ASME B73.1-2001
[Revision of ASME B73.1M-1991(R1999)]

SPECIFICATION FOR HORIZONTAL END SUCTION CENTRIFUGAL PUMPS FOR CHEMICAL PROCESS

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Date of Issuance: February 25, 2002

The next edition of this Standard is scheduled for publication in 2006. There will be no addenda or written interpretations of the requirements of this Standard issued to this edition.

The American Society of Mechanical Engineers
Three Park Avenue, New York, NY 10016-5990

FOREWORD

In 1955, the Standards Committee on Centrifugal Pumps for Chemical Industry Use, B73, undertook the development of centrifugal pump standards to meet the needs of the chemical industry. Although the Standards Committee had not completed its assignment, the work of one of its task forces resulted in the development of a de facto standard which was published by the Manufacturing Chemists Association in 1962 as an American Voluntary Standard. More than a dozen manufacturers of chemical process pumps have been marketing pumps conforming with the AVS since that time.

In 1965 the Hydraulic Institute published a tentative standard similar in content to the AVS, but updated certain portions. Although the Hydraulic Institute Tentative Standard reflected more nearly the current practice of manufacturers and users, it was believed necessary to publish a new document which would supersede both the original AVS and the tentative standard, and which could incorporate the technical content of both documents, in addition to dimensional criteria and features generally accepted by manufacturers and users. The January 1968 revision of the AVS was therefore approved as an American National Standard under the existing standards method and published as ANSI B123.1-1971.

ANSI B73.1 superseded ANSI B123.1-1971 and was first published in 1974. The 1974 edition brought to 15 the number of pump sizes covered by the standard. Since then, the committee has continued to be active and has added five more sizes for a total of 20, and made a number of revisions in the text of the standard.

Shortly thereafter, the American National Standards Committee B73 undertook to revise the standard, and as a result, new information on baseplate rigidity, bearing frame adapter, and bearing housing drain was introduced. The 1984 edition included, for the first time, information that covered documentation of pump and driver outline drawing of the centrifugal pump, data sheet, mechanical seal drawing, stuffing box piping plans, and cooling/heating piping plans.

The 1991 revision included larger and self-venting tapered seal chambers, as well as conventional stuffing boxes, revised baseplate dimensions, with a new identification numbering system, and a ductile material requirement for the bearing frame adapter if it clamps the rear cover plate to the casing.

With the expanding utilization of the ASME B73.1 pumps in the chemical process industry and its growing acceptance in the hydrocarbons processing industry, the B73 committee has continued to improve the B73.1 standard. This revision of the Standard incorporates 7 new sizes of pumps, bringing the total number to 27. Many of the new additions were at the request of the user population. Although inclusion of "ISO" standard size pumps was entertained, the proposed additions of the "ISO" sizes were rejected by the committee. It was thought that the addition of the "ISO" sizes made the standard overly complex and weakened its mechanical fortitude. The material of construction section of the standard was expanded to include readily available corrosion resistant alloys. Recent publications by the Hydraulic Institute in areas such as baseplate tolerance, acceptable nozzle loads, preferred operating region and NPSH margin have been incorporated into this revision. The former Appendix covering documentation has been established as an integral portion of the Standard. This is in part in response to the needs of the user community for compliance to U.S. Government regulations covering chemical process equipment and pumps specifically OSHA

Process Safety Management, 29 CFR 1910.119. In total, these revisions to the standard are intended to better serve process industries and expand the use of ASME B73 pumps world wide.

Suggestions for improvement in this Standard will be welcome and should be sent to the American Society of Mechanical Engineers, Attn: Secretary B73 Committee, Three Park Ave., New York, NY 10016-5990.

This revision was approved as an American National Standard on September 7, 2001.

ASME STANDARDS COMMITTEE B73
Chemical Standard Pumps

(The following is the roster of the Committee at the time of approval of this Standard.)

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CONTENTS

Tables

Nonmandatory Appendix

SPECIFICATION FOR HORIZONTAL END SUCTION CENTRIFUGAL PUMPS FOR CHEMICAL PROCESS

1 SCOPE

This Standard covers centrifugal pumps of horizontal, end suction single stage, centerline discharge design. This Standard includes dimensional interchangeability requirements and certain design features to facilitate installation and maintenance. It is the intent of this Standard that pumps of the same standard dimension designation from all sources of supply shall be interchangeable with respect to mounting dimensions, size and location of suction and discharge nozzles, input shafts, baseplates, and foundation bolt holes (see Tables 1 and 2).

2 ALTERNATIVE DESIGN

Alternate designs will be considered, provided they meet the intent of this Standard and cover construction and performance which are equivalent to and otherwise in accordance with these specifications. All deviations from these specifications shall be described in detail.

3 NOMENCLATURE AND DEFINITIONS

3.1 Source

All nomenclature and definitions of pump components shall be in accordance with HI 1.1–1.2.

4 DESIGN AND CONSTRUCTION FEATURES

4.1 Pressure and Temperature Limits

4.1.1 Pressure Limits. Pressure limitations shall be stated by the pump manufacturer.

4.1.1.1 The design pressure of the casing, including stuffing box or seal chamber and gland, shall be at least as great as the pressure-temperature rating of ASME B16.5 or ASME B16.42 Class 150 flanges for the material used.

4.1.1.2 The design pressure of jackets shall be at least 100 psig (690 kPa gage) at 340°F (170°C). Heating jackets may be required for jacket temperatures to 500°F (260°C) with a reduction in pressure corresponding to the reduction in yield strength of the jacket material.

4.1.1.3 Casing, stuffing box, cover or seal chamber, and jackets shall be designed to withstand a hydrostatic test at 1.5 times the maximum design pressure for the particular component and material of construction used (see para. 5.2.1).

4.1.2 Temperature Limits. Temperature limitations shall be stated by the pump manufacturer. Pumps should be available for temperatures up to 500°F (260°C). Jacketing and other modifications may be required to meet the operating temperature.

4.2 Flanges

Suction and discharge nozzles shall be flanged. Flanges shall conform to ASME B16.5 or ASME B16.42 Class 150 standards except that marking requirements are not applicable and the maximum acceptable tolerance on parallelism of the back of the flange shall be 3 deg and bolt holes may be tapped where noted in Table 1. Through bolt holes are preferred. When tapped holes are supplied, they shall be noted on the outline drawing. As an option, Class 300 flanges in accordance with ASME B16.5 or ASME B16.42 may be offered subject to the manufacturer's casing pressure-temperature limitations. All pumps regardless of flange rating shall conform to the X and Y dimensions shown in Table 1.

4.3 Casing

4.3.1 Drain Connection Boss(es). Pump casing shall have boss(es) to provide for drain connection(s) in the lowest part of the casing. Boss size shall accommodate $\frac{1}{2}$ in. NPT min. Boss(es) shall be drilled and tapped when specified by customer.

4.3.2 Auxiliary Connection Boss(es). The suction and discharge nozzles shall have boss(es) for gage connections. Boss size shall accommodate $\frac{1}{4}$ in. NPT min., $\frac{1}{2}$ in. NPT preferred. Boss(es) shall be drilled and tapped when specified by customer.

