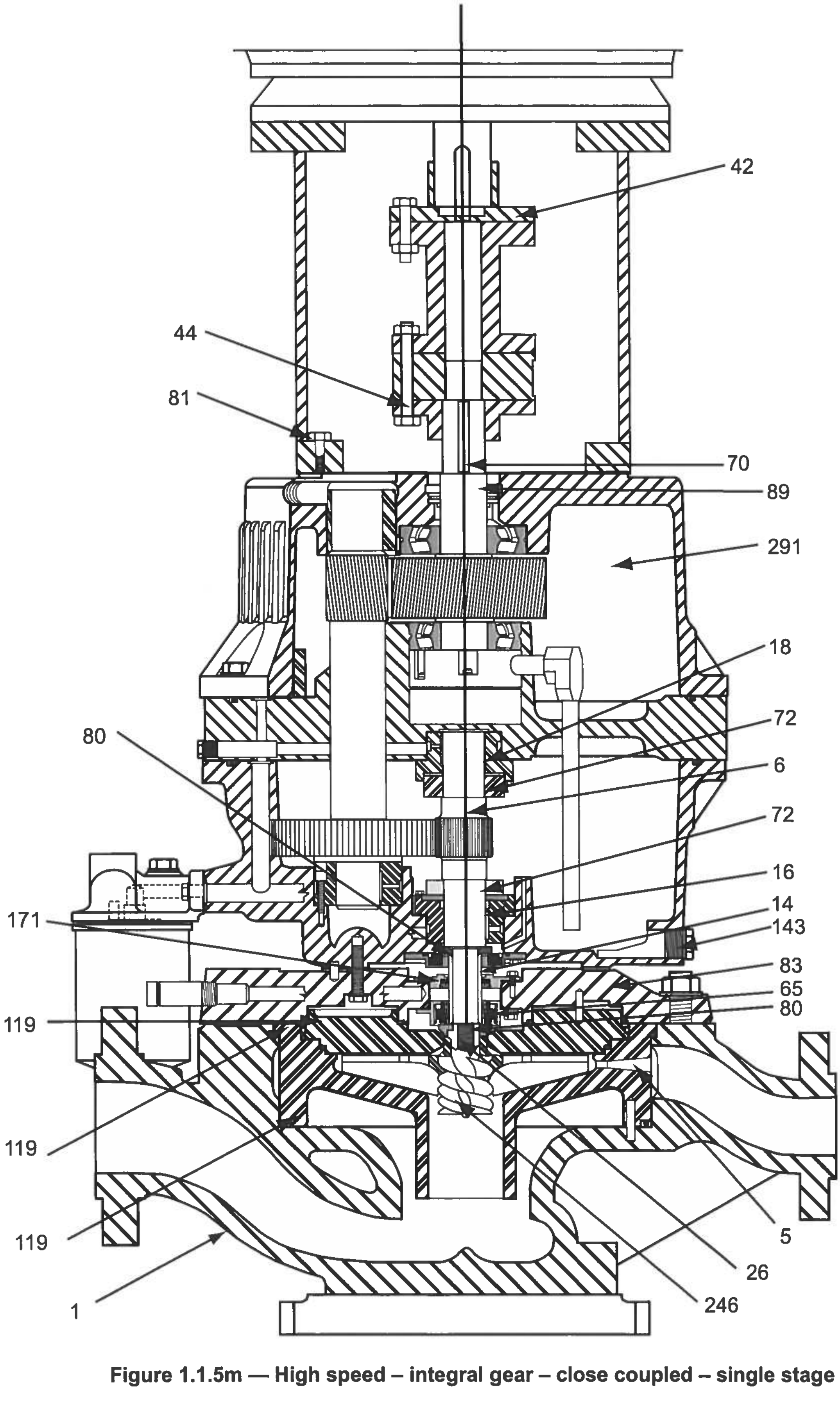


Figure 1.1.5I — Vertical end suction OH5A – close coupled – built together



OH6

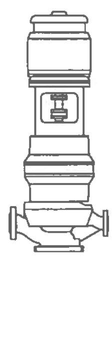


Figure 1.1.5m — High speed – integral gear – close coupled – single stage

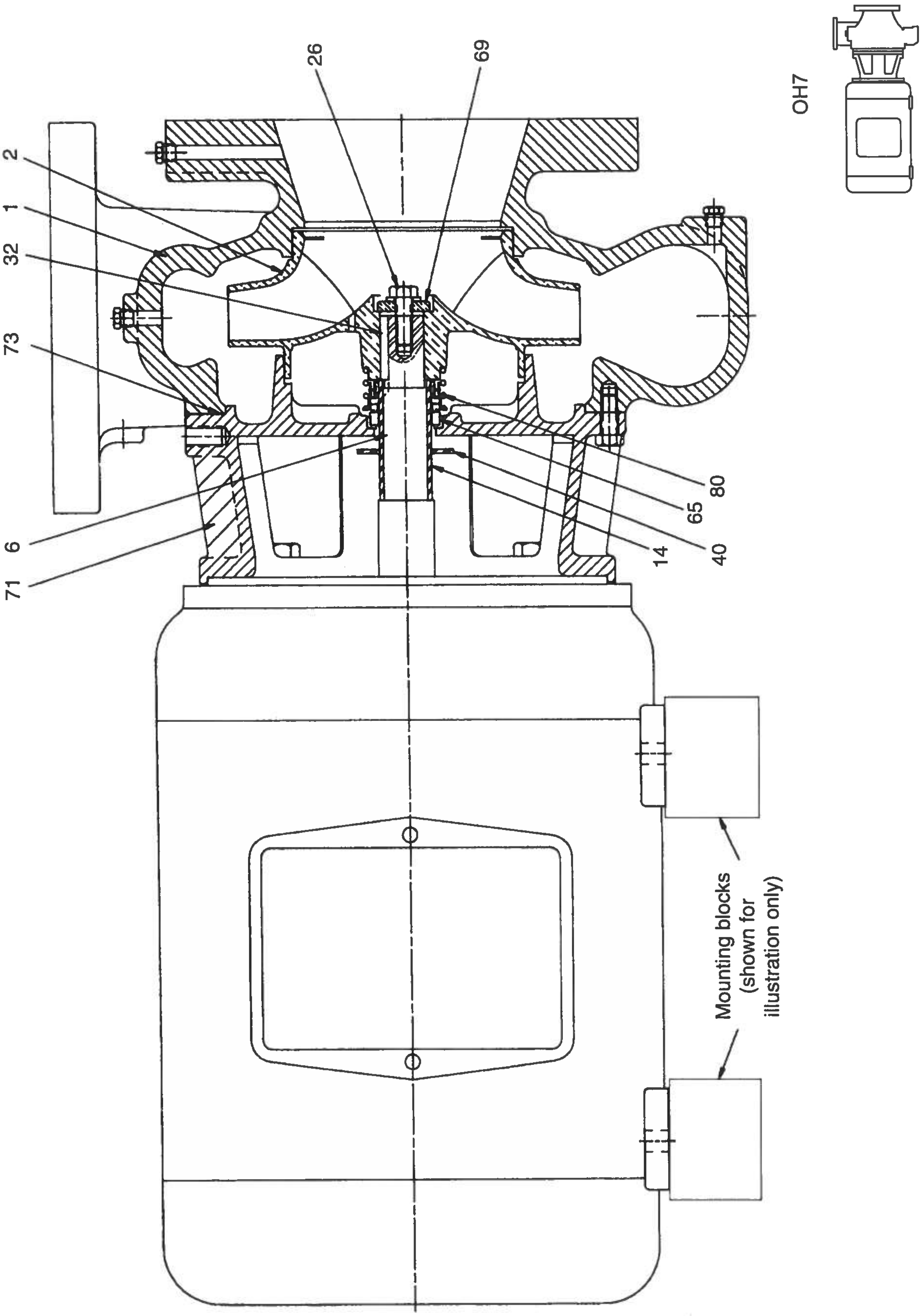
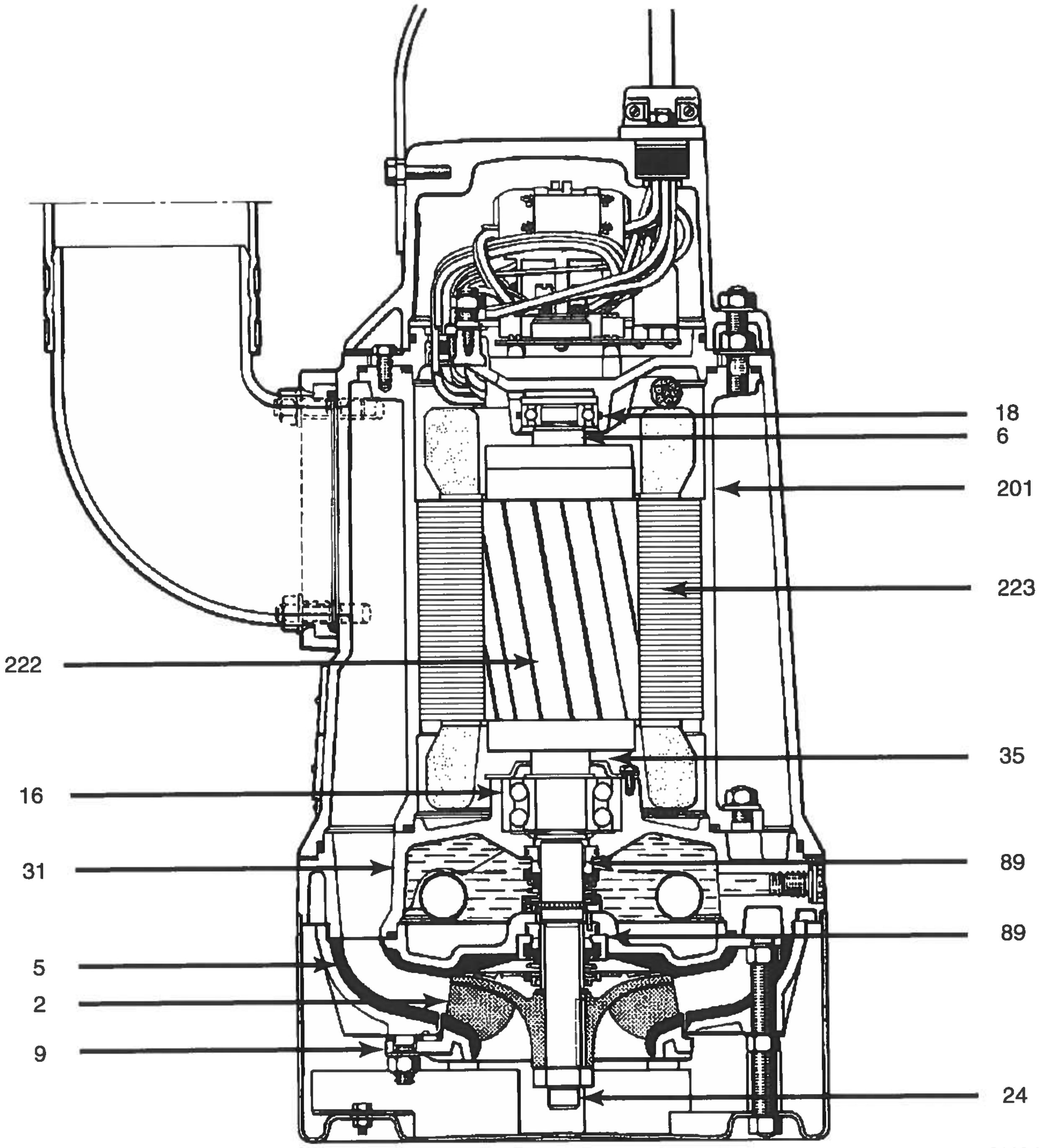


Figure 1.1.5n — Overhung impeller – close coupled – single stage – end suction



OH8A

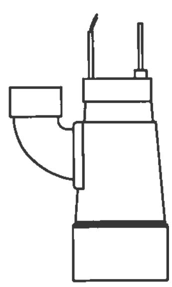


Figure 1.1.5o — Overhung impeller – close coupled – single stage – diffuser style – end suction – submersible

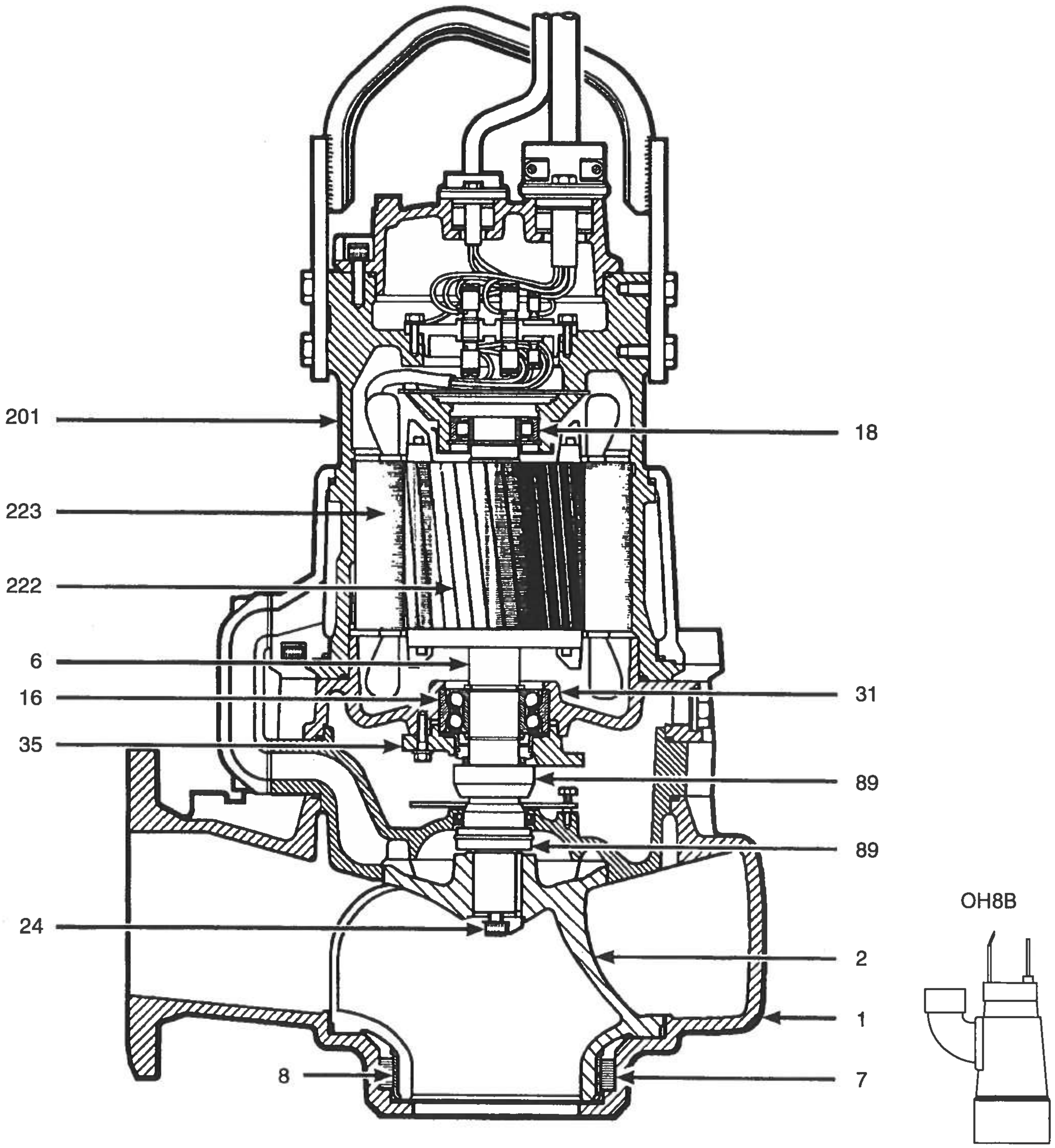
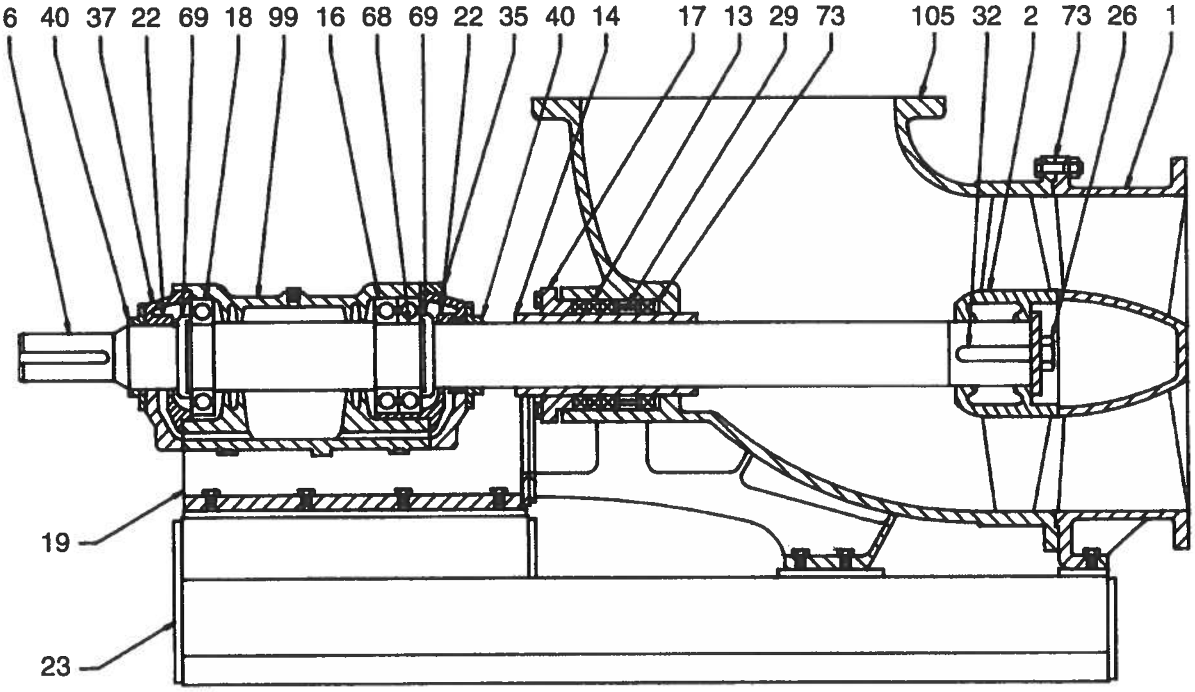
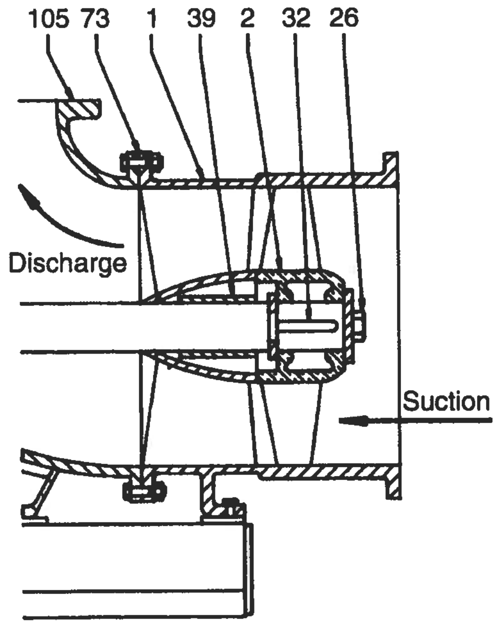
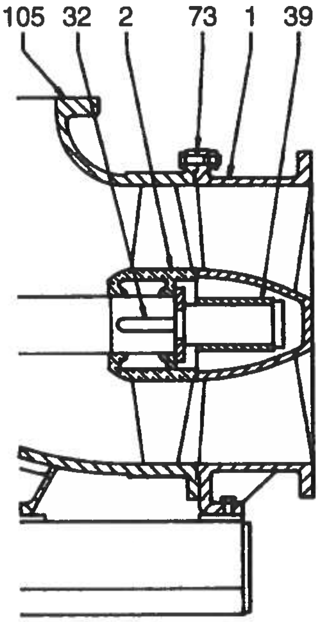


Figure 1.1.5p — Overhung impeller – close coupled – single stage – volute style – end suction submersible





Sleeve Bearing Inboard



Sleeve Bearing Outboard

OH00

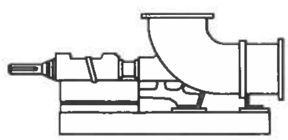
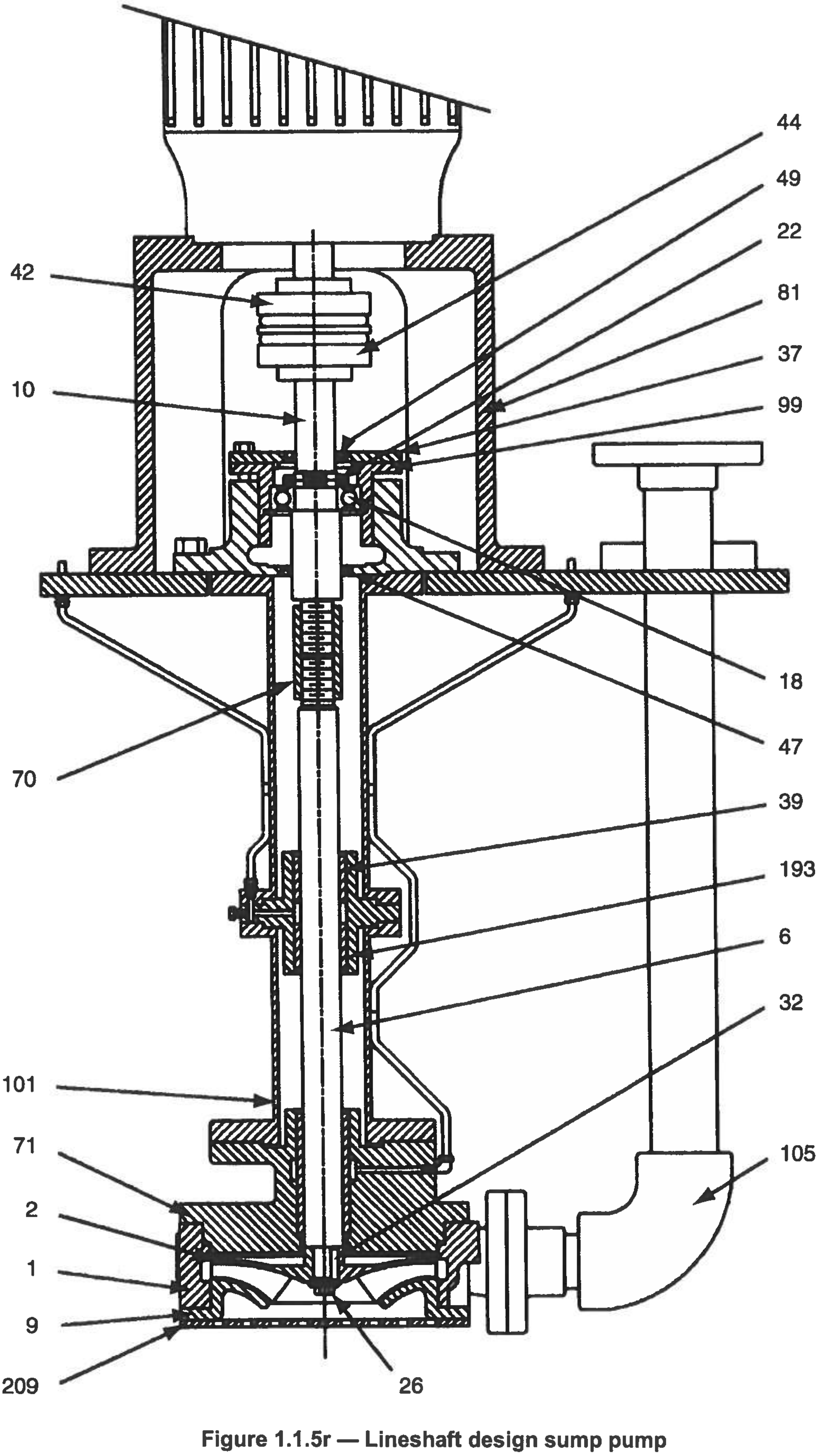


