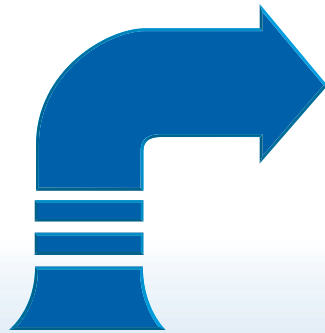




ANSI/HI 9.6.2-2015

American National Standard for

Rotodynamic Pumps

for Assessment of Applied Nozzle
Loads



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Rotodynamic Pumps for Assessment of Applied Nozzle Loads

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Approved May 15, 2015
American National Standards Institute, Inc.

American National Standard

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Foreword (Not part of Standard)

Purpose and aims of the Hydraulic Institute

The purpose and aims of the Institute are to promote the continued growth and well-being of pump manufacturers and further the interests of the public in such matters as are involved in manufacturing, engineering, distribution, safety, transportation, and other problems of the industry, and to this end, among other things:

- a) To develop and publish standards for pumps;
- b) To collect and disseminate information of value to its members and to the public;
- c) To appear for its members before governmental departments and agencies and other bodies in regard to matters affecting the industry;
- d) To increase the amount and to improve the quality of pump service to the public;
- e) To support educational and research activities;
- f) To promote the business interests of its members but not to engage in business of the kind ordinarily carried on for profit or to perform particular services for its members or individual persons as distinguished from activities to improve the business conditions and lawful interests of all of its members.

Purpose of Standards

- 1) Hydraulic Institute Standards are adopted in the public interest and are designed to help eliminate misunderstandings between the manufacturer, the purchaser, and/or the user and to assist the purchaser in selecting and obtaining the proper product for a particular need.
- 2) Use of Hydraulic Institute Standards is completely voluntary. Existence of Hydraulic Institute Standards does not in any respect preclude a member from manufacturing or selling products not conforming to the Standards.

Definition of a Standard of the Hydraulic Institute

Quoting from Article XV, Standards, of the By-Laws of the Institute, Section B:

“An Institute Standard defines the product, material, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing and service for which designed.”

Comments from users

Comments from users of this standard will be appreciated, to help the Hydraulic Institute prepare even more useful future editions. Questions arising from the content of this standard may be sent to the Technical Director of the Hydraulic Institute. The inquiry will then be directed to the appropriate technical committee for provision of a suitable answer.

If a dispute arises regarding contents of a Hydraulic 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 parentheses. Charts, graphs, and sample calculations are also shown in both metric and US customary units. Since values given in metric units are not exact equivalents to values given in US customary units, it is important that the selected units of measure to be applied be stated in reference to this standard. If no such statement is provided, metric units shall govern.

Consensus for this standard was achieved by use of the canvass method

The following organizations, recognized as having an interest in the standardization of centrifugal pumps, were contacted prior to the approval of this revision of the standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

Albemarle Corporation	Leistritz Advanced Technologies Corp.
Black & Beatch (B&V)	LVVWD – Las Vegas Valley Water District
Brown and Caldwell	Patterson Pump Company
DuPont Company	Pentair – Berkeley Pentair - Fairbanks Nijhuis
ekwestrel corp	Summit Pump, Inc.
Fluid Sealing Association	TACO, Inc.
Healy Engineering, Inc.	Tuthill Pump Group
Hidrostal	WEG Electric Corp.
Hydraulic, Measurement, & Inspection Consulting	Weir Floway, Inc.
John Anspach Consulting	Weir Minerals North America
Kemet Inc.	Xylem Inc. – Applied Water Systems

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 - Lucian Dobrot, ITT Corporation
Vice-chair - Jim Roberts, Xylem Inc. - Applied Water Systems

Committee Members

Ravindra Birajdar
Randal Ferman
Hal McKinnon
Ken Patton
Jessica Phillips
Fred Walker
Clint Zentic

Company

Kirloskar Brothers Ltd.
ekwestrel corp.
Lewis Pumps
Colfax Fluid Handling
Flowserve Corporation
Weir Floway, Inc.
Sulzer Pumps (US) Inc.