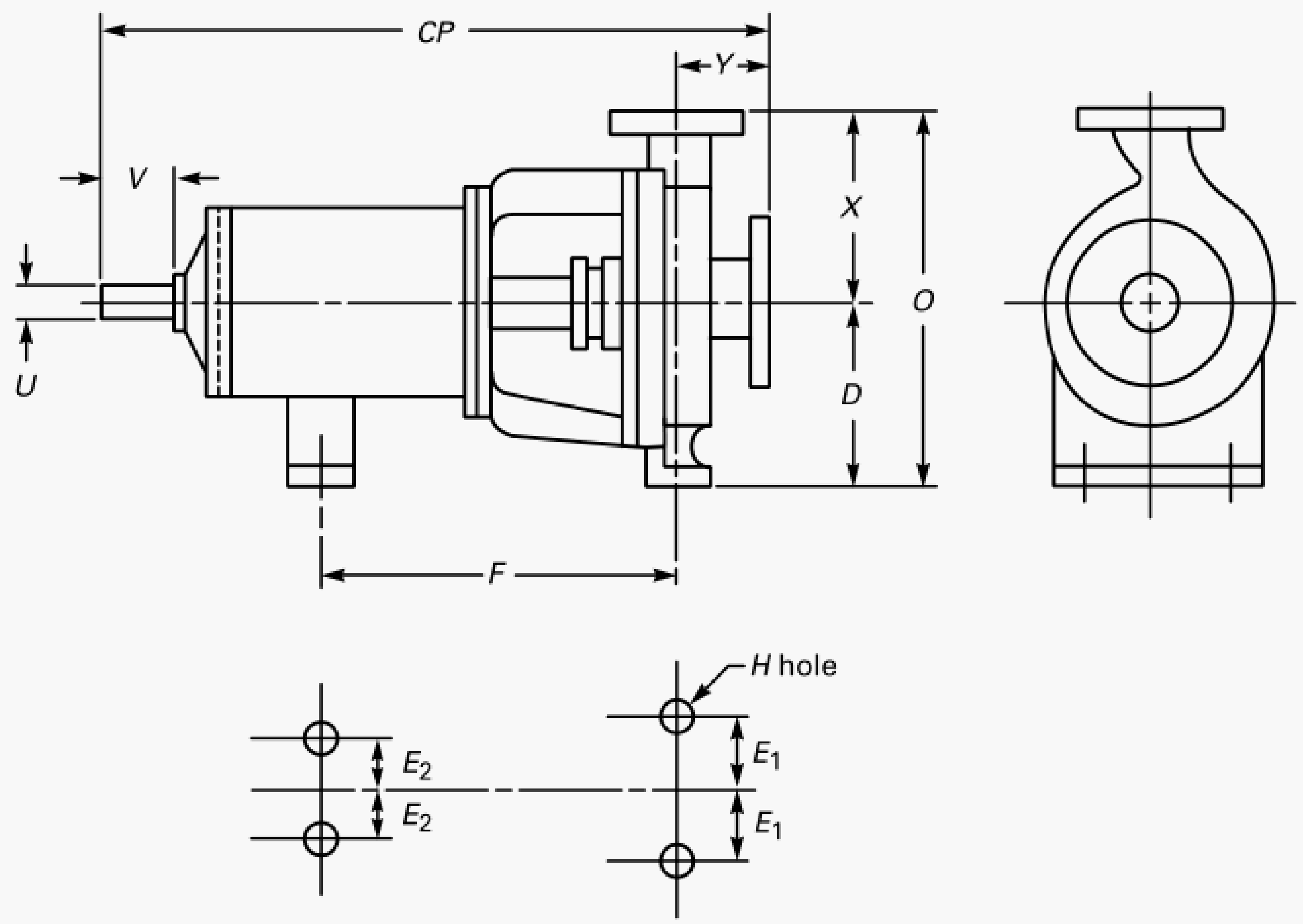

TABLE 1 PUMP DIMENSIONS

Dimension Designation	Size; Suction × Discharge × Nominal Impeller Diameter	*CP*	*D*	$2E_1$	$2E_2$	*F*
AA	1.5×1×6 (40×25×150)	17.5 (445)	5.25 (133)	6 (152)	0	7.25 (184)
AB	3×1.5×6 (80×40×150)	17.5 (445)	5.25 (133)	6 (152)	0	7.25 (184)
AC [Note (2)]	3×2×6 (80×50×150)	17.5 (445)	5.25 (133)	6 (152)	0	7.25 (184)
AA [Note (2)]	1.5×1×8 (40×25×200)	17.5 (445)	5.25 (133)	6 (152)	0	7.25 (184)
AB [Note (2)]	3×1.5×8 (80×40×200)	17.5 (445)	5.25 (133)	6 (152)	0	7.25 (184)
*A*10	3×2×6 (80×50×150)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*50	3×1.5×8 (80×40×200)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*60	3×2×8 (80×50×200)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*70	4×3×8 (100×80×200)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*05 [Note (2)]	2×1×10 (50×25×250)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*50	3×1.5×10 (80×40×250)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*60	3×2×10 (80×50×250)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*70	4×3×10 (100×80×250)	23.5 (597)	8.25 (210)	9.75 (248)	7.25 (184)	12.5 (318)
*A*40	4×3×10 (100×80×250)	23.5 (597)	10 (254)	9.75 (248)	7.25 (184)	12.5 (318)
*A*80 [Note (3)]	6×4×10 (150×100×250)	23.5 (597)	10 (254)	9.75 (248)	7.25 (184)	12.5 (318)
*A*20 [Note (2)]	3×1.5×13 (80×40×330)	23.5 (597)	10 (254)	9.75 (248)	7.25 (184)	12.5 (318)
*A*30	3×2×13 (80×50×330)	23.5 (597)	10 (254)	9.75 (248)	7.25 (184)	12.5 (318)
*A*40	4×3×13 (100×80×330)	23.5 (597)	10 (254)	9.75 (248)	7.25 (184)	12.5 (318)
*A*80 [Note (3)]	6×4×13 (150×100×330)	23.5 (597)	10 (254)	9.75 (248)	7.25 (184)	12.5 (318)
*A*90 [Note (3)]	8×6×13 (200×150×330)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*100 [Note (3)]	10×8×13 (250×200×330)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*105 [Note (3)]	6×4×15 (150×100×380)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*110 [Note (3)]	8×6×15 (200×150×380)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*120 [Note (3)]	10×8×15 (250×200×380)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*105 [Note (3)]	6×4×17 (150×100×430)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*110 [Note (3)]	8×6×17 (200×150×430)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)
*A*120 [Note (3)]	10×8×17 (250×200×430)	33.875 (860)	14.5 (368)	16 (406)	9 (229)	18.75 (476)

(continued)

TABLE 1 PUMP DIMENSIONS (CONT'D)