Figure 1.1.5q — Overhung impeller – flexibly coupled – single stage – axial flow – horizontal



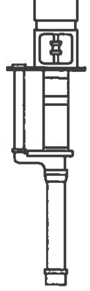
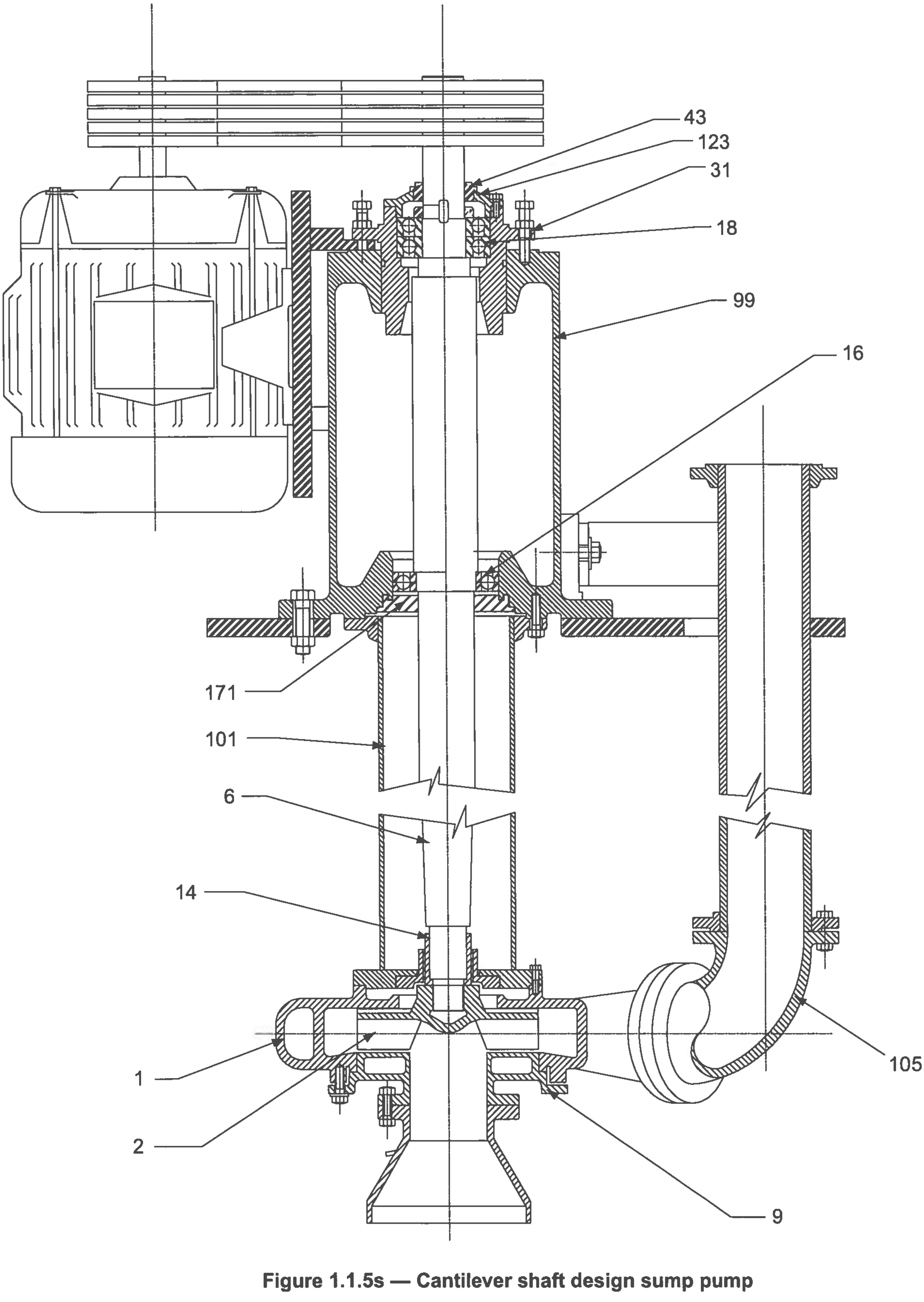


Figure 1.1.5r — Lineshaft design sump pump



VS5

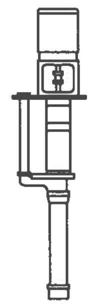


Figure 1.1.5s — Cantilever shaft design sump pump

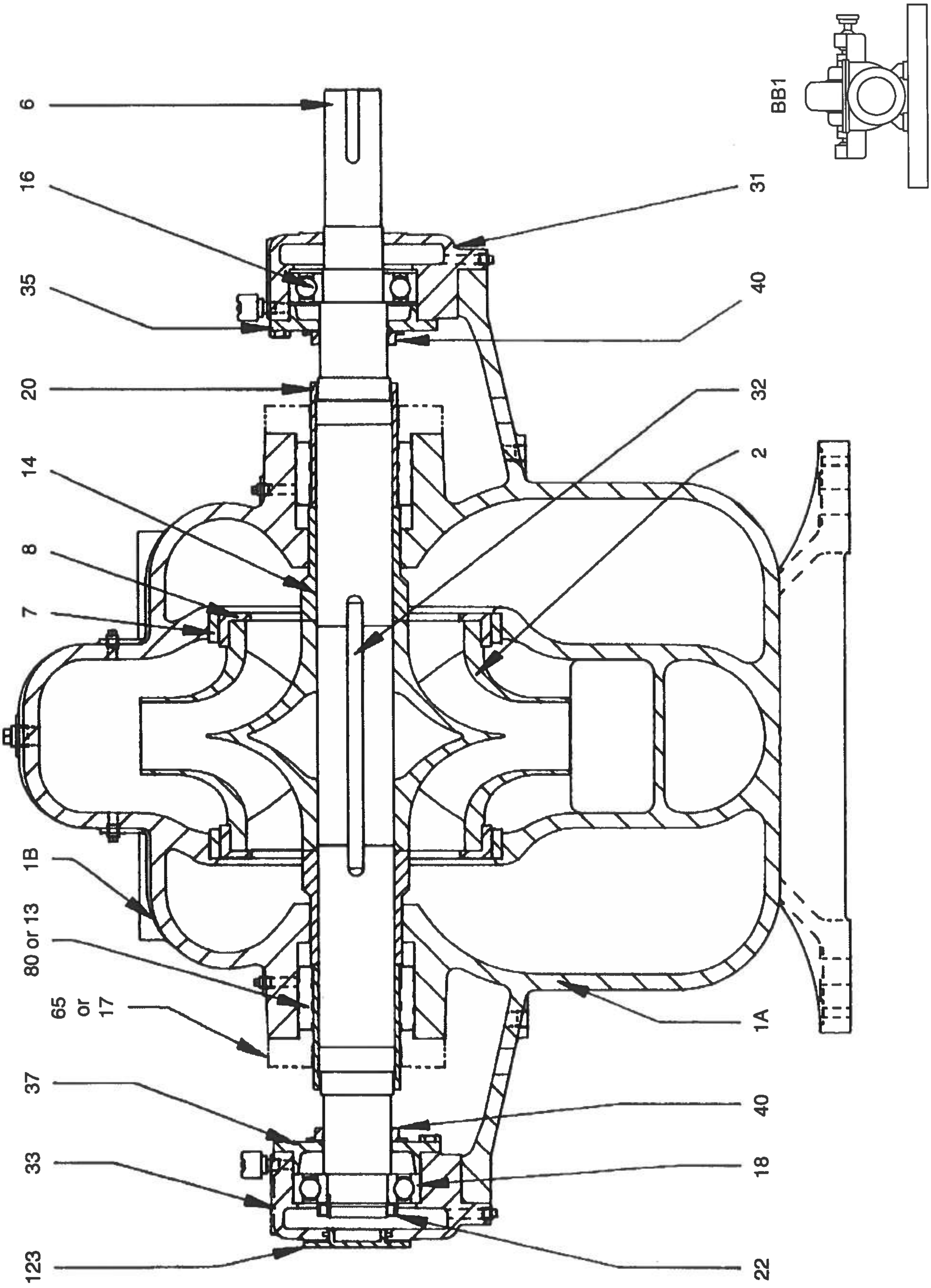
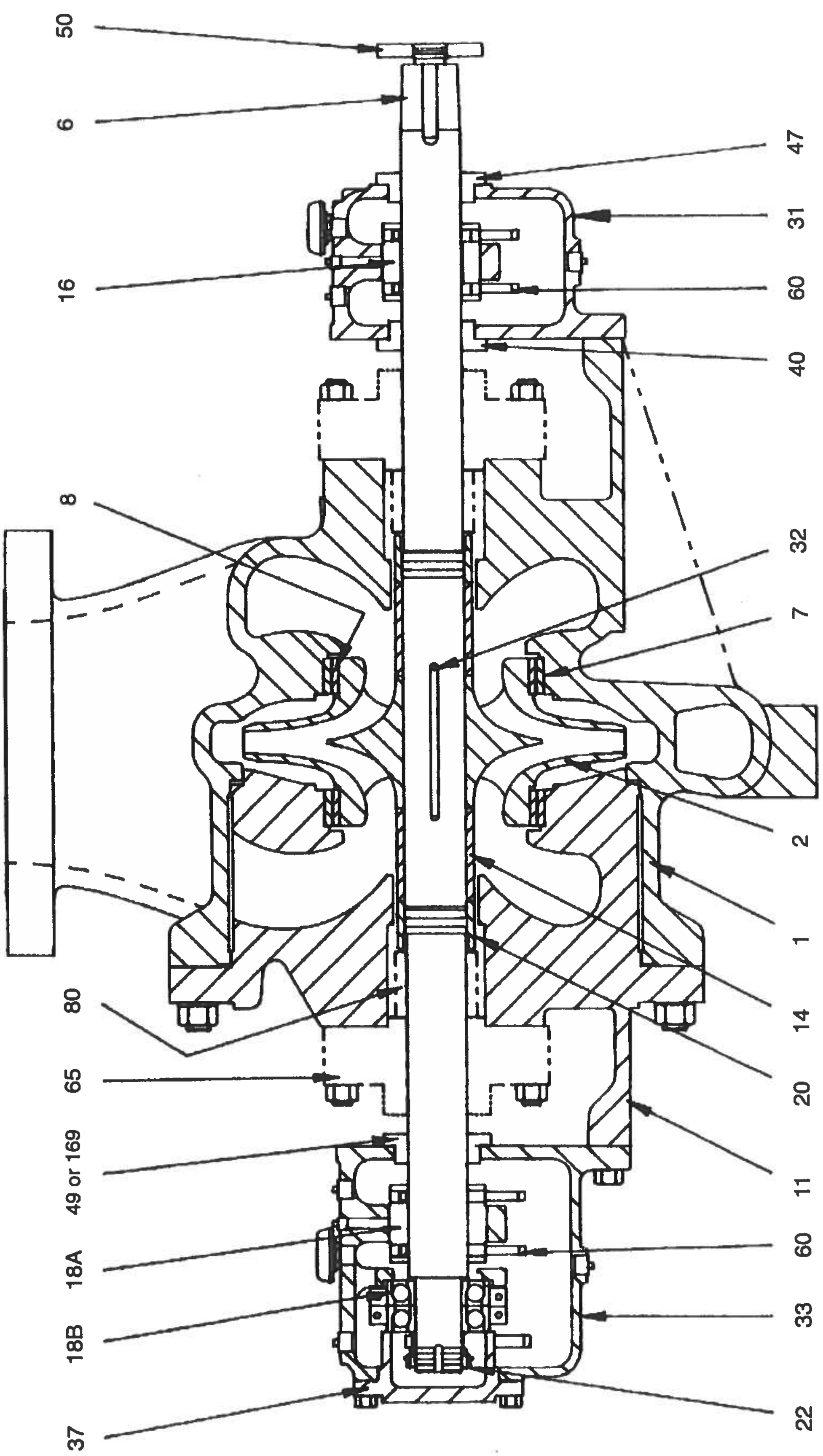


Figure 1.1.5t — Impeller between bearings – flexibly coupled – single stage – axial (horizontal) split case



BB2

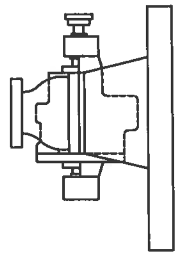


Figure 1.1.5u — Impeller between bearings – flexibly coupled – single stage – radial split case

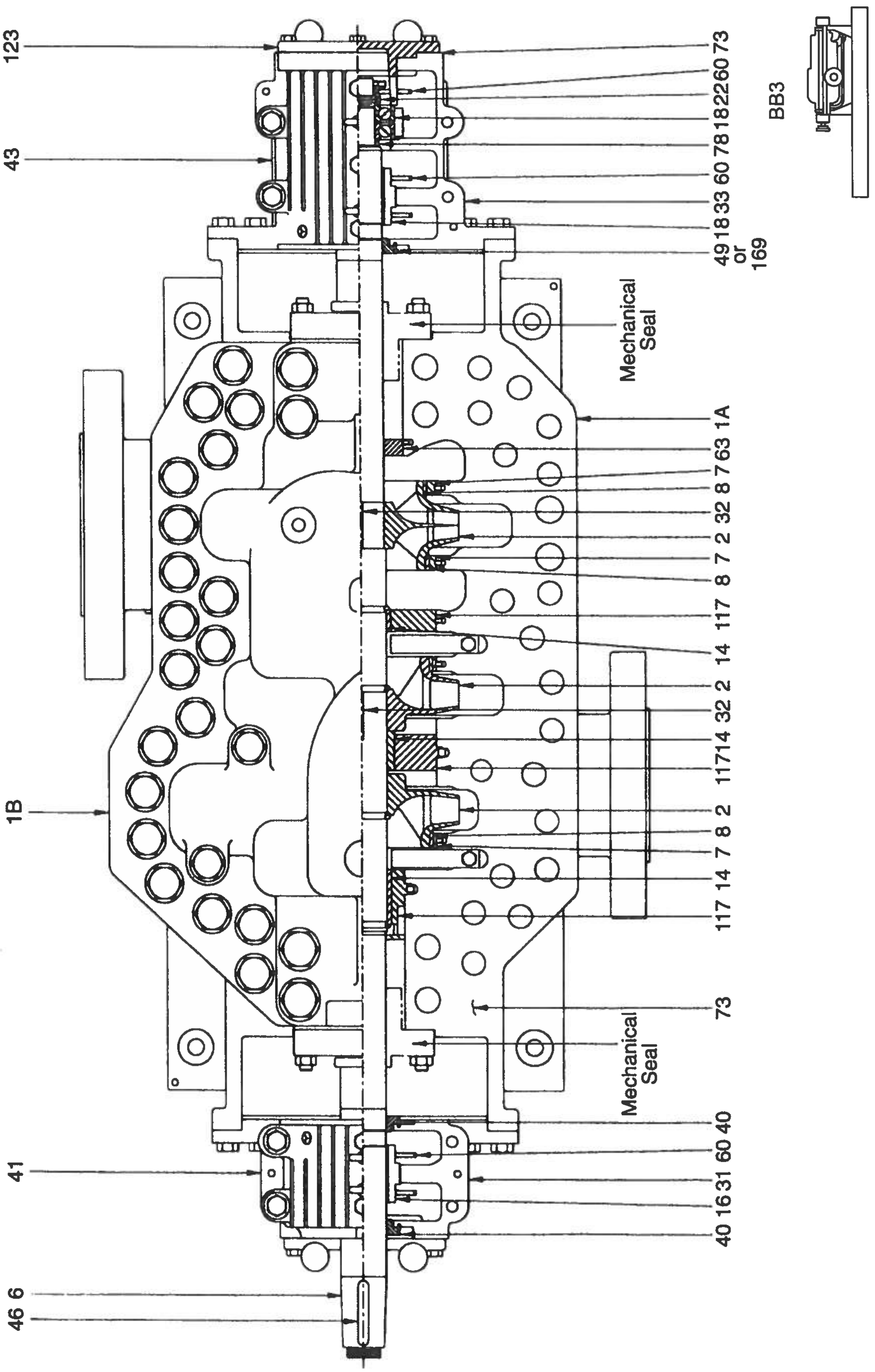


Figure 1.1.5v — Impeller between bearings – flexibly coupled – multistage axial (horizontal) split case

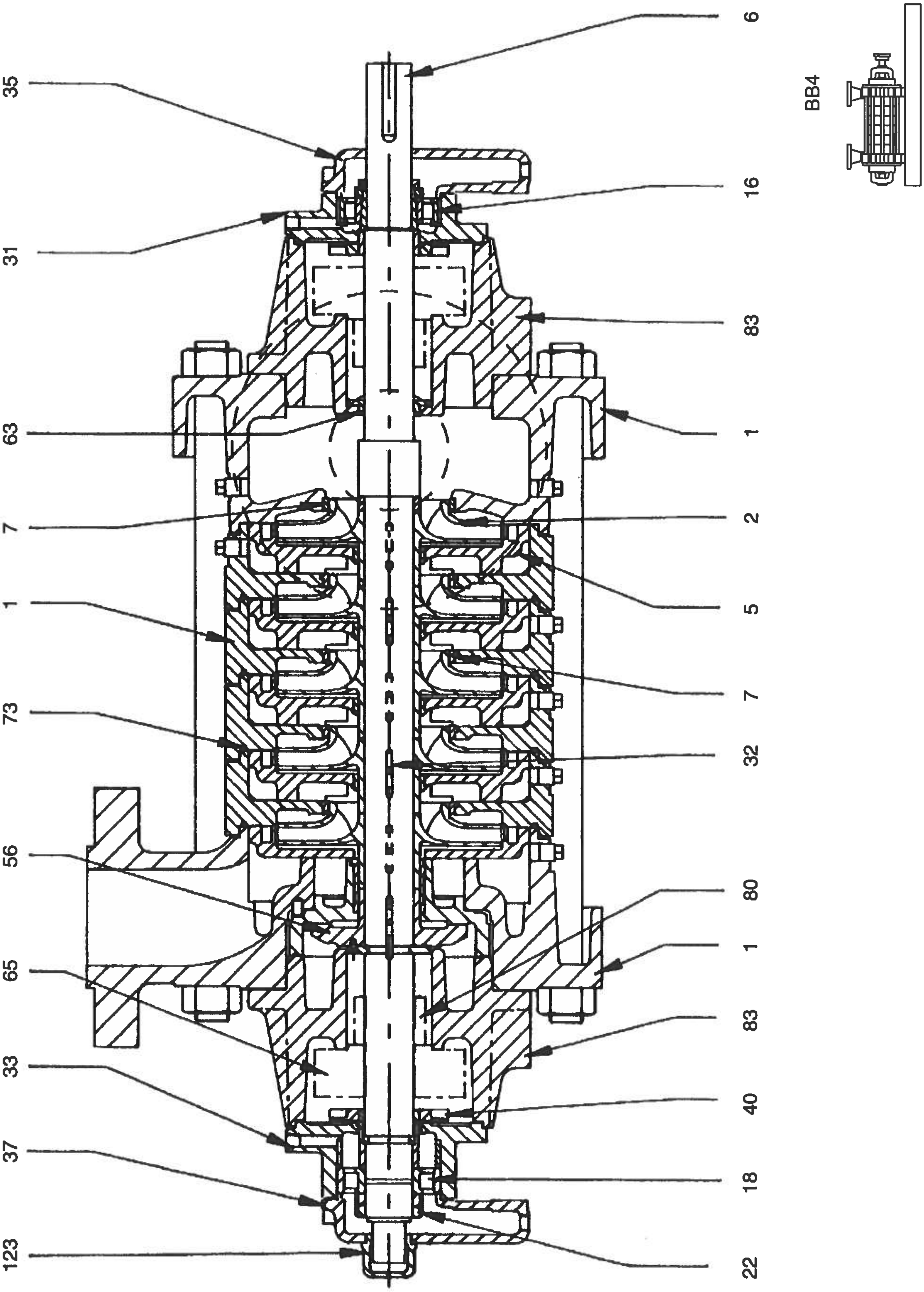


Figure 1.1.5w — Impeller between bearings – flexibly coupled – multistage – radial split case

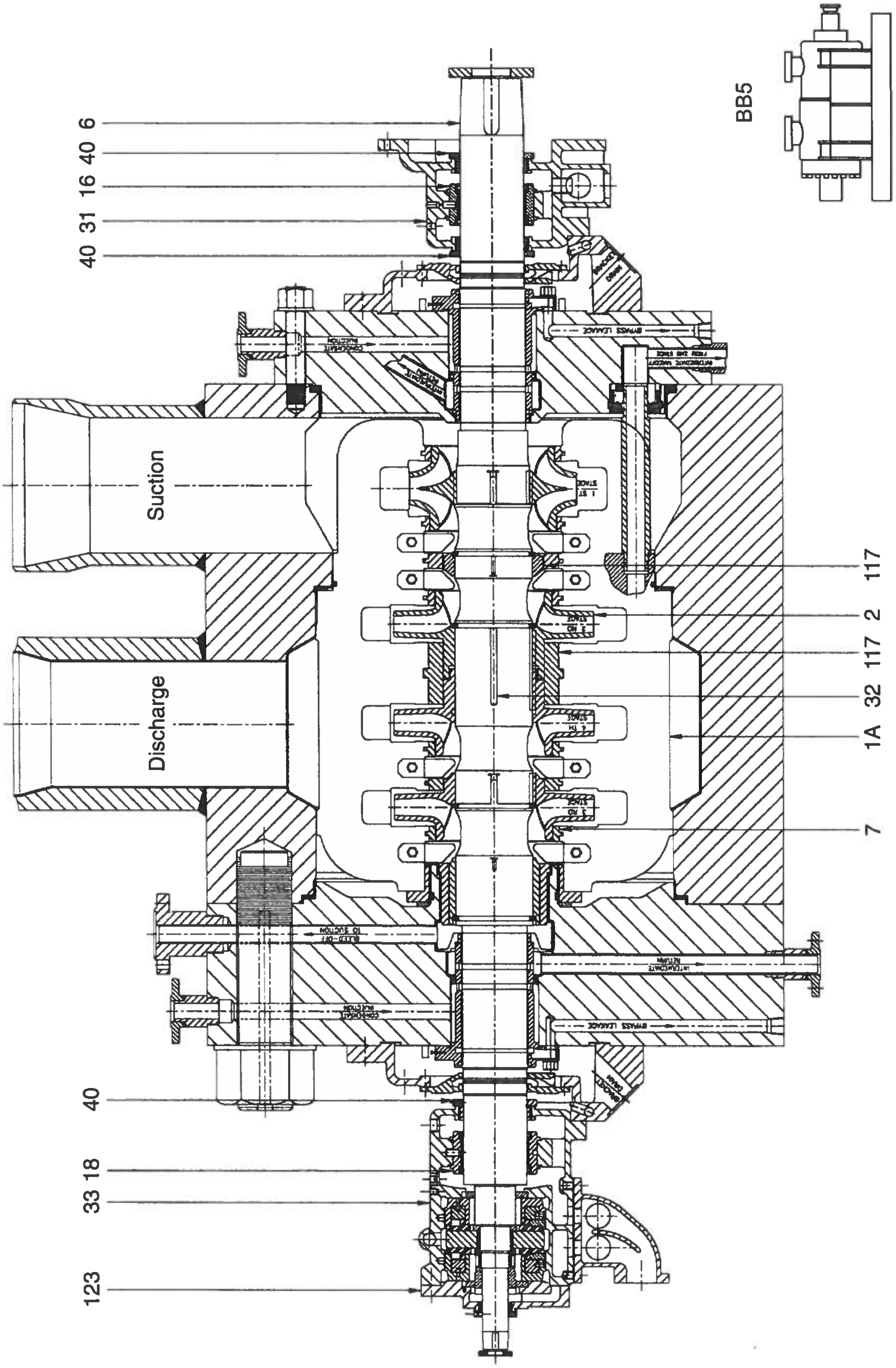


Figure 1.1.5x — Impeller between bearings – flexibly coupled – multistage – radial split-double casing