Alternate Members

Raquel Benito
Dan Boldt
Michael Mueller
Paul Ruzicka

Company

Sulzer Pumps (US) Inc.
Weir Floway, Inc.
Flowserve Corporation
Xylem Inc. - Applied Water Systems

9.6.2 Rotodynamic pumps for assessment of applied nozzle loads

9.6.2.0 Scope

This standard includes recommendations for assessment of applied nozzle loads for the following pump types. When specified by the user, pumps supplied shall conform to these requirements.

- a) Horizontal end suction single stage (ANSI/ASME B73.1 and B73.3).
- b) Vertical in-line single stage (ANSI/ASME B73.2).
- c) Axially split one and two stage (BB1).
- d) Vertically suspended pump single casing discharge through column with diffuser and volute (VS1 and VS2).

Many other pump types are not included because of the different designs that are unique to each manufacturer. For pump types outside the scope of this standard, allowable nozzle loads should be established by the pump manufacturer, applied nozzle loads predicted by the purchaser, and differences, if any, negotiated and resolved by the two parties.

For assessment of applied nozzle loads for slurry pumps, see ANSI/HI 12.1-12.6 *Rotodynamic (Centrifugal) Slurry Pumps for Nomenclature, Definitions, Applications, and Operation*.

9.6.2.1 Horizontal end suction pumps (ANSI/ASME B73.1 and B73.3)

9.6.2.1.1 Scope

This section covers assessment of applied nozzle loads for the following horizontal end suction pump types:

- a) Pumps designed and constructed in accordance with ASME B73.1, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*. For metallic pumps, the pump casing and seal chamber or stuffing box must be constructed of a material listed in Table 9.6.2.1.3.5 and subjected to temperatures between -30 and 370 °C (-20 and 700 °F) unless otherwise specified. For thermoplastic and thermoset polymer material pumps, the pump must be constructed of a material with a modulus of elasticity at 20 °C (68 °F) greater than 6.9×10^9 N/m² (10^6 psi) and may be subjected to temperatures between -30 and 93 °C (-20 and 200 °F).
- b) Magnetic drive pumps designed and constructed in accordance with ASME B73.3, *Specification for Sealless Horizontal End Suction Metallic Centrifugal Pumps for Chemical Process*, with Class 150 and 300 flanges. To be applicable, the pump casing must be constructed of a material listed in Table 9.6.2.1.3.5 and subjected to temperatures between -30 and 260 °C (-20 and 500 °F) unless otherwise specified.

9.6.2.1.2 Nomenclature and definitions

9.6.2.1.2.1 Source

The nomenclature and definitions of pump components shall be in accordance with those promulgated by the Hydraulic Institute.

9.6.2.1.2.2 Definitions (refer to Figure 9.6.2.1.2.2)

F_{x_s} = applied force on x_s -axis on suction nozzle, to be assessed using Equation Sets 1-5

F_{y_s} = applied force on y_s -axis on suction nozzle, to be assessed using Equation Sets 1-5

F_{z_s} = applied force on z_s -axis on suction nozzle, to be assessed using Equation Sets 1-5

M_{x_s} = applied moment about x_s -axis on suction nozzle, to be assessed using Equation Sets 1-5

M_{y_s} = applied moment about y_s -axis on suction nozzle, to be assessed using Equation Sets 1-5

M_{z_s} = applied moment about z_s -axis on suction nozzle, to be assessed using Equation Sets 1-5

F_{x_d} = applied force on x_d -axis on discharge nozzle, to be assessed using Equation Sets 1-5

F_{y_d} = applied force on y_d -axis on discharge nozzle, to be assessed using Equation Sets 1-5

F_{z_d} = applied force on z_d -axis on discharge nozzle, to be assessed using Equation Sets 1-5

M_{x_d} = applied moment about x_d -axis on discharge nozzle, to be assessed using Equation Sets 1-5

M_{y_d} = applied moment about y_d -axis on discharge nozzle, to be assessed using Equation Sets 1-5

M_{z_d} = applied moment about z_d -axis on discharge nozzle, to be assessed using Equation Sets 1-5