Dimension Designation	*H*	*O*	*U* [Note (1)]		*V* Min.	*X*	*Y*
			Diameter	Keyway			
AA	0.625 (16)	11.75 (298)	0.875 (22.23)	0.188×0.094 (4.76×2.38)	2 (51)	6.5 (165)	4 (102)
AB	0.625 (16)	11.75 (298)	0.875 (22.23)	0.188×0.094 (4.76×2.38)	2 (51)	6.5 (165)	4 (102)
AC [Note (2)]	0.625 (16)	11.75 (298)	0.875 (22.23)	0.188×0.094 (4.76×2.38)	2 (51)	6.5 (165)	4 (102)
AA [Note (2)]	0.625 (16)	11.75 (298)	0.875 (22.23)	0.188×0.094 (4.76×2.38)	2 (51)	6.5 (165)	4 (102)
AB [Note (2)]	0.625 (16)	11.75 (298)	0.875 (22.23)	0.188×0.094 (4.76×2.38)	2 (51)	6.5 (165)	4 (102)
*A*10	0.625 (16)	16.5 (420)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	8.25 (210)	4 (102)
*A*50	0.625 (16)	16.75 (425)	1.125 (28.58)	0.25×.0125 (6.35×3.18)	2.625 (67)	8.5 (216)	4 (102)
*A*60	0.625 (16)	17.75 (450)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	9.5 (242)	4 (102)
*A*70	0.625 (16)	19.25 (490)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	11 (280)	4 (102)
*A*05 [Note (2)]	0.625 (16)	16.75 (425)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	8.5 (216)	4 (102)
*A*50	0.625 (16)	16.75 (425)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	8.5 (216)	4 (102)
*A*60	0.625 (16)	17.75 (450)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	9.5 (242)	4 (102)
*A*70	0.625 (16)	19.25 (490)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	11 (280)	4 (102)
*A*40	0.625 (16)	22.5 (572)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	12.5 (318)	4 (102)
*A*80 [Note (3)]	0.625 (16)	23.5 (597)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	13.5 (343)	4 (102)
*A*20 [Note (2)]	0.625 (16)	20.5 (520)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	10.5 (266)	4 (102)
*A*30	0.625 (16)	21.5 (546)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	11.5 (292)	4 (102)
*A*40	0.625 (16)	22.5 (572)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	12.5 (318)	4 (102)
*A*80 [Note (3)]	0.625 (16)	23.5 (597)	1.125 (28.58)	0.25×0.125 (6.35×3.18)	2.625 (67)	13.5 (343)	4 (102)
*A*90 [Note (3)]	0.875 (22)	30.5 (775)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	16 (406)	6 (152)
*A*100 [Note (3)]	0.875 (22)	32.5 (826)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	18 (457)	6 (152)
*A*105 [Note (3)]	0.875 (22)	30.5 (775)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	16 (406)	6 (152)
*A*110 [Note (3)]	0.875 (22)	32.5 (826)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	18 (457)	6 (152)
*A*120 [Note (3)]	0.875 (22)	33.5 (851)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	19 (483)	6 (152)
*A*105 [Note (3)]	0.875 (22)	30.5 (775)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	16 (406)	6 (152)
*A*110 [Note (3)]	0.875 (22)	32.5 (826)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	18 (457)	6 (152)
*A*120 [Note (3)]	0.875 (22)	33.5 (851)	2.375 (60.33)	0.625×0.313 (15.88×7.94)	4 (102)	19 (483)	6 (152)

GENERAL NOTES:
(a) Dimensions in parentheses are approximate equivalents in millimeters.
(b) All other dimensions are in inches.

NOTES:
(1) "*U*" Diameter may be 1.625 in. (41.28 mm) in *A*05 through *A*80 sizes to accomodate high torque values.
(2) Discharge flange may have tapped bolt holes.
(3) Suction flange may have tapped bolt holes.

4.3.3 Support. The casing shall be supported by feet beneath the casing or a suitable support between the casing and baseplate.

4.3.4 Disassembly. The design shall permit back removal of the rotating element from the casing without disturbing the suction and discharge connections or the driver. Tapped holes for jackscrews, or equivalent means, shall be provided to facilitate disassembly of the casing and stuffing box cover or seal chamber and to avoid the necessity of drive wedges or prying implements.

4.3.5 Jackets

4.3.5.1 Jackets for heating or cooling the casing, stuffing box, or seal chamber are optional. Connection shall be $^3\!/_8$ in. NPT min., with $^1\!/_2$ in. NPT preferred. When a jacket is to be used for heating by steam, the inlet connection shall be located at the top quadrant of the casing, stuffing box, or seal chamber; and the drain connection shall be located at the bottom portion of the casing, stuffing box, or seal chamber to prevent the formation of water pockets. Jackets for water cooling shall have a drain for freeze protection.

4.3.5.2 There are several available methods of cooling or heating specific areas of most ASME pumps. The following are examples of acceptable methods and should be available as optional features.