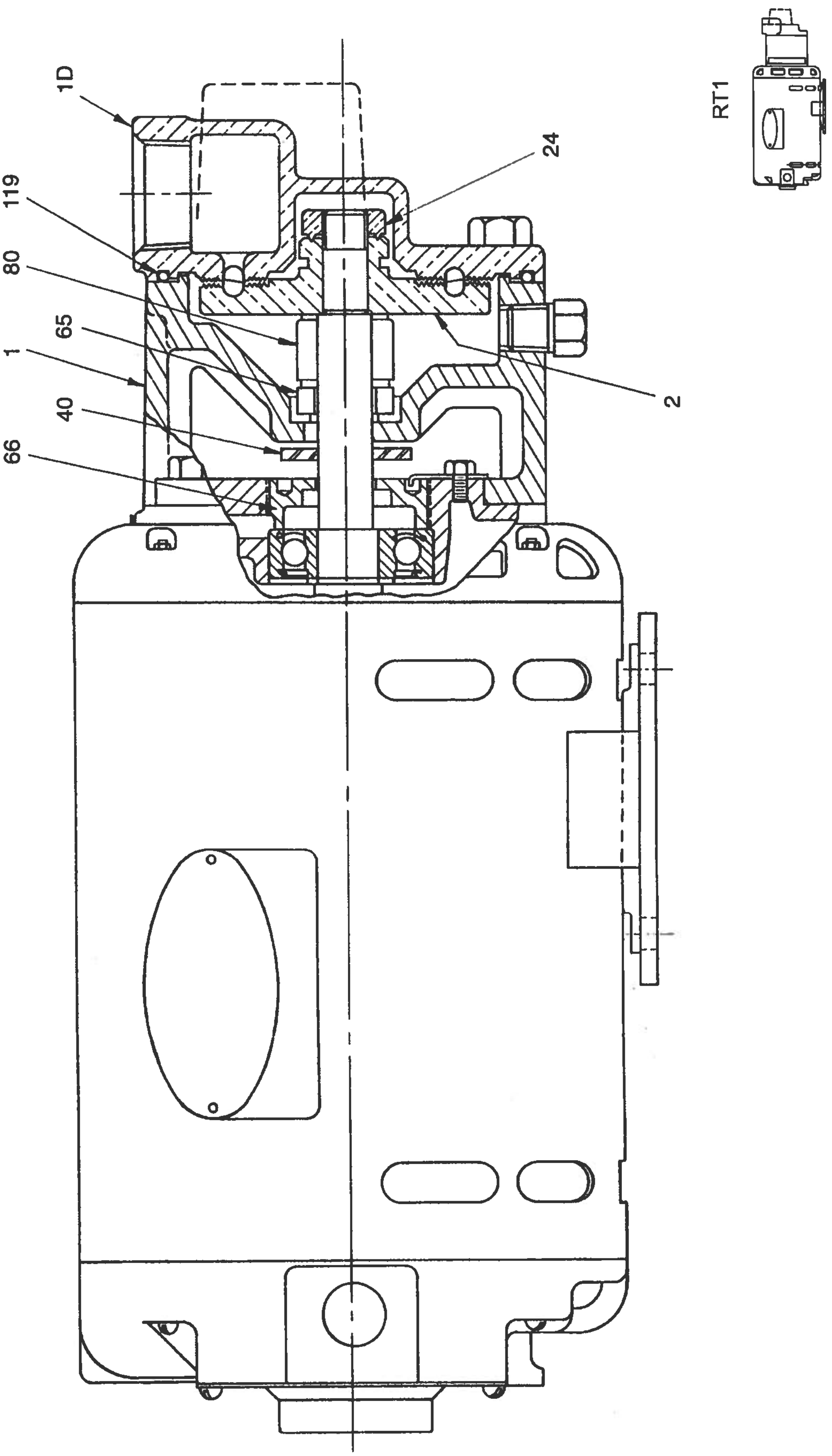


Figure 1.1.5y — Regenerative turbine – side channel single stage

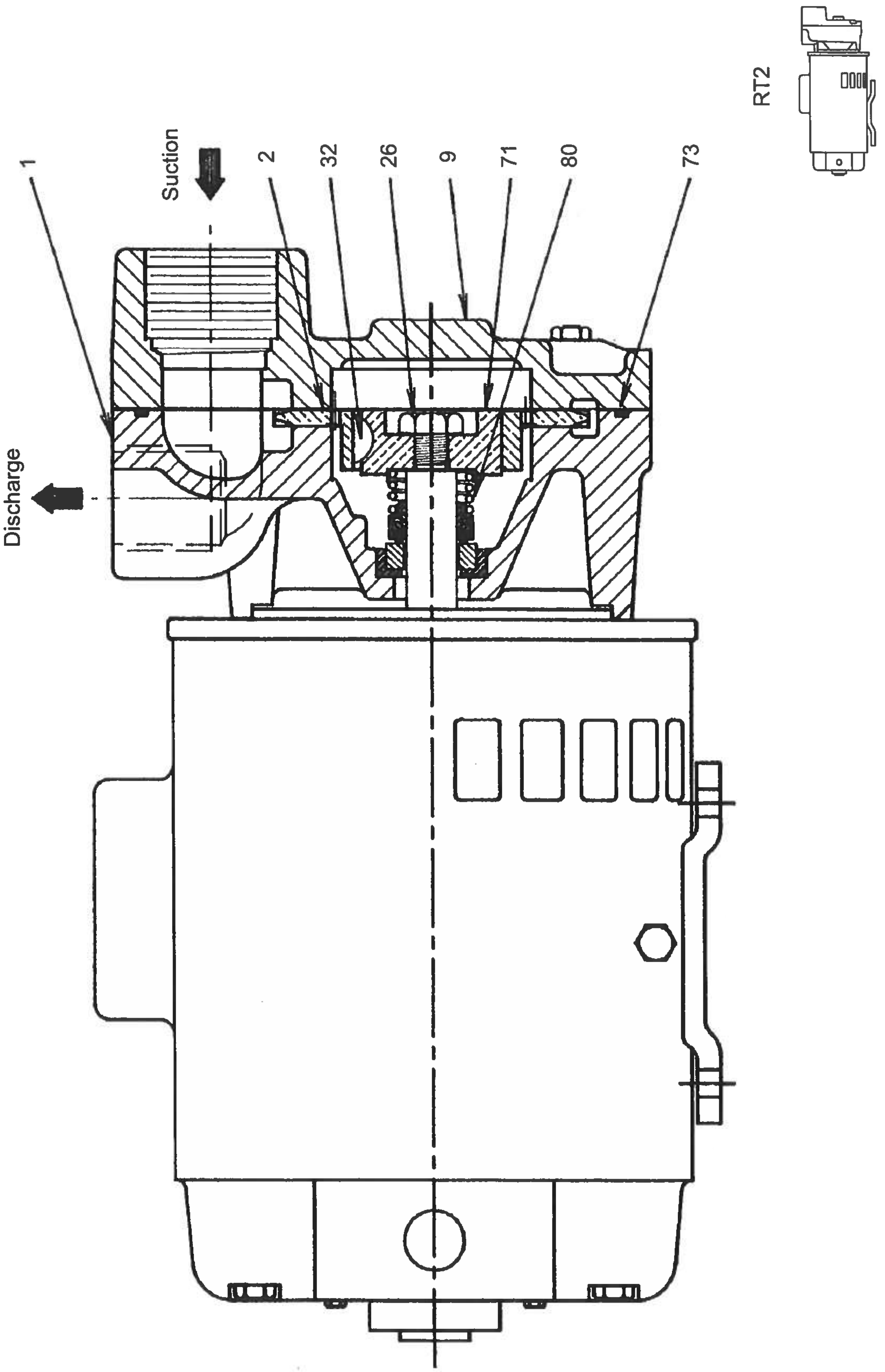


Figure 1.1.5z — Regenerative turbine – peripheral single stage

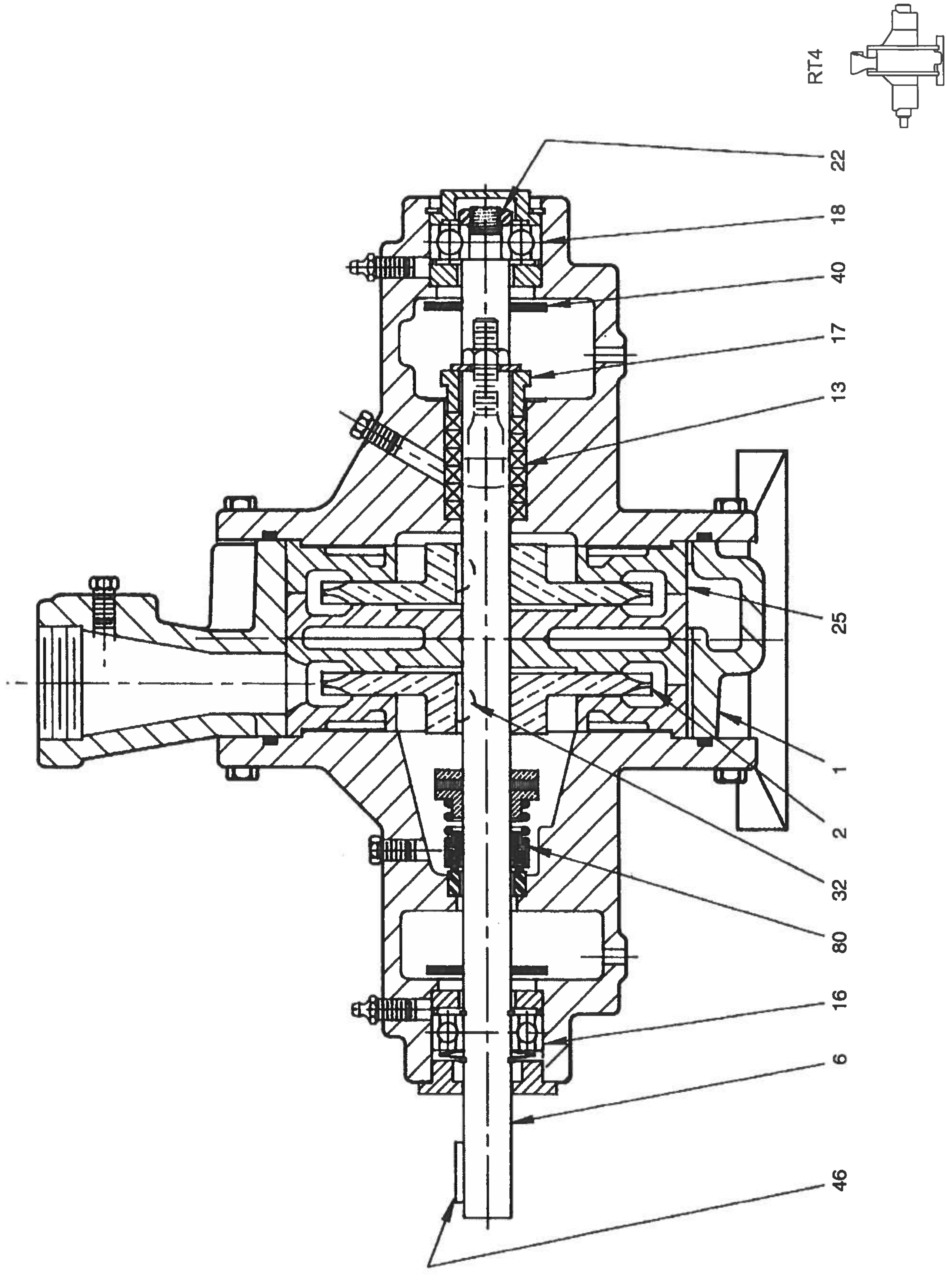
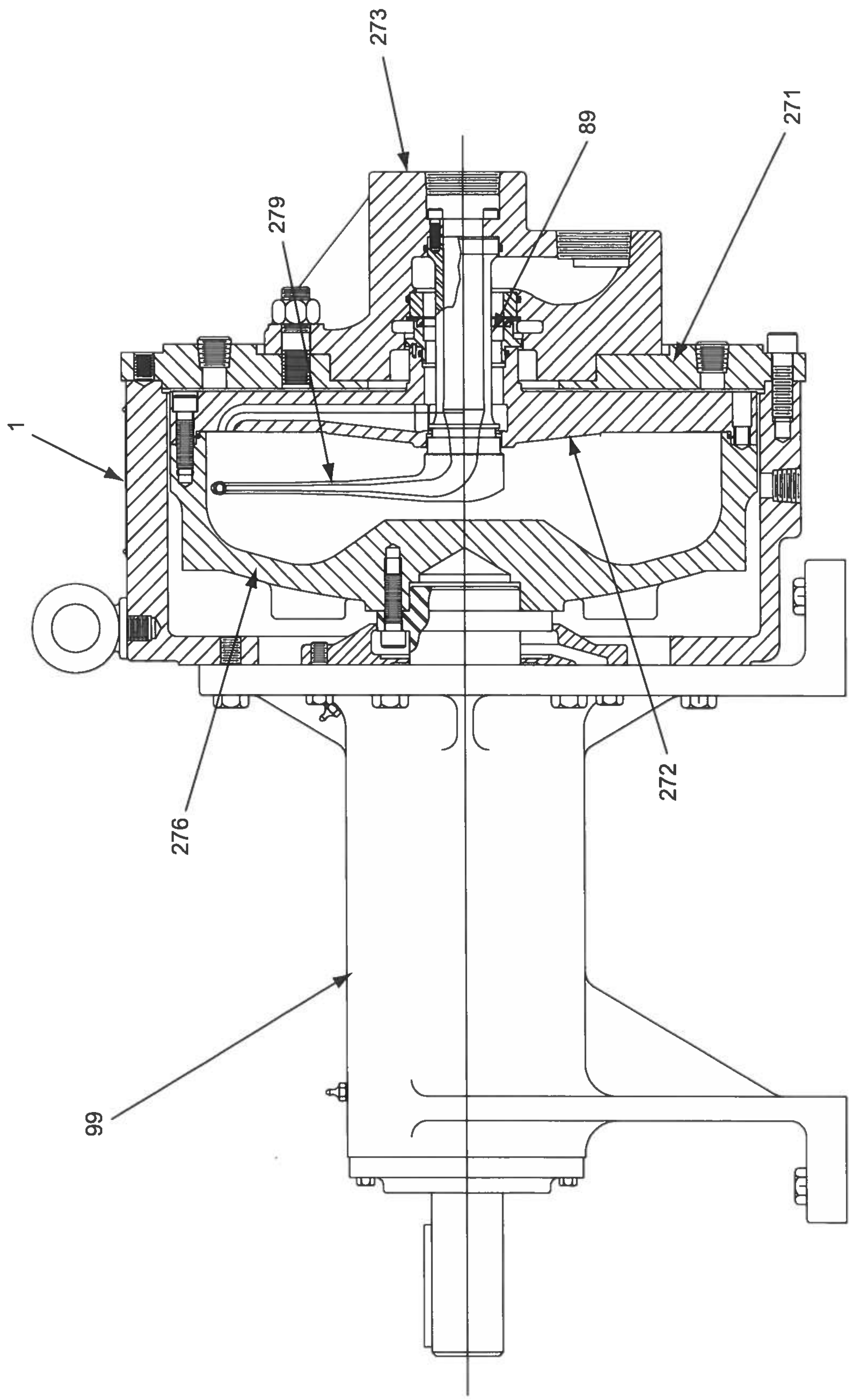


Figure 1.1.5aa — Regenerative turbine – impeller between bearings – two stage



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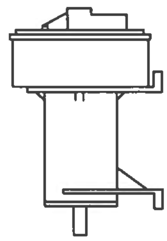


Figure 1.1.5bb — Pitot pump – flexibly coupled – single stage – frame mounted

1.1.6 General information

1.1.6.1 Size of a rotodynamic pump

The standard Hydraulic Institute nomenclature for pump size is "discharge opening size by maximum rated nominal impeller diameter (each indicated in millimeters)." For example, a pump with 80-mm suction, 50-mm discharge openings, and a 160-mm maximum rated nominal impeller diameter, will be referred in SI terms as a 50-160 pump. Conversely, US nomenclature refers to pumps by using the notation: inlet opening size by discharge opening size by maximum rated nominal impeller diameter, all measured in inches. The pump measured above in US customary units may be referred to as a "3×2×6" pump, i.e., the smaller of the numbers is the discharge size. The pump described above in ISO standards would be referred to as an "80-50-160" pump.

These methods are in compliance with methods used in other reference industry standards such as ISO 5199 and ANSI/ASME B 73.1M.

1.1.6.2 Duplicate performance pump

A duplicate pump is one in which the performance characteristics are the same as another, within the variations permitted by ISO 9906 or ANSI/HI 1.6 test standards, and parts are of the same type. But, by reason of improved design and/or materials, mounting dimensions and parts are not necessarily interchangeable.

1.1.6.3 Dimensionally interchangeable pump

An interchangeable pump is one in which the mounting dimensions are such that the replacement pump can be mounted on the existing bedplate and match existing piping and driver, with hydraulic characteristics and materials to be specified. Interchangeability may involve some variation, not necessarily significant, as a result of manufacturing tolerances.

1.1.6.4 Identical pump (performance and dimensional)

An identical pump is a replica of, and is interchangeable with, a specific pump. Where it is intended that a pump is to be identical in all respects, including parts, mountings, connecting flange dimensions, and materials, it should be identified as identical with pump serial number XXXXXX. An identical pump will replicate the original pump in performance and dimensions as closely as the manufacturing tolerances allow.

1.1.6.5 Definitions for bare rotor and rotating assembly

1.1.6.5.1 Overhung pumps

1.1.6.5.1.1 Liquid end (or wet end) assembly

Term used for overhung pumps to describe the wetted parts, specifically the casing, cover, stuffing box or seal chamber, impeller, and associated fasteners and gaskets. See Figure 1.1.6.5.1.1.

1.1.6.5.1.2 Power end (or frame assembly)

Term used for overhung pumps to describe the assembly that connects the motor to the pump.

The assembly contains: shaft, sleeve (if supplied), thrust bearing, radial bearing, housing, and frame.

See Figure 1.1.6.5.1.2.

1.1.6.5.1.3 Back pull-out assembly

The major assembly for overhung pumps, which includes all parts other than the casing.

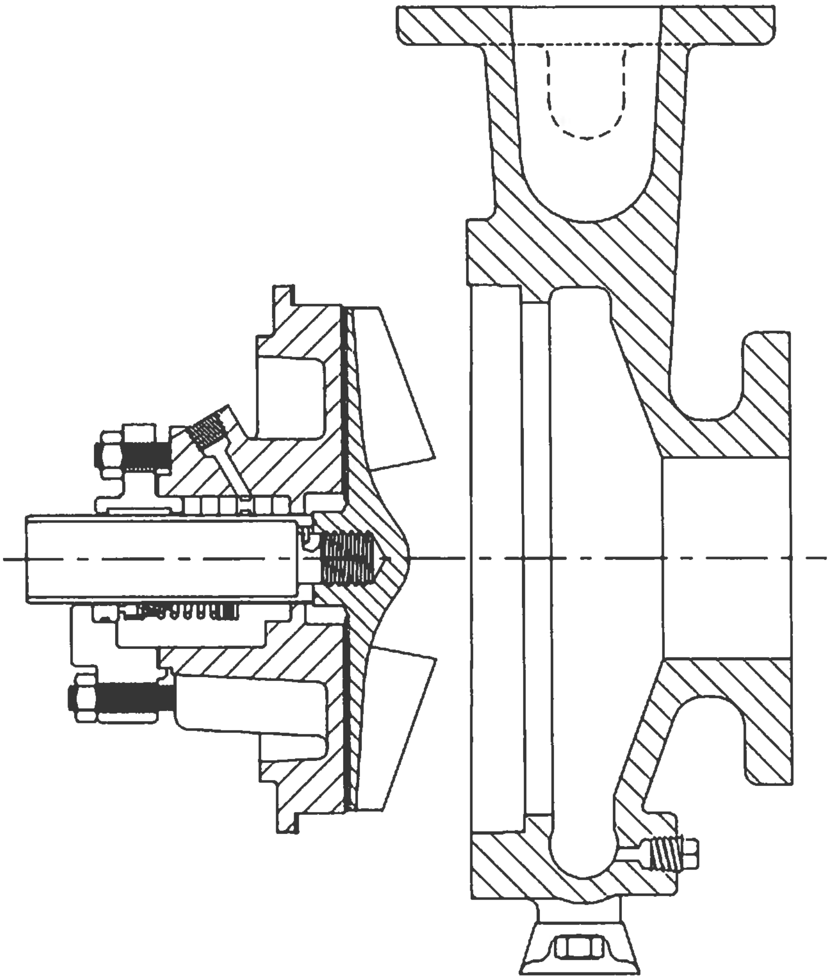


Figure 1.1.6.5.1.1 — Liquid end (or wet end) assembly

The assembly contains: casing cover, stuffing box or seal chamber, mechanical seal assembly or packed gland assembly, adapter (if fitted), power end, and impeller.

The back pull-out assembly is configured as an aid to assembly/disassembly and may be arranged to be installed and removed without disturbing the pump casing or the driver. It thereby provides an aid to improve maintenance by allowing quick change-out of parts and minimized downtime.

See Figure 1.1.6.5.1.3.