$F_{x_s \max}$ = maximum value of force on x_s -axis on suction nozzle, to be used with Equation Sets 1-5

$F_{y_s \max}$ = maximum value of force on y_s -axis on suction nozzle, to be used with Equation Sets 1-5

$F_{z_s \max}$ = maximum value of force on z_s -axis on suction nozzle, to be used with Equation Sets 1-5

$M_{x_s \max}$ = maximum value of moment about x_s -axis on suction nozzle, to be used with Equation Sets 1-5

$M_{y_s \max}$ = maximum value of moment about y_s -axis on suction nozzle, to be used with Equation Sets 1-5

$M_{z_s \max}$ = maximum value of moment about z_s -axis on suction nozzle, to be used with Equation Sets 1-5

$F_{x_d \max}$ = maximum value of force on x_d -axis on discharge nozzle, to be used with Equation Sets 1-5

$F_{y_d \max}$ = maximum value of force on y_d -axis on discharge nozzle, to be used with Equation Sets 1-5

$F_{z_d \max}$ = maximum value of force on z_d -axis on discharge nozzle, to be used with Equation Sets 1-5

$M_{x_d \max}$ = maximum value of moment about x_d -axis on discharge nozzle, to be used with Equation Sets 1-5

$M_{y_d \max}$ = maximum value of moment about y_d -axis on discharge nozzle, to be used with Equation Sets 1-5

$M_{z_d \max}$ = maximum value of moment about z_d -axis on discharge nozzle, to be used with Equation Sets 1-5

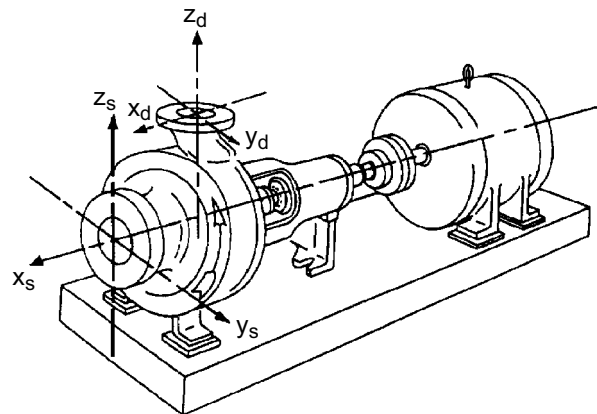


Figure 9.6.2.1.2.2 — Coordinate system for ASME B73.1 and B73.3 horizontal end suction pumps

Group 1 is defined as ASME B73.1 and B73.3 sizes AA and AB; two-/four-pole, 60-cycle speed, and up to 15/7.5 kW (20/10 hp).

Group 2 is defined as ASME B73.1 and B73.3 sizes A05, A10, A20, A30, A50, A40, A60, A70, and A80; two-/four-pole, 60-cycle speed, and up to 97/48 kW (130/65 hp).

Group 3 is defined as ASME B73.1 and B73.3 sizes A90, A100, A110, and A120; four-/six-pole, 60-cycle speed, and up to 164/109 kW (220/146 hp).

9.6.2.1.3 Criteria for loading allowances

9.6.2.1.3.1 Driver/pump coupling alignment

The radial movement of the pump shaft at the pump coupling hub due to nozzle loads shall not exceed 0.125 mm (0.005 in) relative to initial alignment. Axial movement of the pump shaft at the pump coupling hub is not considered in this standard.

9.6.2.1.3.2 Internal pump distortion

No contact between casing and impeller is allowed.

The radial movement of the pump shaft with respect to the seal chamber due to nozzle loads shall not exceed 0.05 mm (0.002 in) relative to initial position.

9.6.2.1.3.3 Pump hold-down bolts

Fasteners used for hold-down bolts should have yield strength greater than or equal to the minimum yield strength of SAE J429 Grade 1 fasteners (2.5×10^8 N/m² or 36,000 psi). The maximum allowable tensile stress in the pump hold-down bolts should be 90% of fastener's material yield strength. The maximum allowable shear stress in the pump hold-down bolts should be 90% of fastener's material shear strength (the shear strength of carbon steel fasteners can be approximated to be 60% of their minimum tensile strengths).