(a) Stuffing Box Jacket
(b) Seal Chamber Jacket

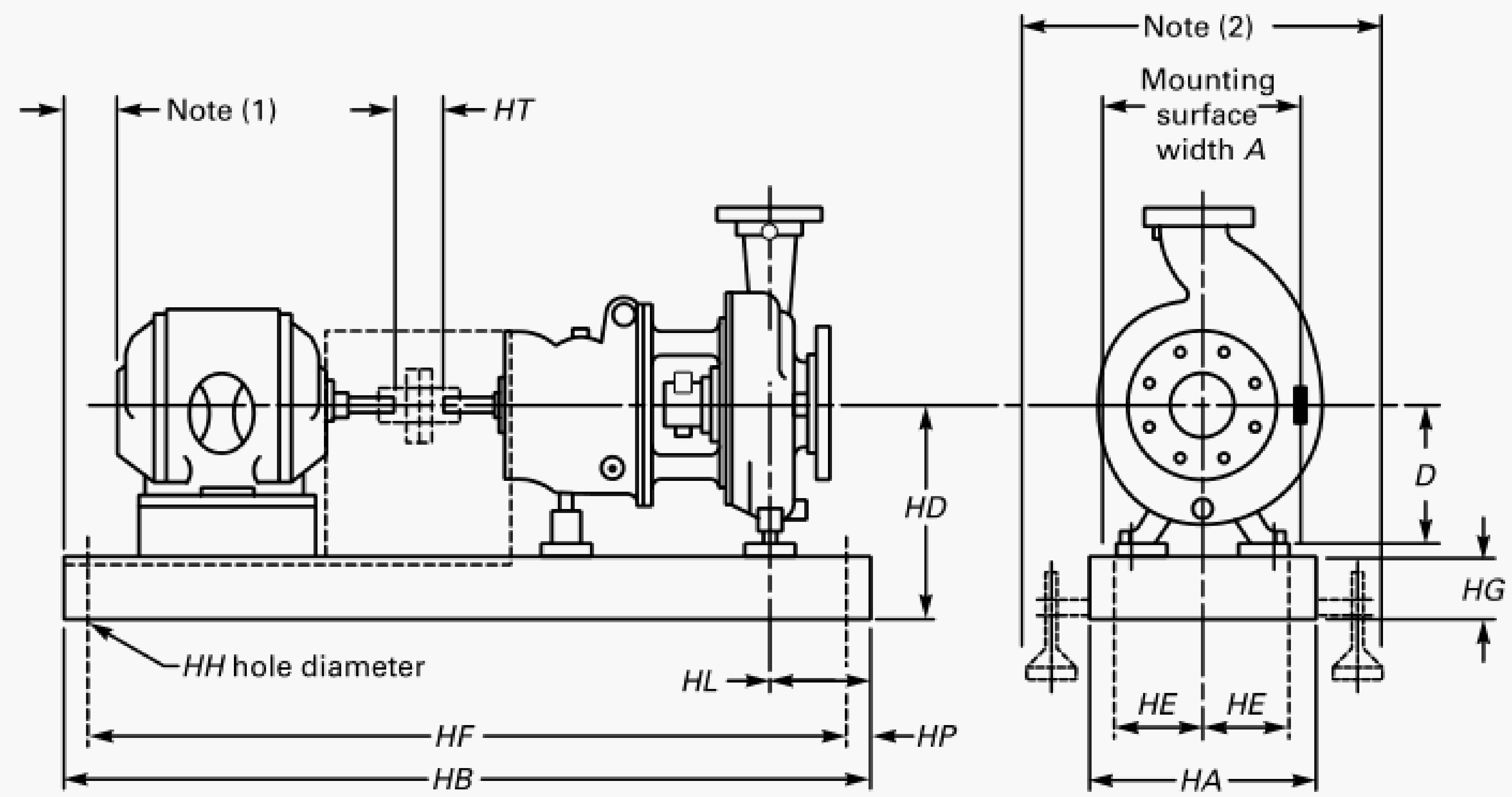

TABLE 2 BASEPLATE DIMENSIONS

Max. NEMA Frame	Baseplate No. [Note (3)]	A Min.	HA Max. [Note (2)]	HB	HT Min.	HD Max. [Note (4)] D=5.25 (133)	D=8.25 (210)	D=10 (254)	D=14.5 (1368)	HE	HF	HG Max.	HH	HL	HP
184*T*	139	12 (305)	15 (381)	39 (991)	3.5 (89)	9 (229)	...	...	...	4.5 (114)	36.5 (927)	3.75 (95)	0.75 (19)	4.5 (114)	1.25 (32)
256*T*	148	15 (381)	18 (457)	48 (1219)	3.5 (89)	10.5 (267)	...	...	...	6 (152)	45.5 (1156)	4.13 (105)	0.75 (19)	4.5 (114)	1.25 (32)
326*TS*	153	18 (457)	21 (533)	53 (1346)	3.5 (89)	12.88 (327)	...	...	...	7.5 (191)	50.5 (1283)	4.75 (121)	0.75 (19)	4.5 (114)	1.25 (32)
184*T*	245	12 (305)	15 (381)	45 (1143)	3.5 (89)	...	12 (305)	13.75 (349)	...	4.5 (114)	42.5 (1080)	3.75 (95)	0.75 (19)	4.5 (114)	1.25 (32)
215*T*	252	15 (381)	18 (457)	52 (1321)	3.5 (89)	...	12.38 (314)	14.13 (359)	...	6 (152)	49.5 (1257)	4.13 (105)	0.75 (19)	4.5 (114)	1.25 (32)
286*T*	258	18 (457)	21 (533)	58 (1473)	3.5 (89)	...	13 (330)	14.75 (375)	...	7.5 (191)	55.5 (1410)	4.75 (121)	1 (25)	4.5 (114)	1.25 (32)
365*T*	264	18 (457)	21 (533)	64 (1626)	3.5 (89)	...	13.88 (353)	14.75 (375)	...	7.5 (191)	61.5 (1562)	4.75 (121)	1 (25)	4.5 (114)	1.25 (32)
405*TS*	268	22 (559)	26 (660)	68 (1727)	3.5 (89)	...	14.88 (378)	14.88 (378)	...	9.5 (241)	65.5 (1664)	4.75 (121)	1 (25)	4.5 (114)	1.25(32)
449*TS*	280	22 (559)	26 (660)	80 (2032)	3.5 (89)	...	15.88 (403)	15.88 (403)	...	9.5 (241)	77.5 (1969)	4.75 (121)	1 (25)	4.5 (114)	1.25 (32)
286*T*	368	22 (559)	26 (660)	68 (1727)	5 (127))	...	...	...	19.25 (489)	9.5 (241)	65.5 (1664)	4.75 (121)	1 (25)	6.5 (165)	1.25 (32)
405*T*	380	22 (559)	26 (660)	80 (2032)	5 (127)	...	...	...	19.25 (489)	9.5 (241)	77.5 (1969)	4.75 (121)	1 (25)	6.5 (165)	1.25 (32)
449*T*	398	22 (559)	26 (660)	98 (2489)	5 (127)	...	...	...	19.25 (489)	9.5 (241)	95.5 (2426)	4.75 (121)	1 (25)	6.5 (165)	1.25 (32)

GENERAL NOTES:
(a) Dimensions in parentheses are approximate equivalents in millimeters.
(b) All other dimensions are in inches.

NOTES:
(1) Motor should not extend beyond end of baseplate.
(2) Contact manufacturer for additional space required for free standing baseplates.
(3) Baseplate number denotes pump frame 1, 2, or 3 and baseplate *HB* in inches.
(4) Includes 0.13 in. (3 mm) shimming allowance where motor height controls.

(c) Pump Casing Jacket
(d) Bolt on External Heating and Cooling Jacket
(e) Bearing Housing Cooling

4.3.6 Gasket(s). The casing-to-cover gasket shall be confined on the atmospheric side to prevent blowout.

4.4 Impeller

4.4.1 Types. Impellers of open, semi-open, and closed designs are optional.

4.4.2 Adjustment. Means for external adjustment (without disassembly of the pump except for the coupling guard) of the impeller axial clearance shall be provided if adjustment is required by the design.

4.4.3 Balance. Impellers shall meet ISO 1940 Grade 6.3 after final machining.

4.4.4 Attachment. The impeller may be keyed or threaded to the shaft with rotation to tighten. Shaft threads and keyways shall be protected so they will not be wetted by the pumped liquid.

4.5 Shaft

4.5.1 Diameter. The seal mounting surface includes the shaft or shaft sleeve outside diameter within the stuffing box or seal chamber and enough length beyond to accommodate outside seals. The diameter of the seal mounting surface shall be sized in increments of $\frac{1}{8}$ in. (3.2 mm). To provide for the use of mechanical seals, the tolerance on that diameter shall not exceed nominal to minus 0.002 in. (0.05 mm).

4.5.2 Finish. Surface finish of the shaft or sleeve through the stuffing box or seal chamber and at rubbing contact bearing housing seals shall not exceed an arithmetic roughness average of 32 μin. (0.8 μm) unless otherwise required for the mechanical seal.

4.5.3 Runout. Shaft runout shall be limited as follows:

(a) shaft rotated on centers: 0.001 in. (0.025 mm) full indicator movement (FIM) reading at any point;

(b) outside diameter of shaft or removable sleeve when installed in pump: 0.002 in. (0.05 mm) FIM at the gland end of stuffing box or seal chamber (see Fig. 1).

4.5.4 Deflection. Dynamic shaft deflection at the impeller centerline shall not exceed 0.005 in. (0.13 mm) anywhere within the design region as specified in para. 5.1.6. Hydraulic loads and shaft deflection shall be calculated in accordance with HI 1.3.

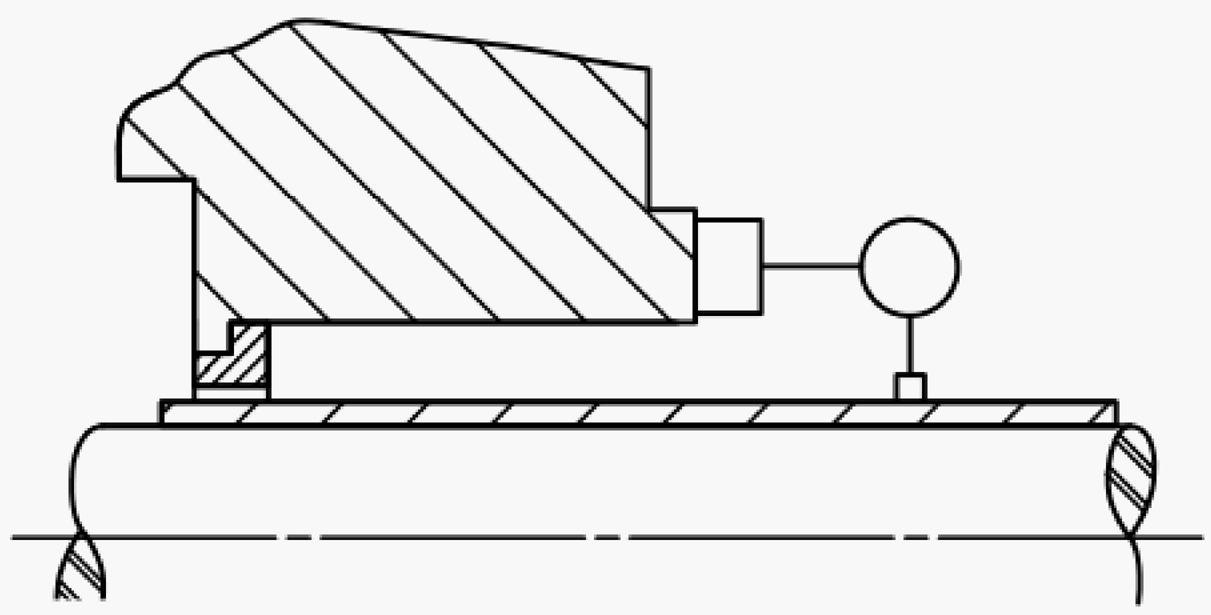

FIG. 1 SHAFT SLEEVE RUNOUT

4.5.5 Running Clearances. Running clearance must be sufficient to prevent internal rubbing contact within the design region (para. 5.1.6) and is subjected to the maximum allowable flange loads as specified in para. 5.1.2.