1.1.6.5.1.4 Bare rotor

A bare rotor shall consist of the following as an assembly (where used):

- A shaft with all nuts
- Keys
- Impeller
- Impeller ring(s)
- Shaft sleeves

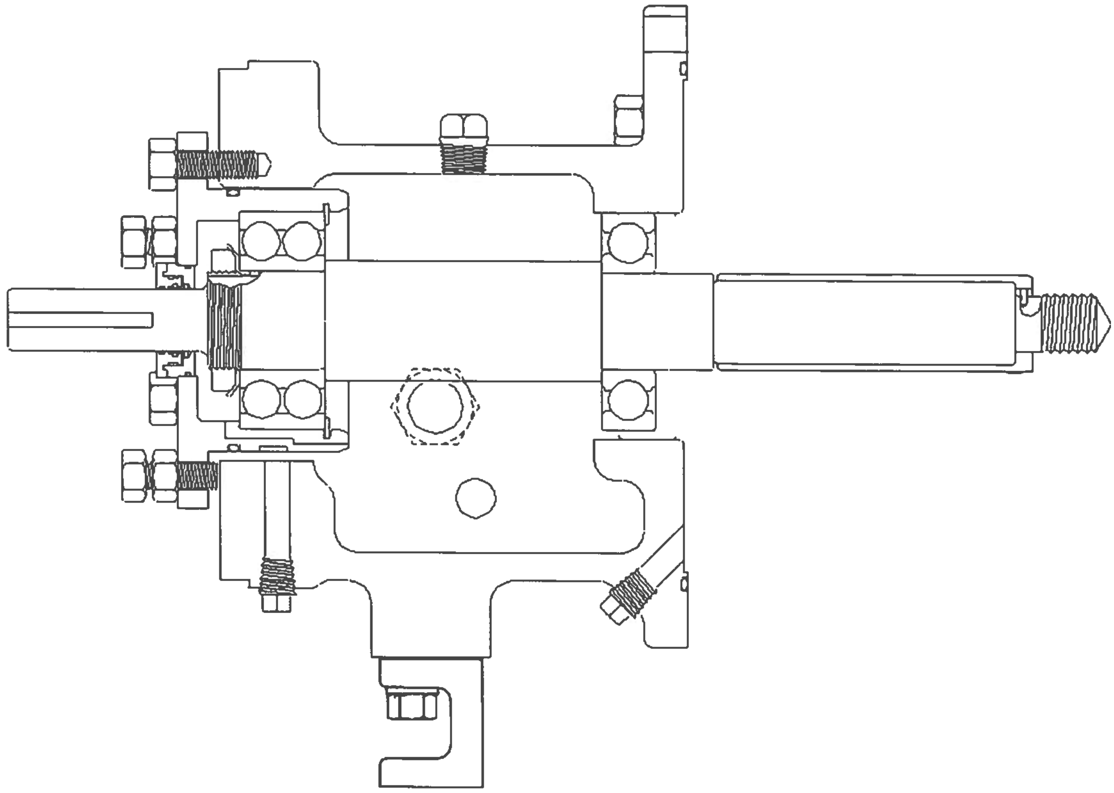


Figure 1.1.6.5.1.2 — Power end (or frame assembly)

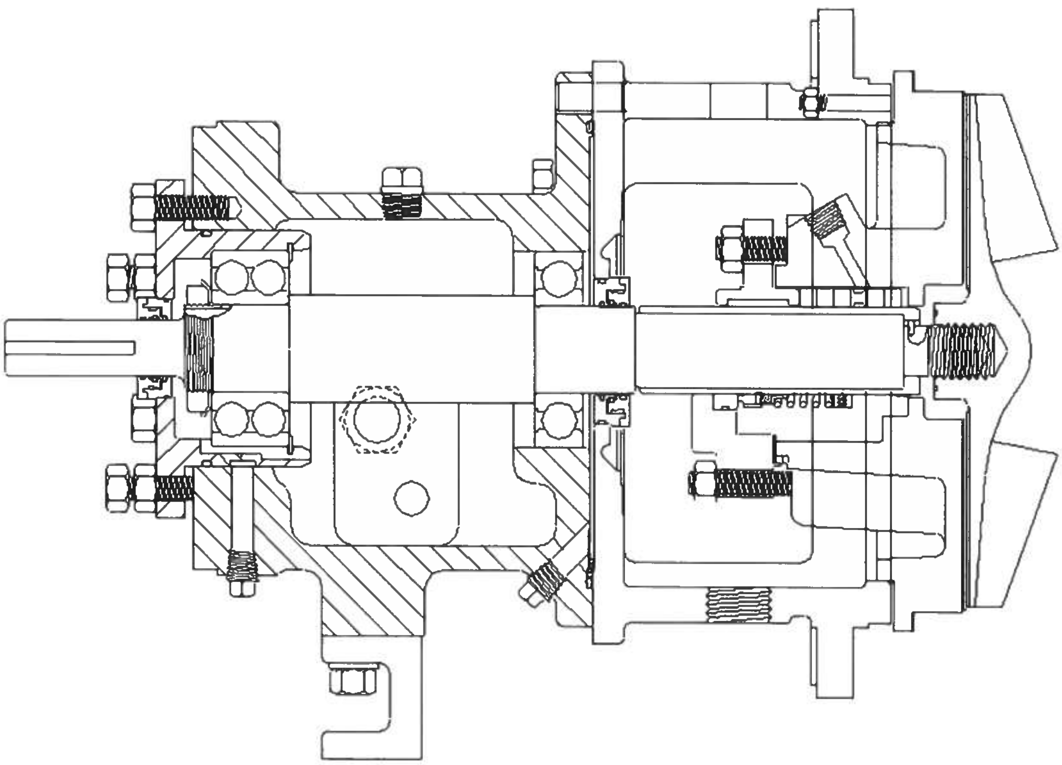


Figure 1.1.6.5.1.3 — Back pull-out assembly

It shall not include such items as mechanical seal(s), gland(s), lantern ring(s), packing, water shield(s), oil thrower(s) or oil ring(s), bearings, bearing appurtenances, coupling, pulley, or sheave.

1.1.6.5.1.5 Rotating assembly

A rotating assembly shall consist of a bare rotor plus casing wearing rings (where used), casing bushings (where used), bearings, and all other stationary or rotating parts required to be assembled over the shaft.

A rotating assembly shall include the following (where used):

- Packing and gland(s)
- Mechanical seal(s) and gland(s)
- Water shield(s)
- Oil thrower(s)
- Oil ring(s)
- Bearing housing cover(s)

It shall not include coupling, pulley, or sheave, nor shall it include bearing housings except when these are of a design that requires that they be assembled prior to mounting of the bearings.

1.1.6.6 Position of casing

The normal position of the discharge nozzle of an end suction horizontal pump shall be top vertical. Optional positions of the discharge nozzle shall be designated by degrees of rotation, measured from the vertical centerline in the clockwise (CW) [c] direction, facing the drive end of the pump (see Figure 1.1.6.6).

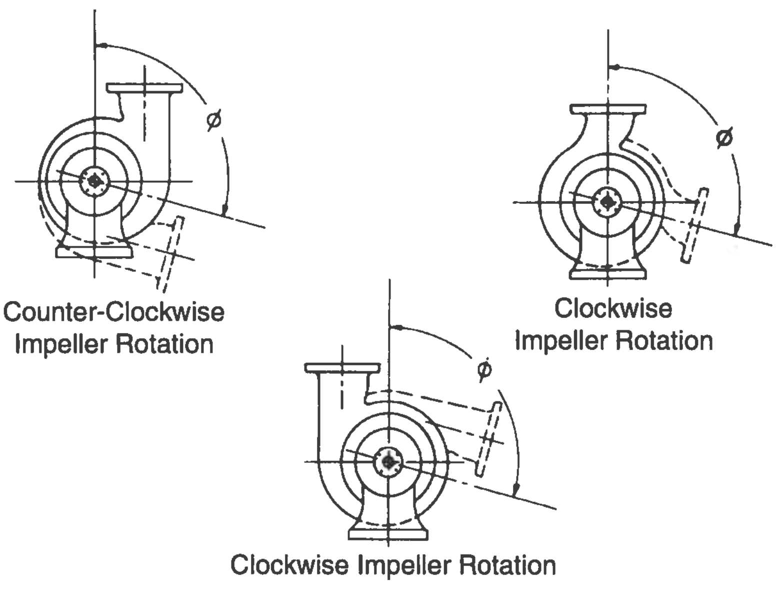


Figure 1.1.6.6 — Position of casing and shaft rotation

1.1.6.7 Rotation of shaft

Pumps are designated as having clockwise (CW) [c] or counterclockwise (CCW) [cc] rotation when facing the drive end of the pump (see Figures 1.1.6.6, 1.1.6.7a, and 1.1.6.7b).

To determine the rotation of a horizontal pump, stand at the driver end facing the pump (Figure 1.1.6.7a). If the top of the shaft revolves from the left to the right, the rotation is clockwise (CW) [c], and if the top of the shaft revolves from right to left, the rotation is counterclockwise (CCW) [cc].

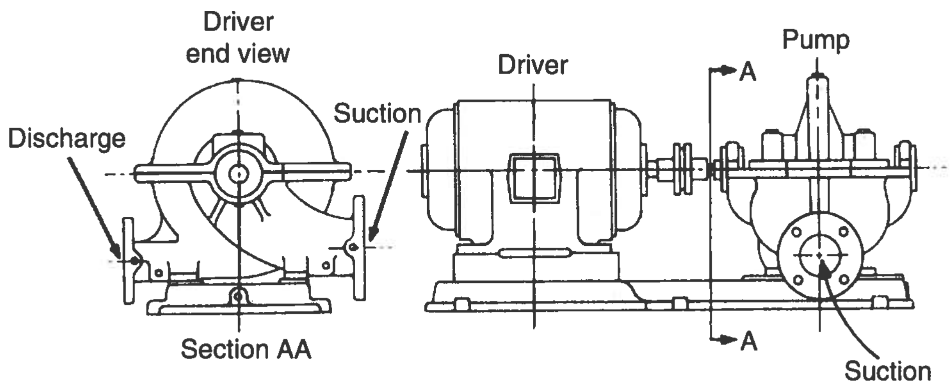


Figure 1.1.6.7a — Horizontal pump – shaft rotation (CW rotation)

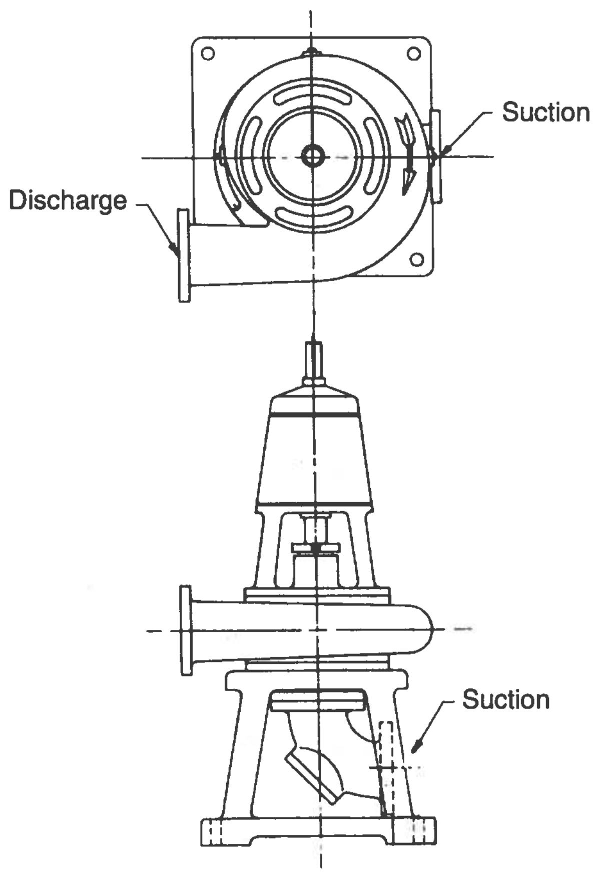


Figure 1.1.6.7b — Vertical pump – shaft rotation (CW rotation)

1.1.6.8 Special case ASME/ANSI B73.1, C-frame adapter

The C-frame adapter is cast or fabricated with rabbet fits on either end. One end is mounted to the rabbet of a C-frame NEMA motor, the other end is mounted to a rabbet fit on the bearing frame of the pump. The rabbet fits preclude the need for realignment of the coupling following normal maintenance on the wet end of the pump. Installation requires control of manufacturing tolerances, proper coupling selection, and in some cases, initial motor alignment. Motor weight may also be limited due to the cantilevered construction.

Tolerances cannot always be controlled to ensure that shaft alignment will meet requirements with all pump components, therefore, special components, such as adjustment features and/or soft couplings, must be used to ensure satisfactory operation. Larger motors may also be supported from the baseplate. They should not, however, be bolted down to the baseplate unless normally used casing bolts are eliminated as this could induce additional misalignment. Designs differ between manufacturers, so manufacturers' instructions for installation and operation must be followed to get satisfactory operation and life. Figure 1.1.6.8 depicts a typical configuration of the C-frame adapter to an overhung pump.

1.1.7 Centrifugal pumps nomenclature

The following nomenclature and definitions provide a means for identifying the various pump components covered by the Hydraulic Institute Standards and to serve as a common language between the purchaser, the manufacturer, and those writing specifications for pumps and pumping equipment.

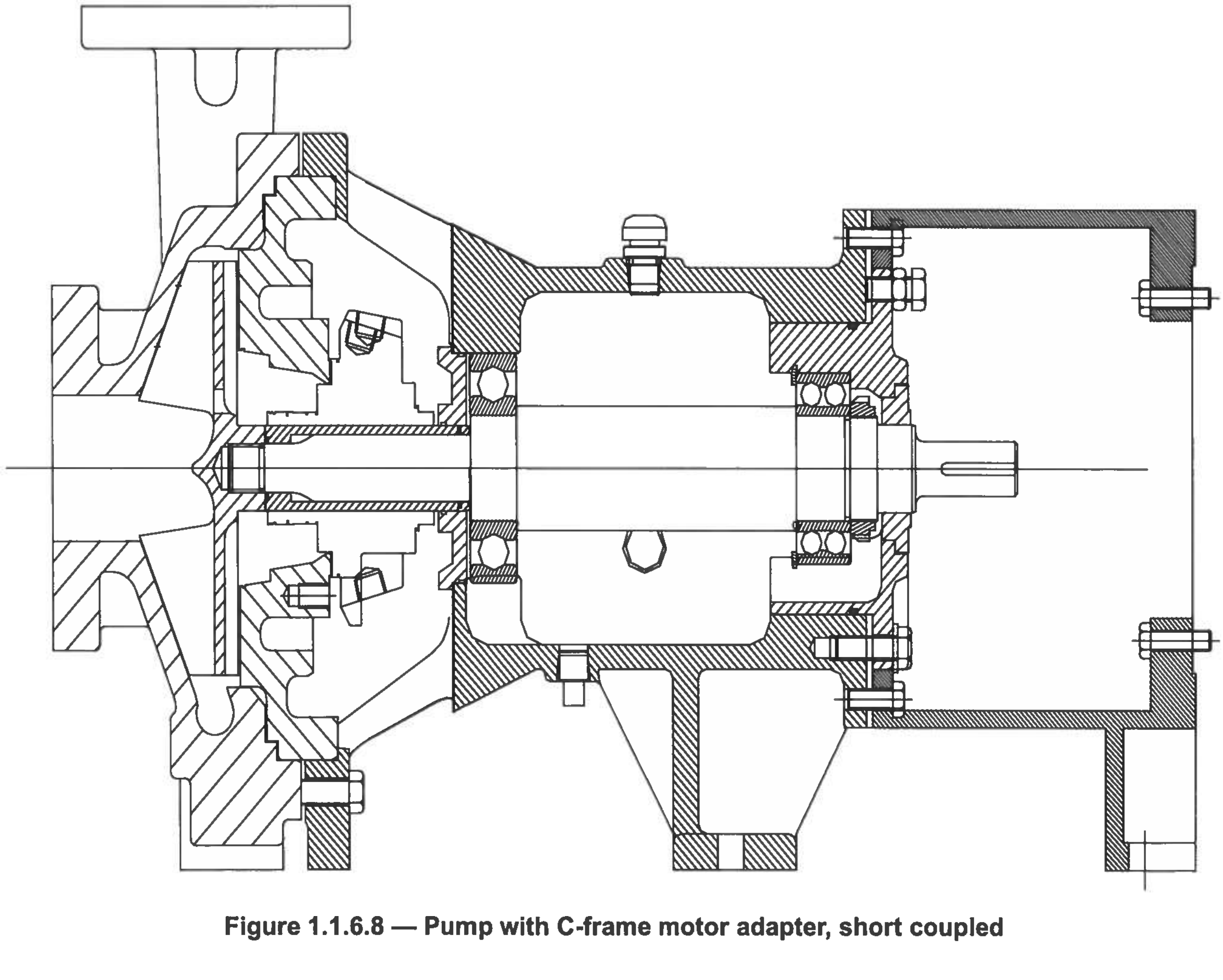


Figure 1.1.6.8 — Pump with C-frame motor adapter, short coupled

1.1.7.1 Definitions — part names

Table 1.1.7.1a is arranged in four columns as follows: part names in alphabetical order, item numbers used to identify part names on sectional drawings, abbreviations, and definitions of pump part names.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing

Part name	Item No.	Abbreviation	Definition
Adapter	71	Adpt	A machined piece used to permit assembly of two other parts or for a spacer.
Assembly, motor rotor core	222	Assy rtr core	The rotating assembly of an electrical machine containing laminations and conductors, which, when interacting with stator core assembly, produces torque.
Assembly, motor stator core	223	Assy sttr core	The fixed assembly of an electrical machine containing laminations and windings that creates magnetic fields.
Base	53	Base	A structure to support a pump.
Baseplate	23	Base pl	A member on which the pump and its driver are mounted.
Bearing, inboard	16	Brg inbd	The bearing nearest the coupling of a between-bearing pump but farthest from the coupling of an end suction pump.
Bearing, outboard	18	Brg outbd	The bearing most distant from the coupling of a between-bearing pump but nearest to the coupling of an end suction pump.
Bell, end	271	Bell end	The end bell performs two functions. First, it acts as a cover for the rotating assembly. Second, it provides a support for the manifold.
Bracket, bearing	125	Bkt brg	Detachable bracket that contains a bearing.
Bushing, bearing	39	Bush brg	The removable portion of a sleeve bearing in contact with the journal.
Bushing, interstage diaphragm	113	Bush instg diaph	A tubular-shaped replaceable piece mounted in the interstage diaphragm.
Bushing, pressure reducing	117	Bush press red	A replaceable piece used to reduce the liquid pressure at the stuffing box or seal chamber by throttling the flow.
Bushing, stuffing box	63	Bush stfg box	A replaceable sleeve or ring placed in the end of the stuffing box opposite the gland.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Bushing, throttle, auxiliary	171	Bush throt aux	A stationary ring or sleeve placed in the gland of a mechanical seal subassembly to restrict leakage in the event of seal failure.
Cap, bearing, inboard	41	Cap brg inbd	The removable upper portion of the inboard bearing housing.
Cap, bearing, outboard	43	Cap brg outbd	The removable upper portion of the outboard bearing housing.
Casing	1	Csg	The portion of the pump that includes the impeller chamber and volute or diffuser.
Casing, gland half	1C	Csg gld half	The gland (drive) half of a radially split casing.
Casing, lower half	1A	Csg lwr half	The lower or supporting half of the casing of an axially split pump.
Casing, suction half	1D	Csg suc half	The suction half of a radially split casing.
Casing, upper half	1B	Csg upr half	The upper or removable half of the casing of an axially split pump.
Collar, release	36	Clr rel	Split ring device to ease movement of screwed-on impellers.
Collar, shaft	68	Clr sft	A ring used on a shaft to establish a shoulder.
Collar, thrust	72	Clr thr	A circular collar mounted on a shaft to retain a split ring and transmit axial thrust.
Coupling half, driver	42	Cplg half drvr	The coupling half mounted on driver shaft.
Coupling half, pump	44	Cplg half pump	The coupling half mounted on pump shaft.
Coupling, oil pump	120	Cplg oil pump	A means of connecting the driver shaft to the oil pump shaft.
Coupling, shaft	70	Cplg sft	A mechanism used to transmit power from the drive shaft to the pump shaft, or to connect two shafts.
Cover, bearing end	123	Cov brg end	A plate closing the outboard bearing housing.
Cover, bearing, inboard	35	Cov brg inbd	An enclosing plate for either end of an inboard bearing of between-bearing or multistage pumps, or for the impeller end of the bearing of end suction pumps.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Cover, bearing, outboard	37	Cov brg outbd	An enclosing plate for either end of the outboard bearing of double suction or multistage pumps, or for the coupling end of the bearing of end suction pumps.
Cover, casing	239	Cov csg	A removable piece that provides access to the internal flow passages. This piece is bolted to the case to seal the access point.
Cover, motor end	207	Cov mot end	A removable piece that encloses the end(s) of a motor stator housing.
Cover, oil bearing cap	45	Cov oil brg cap	A lid or plate over an oil filler hole or inspection hole in a bearing cap.
Cover, rotor	272	Cov rot	The rotor cover bolts to the rotor and acts as an impeller to conduct the liquid into the rotor assembly. Together with the rotor, the rotor cover forms the rotor assembly. The purpose of the rotor assembly in a pitot tube pump is to increase the rotational velocity of the fluid and allow it to be conducted into the pitot tube opening.
Cover, stuffing box and seal chamber	11	Cov stfg box Cov seal cham	A removable piece, with stuffing box or seal chamber integral, used to enclose the outboard side of the impeller in the casing of end suction pumps.
Cover, suction	9	Cov suct	A removable piece, with which the inlet nozzle may be integral, used to enclose the suction side of the casing of an end suction pump.
Crossover, interstage	111	Xover instg	A specifically designed piece that carries the flow from one stage to another in a multistage pump.
Deflector	40	Defl	A flange or collar mounted on a shaft and rotating with it to prevent passage of liquid, grease, oil, or heat along the shaft.
Diaphragm, interstage	109	Diaph instg	A removable stationary partition between stages of a multistage pump.
Diffuser	5	Diff	A piece, adjacent to the impeller exit, which has multiple passages of increasing area for converting velocity to pressure.
Disc or drum, balancing	56	Disc/drum bal	The rotary member of a hydraulic balancing device.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Elbow, discharge	105	Ell disch	An elbow in an axial flow or mixed flow pump by which the liquid leaves the pump.
Elbow, suction	57	Ell suct	A curved water passage, usually 90 degrees, attached to the pump inlet.
Frame	19	Fr	A member of an end suction pump to which is assembled the liquid end and rotating element.
Gasket	73	Gskt	Resilient material used to seal joints between nonrotating parts to prevent leakage.
Gasket, impeller screw	28	Gskt imp scr	Resilient material used to seal joint between hub of impeller and the impeller screw.
Gasket, shaft sleeve	38	Gskt sft slv	Resilient material used to provide a seal between the shaft sleeve and the impeller.
Gauge, sight, oil	143	Ga sight oil	A device for the visual determination of the oil level.
Gland	17	Gld	A retainer that compresses packing in a stuffing box or retains the stationary element of a mechanical seal.
Gland, stuffing box, auxiliary	133	Gld stfg box aux	A follower provided for compression of packing in an auxiliary stuffing box.
Guard, coupling	131	Grd cplg	A protective shield over a shaft coupling.
Gearbox assembly	291	Gbx assy	A device to mechanically increase or decrease the driver speed via a specified gear ratio.
Handle	227	Hdl	A piece that can be used to hand-carry a pump.
Housing, bearing	99	Hsg brg	A body in which the bearing(s) is mounted.
Housing, bearing, inboard	31	Hsg brg inbd	*See* bearing (inboard) and bearing housing.
Housing, bearing, outboard	33	Hsg brg outbd	*See* bearing (outboard) and bearing housing.
Housing, manifold	273	Hsg man	A body containing the passageway for liquid into and out of the pump.
Housing, stator	201	Hsg sttr	A body in which a stator core assembly is mounted.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Impeller	2	Imp	The bladed member of a rotating assembly of the pump, which imparts the principal force to the liquid pumped.
Inducer	246	Ind	A single stage axial flow helix installed in the suction eye of an impeller to lower the NPSHR.
Journal, thrust bearing	74	Jnl thr brg	A removable cylindrical piece mounted on the shaft and which turns in the bushing. It may have an integral thrust collar.
Key, bearing journal	76	Key brg jnl	A parallel-sided piece used for preventing the bearing journal from rotating relative to the shaft.
Key, coupling	46	Key cplg	A parallel-sided piece used to prevent the shaft from turning in a coupling half.
Key, impeller (propeller)	32	Key imp	A parallel-sided piece used to prevent the impeller from rotating relative to the shaft.
Liner, casing	219	Lnr csg	A replaceable metal, rubber, or phenolic insert to protect the casing from abrasive wear or damage.
Liner, gland half	21D	Lnr, gld half	A part within the casing, gland half.
Liner, stuffing-box cover or seal chamber	21B	Lnr, stfg box cov Lnr, seal cham cov	A part within the stuffing-box or seal chamber cover.
Liner, suction cover	21A	Lnr, suct cov	A part within the suction cover.
Liner, suction half	21C	Lnr, suct half	A part within the casing, suction half.
Locknut, bearing	22	Lknut brg	A fastener that positions an anti-friction bearing on the shaft.
Locknut, coupling	50	Lknut cplg	A fastener holding a coupling half in position on a tapered shaft.
Lockwasher	69	Lkwash	A device to prevent loosening of a nut.
Nut, impeller	24	Nut imp	A threaded piece used to fasten the impeller on the shaft.
Nut, shaft adjusting	66	Nut sft adj	A threaded piece for altering the axial position of the rotating assembly.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Nut, shaft sleeve	20	Nut sft slv	A threaded piece used to locate the shaft sleeve on the shaft.
O-ring	119	O-ring	A radial or axial type seal.
Packing	13	Pkg	A lubricated material used to control leakage around the portion of the shaft located in the stuffing box.
Pedestal, driver	81	Ped drvr	A support for the driver of a vertical pump.
Pipe, column	101	Pipe col	A vertical pipe by which the pumping element is suspended.
Plate, side	61	Pl side	A replaceable piece in the casing or cover of an open impeller pump to maintain a close clearance along the impeller face.
Plate, stack	278	St pl	The stacking plate fixes the position of the bearings in the frame, thus locating the rotor in the correct relationship to the stationary parts.
Plate, wear	225	Wp pl	A replaceable, axial clearance part used to protect the casing, stuffing box, or suction cover from wear.
Pump, oil	121	Pump oil	A device for supplying lubricating oil under pressure.
Retainer, bearing	193	Ret brg	A device used to support the lineshaft bearing.
Retainer, grease	51	Ret grs	A contact seal or cover to retain grease.
Ring, balancing	115	Ring bal	The stationary member of a hydraulic balancing device.
Ring, casing	7	Ring csg	A stationary replaceable ring to protect the casing at the running fit with the impeller ring or the impeller.
Ring, impeller	8	Ring imp	A replaceable ring mounted on one or both sides of the impeller.
Ring, lantern	29	Ring ltrn	An annular piece used to establish a liquid seal around the shaft and to lubricate the stuffing-box packing.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Ring, oil	60	Ring oil	A rotating ring used to carry oil from the reservoir to the bearing.
Ring, stuffing-box cover	27	Ring stfg box cov	A stationary ring to protect the stuffing-box cover at the running fit with the impeller ring or impeller.
Ring, suction cover	25	Ring suct cov	A stationary ring to protect the suction cover at the running fit with the impeller ring or impeller.
Ring, thrust, split	86	Ring thr split	A split ring mounted on a shaft to absorb the unbalanced axial thrust of the impeller in the pump.
Rotor	276	Rot	The rotor is connected directly to the drive shaft of the pump. Together with the rotor cover, the rotor forms the rotor assembly. The purpose of the rotor assembly in a pitot tube pump is to increase the rotational velocity of the fluid and allow it to be conducted into the pitot tube opening.
Screw, impeller	26	Scr imp	A screw to fasten the impeller to the shaft.
Screw, impeller, adjusting	149	Scr imp adj	A special screw to adjust the axial movement of shaft/impeller to control clearance between the rotating impeller and the raceway.
Seal, bearing cover, inboard	47	Seal brg cov inbd	A contact seal for the bearing cover (inboard).
Seal, bearing cover, outboard	49	Seal brg cov outbd	A contact seal for the bearing cover (outboard).
Seal, bearing housing	169	Seal brg hsg	A contact seal for a bearing housing.
Seal, mechanical	89	Seal mech	A device that prevents the leakage of fluids along rotating shafts.
Seal, mechanical, rotating element	80	Seal mech rot elem	A device flexibly mounted on a shaft in or on the stuffing box and having a smooth, flat seal face held against the stationary sealing face.
Seal, mechanical, stationary element	65	Seal mech sta elem	A subassembly consisting of one or more parts mounted in or on a stuffing box and having a smooth flat sealing face.
Shaft	6	Sft	The cylindrical member on which the impeller is mounted and through which power is transmitted to the impeller.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Shaft, head	10	Sft hd	The upper cylindrical member in a vertical pump, which transmits power from the driver to the drive shaft.
Shell, lower half, bearing inboard	135	Shl lwr half brg inbd	A semi-cylindrical piece supporting the bearing bushing located in the lower half of the inboard bearing housing.
Shell, lower half, bearing outboard	139	Shl lwr half brg outbd	A piece supporting the bearing bushing located in the lower half of the outboard housing.
Shell, upper half, bearing inboard	137	Shl upr half brg inbd	A piece supporting the bearing bushing located in the upper half of the inboard bearing housing.
Shell, upper half, bearing outboard	141	Shl upr half brg outbd	A piece supporting the bearing bushing located in the upper half of the outboard bearing housing.
Shim	67	Shim	A piece of material placed between two members to adjust their position or fill in a gap.
Sleeve, impeller hub	34	Slv imp hub	A replaceable, cylindrical wearing part mounted on the extended pump impeller hub.
Sleeve, interstage	58	Slv instg	A cylindrical piece mounted on the pump shaft between impellers.
Sleeve, shaft	14	Slv sft	A cylindrical piece fitted over the shaft to protect the shaft through the stuffing box or seal chamber, and which may also serve to locate the impeller axially on the shaft.
Spacer, bearing	78	Spcr brg	A cylindrical piece that fits over the shaft to space or locate rolling element bearings.
Spacer, coupling	88	Spcr cplg	A cylindrical piece used to provide axial space for the removal of the rotating assembly without removing the driver.
Strainer	209	Str	A device used to prevent large objects from entering the pump.
Stuffing box	83	Stfg box	A portion of the casing or casing cover, through which packing and a gland or a mechanical seal is placed to prevent leakage.
Stuffing box, auxiliary	75	Stfg box aux	A recessed portion of the gland and cover of a mechanical seal subassembly designed to accommodate one or more rings of packing.