The pump shall be bolted to the baseplate at both the casing feet and rear foot position(s) and sufficiently tightened to prevent slippage of the pump on the baseplate. Required torque values should be calculated based on the required clamp load. It may be necessary to arrange for periodic tightening of the bolts to maintain required torque levels.

9.6.2.1.3.4 Pump mounting

The base for which the loads in Tables 9.6.2.1.4b through 9.6.2.1.4e are established must be a fully grouted metal baseplate with anchor bolts. The base as a minimum must withstand the applied nozzle loads combined with normal operating loads (e.g., driver weight and pump weight).

It is recommended the baseplate be installed and grouted in accordance with ANSI/HI 1.4 *Rotodynamic (Centrifugal) Pumps for Manuals Describing Installation, Operation, and Maintenance*.

9.6.2.1.3.5 Nozzle stress

The maximum stresses developed in the pump nozzles and flanges, constructed of a material listed in Table 9.6.2.1.3.5, by the applied nozzle loads, combined with internal pressure, shall not exceed 1.8×10^8 N/m² (26,250 psi) tensile and 9×10^7 N/m² (13,125 psi) shear. By applying the temperature and material adjustment factors of Section 9.6.2.1.3.5, applied nozzle loads may be increased for stronger materials and must be decreased for weaker materials.

Table 9.6.2.1.3.5 — List of material specifications as used in Table 9.6.2.1.6.2.2

Material Groups		Castings	
Material Group No.	Nominal Designation	Spec. No.	Grade(s)
1.0	Ductile Iron	A395	---
1.1	Carbon Steel	A216	WCB
2.1	Type 304	A744	CF-8
2.2	Type 316	A744	CF-8M
2.3	Type 304L Type 316L	A744	CF-3 CF-3M
2.4	Type 321	---	---
2.8	CD-4MCu CD-4MCu	A744 A890	CD-4MCu CD-4MCu Grade 1A, 1B
3.1	Alloy 20	A744	CN-7M
3.2	Nickel	A494	CZ-100
3.4	Monel	A744	M-35-1 M-30C M-35-2
3.5	Inconel 600 Inconel 625 Inconel 825	A744 A744 A744	CY-40 CW-6MC Cu-5MCuC
3.7	Hastelloy B	A494	N-12MV N-7M
3.8	Hastelloy C	A494	CW-6M CW-2M CW-12MW CX-2MW

The allowable suction nozzle stress was based on three-dimensional stress analysis methods. The allowable discharge nozzle stress was based on the method contained in the ASME Boiler and Pressure Vessel Code, 1983 edition, Section III, NC 3653, due to its complex geometry.

9.6.2.1.3.6 Pressure/temperature

Any temperature referenced in Section 9.6.2.1 is the temperature of the pressure-containing components of the pump. In general, this temperature is the same as that of the contained liquid.

Use of a pressure rating as specified in ANSI/ASME B16.5 corresponding to a temperature other than that of the contained liquid is the responsibility of the user, subject to the requirements of the applicable code or regulation.

Low-temperature and high-temperature considerations addressed in ANSI/ASME B16.5 should be examined.

9.6.2.1.4 ANSI/ASME B73.1 pump assessment of applied nozzle loads

9.6.2.1.4.1 Metallic pumps

Loads given in Tables 9.6.2.1.4b through 9.6.2.1.4e are applicable for ASME B73.1 pumps constructed of ASTM A351/A351M - Grade CF8M (Type 316SS) operated between -30 and 38 °C (-20 and 100 °F) and mounted on a grouted metal baseplate with anchor bolts.

For an individual force or moment, pumps must be capable of satisfactory operation when subjected to loads shown in Table 9.6.2.1.4b (adjusted if applicable) while meeting the criteria of Equation Set 1 (see Table 9.6.2.1.4a).

For a combination of more than one force and/or moment, pumps must be capable of satisfactory operation when subjected to the loads in Tables 9.6.2.1.4c through 9.6.2.1.4e (adjusted if applicable) while meeting the criteria of Equation Sets 2 – 5. When combining loads, the absolute value of any individual load must not exceed the value given in Table 9.6.2.1.4b.