4.5.6 Critical Speed. The first lateral critical speed of the rotating assembly shall be at least 120% of the maximum operating speed. A ''dry critical speed'' calculation (see HI 9.6.4) is adequate to verify compliance. HI 9.6.4 shall be used to calculate static deflections used for the critical speed calculation.

4.5.7 Fillets and Radii. All shaft shoulder fillets and radii shall be made as large as practical and finished to reduce additional stress risers.

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(d) Bolt on External Heating and Cooling Jacket
(e) Bearing Housing Cooling

4.3.6 Gasket(s). The casing-to-cover gasket shall be confined on the atmospheric side to prevent blowout.

4.4 Impeller

4.4.1 Types. Impellers of open, semi-open, and closed designs are optional.

4.4.2 Adjustment. Means for external adjustment (without disassembly of the pump except for the coupling guard) of the impeller axial clearance shall be provided if adjustment is required by the design.

4.4.3 Balance. Impellers shall meet ISO 1940 Grade 6.3 after final machining.

4.4.4 Attachment. The impeller may be keyed or threaded to the shaft with rotation to tighten. Shaft threads and keyways shall be protected so they will not be wetted by the pumped liquid.

4.5 Shaft

4.5.1 Diameter. The seal mounting surface includes the shaft or shaft sleeve outside diameter within the stuffing box or seal chamber and enough length beyond to accommodate outside seals. The diameter of the seal mounting surface shall be sized in increments of $\frac{1}{8}$ in. (3.2 mm). To provide for the use of mechanical seals, the tolerance on that diameter shall not exceed nominal to minus 0.002 in. (0.05 mm).

4.5.2 Finish. Surface finish of the shaft or sleeve through the stuffing box or seal chamber and at rubbing contact bearing housing seals shall not exceed an arithmetic roughness average of 32 μin. (0.8 μm) unless otherwise required for the mechanical seal.

4.5.3 Runout. Shaft runout shall be limited as follows:

(a) shaft rotated on centers: 0.001 in. (0.025 mm) full indicator movement (FIM) reading at any point;

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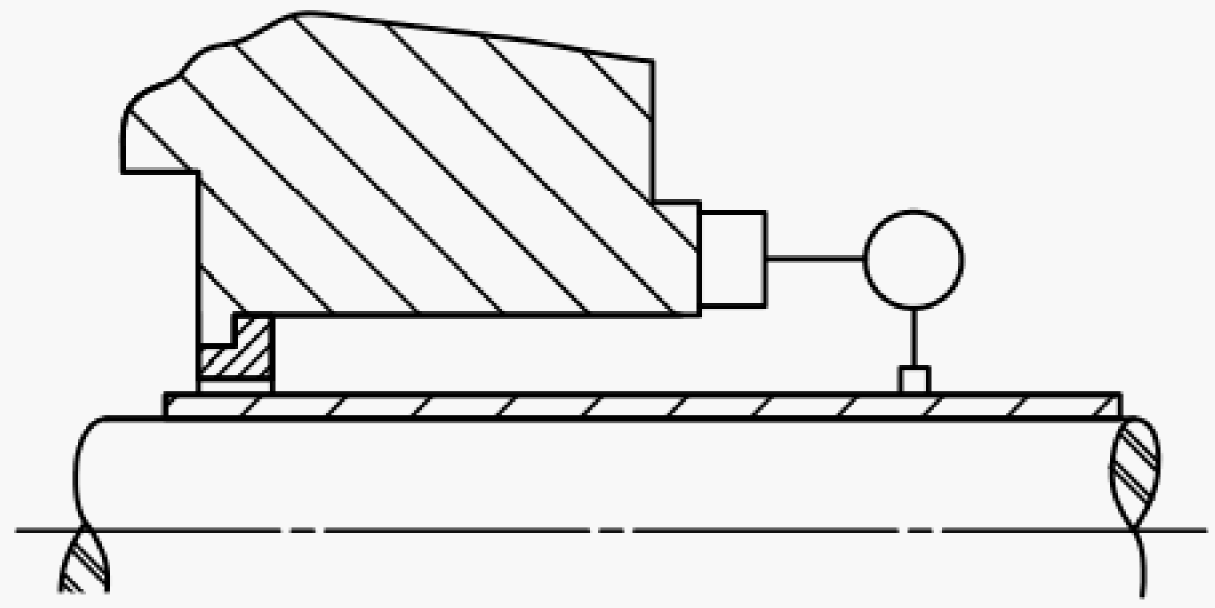
4.5.4 Deflection. Dynamic shaft deflection at the impeller centerline shall not exceed 0.005 in. (0.13 mm) anywhere within the design region as specified in para. 5.1.6. Hydraulic loads and shaft deflection shall be calculated in accordance with HI 1.3.



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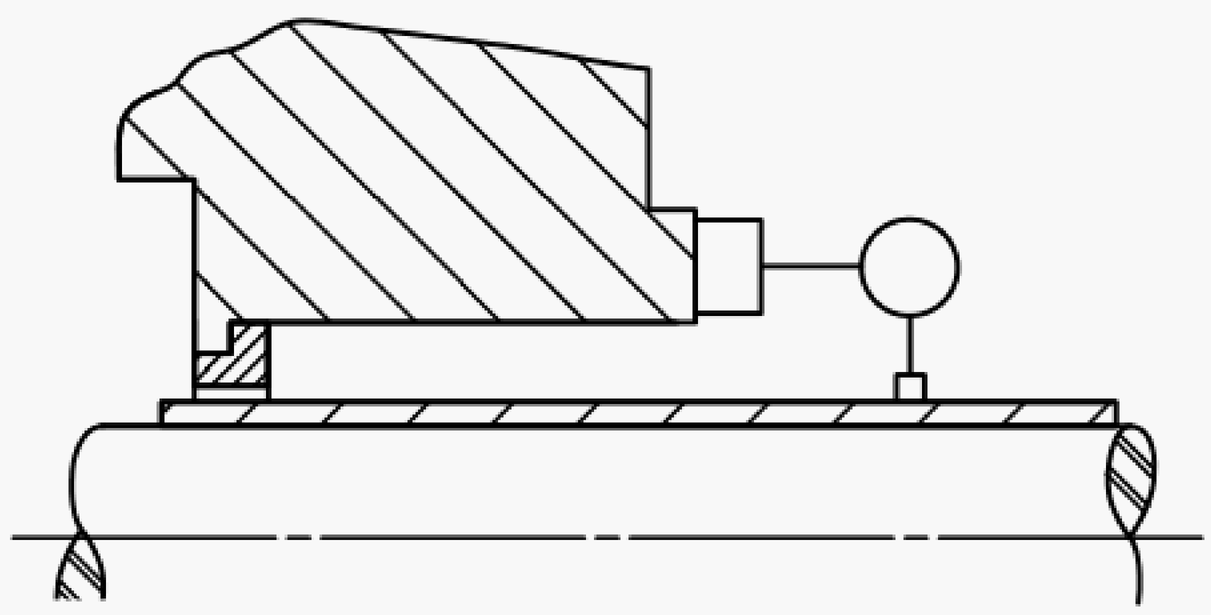