Table 1.1.7.1a — Centrifugal pump nomenclature – alphabetical listing (*continued*)

Part name	Item No.	Abbreviation	Definition
Thrower (oil or grease)	62	Thwr (oil or grs)	A disc rotating with the pump shaft to distribute the lubricant from the reservoir to the bearing (also known as a *slinger*).
Tube, pitot	279	Pitot	The pitot tube extends from the manifold into the rotor assembly. The entrance to the pitot tube is located near the periphery of the rotor assembly. In operation, the pitot tube converts the velocity head within the rotor assembly to pressure, thus serving the same function as a volute or diffuser in a conventional centrifugal pump.

Table 1.1.7.1b is arranged by item number and part name.

All parts having even item numbers constitute a part of the rotating element.

The cross-sectional drawings in Figures 1.1.5a through 1.1.5bb illustrate the largest possible number of parts in their proper relationship. They also show a few typical construction modifications but do not represent recommended design.

Numbers shown are for convenient cross-reference between tabulated names of parts and cross-sectional drawings. These numbers do not necessarily represent standard part numbers in use by any manufacturer.

Table 1.1.7.1b — Centrifugal pump nomenclature – numerical listing

Item no.	Part name
1	Casing
1A	Casing, lower half
1B	Casing, upper half
1C	Casing, gland (drive) half
1D	Casing, suction half
2	Impeller (propeller)
5	Diffuser
6	Shaft
7	Ring, casing
8	Ring, impeller
9	Cover, suction

Table 1.1.7.1b — Centrifugal pump nomenclature – numerical listing (*continued*)

Item no.	Part name
10	Shaft, head
11	Cover, stuffing box or seal chamber
13	Packing
14	Sleeve, shaft
16	Bearing, inboard
17	Gland
18	Bearing, outboard
19	Frame
20	Nut, shaft sleeve
21A	Liner, suction cover
21B	Liner, stuffing-box cover

Table 1.1.7.1b — Centrifugal pump nomenclature – numerical listing (*continued*)

Item no.	Part name
21C	Liner, suction half
21D	Liner, gland half
22	Locknut, bearing
23	Baseplate
24	Nut, impeller
25	Ring, suction cover
26	Screw, impeller
27	Ring, stuffing-box cover
28	Gasket, impeller screw
29	Ring, lantern
31	Housing, bearing, inboard
32	Key, impeller
33	Housing, bearing, outboard
34	Sleeve, impeller hub
35	Cover, bearing, inboard
36	Collar, release
37	Cover, bearing, outboard
38	Gasket, shaft sleeve
39	Bushing, bearing
40	Deflector
41	Cap, bearing, inboard
42	Coupling half, driver
43	Cap, bearing, outboard
44	Coupling half, pump
45	Cover, oil bearing cap

Table 1.1.7.1b — Centrifugal pump nomenclature – numerical listing (*continued*)

Item no.	Part name
46	Key, coupling
47	Seal, bearing cover, inboard
49	Seal, bearing cover, outboard
50	Locknut, coupling
51	Retainer, grease
53	Base
56	Disc or drum, balancing
57	Elbow, suction
58	Sleeve, interstage
60	Ring, oil
61	Plate, side
62	Thrower or slinger (oil or grease)
63	Bushing, stuffing box
65	Seal, mechanical, stationary element
66	Nut, shaft adjusting
67	Shim
68	Collar, shaft
69	Lockwasher
70	Coupling, shaft
71	Adapter
72	Collar, thrust
73	Gasket
74	Journal, thrust bearing
75	Stuffing box, auxiliary
76	Key, bearing journal

Table 1.1.7.1b — Centrifugal pump nomenclature – numerical listing (*continued*)

Item no.	Part name
78	Spacer, bearing
80	Seal, mechanical, rotating element
81	Pedestal, driver
83	Stuffing box
86	Ring, thrust, split
88	Spacer, coupling
89	Seal
99	Housing, bearing
101	Pipe, column
105	Elbow, discharge
109	Diaphragm, interstage
111	Crossover, interstage
113	Bushing, interstage diaphragm
115	Ring, balancing
117	Bushing, pressure reducing
119	O-ring
120	Coupling, oil pump
121	Pump, oil
123	Cover, bearing end
125	Bracket, bearing
131	Guard, coupling
133	Gland, stuffing-box, auxiliary
135	Shell, lower half, bearing inboard
137	Shell, upper half, bearing inboard
139	Shell, lower half, bearing outboard

Table 1.1.7.1b — Centrifugal pump nomenclature – numerical listing (*continued*)

Item no.	Part name
141	Shell, upper half, bearing outboard
143	Gauge, sight, oil
149	Screw, impeller, adjusting
169	Seal bearing housing
171	Bushing, throttle, auxiliary
193	Retainer, bearing
201	Housing, stator
207	Cover, motor end
209	Strainer
219	Liner, casing
222	Assembly, motor rotor core
223	Assembly, motor stator core
225	Plate, wear
227	Handle
239	Cover casing
246	Inducer
271	Bell, end
272	Cover, rotor
273	Housing, manifold
276	Rotor
278	Plate, stack
279	Tube, pitot
291	Gearbox assembly

1.1.7.2 Letter designations

The letter designations used on the following drawings were prepared to provide a common means for identifying various pump dimensions and to serve as a common language that will be mutually understandable to the purchaser, manufacturer, and anyone writing specifications for pumps and pumping equipment.

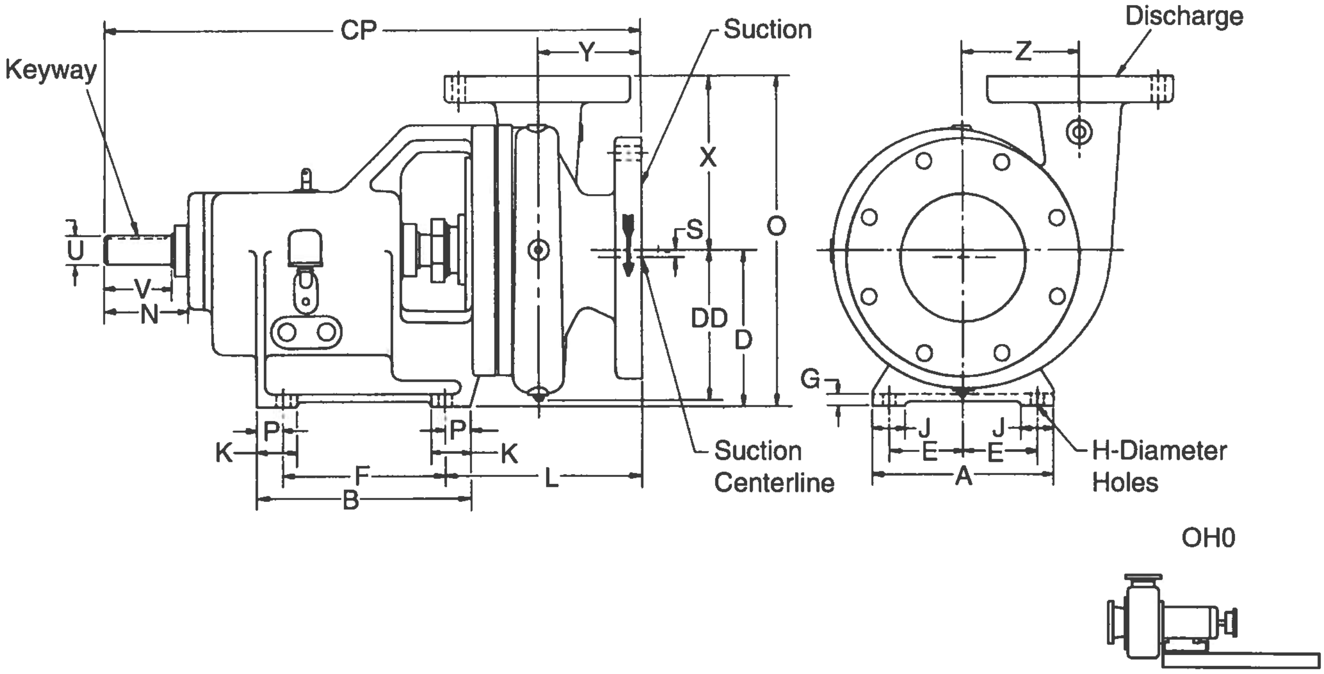


Figure 1.1.7.2a — Overhung impeller – flexibly coupled – single stage – frame mounted

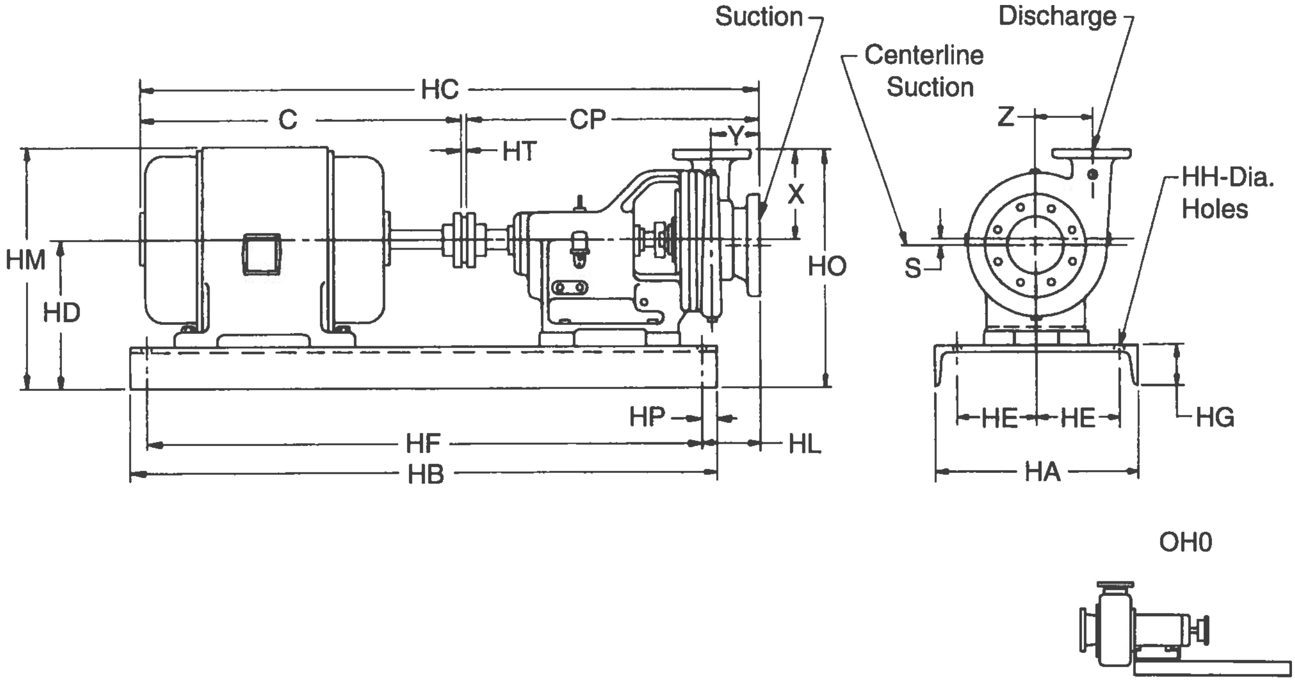
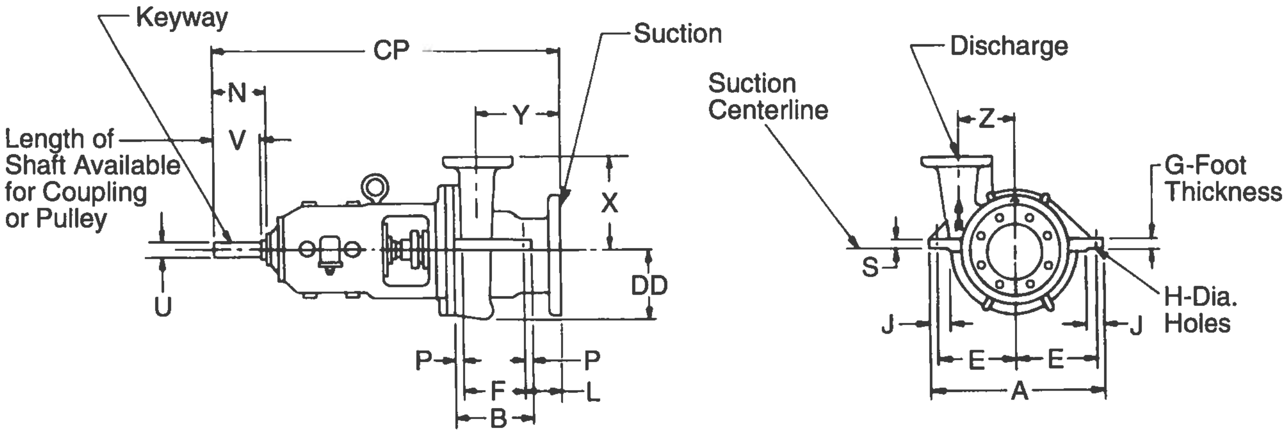


Figure 1.1.7.2b — Overhung impeller – flexibly coupled – single stage – frame mounted – pump on baseplate



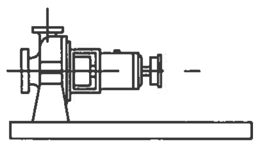
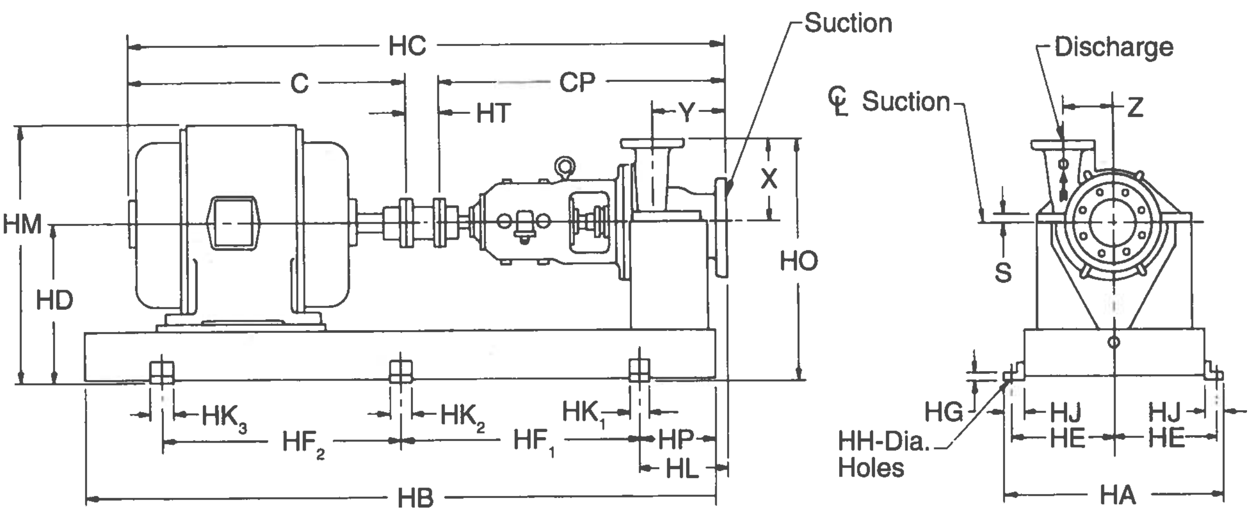


Figure 1.1.7.2c — Overhung impeller – flexibly coupled – single stage – centerline mounted



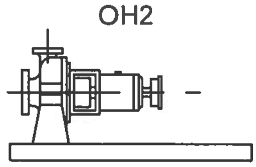


Figure 1.1.7.2d — Overhung impeller – flexibly coupled – single stage – centerline mounted – pump on baseplate

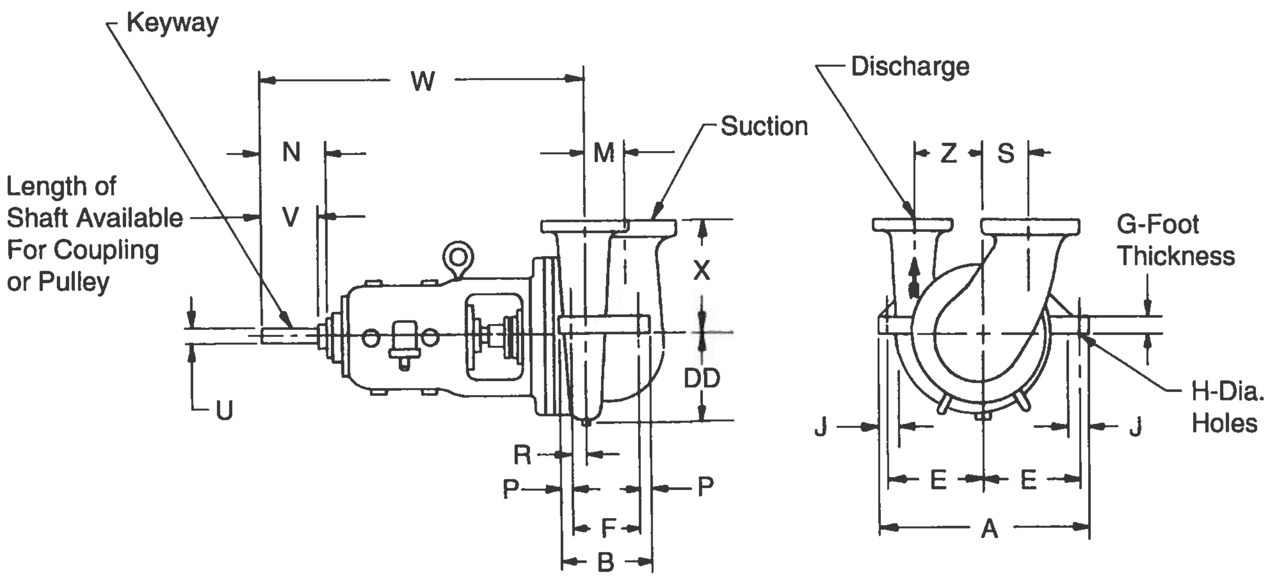


Figure 1.1.7.2e — Overhung impeller – flexibly coupled – single stage – centerline mounted (top suction)