Adjustment of the tabulated maximum forces and moments load values is required if any of the following occur:

- Temperature is above 38 °C (100 °F).
- The pump material construction is not ASTM A351/A351M - Grade CF8M.
- The base is not a fully grouted metal baseplate with anchor bolts.

Refer to Section 9.6.2.1.6 for adjustment factors.

Table 9.6.2.1.4a — Equation Sets 1 through 5 (Using the maximum forces and moments of the referenced tables, applied loads shall satisfy the criteria defined by these equations.)

Set	Equation	Reference	Remarks
1	$\left \frac{F_{x_s}}{F_{x_s \max}} \right \leq 1, \left \frac{F_{y_s}}{F_{y_s \max}} \right \leq 1, \left \frac{F_{z_s}}{F_{z_s \max}} \right \leq 1, \left \frac{M_{x_s}}{M_{x_s \max}} \right \leq 1, \left \frac{M_{y_s}}{M_{y_s \max}} \right \leq 1, \left \frac{M_{z_s}}{M_{z_s \max}} \right \leq 1,$ $\left \frac{F_{x_d}}{F_{x_d \max}} \right \leq 1, \left \frac{F_{y_d}}{F_{y_d \max}} \right \leq 1, \left \frac{F_{z_d}}{F_{z_d \max}} \right \leq 1, \left \frac{M_{x_d}}{M_{x_d \max}} \right \leq 1, \left \frac{M_{y_d}}{M_{y_d \max}} \right \leq 1, \left \frac{M_{z_d}}{M_{z_d \max}} \right \leq 1$	Table 9.6.2.1.4b	Individual loading
2	$\left \frac{F_{x_s}}{F_{x_s \max}} \right + \left \frac{F_{y_s}}{F_{y_s \max}} \right + \left \frac{F_{z_s}}{F_{z_s \max}} \right + \left \frac{M_{x_s}}{M_{x_s \max}} \right + \left \frac{M_{y_s}}{M_{y_s \max}} \right + \left \frac{M_{z_s}}{M_{z_s \max}} \right +$ $\left \frac{F_{x_d}}{F_{x_d \max}} \right + \left \frac{F_{y_d}}{F_{y_d \max}} \right + \left \frac{F_{z_d}}{F_{z_d \max}} \right + \left \frac{M_{x_d}}{M_{x_d \max}} \right + \left \frac{M_{y_d}}{M_{y_d \max}} \right + \left \frac{M_{z_d}}{M_{z_d \max}} \right \leq 2$	Table 9.6.2.1.4c	Nozzle stress, hold-down bolt stress, pumps slippage
3	$a = \left \frac{F_{y_s}}{F_{y_s \max}} + \frac{M_{x_s}}{M_{x_s \max}} + \frac{M_{y_s}}{M_{y_s \max}} + \frac{M_{z_s}}{M_{z_s \max}} + \frac{F_{y_d}}{F_{y_d \max}} + \frac{M_{x_d}}{M_{x_d \max}} + \frac{M_{y_d}}{M_{y_d \max}} + \frac{M_{z_d}}{M_{z_d \max}} \right \leq 1$	Table 9.6.2.1.4d	y-axis movement
4	$b = \left \frac{F_{x_s}}{F_{x_s \max}} + \frac{F_{z_s}}{F_{z_s \max}} + \frac{M_{x_s}}{M_{x_s \max}} + \frac{M_{y_s}}{M_{y_s \max}} + \frac{M_{z_s}}{M_{z_s \max}} + \frac{F_{x_d}}{F_{x_d \max}} \right.$ $\left. + \frac{F_{y_d}}{F_{y_d \max}} + \frac{M_{x_d}}{M_{x_d \max}} + \frac{M_{y_d}}{M_{y_d \max}} + \frac{M_{z_d}}{M_{z_d \max}} \right \leq 1$	Table 9.6.2.1.4e	z-axis movement
5	$a^2 + b^2 \leq 1$	Equation Sets 3 and 4	Combined axis movement

Table 9.6.2.1.4b — Maximum forces and moments for use with Equation Set 1 to assess applied loads