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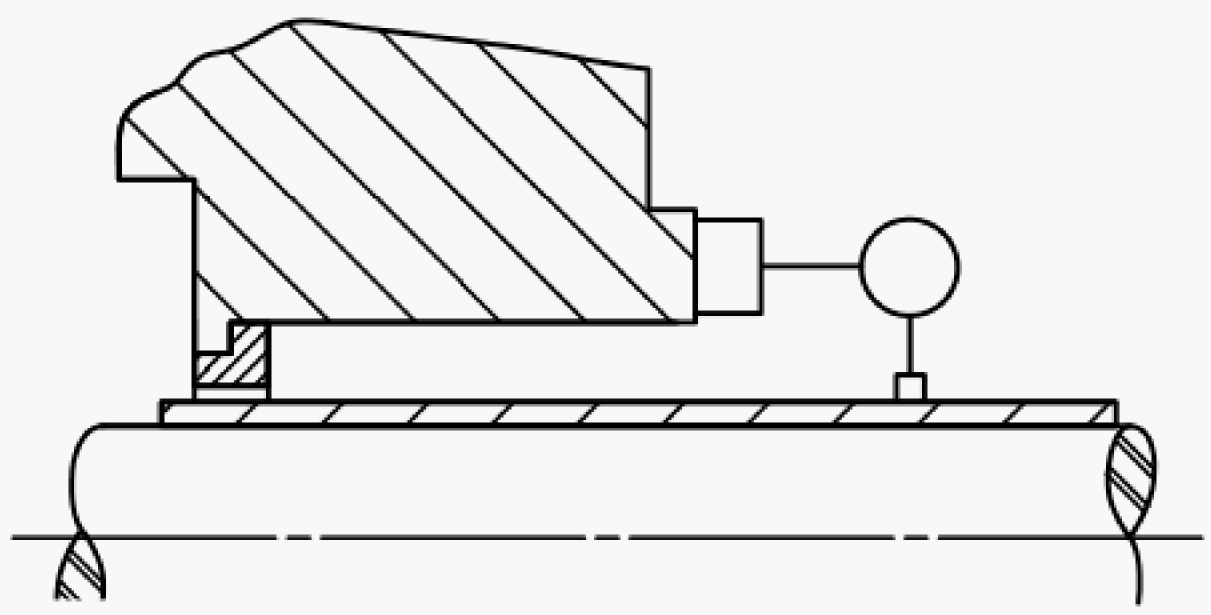

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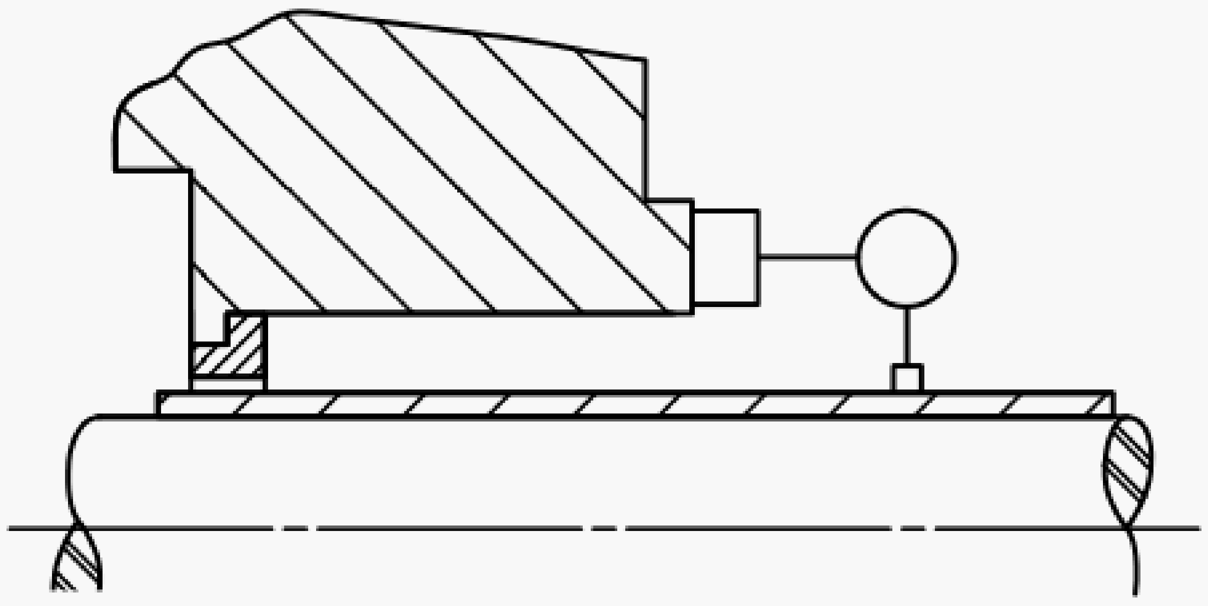

FIG. 1 SHAFT SLEEVE RUNOUT

4.5.4 Deflection. Dynamic shaft deflection at the impeller centerline shall not exceed 0.005 in. (0.13 mm) anywhere within the design region as specified in para. 5.1.6. Hydraulic loads and shaft deflection shall be calculated in accordance with HI 1.3.

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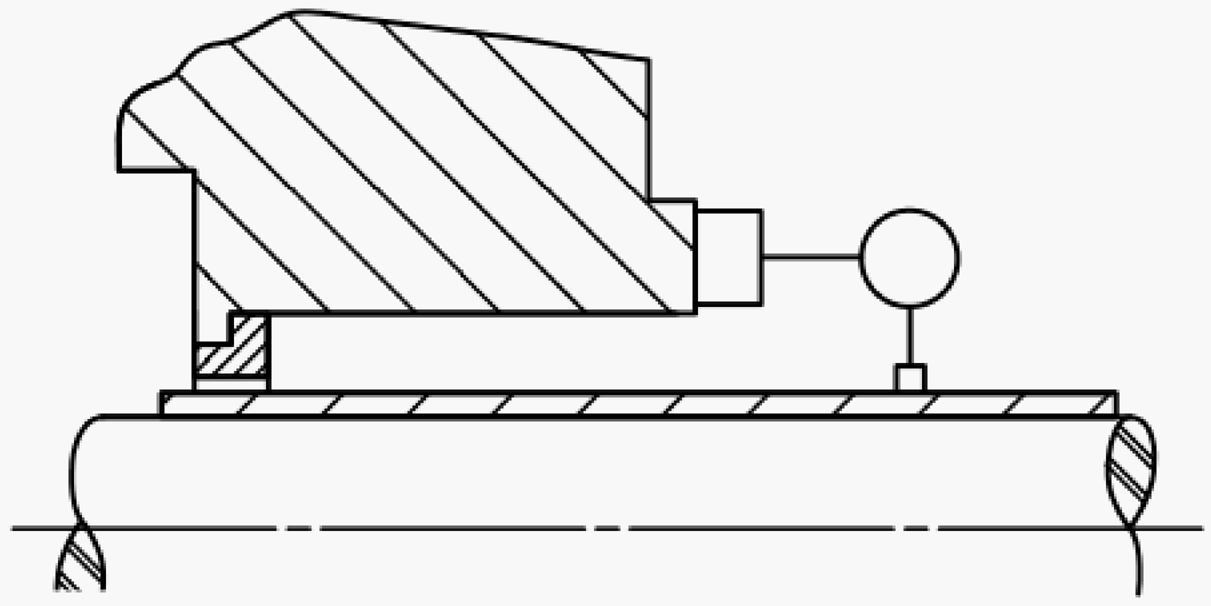