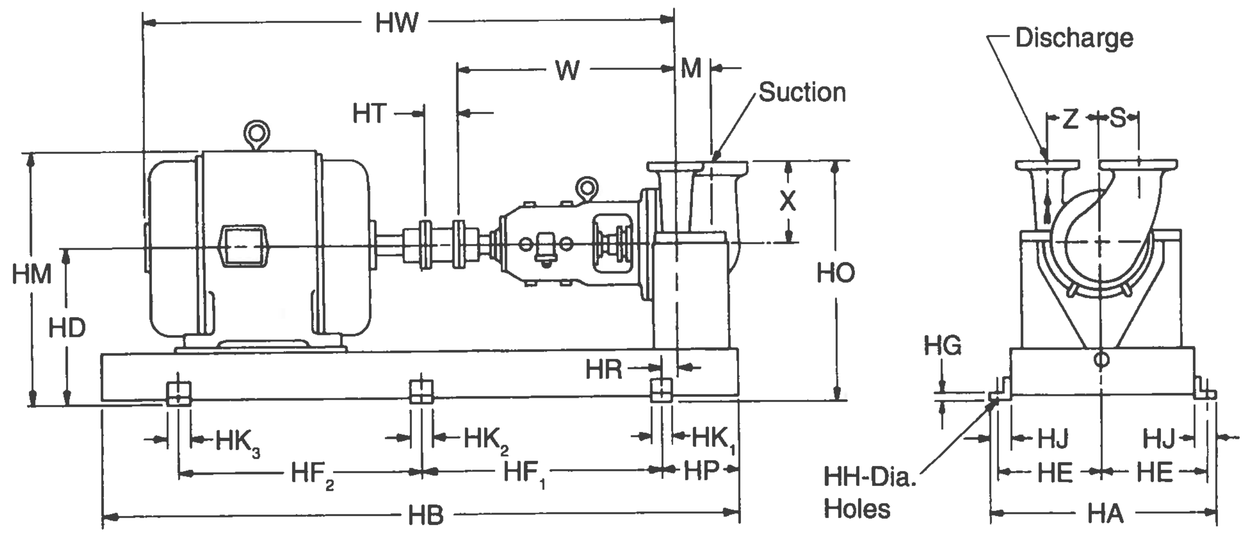


Figure 1.1.7.2f — Overhung impeller – flexibly coupled – single stage – centerline mounted – pump on baseplate (top suction)

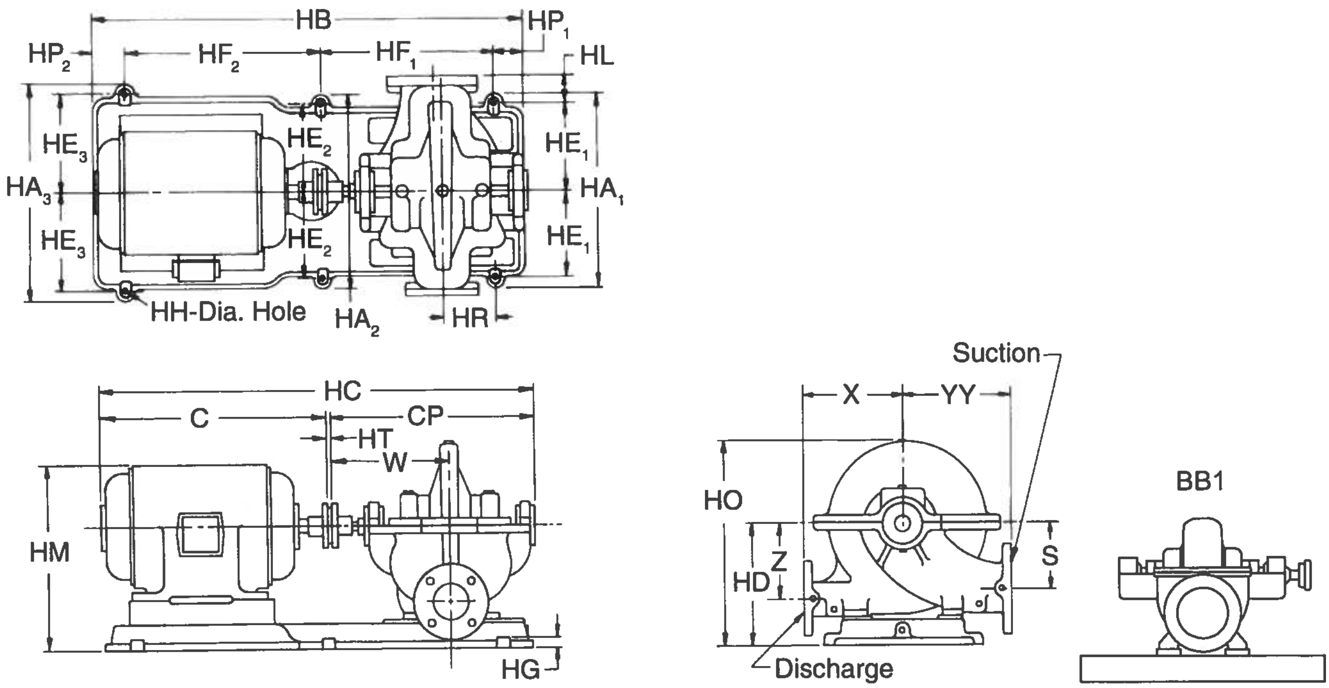


Figure 1.1.7.2g — Impeller between bearings – flexibly coupled – single stage – axial (horizontal) split case – pump on baseplate

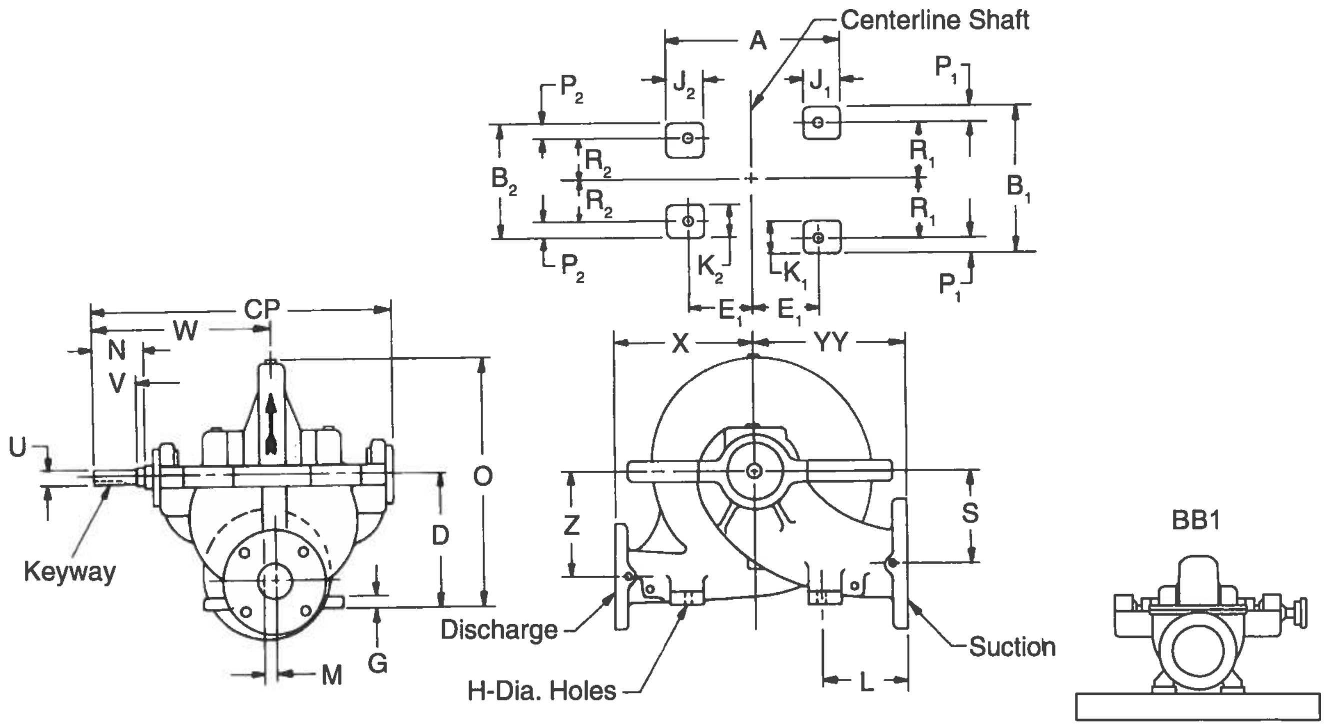


Figure 1.1.7.2h — Impeller between bearings – flexibly coupled – single stage – axial (horizontal) split case

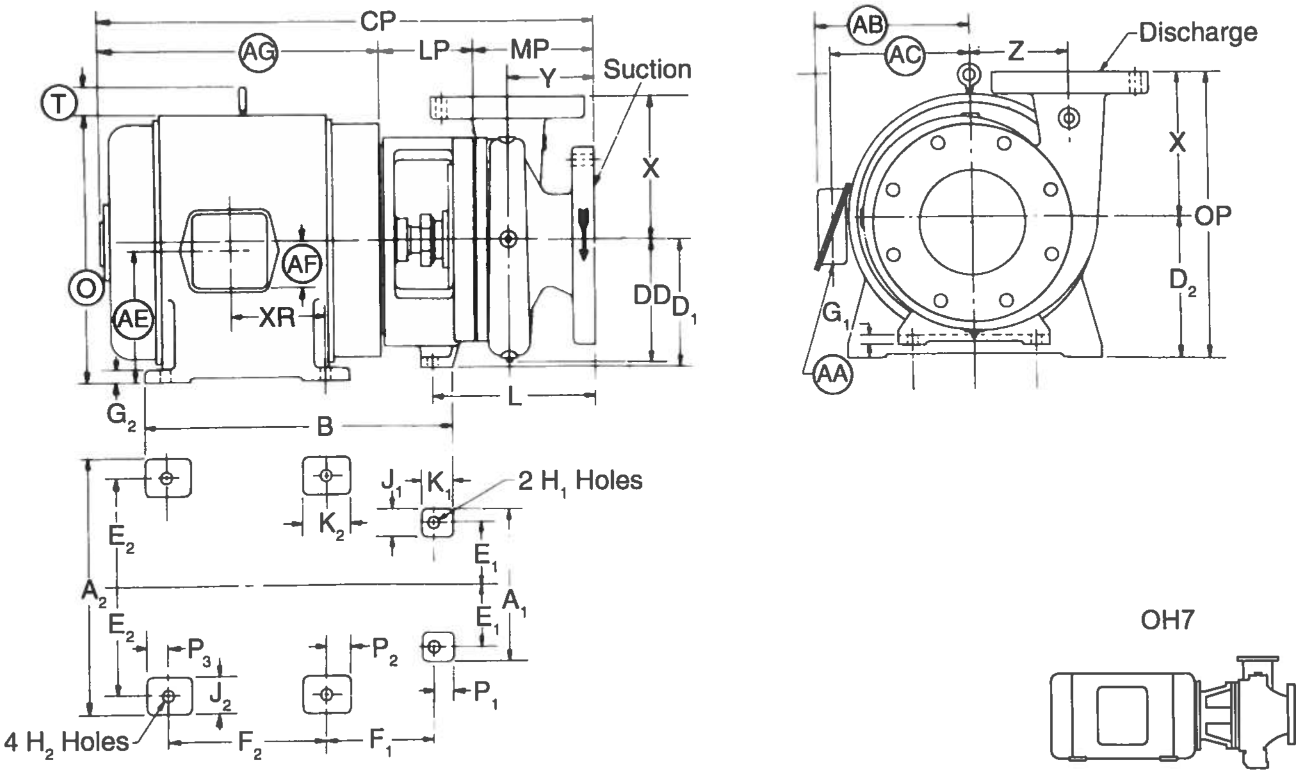


Figure 1.1.7.2i — Overhung impeller – close coupled – single stage – end suction

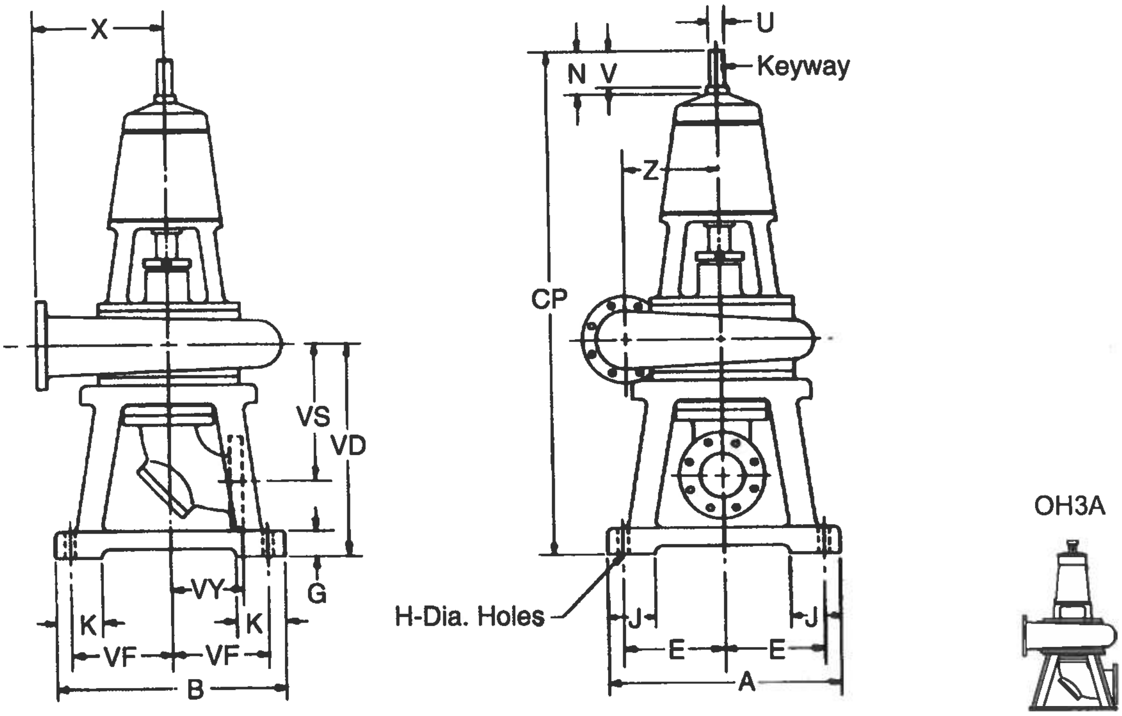


Figure 1.1.7.2j — Overhung impeller – separately coupled – single stage – frame mounted (vertically mounted)

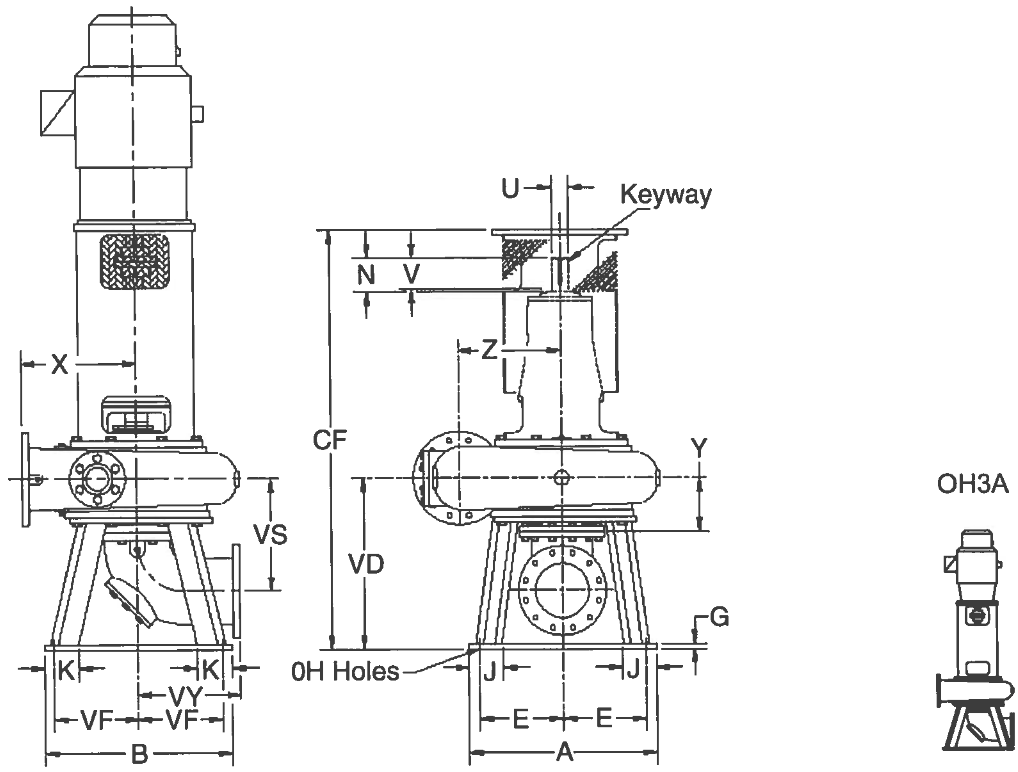


Figure 1.1.7.2k — Overhung impeller – integral bearing frame – single stage – vertical end suction with flexible coupling

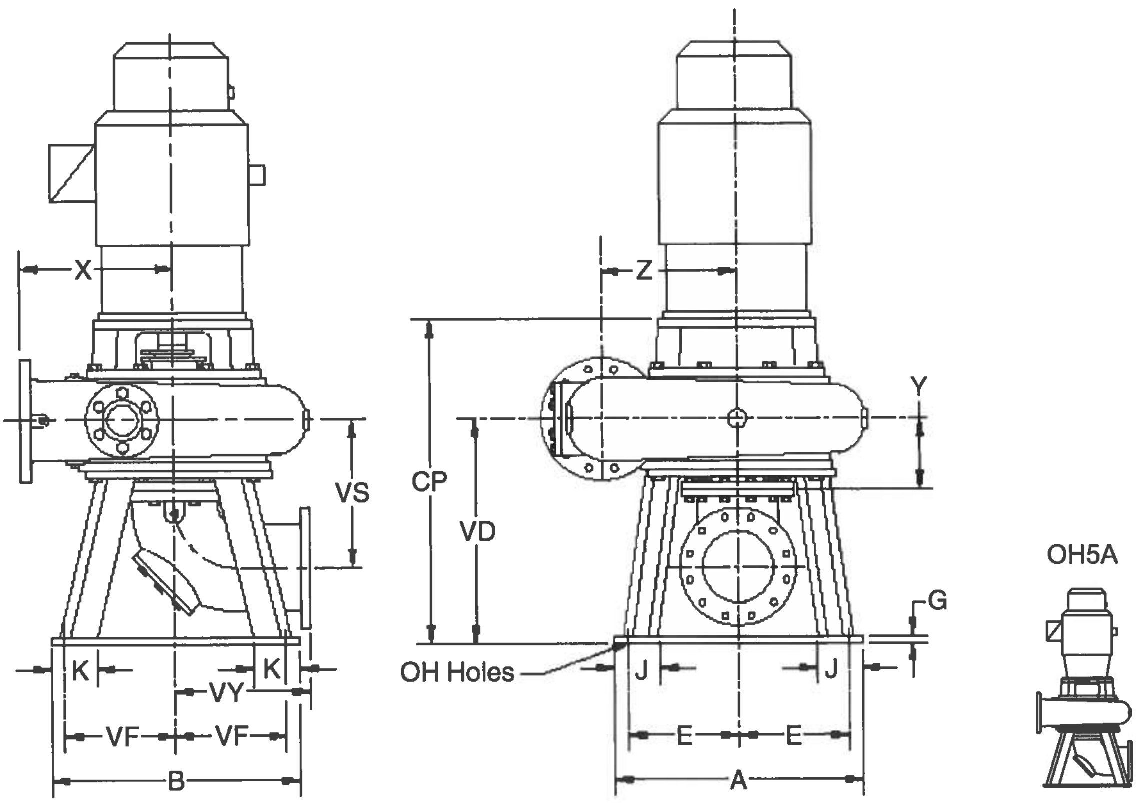


Figure 1.1.7.2l — Overhung impeller close coupled – single stage – vertical end suction

1.2 Definitions

The purpose of this section is to define terms used in pump applications. Symbols, terms, and units are shown in Table 1.2a, and subscripts in Table 1.2b.

Table 1.2a — Principal symbols

Symbol	Term	Metric unit	Abbr.	US customary unit	Abbr.	Conversion factor[a]
A	Area	square millimeter	mm^2	square inch	in^2	645.2
Bar	Pressure	bar	bar	pound/square inch	psi	0.0689
BEP	Best efficiency point	cubic meter/ hour	m^3/h	US gallon/ minute	gpm	0.2271
D	Diameter	millimeter	mm	inch	in	25.4
δ (delta)	Deflection	millimeter	mm	inch	in	25.4
Δ (delta)	Difference	dimensionless[b]	—	dimensionless[b]	—	—
η (eta)	Efficiency	percent	%	percent	%	1
F	Force	newton	N	pound (force)	lbf	4.448
g	Gravitational acceleration	meter/second squared	m/s^2	foot/second squared	ft/s^2	0.3048
h	Head	meter	m	foot	ft	0.3048
H	Total head	meter	m	foot	ft	0.3048
l	Static lift	meter	m	foot	ft	0.3048
n	Speed	revolution/ minute	rpm	revolution/ minute	rpm	1
NPSHA	Net positive suction head available	meter	m	foot	ft	0.3048
NPSHR	Net positive suction head required	meter	m	foot	ft	0.3048
NPSH3	Net positive suction head required for 3% head reduction at first stage	meter	m	foot	ft	0.3048

Table 1.2a — Principal symbols (*continued*)

Symbol	Term	Metric unit	Abbr.	US customary unit	Abbr.	Conversion factor[a]
n_s (N_S)	Specific speed $n_s = nQ^{0.5}/H^{0.75}$	Index number	—	Index number	—	0.0194
ν (nu)	Kinematic viscosity	millimeter squared/ second	mm^2/s	foot squared/ second	ft^2/s	92,900
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/ second	m^3/s	US gallon/ minute	gpm	0.0000631
Q	Rate of flow (capacity)	cubic meter/ hour	m^3/h	US gallon/ minute	gpm	0.2271
ρ (rho)	Density	kilogram/ cubic meter	kg/m^3	pound mass/ cubic foot	lbm/ft^3	16.02
S (N_{SS})	Suction specific speed = $nQ^{0.5}/NPSH3^{0.75}$	Index number	—	Index number	—	0.194
s	Specific gravity	dimensionless	—	dimensionless	—	1
t	Temperature	degree Celsius	°C	degree Fahrenheit	°F	(°F–32) × $^5/_9$
τ (tau)	Torque	newton-meter	N•m	pound-foot	lb-ft	1.356
U	Residual unbalance	gram-millimeter	g•mm	ounce-inch	oz-in	720
v	Velocity	meter/second	m/s	foot/second	ft/s	0.3048
Z	Elevation gauge distance above or below datum	meter	m	foot	ft	0.3048

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

[b] Δ is a dimensionless symbol used to indicate a difference. This term takes on the units of the measured or calculated quantity associated with the difference.

Table 1.2b — Subscripts

Subscript	Term	Subscript	Term	Subscript	Term
1	Test condition or model	f	Friction	R	Radial
2	Specific condition or prototype	g	Gauge	s	Suction
a	Absolute	max	Maximum	t	Theoretical
A	Axial	min	Minimum	v	Velocity
Atm	Atmospheric	mot	Motor	vp	Vapor pressure
B	Barometric	N	Net	w	Water
C	Casing	ot	Operating temperature		
D	Discharge	OA	Overall unit		
Dvr	Driver input	p	Pump		

1.2.1 Rate of flow (Q) [Q]

The rate of flow of a pump is the total volume throughput per unit of time at suction conditions. It assumes no entrained gases at the stated operating conditions. The term *capacity* is also used.

1.2.1.1 BEP rate of flow [Q_{opt}]

BEP rate of flow is defined as the rate of flow, with any given pump impeller diameter, at which the pump efficiency is maximized.

1.2.1.2 Minimum continuous stable flow [$Q_{min\ all\ stable}$]

The minimum continuous stable flow is defined as the lowest rate of flow at which the pump operates without a significant compromise to its mechanical integrity, i.e., within acceptable vibration, noise, and reliability expectations.