ASME B73 Designation	Pump Size	Suction						Discharge					
		Forces, N (lbf)			Moments, N•m (lbf•ft)			Forces, N (lbf)			Moments, N•m (lbf•ft)		
		$F_{x_s \max}$	$F_{y_s \max}$	$F_{z_s \max}$	$M_{x_s \max}$	$M_{y_s \max}$	$M_{z_s \max}$	$F_{x_d \max}$	$F_{y_d \max}$	$F_{z_d \max}$	$M_{x_d \max}$	$M_{y_d \max}$	$M_{z_d \max}$
AA	1.5 × 1 × 6	4671 (1050)	3336 (750)	3336 (750)	976 (720)	230 (170)	230 (170)	3559 (800)	6005 (1350)	13,345 (3000)	556 (410)	556 (410)	556 (410)
AB	3 × 1.5 × 6	4671 (1050)	5516 (1240)	5560 (1250)	1220 (900)	664 (490)	664 (490)	3559 (800)	6005 (1350)	13,345 (3000)	678 (500)	746 (550)	691 (510)
A10	3 × 2 × 6	4671 (1050)	4671 (1050)	4671 (1050)	1220 (900)	298 (220)	298 (220)	3559 (800)	6005 (1350)	13,345 (3000)	678 (500)	1356 (1000)	691 (510)
AA	1.5 × 1 × 8	4671 (1050)	5382 (1210)	5382 (1210)	976 (720)	258 (190)	258 (190)	3559 (800)	6005 (1350)	13,345 (3000)	488 (360)	488 (360)	488 (360)
---	3 × 1.5 × 8 ^a	4671 (1050)	5516 (1240)	4671 (1050)	1220 (900)	664 (490)	664 (490)	3559 (800)	6005 (1350)	13,345 (3000)	597 (440)	597 (440)	597 (440)
A50	3 × 1.5 × 8	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	502 (370)	502 (370)	6228 (1400)	6005 (1350)	14,457 (3250)	624 (460)	624 (460)	624 (460)
A60	3 × 2 × 8	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	813 (600)	813 (600)	6228 (1400)	6005 (1350)	14,457 (3250)	895 (660)	895 (660)	895 (660)
A70	4 × 3 × 8	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	475 (350)	475 (350)	6228 (14000)	6005 (1350)	14,457 (3250)	1627 (1200)	1980 (1460)	936 (690)
A05	2 × 1 × 10	10,409 (2340)	4270 (960)	4270 (960)	1722 (1270)	298 (220)	298 (220)	6228 (1400)	6005 (1350)	14,457 (3250)	895 (660)	895 (660)	895 (660)
A50	3 × 1.5 × 10	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	569 (420)	569 (420)	6228 (1400)	6005 (1350)	14,457 (3250)	502 (370)	502 (370)	502 (370)
A60	3 × 2 × 10	12,010 (2700)	6005 (1350)	6583 (1480)	1763 (1300)	420 (310)	420 (310)	6228 (1400)	6005 (1350)	14,457 (3250)	759 (560)	759 (560)	759 (560)
A70	4 × 3 × 10	10,231 (2300)	6005 (1350)	6672 (1500)	1763 (1300)	420 (310)	420 (310)	6228 (1400)	6005 (1350)	14,457 (3250)	1627 (1200)	1980 (1460)	936 (690)
A80	6 × 4 × 10	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	1491 (1100)	1491 (1100)	6228 (1400)	6005 (1350)	14,457 (3250)	1627 (1200)	2034 (1500)	936 (690)
A20	3 × 1.5 × 13	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	908 (670)	908 (670)	6228 (1400)	6005 (1350)	14,457 (3250)	719 (530)	719 (530)	719 (530)
A30	3 × 2 × 13	8541 (1920)	5471 (1230)	5471 (1230)	1763 (1300)	475 (350)	475 (350)	6228 (1400)	6005 (1350)	14,457 (3250)	1627 (1200)	1722 (1270)	936 (690)
A40	4 × 3 × 13	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	542 (400)	542 (400)	6228 (1400)	6005 (1350)	14,457 (3250)	1627 (1200)	2034 (1500)	936 (690)
A80	6 × 4 × 13	12,010 (2700)	6005 (1350)	6672 (1500)	1763 (1300)	1763 (1300)	1491 (1100)	6228 (1400)	6005 (1350)	14,457 (3250)	1627 (1200)	2034 (1500)	936 (690)
A90	8 × 6 × 13	15,569 (3500)	14,145 (3180)	8896 (2000)	2034 (1500)	1586 (1170)	1586 (1170)	6672 (1500)	13,345 (3000)	15,569 (3500)	1695 (1250)	3851 (2840)	3851 (2840)
A100	10 × 8 × 13	15,569 (3500)	14,145 (3180)	8896 (2000)	2034 (1500)	2712 (2000)	2150 (2915)	6672 (1500)	13,345 (3000)	15,569 (3500)	1695 (1250)	3851 (2840)	3851 (2840)
A110	8 × 6 × 15	15,569 (3500)	14,145 (3180)	8896 (2000)	2034 (1500)	2007 (1480)	2007 (1480)	6672 (1500)	13,345 (3000)	15,569 (3500)	1695 (1250)	3851 (2840)	3851 (2840)
A120	10 × 8 × 15	15,569 (3500)	14,145 (3180)	8896 (2000)	2034 (1500)	1532 (1130)	1532 (1130)	6672 (1500)	13,345 (3000)	15,569 (3500)	1695 (1250)	3851 (2840)	3851 (2840)