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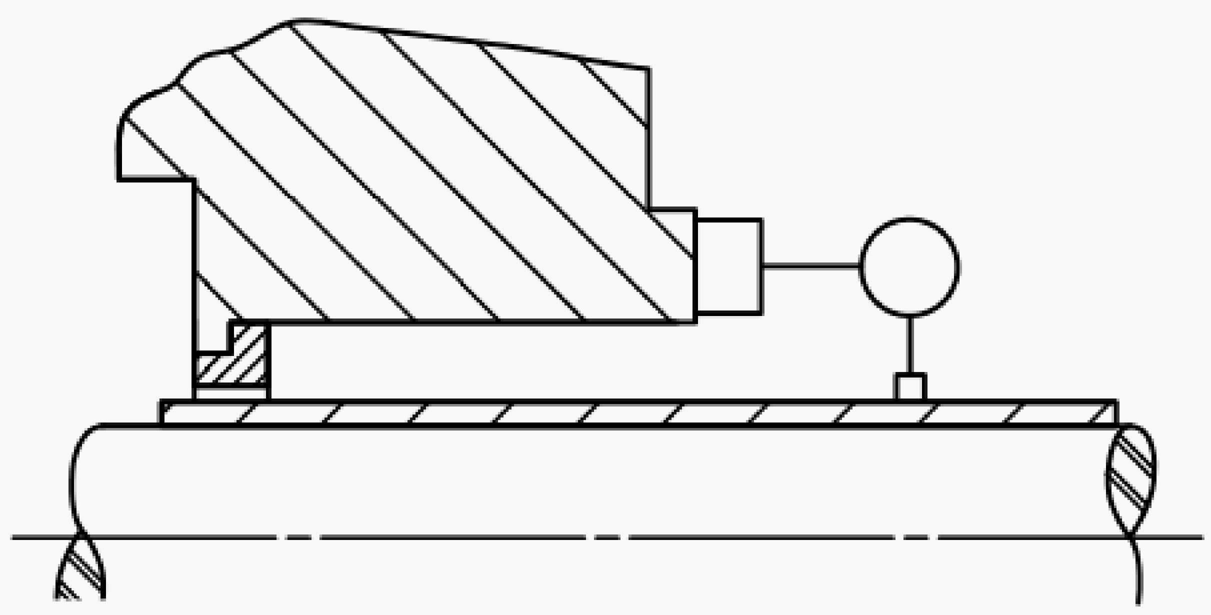

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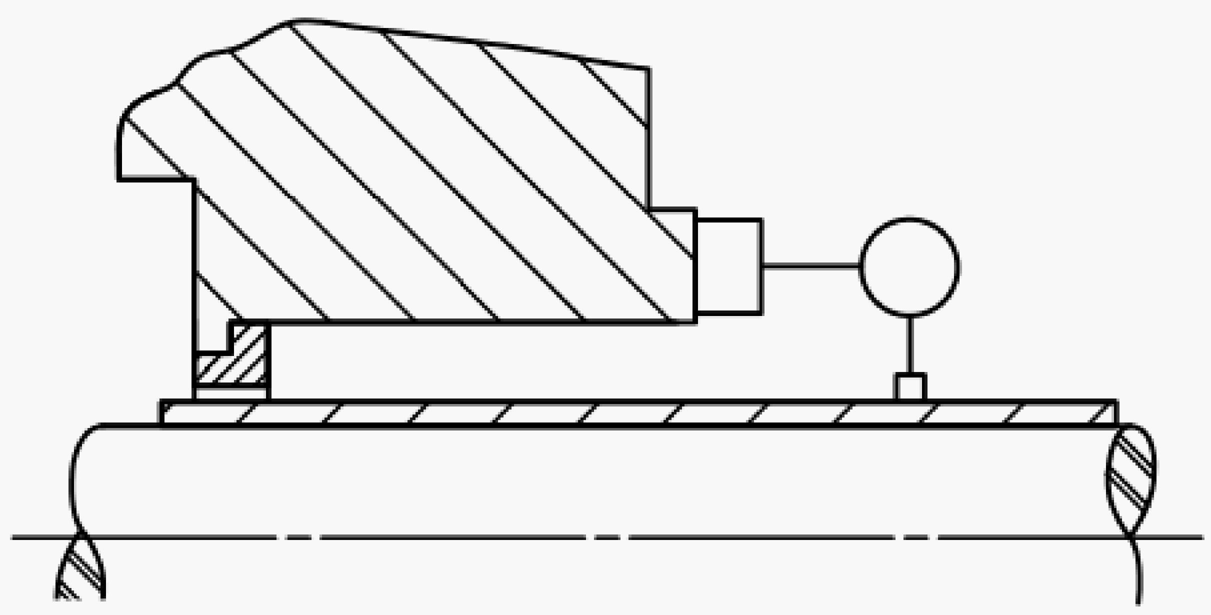

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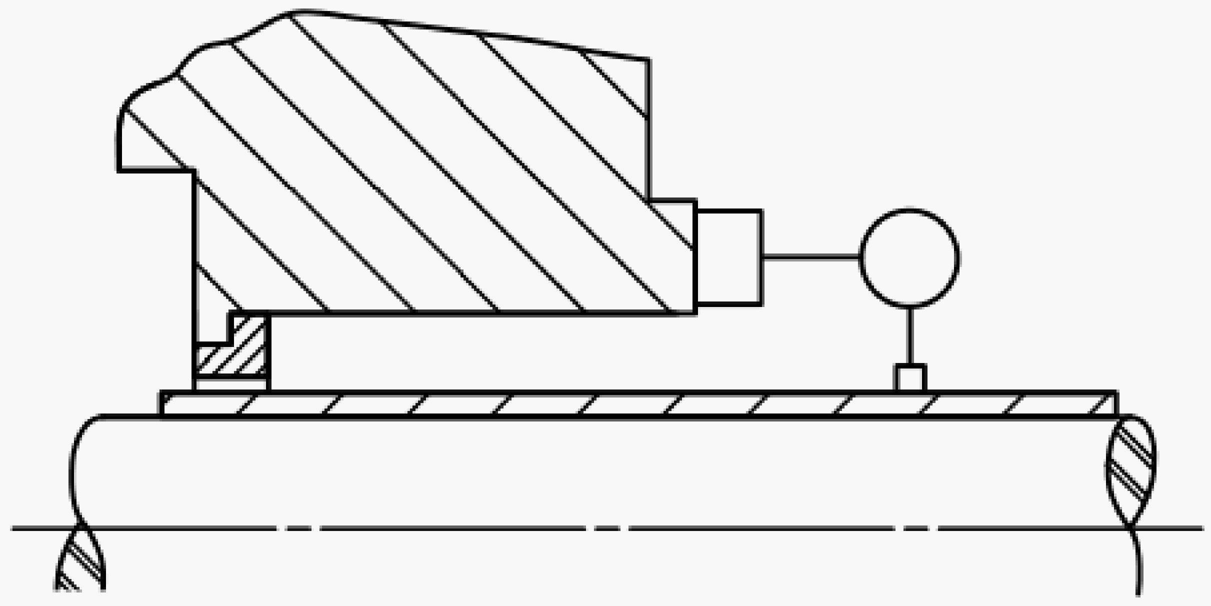


FIG. 1 SHAFT SLEEVE RUNOUT

4.5.5 Running Clearances. Running clearance must be sufficient to prevent internal rubbing contact within the design region (para. 5.1.6) and is subjected to the maximum allowable flange loads as specified in para. 5.1.2.

4.5.6 Critical Speed. The first lateral critical speed of the rotating assembly shall be at least 120% of the maximum operating speed. A ''dry critical speed'' calculation (see HI 9.6.4) is adequate to verify compliance. HI 9.6.4 shall be used to calculate static deflections used for the critical speed calculation.