1.2.1.3 Minimum continuous thermal flow [$Q_{min\ thermal}$]

Minimum continuous thermal flow is defined as the lowest rate of flow at which the pump operates without an adverse performance impact resulting from a temperature rise in the pumped liquid.

1.2.1.4 Maximum allowable flow [$Q_{max\ all}$]

Maximum allowable flow, as allowed by the pump manufacturer, is the greatest rate of flow at which the pump can be expected to operate continuously without risk of internal damage. This is also dependent on operating speed and specific pumped liquid.

1.2.2 Speed (n)

Speed is defined as the number of revolutions the shaft makes in a given unit of time. Speed is typically expressed as revolutions per minute.

1.2.2.1 Maximum allowable continuous speed [$n_{max\ all}$]

The maximum allowable continuous speed is defined as the highest pump speed at which the manufacturer permits continuous operation.

1.2.2.2 Minimum allowable continuous speed [$n_{min\ all}$]

The minimum allowable continuous speed is defined as the lowest pump speed at which the manufacturer permits continuous operation.

1.2.2.3 Rated speed [n_r]

The rated speed is defined as the pump operating speed directly associated with the contractual conditions of service.

1.2.3 Head (h) [H]

Head is the expression of the energy content of a liquid in reference to any arbitrary datum. It is expressed in units of energy per unit weight of liquid. The measuring unit for head is meters (feet) of liquid.

1.2.3.1 Gauge head (h_g) [H_{Mx}]

Gauge head is the energy of the liquid due to its pressure as determined by a pressure gauge or other pressure measuring device.

1.2.3.2 Velocity head (h_v)

Velocity head is the kinetic energy per unit mass of the liquid in movement divided by g. Velocity head is expressed by the following equation:

$$h_v = \frac{v^2}{2g}$$

Where:

v = fluid velocity (m/s [ft/s]) derived by dividing the rate of flow (m^3/h [gpm]) by the cross-sectional area (mm^2 [in^2]) at the point of the gauge connection:

$$\text{(Metric)}\quad v = \frac{278 \times Q}{A}$$

$$\text{(US customary units)}\quad v = \frac{0.321 \times Q}{A}$$

1.2.3.3 Elevation head (Z) [H_{stat}]

Elevation head is the potential energy of the liquid due to its elevation relative to a datum level measured to the center of the pressure gauge or liquid surface.

1.2.3.4 NPSH datum plane

In the first stage in the case of multistage pumps, the pump's datum is the horizontal plane through the center of the impeller described by the external points of the entrance edges of the impeller blade. In the case of double inlet pumps with vertical or inclined axis, it is the plane through the higher center. The manufacturer should indicate the position of the plane with respect to precise reference points on the pump (see Figure 1.2.3.4).

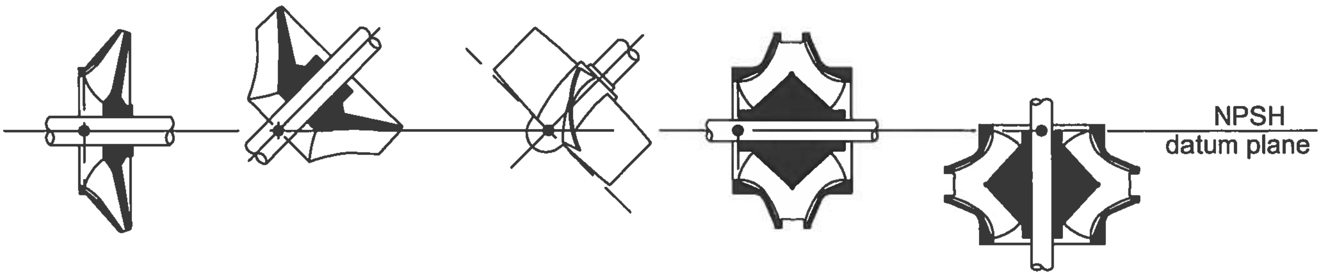


Figure 1.2.3.4 — Datum elevation for various pump designs at eye of first-stage impeller

1.2.3.5 Total suction head (h_s), open suction

For open suction (wet pit) installations, the first-stage impeller is submerged in a pit. The total suction head (h_s) at the datum is the submergence (Z_w). If the average velocity head of the flow in the pit is small enough to be neglected, then:

$$h_s = Z_w$$

Where:

Z_w = vertical distance in meters (feet) from free water surface to datum

1.2.3.6 Total suction head (h_s), closed suction test

For closed suction installations, the pump suction nozzle may be located either above or below grade level.

The total suction head (h_s), referring to the eye of the first-stage impeller, is the sum of the suction gauge head (h_{gs}) plus the velocity head (h_{vs}) at point of gauge attachment plus the elevation head (Z_s) from the suction gauge centerline (or manometer zero) to the pump datum:

$$h_s = h_{gs} + h_{vs} + Z_s$$

The suction head (h_s) is positive when the suction gauge reading is above atmospheric pressure and negative when the suction gauge reading is below atmospheric pressure and the sum of all three heads is less than 0.

1.2.3.7 Total discharge head (h_d)

The total discharge head (h_d) is the sum of the discharge gauge head (h_{gd}) plus the velocity head (h_{vd}) at point of gauge attachment plus the elevation head (Z_d) from the discharge gauge centerline to the pump datum:

$$h_d = h_{gd} + h_{vd} + Z_d$$

1.2.3.8 Total head (H) [H_{tx}]

This is the measure of energy increase, per unit weight of the liquid, imparted to the liquid by the pump, and is the difference between the total discharge head and the total suction head.

This is the head normally specified for pumping applications because the complete characteristics of a system determine the total head required.

1.2.3.9 Atmospheric head (h_{atm})

Atmospheric head is the amount of head at local atmospheric pressure expressed in meters (feet) of liquid.

1.2.3.10 Friction head (h_f)

Friction head is the hydraulic energy required to overcome frictional resistance of a piping system to liquid flow expressed in meters (feet) of liquid.

1.2.4 Condition points

1.2.4.1 Rated condition point [*r* or *d*]

Rated condition applies to the rate of flow, head, net positive suction head, and speed of the pump, as specified by the order.

1.2.4.2 Specified condition point

Specified condition point is synonymous with rated condition point.

1.2.4.3 Normal condition point [*n*]

Applies to the point on the performance curve at which the pump will normally operate. It may be the same as the rated condition point.

1.2.4.4 Best efficiency point (BEP) [Q_{opt}]

The best efficiency point (BEP) is the rate of flow and head at which the pump efficiency is a maximum at rated rpm.

1.2.4.5 Shutoff (*SO*)

The condition of zero flow when no liquid is flowing through the pump, but the pump is primed and running.

1.2.4.6 Allowable operating region

This is the flow range at the specified speeds with the impeller supplied as limited by cavitation, heating, vibration, noise, shaft deflection, fatigue, and other similar criteria. This range shall be specified by the manufacturer. See ANSI/HI 9.6.3 *Rotodynamic (Centrifugal and Vertical) Pumps for Allowable Operation Region* for additional details.

1.2.5 Suction conditions

1.2.5.1 Submerged suction

A submerged suction exists when the centerline of the pump inlet port is below the level of the liquid in the supply tank and the liquid is exposed to atmosphere. However, the absolute pressure of the liquid entering the centerline of the pump inlet port may still be below atmospheric pressure while the pump is operating, even with submerged suction.

1.2.5.1.1 Flooded suction

Flooded suction implies that the liquid will flow from a source to the pump with the average pressure at the intake port staying above atmospheric pressure when the pump is operating at a specified rate of flow.

1.2.5.2 Static suction lift (l_s)

Static suction lift is a hydraulic pressure below atmospheric at the intake port of the pump.

1.2.5.3 Net positive suction head available (NPSHA)

Net positive suction head available is the total suction head of liquid absolute, determined at the first-stage impeller datum minus the absolute vapor pressure of the liquid at a specific rate of flow:

$$\text{NPSHA} = h_{sa} - h_{vp}$$

Where:

h_{sa} = total suction head absolute = $h_{atm} + h_s$,

or $\text{NPSHA} = h_{atm} + h_s - h_{vp}$

NOTE: h_{atm} will vary with elevation and weather.

1.2.5.4 Net positive suction head required (NPSHR) [NPSH3]

NPSHR is the amount of suction head, over vapor pressure, required to operate the pump at a specific rate of flow. This value is normally recommended by the pump vendor.

NPSH3 is the net positive suction head that results in a 3% loss of head (first-stage head in a multistage pump) determined by the vendor by testing with water.

1.2.5.5 Maximum suction pressure ($p_{s\ max}$) [$p_{1\ max\ op}$ or $p_{1\ max\ all}$]

This is the highest suction pressure to which the pump will be subjected during operation.

1.2.6 Power

1.2.6.1 Electric motor input power (P_{mot}) [P_1]

The electrical input power to the motor.

$$P_{mot[\text{hp}]} = \frac{P_{mot[\text{kW}]}}{0.746}$$

1.2.6.2 Pump input power (P_p) [P]

The power delivered to the pump shaft at the driver to pump coupling. It is also called *brake horsepower* (bhp).

1.2.6.3 Pump output power (P_w) [P_u]

The power imparted to the liquid by the pump. It is also called *water horsepower*.

(Metric, kW) $P_w = \frac{Q \times H \times \rho \times g}{1000}$

Where: Q is in cubic meters per second, H is in meters, ρ (rho) is in kilograms per cubic meter, and g (the gravity constant) is in meters per second squared.

(US customary units, hp) $P_w = \frac{Q \times H \times s}{3960}$

Where: Q is in gallons per minute, H is in feet, and s is specific gravity (dimensionless).

1.2.6.4 Overall efficiency (η_{OA})

This is the ratio of the energy imparted to the liquid (P_w) by the pump to the electrical energy supplied to the motor (P_{mot}); that is, the ratio of the water horsepower to the power input to the primary driver, expressed in percent. This is sometimes referred to as the *wire-to-water* efficiency.

1.2.6.5 Pump efficiency (η_p)

This is the ratio of the energy imparted to the liquid by the pump (P_w) to the energy delivered to the pump shaft (P_p), expressed in percent.

1.2.7 Pump pressures

1.2.7.1 Working pressure (p_d) [$p_{2\ max\ op}$]

Working pressure is the sum of the maximum suction pressure and the maximum differential pressure, which is derived from the furnished impeller when operating at the rated speed and with the specified liquid density.

1.2.7.2 Maximum allowable working pressure [*MAWP*]

Maximum continuous pressure for which the manufacturer has designed the pump (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature. This pressure shall be equal to or greater than the maximum discharge pressure. In the case of some pumps (double suction, axial split case, can pumps, or multistage, for example), the maximum allowable casing working pressure on the suction side may be different from that on the discharge side.

1.2.7.3 Maximum suction pressure ($p_{s\ max}$) [$p_{1\ max\ op}$]

Maximum suction pressure is the highest suction pressure to which the pump will be subjected during operation.

1.2.7.4 Field-test pressure

Field-test pressure is the maximum hydrostatic test pressure to be used for leak-testing a closed pumping system in the field if the pumps are not isolated. Normally, this is taken as 125% of the maximum allowable working pressure. In cases where mechanical seals are used, this pressure may be limited by the pressure-containing capabilities of the seal.

See Section 1.2.7.2 Maximum allowable working pressure [*MAWP*]. Consideration of this may limit the field-test pressure of the pump to 125% of the maximum allowable casing working pressure on the suction side of double suction split case pumps and certain other pump types.

1.2.7.5 Rated discharge pressure

The pressure of a pump at its discharge flange with rated (guarantee) conditions including flow, speed, suction pressure, and liquid density.

1.2.8 Impeller balancing

1.2.8.1 Single-plane balancing (formerly called *static balancing*)

Single-plane balancing is the correction of residual unbalance to a specified maximum limit by removing or adding weight in one correction plane only. Can be accomplished statically using balance rails or by spinning.

1.2.8.2 Two-plane balancing (formerly called *dynamic balancing*)

Two-plane balancing is the correction of residual unbalance to a specified limit by removing or adding weight in two correction planes. This can be accomplished by spinning on appropriate balancing machines.

1.2.9 Rotodynamic pump icons

This section identifies icons used to represent the various product designs described in this standard. These designations support internationally recognized ISO 13709 and API 610 standards.

1.2.9.1 Overhung impeller types

1.2.9.1.1 Pump type OH00: Horizontal, flexibly coupled, axial flow, single stage, overhung design

The driver is mounted separately and flexibly coupled through a bearing bracket.

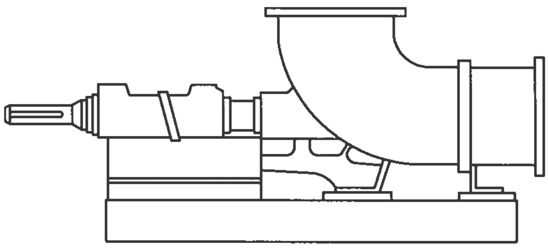


Figure 1.2.9.1.1 — Pump type OH00: Horizontal, flexibly coupled, axial flow, single stage, overhung design

1.2.9.1.2 Pump type OH0: Horizontal, frame mounted, flexibly coupled, single stage, overhung design

The driver is mounted on a baseplate and flexibly coupled through a bearing bracket.

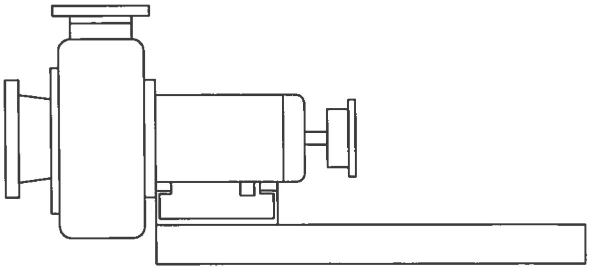


Figure 1.2.9.1.2 — Pump type OH0: Horizontal, frame mounted, flexibly coupled, single stage, overhung design

1.2.9.1.3 Pump type OH1: Horizontal, foot mounted, single stage, overhung design

The driver is mounted on a baseplate and flexibly coupled through a bearing bracket. This icon may represent both sealed and sealless configurations.

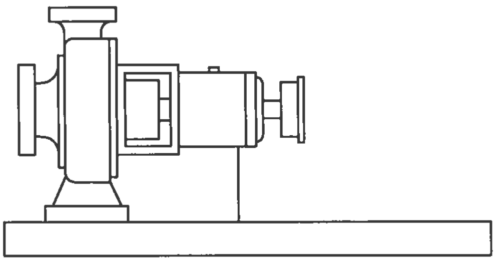


Figure 1.2.9.1.3 — Pump type OH1: Horizontal, foot mounted, single stage, overhung design

1.2.9.1.4 Pump type OH2: Horizontal, centerline mounted, single stage, overhung design

The driver is mounted on a baseplate and flexibly coupled through a bearing bracket.

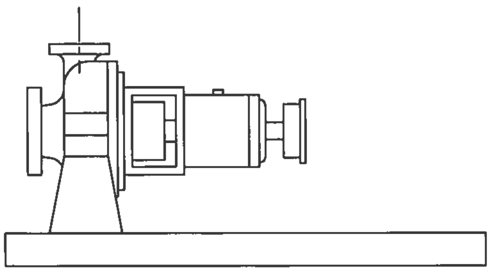


Figure 1.2.9.1.4 — Pump type OH2: Horizontal, centerline mounted, single stage, overhung design

1.2.9.1.5 Pump type OH3: Vertical, in-line mounted, single stage, with integral bearing bracket

The driver may be supported from the pump housing and is flexibly coupled to the impeller shaft.

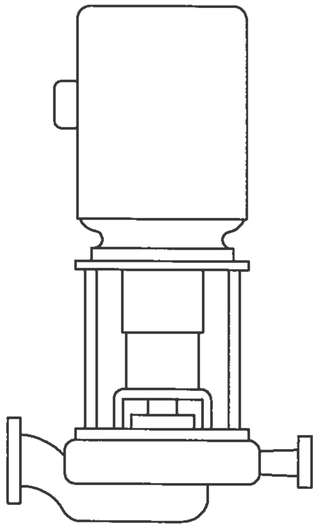


Figure 1.2.9.1.5 — Pump type OH3: Vertical, in-line mounted, single stage, with integral bearing bracket

1.2.9.1.6 Pump type OH4: Vertical, in-line mounted, single stage, rigidly coupled to the driver shaft

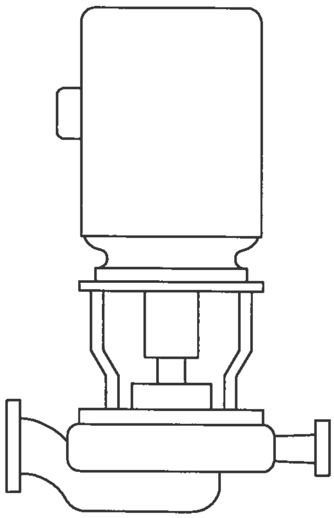


Figure 1.2.9.1.6 — Pump type OH4: Vertical, in-line mounted, single stage, rigidly coupled to the driver shaft

1.2.9.1.7 Pump type OH5: Vertical, in-line mounted, single stage, close coupled to the driver shaft

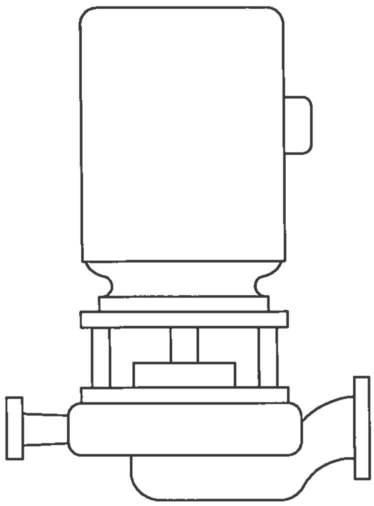


Figure 1.2.9.1.7 — Pump type OH5: Vertical, in-line mounted, single stage, close coupled to the driver shaft

1.2.9.1.8 Pump type OH6: High-speed, integral gear driven, single stage, overhung design

The speed-increasing gearbox is integral to the pump, and the impeller is mounted on the gearbox output shaft. The gearbox may be flexibly coupled or spline-shaft coupled to the driver. The pump may be configured vertically or horizontally.

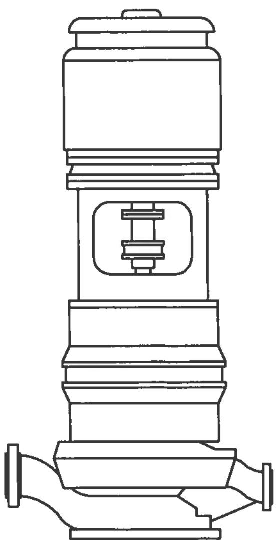


Figure 1.2.9.1.8 — Pump type OH6: High-speed, integral gear driven, single stage, overhung design

1.2.9.1.9 Pump types OH8A and OH8B

These pump classifications are submersible variations (diffuser and volute) of traditional, close-coupled, overhung designs. See ANSI/HI 1.3 *Rotodynamic (Centrifugal) Pumps for Design and Application* for further details.

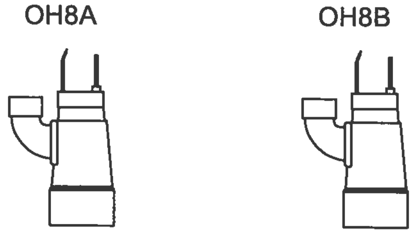


Figure 1.2.9.1.9 — Pump types OH8A and OH8B

1.2.9.1.10 Pump types OH9, OH10, OH11, and OH12

These pump classifications are sealless (flexibly coupled magnetic driven and close-coupled canned motor) variations of traditional sealed/packed, close-coupled, overhung designs. See ANSI/HI 5.1-5.6 *Sealless Centrifugal Pumps for Nomenclature, Definitions, Application, Operation and Test* for further details.

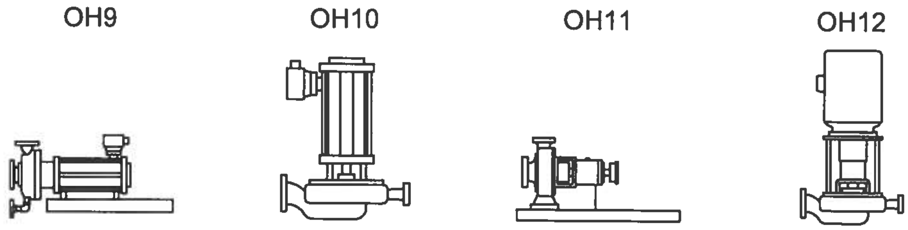


Figure 1.2.9.1.10 — Pump types OH9, OH10, OH11, and OH12

1.2.9.2 Between-bearing impeller types

1.2.9.2.1 Pump type BB1: Horizontal, axial split, single and two stage, between-bearings design. Flexibly coupled to the driver.

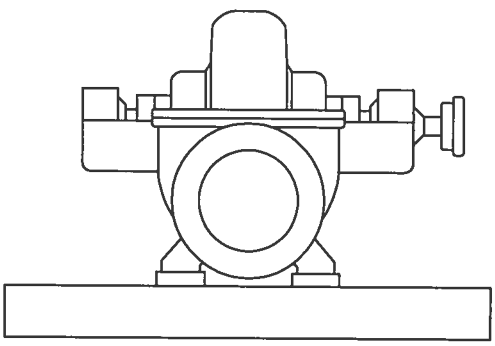


Figure 1.2.9.2.1 — Pump type BB1: Horizontal, axial split, single and two stage, between-bearings design

1.2.9.2.2 Pump type BB2: Horizontal, radial split, single and two stage, between-bearings design. Flexibly coupled to the driver.

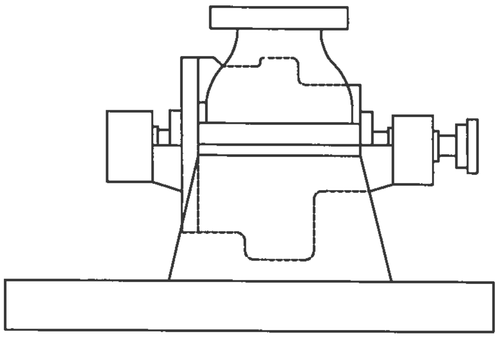


Figure 1.2.9.2.2 — Pump type BB2: Horizontal, radial split, single and two stage, between-bearings design

1.2.9.2.3 Pump type BB3: Horizontal, axial split, multistage, between-bearings design. Flexibly coupled to the driver.

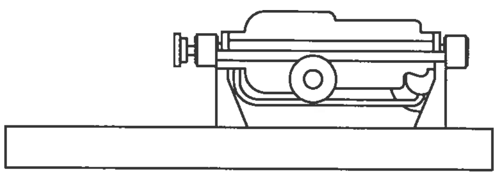


Figure 1.2.9.2.3 — Pump type BB3: Horizontal, axial split, multistage, between-bearings design

1.2.9.2.4 Pump type BB4: Horizontal, radially split, multistage, between-bearings design. Flexibly coupled to the driver. Sometimes referred to as a *segmented (segmental) ring* design.

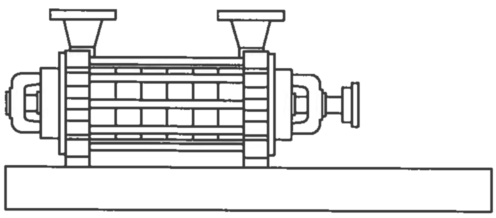


Figure 1.2.9.2.4 — Pump type BB4: Horizontal, radially split, multistage, between-bearings design

1.2.9.2.5 Pump type BB5: Horizontal, radially split, multistage, double casing, between-bearings design. Flexibly coupled to the driver. Sometimes referred to as a *barrel* design.