4.5.7 Fillets and Radii. All shaft shoulder fillets and radii shall be made as large as practical and finished to reduce additional stress risers.

4.6 Shaft Sealing

4.6.1 Design. Two basic types of sealing covers shall be offered, one called a seal chamber and a second called a stuffing box. The seal chamber is designed to accommodate mechanical seals only and can be of several designs for various types of seals. The design includes a separate gland plate where required. The stuffing box is designed for packing, but may be able to accommodate mechanical seals as an alternative. Figures 2 and 3 show some piping systems that can be used with the various seals shown in Fig. 4. A separate universal cover adapter to accommodate either a seal chamber or stuffing box is optional.

4.6.2 Seal Chamber. The seal chamber can be a cylindrical or a tapered design. The tapered bore seal chamber shall have a minimum of a 4 deg taper open toward the pump impeller.

(c) Pump Casing Jacket
(d) Bolt on External Heating and Cooling Jacket
(e) Bearing Housing Cooling

4.3.6 Gasket(s). The casing-to-cover gasket shall be confined on the atmospheric side to prevent blowout.

4.4 Impeller

4.4.1 Types. Impellers of open, semi-open, and closed designs are optional.

4.4.2 Adjustment. Means for external adjustment (without disassembly of the pump except for the coupling guard) of the impeller axial clearance shall be provided if adjustment is required by the design.

4.4.3 Balance. Impellers shall meet ISO 1940 Grade 6.3 after final machining.

4.4.4 Attachment. The impeller may be keyed or threaded to the shaft with rotation to tighten. Shaft threads and keyways shall be protected so they will not be wetted by the pumped liquid.

4.5 Shaft

4.5.1 Diameter. The seal mounting surface includes the shaft or shaft sleeve outside diameter within the stuffing box or seal chamber and enough length beyond to accommodate outside seals. The diameter of the seal mounting surface shall be sized in increments of $\frac{1}{8}$ in. (3.2 mm). To provide for the use of mechanical seals, the tolerance on that diameter shall not exceed nominal to minus 0.002 in. (0.05 mm).

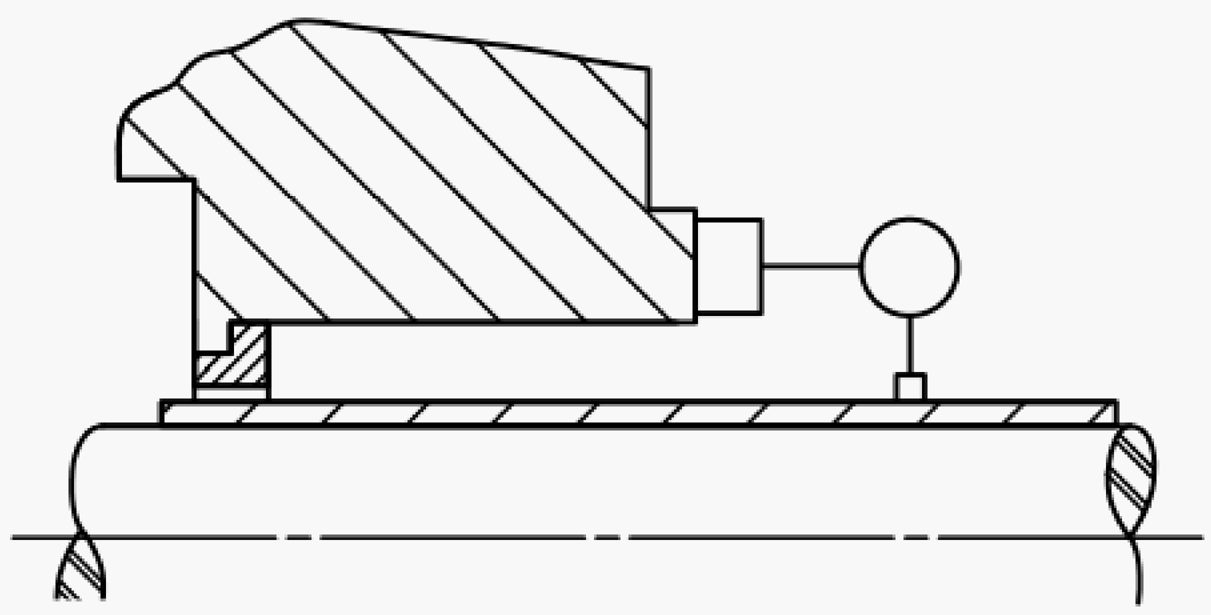
4.5.2 Finish. Surface finish of the shaft or sleeve through the stuffing box or seal chamber and at rubbing contact bearing housing seals shall not exceed an arithmetic roughness average of 32 μin. (0.8 μm) unless otherwise required for the mechanical seal.

4.5.3 Runout. Shaft runout shall be limited as follows:

(a) shaft rotated on centers: 0.001 in. (0.025 mm) full indicator movement (FIM) reading at any point;

(b) outside diameter of shaft or removable sleeve when installed in pump: 0.002 in. (0.05 mm) FIM at the gland end of stuffing box or seal chamber (see Fig. 1).

4.5.4 Deflection. Dynamic shaft deflection at the impeller centerline shall not exceed 0.005 in. (0.13 mm) anywhere within the design region as specified in para. 5.1.6. Hydraulic loads and shaft deflection shall be calculated in accordance with HI 1.3.



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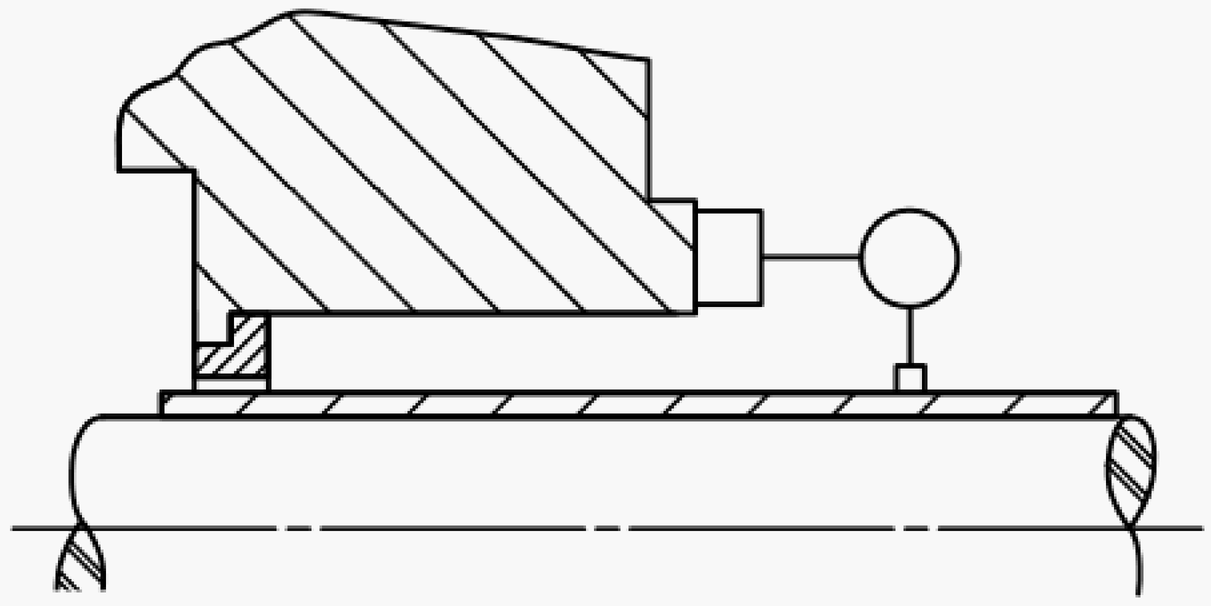

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