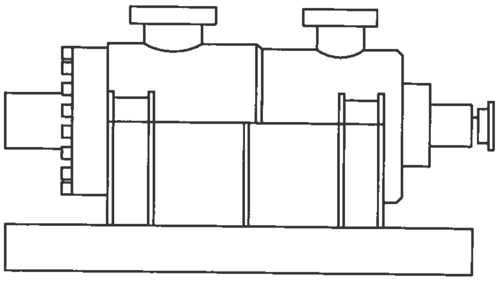


Figure 1.2.9.2.5 — Pump type BB5: Horizontal, radially split, multistage, double casing, between-bearings design

1.2.9.3 Vertically suspended types

NOTE: The following two vertically suspended configurations are commonly associated with other centrifugal designs and thus referenced in this standard. Related information may be found in ANSI/HI 2.1-2.2 *Rotodynamic (Vertical) Pumps for Nomenclature and Definitions.*

1.2.9.3.1 Pump type VS4: Vertical, single volute casing, lineshaft, flexibly coupled to the driver

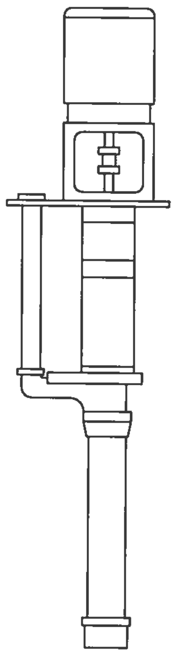


Figure 1.2.9.3.1 — Pump type VS4: Vertical, single volute casing, lineshaft, flexibly coupled to the driver

1.2.9.3.2 Pump type VS5: Vertical, single volute casing, stiff-shaft cantilever, flexibly coupled to the driver

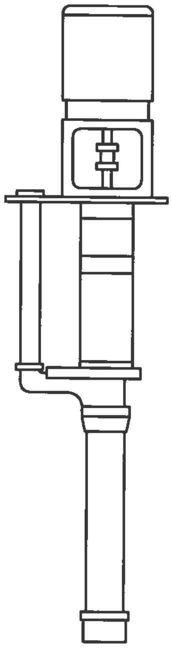


Figure 1.2.9.3.2 — Pump type VS5: Vertical, single volute casing, stiff-shaft cantilever, flexibly coupled to the driver

1.2.9.4 Regenerative turbine

1.2.9.4.1 Pump type RT1: Overhung, close-coupled, side channel design

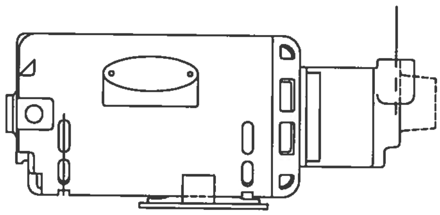


Figure 1.2.9.4.1 — Pump type RT1: Overhung, close-coupled, side channel design

1.2.9.4.2 Pump type RT2: Overhung, close-coupled, peripheral design

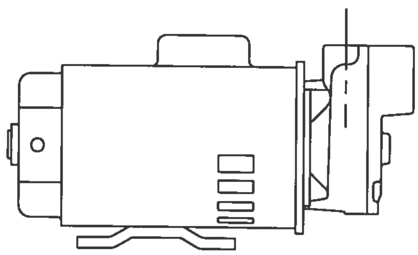


Figure 1.2.9.4.2 — Pump type RT2: Overhung, close-coupled, peripheral design

1.2.9.4.3 Pump type RT3: Between-bearing, flexibly coupled, side channel design

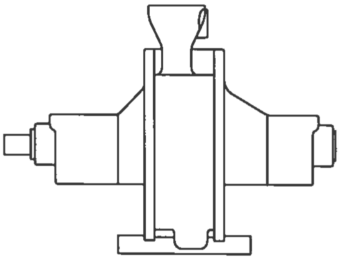


Figure 1.2.9.4.3 — Pump type RT3: Between-bearing, flexibly coupled, side channel design

1.2.9.4.4 Pump type RT4: Between-bearing, flexibly coupled, peripheral design

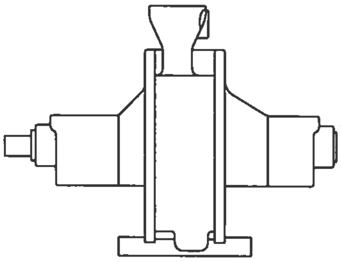


Figure 1.2.9.4.4 — Pump type RT4: Between-bearing, flexibly coupled, peripheral design

1.2.9.5 Special effect types

1.2.9.5.1 Pitot (rotating casing) pumps (unclassified)

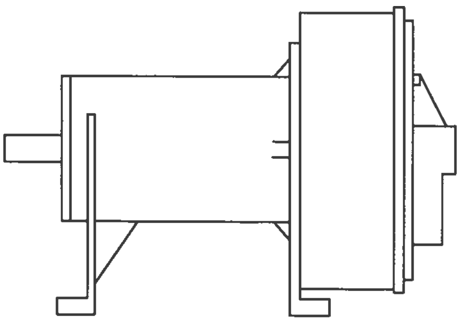


Figure 1.2.9.5.1 — Pitot (rotating casing) pumps

Appendix A

References

This appendix is not part of Hydraulic Institute Standard 1.1–1.2, and is included for informative purposes only.

NEMA-National Electrical Manufacturers Association

NEMA-MG1, *Motors and Generators*

National Electrical Manufacturers Association
2101 L Street, NW, Suite 300
Washington, D.C. 20037

www.nema.org

Appendix B

Standard Dimension for HI – NEMA Type C Face-Mounted Motors

This appendix is not part of Hydraulic Institute Standard 1.1–1.2, and is included for informative purposes only.

Tabulated dimensions were developed jointly by NEMA and the Hydraulic Institute and are the same as those given on NEMA Standard MG1.

Figure B.1 and Tables B.1 and B.2 provide interface details and dimensions of face-mounting, close-coupled motors, which are used in conjunction with overhung impeller, close-coupled, single-stage end suction (OH7 type) pumps. (See Figure 1.1.5n.)

Figure B.2 and Table B.4 provide interface details and dimensions of vertical solid shaft motors, which are used in conjunction with overhung impeller, ridged-coupled, single-stage vertical in-line (OH4) pumps. (See Figure 1.1.5j.)

Open drip-proof frame selections			
HP	3600 RPM	1800 RPM	1200 RPM
1	–	143JM	145JM
1.5	143JM	145JM	182JM
2	145JM	145JM	184JM
3	145JM	182JM	213JM
5	182JM	184JM	215JM
7.5	184JM	213JM	254JM
10	213JM	215JM	256JM
15	215JM	254JM	284JM
20	254JM	256JM	286JM
25	256JM	284JM	324JM
30	284JM	286JM	326JM
40	286JM	324JM	–
50	324JM	326JM	–
60	326JM	–	–

TEFC frame selections			
HP	3600 RPM	1800 RPM	1200 RPM
1	–	143JM	145JM
1.5	143JM	145JM	182JM
2	145JM	145JM	184JM
3	182JM[a]	182JM	213JM
5	184JM	184JM	215JM
7.5	213JM[a]	213JM	254JM
10	215JM	215JM	256JM
15	254JM[a]	254JM	284JM
20	256JM	256JM	286JM
25	284JM[a]	284JM	324JM
30	286JM	286JM	326JM
40	324JM	324JM	–
50	326JM	326JM	–
60	–	–	–

[a] Rating may be available in open drip-proof frame assignment.

The frame assignments are based on NEMA standard frame assignments.

Table B.1 — Dimensions for type JM, alternating current, face-mounting, close-coupled pump motors (US customary units)

Frame Designations	U	AH	AJ	AK	BB	BD Max	BF Number	BF Tap Size	BF Bolt Penetration Allowance
143JM and 145JM	0.8745	4.281	5.875	4.500	0.156	6.62	4	$^3/_8$-16	0.56
	0.8740	4.219		4.497	0.125				
182JM and 184JM	0.8745	4.281	5.875	4.500	0.156	6.62	4	$^3/_8$-16	0.56
	0.8740	4.219		4.497	0.125				
213JM and 215JM	0.8745	4.281	7.250	8.500	0.312	9.00	4	$^3/_8$-16	0.75
	0.8740	4.219		8.497	0.250				
254JM and 256JM	1.2495	5.281	7.250	8.500	0.312	10.0	4	$^1/_2$-13	0.75
	1.2490	5.219		8.497	0.250				
284JM and 286JM	1.2495	5.281	11.000	12.500	0.312	14.00	4	$^1/_2$-13	0.94
	1.2490	5.219		12.495	0.250				
324JM and 326JM	1.2495	5.281	11.000	12.500	0.312	14.00	4	$^1/_2$-13	0.94
	1.2490	5.219		12.495	0.250				

Table B.1 — Dimensions for type JM, alternating current, face-mounting, close-coupled pump motors (US customary units) (*continued*)

Frame Designations	EL	EM	EN Tap Size	EN Penetration Allowance Tap Drill	EN Penetration Allowance Bolt	EP Min	EQ	ER Min	Key Seat R	Key Seat ES Min	Key Seat S	ET
143JM and 145JM	1.156	1.0000	$^3/_8$-16	1.12	0.75	1.156	0.640	4.250	0.771-0.756	1.65	0.190	2.890
	1.154	0.9995					0.610				0.188	2.860
182JM and 184JM	1.250	1.0000	$^3/_8$-16	1.12	0.75	1.250	0.640	4.250	0.771-0.756	1.65	0.190	2.890
	1.248	0.9995					0.610				0.188	2.860
213JM and 215JM	1.250	1.000	$^3/_8$-16	1.12	0.75	1.750	0.640	4.250	1.112-1.097	1.65	0.190	2.890
	1.248	0.9995					0.610				0.188	2.860
254JM and 256JM	1.750	1.3750	$^1/_2$-13	1.50	1.00	1.750	0.640	5.250	1.112-1.097	2.53	0.252	3.015
	1.748	1.3745					0.610				0.250	2.885

Table B.1 — Dimensions for type JM, alternating current, face-mounting, close-coupled pump motors (US customary units) (*continued*)

Frame Designations	EL	EM	EN Tap Size	EN Penetration Allowance Tap Drill	EN Penetration Allowance Bolt	EP Min	EQ	ER Min	Key Seat R	Key Seat ES Min	Key Seat S	ET
284JM and 286JM	1.750	1.3750	$^1/_2$-13	1.50	1.00	2.125	0.640	5.250	1.112-1.097	2.53	0.252	3.015
	1.748	1.3745					0.610				0.250	2.885
324JM and 326JM	1.750	1.3750	$^1/_2$-13	1.50	1.00	2.125	0.640	5.250	1.112-1.097	2.53	0.252	3.015
	1.748	1.3745					0.610				0.250	2.885

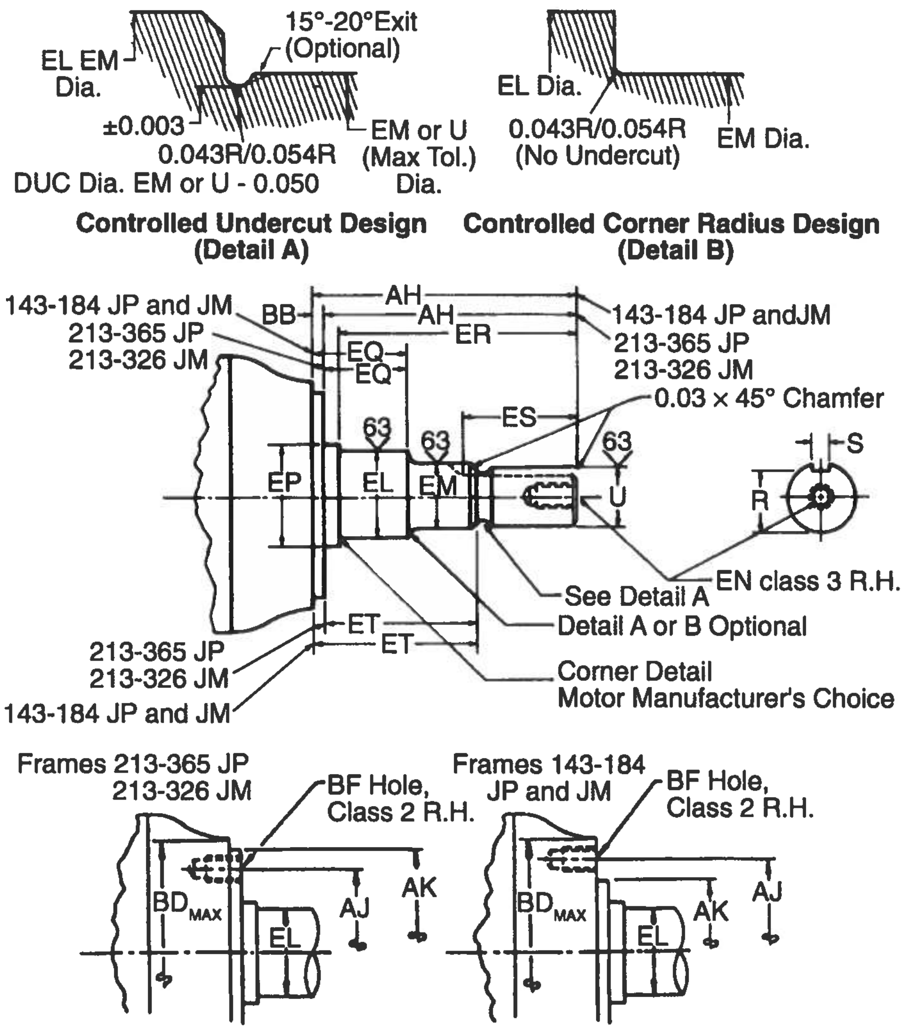


Figure B.1 — Dimensions for types JM and JP, alternating current, face-mounting, close-coupled pump motors having rolling element contact bearings. (This figure relates to Tables B.1 and B.2)

Table B.2 — Dimensions for type JP, alternating current, face-mounting, close-coupled pump motors (US customary units)

Frame Designations	U	AH	AJ	AK	BB	BD Max	BF		
							Number	Tap Size	Bolt Penetration Allowance
143JP and 145JP	0.8745	7.343	5.875	4.500	0.156	6.62	4	$^3/_8$-16	0.56
	0.8740	7.281		4.497	0.125				
182JP and 184JP	0.8745	7.343	5.875	4.500	0.156	6.62	4	$^3/_8$-16	0.56
	0.8740	7.281		4.497	0.125				
213JP and 215JP	1.2495	8.156	7.250	8.500	0.312	9.00	4	$^1/_2$-16	0.75
	1.2490	8.094		8.497	0.250				
254JP and 256JP	1.2495	8.156	7.250	8.500	0.312	10.0	4	$^1/_2$-13	0.75
	1.2490	8.094		8.497	0.250				
284JP and 286JP	1.2495	8.156	11.000	12.500	0.312	14.00	4	$^5/_8$-11	0.94
	1.2490	8.094		12.495	0.250				
324JP and 326JP	1.2495	8.156	11.000	12.500	0.312	14.00	4	$^5/_8$-11	0.94
	1.2490	8.094		12.495	0.250				
364JP and 365JP	1.6245	8.156	11.000	12.500	0.312	14.00	4	$^5/_8$-11	0.94
	1.6240	8.094		12.495	0.250				

Table B.2 — Dimensions for type JP, alternating current, face-mounting, close-coupled pump motors (US customary units) (continued)

Frame Designations	EL	EM	EN			EP Min	EQ	ER Min	Key Seat			ET
			Tap Size	Penetration Allowance								
				Tap Drill	Bolt				R	ES Min	S	
143JP and 145JP	1.156	1.0000	$^3/_8$-16	1.12	0.75	1.156	1.578	7.312	0.771-0.756	1.65	0.190	5.952
	1.154	0.9995					1.548				0.188	5.922
182JP and 184JP	1.250	1.0000	$^3/_8$-16	1.12	0.75	1.250	1.578	7.312	0.771-0.756	1.65	0.190	5.952
	1.248	0.9995					1.548				0.188	5.922
213JP and 215JP	1.750	1.3750	$^1/_2$-13	1.50	1.00	1.750	2.390	8.125	1.112-1.097	2.53	0.252	5.890
	1.748	1.3745					2.360				0.250	5.860

Table B.2 — Dimensions for type JP, alternating current, face-mounting, close-coupled pump motors (US customary units) (continued)

Frame Designations	EL	EM	EN			EP Min	EQ	ER Min	Key Seat			ET
			Tap Size	Penetration Allowance					R	ES Min	S	
				Tap Drill	Bolt							
254JP and 256JP	1.750	1.3750	1/2-13	1.50	1.00	1.750	2.390	8.125	1.112-1.097	2.53	0.252	5.890
	1.748	1.3745					2.360				0.250	5.860
284JP and 286JP	1.750	1.3750	1/2-13	1.50	1.00	2.125	2.390	8.125	1.112-1.097	2.53	0.252	5.895
	1.748	1.3745					2.360				0.250	5.855
324JP and 326JP	1.750	1.3750	1/2-13	1.50	1.00	2.125	2.395	8.125	1.112-1.097	2.53	0.252	5.895
	1.748	1.3745					2.355				0.250	5.855
364JP and 365JP	2.125	1.7500	1/2-13	1.50	1.00	2.500	2.395	8.125	1.416-1.401	2.53	0.377	5.895
	2.123	1.7495					2.355				0.375	5.855

Table B.3 — Open drip-proof frame selections

H.P.	3600 RPM	1800 RPM	1200 RPM
3/4	—	—	143 HP
1	—	143 HP	145 HP
1 1/2	143 HP	145 HP	182 HP
2	145 HP	145 HP	184 HP
3	145 HP	183 HP	213 HP
5	182 HP	184 HP	215 HP
7 1/2	184 HP	213 HP	254 HP
10	213 HP	215 HP	256 HP
15	215 HP	254 HP	284 HP
20	254 HP	256 HP	286 HP
25	256 HP	284 HP	324 HP
30	284 HP	286 HP	326 HP
40	286 HP	324 HP	364 HP
50	324 HP	326 HP	365 HP
60	326 HP	364 HP	404 HP

Table B.3 — Open drip-proof frame selections (*continued*)

H.P.	3600 RPM	1800 RPM	1200 RPM
75	364 HP	365 HP	405 HP
100	365 HP	404 HP	444 HP
125	404 HP	405 HP	445 HP
150	405 HP	444 HP	—
200	444 HP	445 HP	—
250	445 HP	—	—

NOTES:

1. Dimensions measured with motor in vertical position shaft down.
2. AJ centerline of bolt holes within 0.025 in for all frames of true locations. True location is defined as angular and diametrical location with reference to centerline of AK.
3. Shaft and play shall not exceed the bearing internal axial movement. The bearing mounting fits shall be as recommended by the bearing manufacturer for pump application.
4. The above applies to open and totally enclosed motors; for explosion-proof motors, contact individual manufacturer.

Table B.4 — Standard dimensions for HI - NEMA type HP and HPH vertical solid-shaft motors (US customary units)

					BF Clearance Hole						Key seat			
Frame Designations	AJ	AK	BB Min	BD Max	No.	Size	U	V Min	AH	EP Min	EU	R	ES Min	S
143HP and 145HP	9.125	8.253	0.19	10.00	4	0.44	0.8750	2.75	2.781	1.156	0.688	0.771-0.756	1.28	0.190-0.188
		8.250					0.8745		2.719		0.683			
182HP and 184HP	9.125	8.253	0.19	10.00	4	0.44	1.1250	2.75	2.781	1.156	0.875	0.986-0.971	1.28	0.252-0.250
		8.250					1.1245		2.719		0.870			
213HP and 215HP	9.125	8.253	0.19	10.00	4	0.44	1.1250	2.75	2.781	1.375	0.875	0.986-0.971	1.28	0.252-0.250
		8.250					1.1245		2.719		0.870			
254HP and 256HP	9.125	8.253	0.19	10.00	4	0.44	1.1250	2.75	2.781	1.750	0.875	0.986-0.971	1.28	0.252-0.250
		8.250					1.1245		2.719		0.870			
284HP and 286HP[a]	9.125	8.253	0.19	10.00	4	0.44	1.1250	2.75	2.781	1.750	0.875	0.986-0.971	1.28	0.252-0.250
		8.250					1.1245		2.719		0.870			
324HP and 326HP	14.750	13.505	0.25	16.50	4	0.69	1.6250	4.50	4.531	2.125	1.250	1.416-1.401	3.03	0.377-0.375
		13.500					1.6245		4.469		1.245			
364HP and 365HP	14.750	13.505	0.25	16.50	4	0.69	1.6250	4.50	4.531	2.250	1.250	1.416-1.401	3.03	0.377-0.375
		13.500					1.6245		4.469		1.245			

Table B.4 — Standard dimensions for HI - NEMA type HP and HPH vertical solid-shaft motors (US customary units) (*continued*)

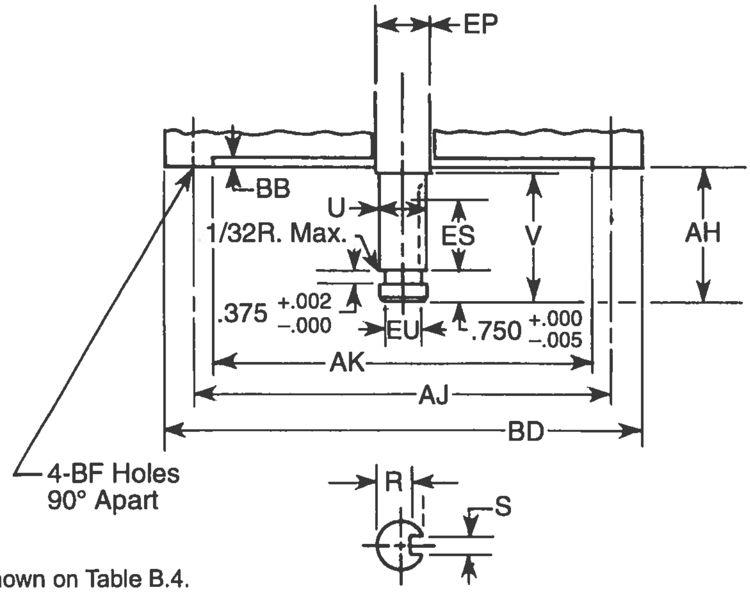
Frame Designations	AJ	AK	BB Min	BD Max	BF Clearance Hole No.	BF Clearance Hole Size	U	V Min	AH	EP Min	Key seat EU	Key seat R	Key seat ES Min	Key seat S
404HP and 405HP[a]	14.750	13.505	0.25	16.50	4	0.69	1.6250	4.50	4.562	2.250	1.250	1.416-1.401	3.03	0.377-0.375
		13.500					1.6245		4.438		1.245			
444HP and 445HP	14.750	13.505	0.25	16.50	4	0.69	2.1250	4.50	4.562	2.250	1.750	1.845-1.830	3.03	0.502-0.500
		13.500					2.1240		4.438		1.745			

[a] These frames have the following alternate dimensions:

284HPH and 286HPH	14.750	13.505	0.25	16.50	4	0.69	1.6250	4.50	4.531	1.750	1.250	1.416-1.401	3.03	0.377-0.375
		13.500					1.6245		4.469		1.245			
404HPH and 405HPH	14.750	13.505	0.25	16.50	4	0.69	2.1250	4.50	4.562	2.250	1.750	1.845-1.830	3.03	0.502-0.500
		13.500					2.1240		4.438		1.745			

NOTES:

1. These standard dimensions were developed jointly by the Hydraulic Institute and NEMA.
2. All dimensions in inches. The above are integral-horsepower, AC, squirrel-cage induction motors for process, in-line, and other applications.



NOTE: Dimensions shown on Table B.4.

Figure B.2 — Standard dimensions for HI - NEMA type HP and HPH vertical, solid-shaft motors

Appendix C

Index

This appendix is not part of this standard, but is presented to help the user in considering factors beyond this standard. Hydraulic Institute symbols are indicated in parentheses (xx); ISO symbols are indicated in brackets [xx].

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

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