NOTE: Please note that certain sizes do not follow a trend of increased allowable nozzle loads with increased pump size. This is due to interaction of individual pump geometry (i.e., nozzle wall thickness, distance from flange face to nozzle connection with casing, etc.).

^a This is not an ASME size. It is included here as a special Group 1 size that is common among manufacturers.

Table 9.6.2.1.4c — Maximum forces and moments for use with Equation Set 2 to assess applied loads

ASME B73 Design- ation	Pump Size	Suction						Discharge					
		Forces, N (lbf)			Moments, N•m (lbf•ft)			Forces, N (lbf)			Moments, N•m (lbf•ft)		
		$F_{x_s \max}$	$F_{y_s \max}$	$F_{z_s \max}$	$M_{x_s \max}$	$M_{y_s \max}$	$M_{z_s \max}$	$F_{x_d \max}$	$F_{y_d \max}$	$F_{z_d \max}$	$M_{x_d \max}$	$M_{y_d \max}$	$M_{z_d \max}$
AA	1.5 × 1 × 6	8985 (2020)	3336 (750)	3336 (750)	2481 (1830)	230 (170)	230 (170)	8985 (2020)	6005 (1350)	27,757 (6240)	556 (410)	556 (410)	556 (410)
AB	3 × 1.5 × 6	8985 (2020)	5516 (1240)	9386 (2110)	3105 (2290)	664 (490)	664 (490)	8985 (2020)	6005 (1350)	27,757 (6240)	746 (550)	746 (550)	746 (550)
A10	3 × 2 × 6	8985 (2020)	4671 (1050)	4671 (1050)	3105 (2290)	298 (220)	298 (220)	8985 (2020)	6005 (1350)	27,757 (6240)	1396 (1030)	1396 (1030)	691 (510)
AA	1.5 × 1 × 8	8985 (2020)	5382 (1210)	5382 (1210)	2481 (1830)	258 (190)	258 (190)	8985 (2020)	6005 (1350)	27,757 (6240)	488 (360)	488 (360)	488 (360)
—	3 × 1.5 × 8 ^a	8985 (2020)	5516 (1240)	7295 (1640)	3105 (2290)	664 (490)	664 (490)	8985 (2020)	6005 (1350)	27,757 (6240)	597 (440)	597 (440)	597 (440)
A50	3 × 1.5 × 8	12,010 (2700)	6005 (1350)	8096 (1820)	5057 (3730)	502 (370)	502 (370)	8985 (2020)	6005 (1350)	27,757 (6240)	624 (460)	624 (460)	624 (460)
A60	3 × 2 × 8	12,010 (2700)	6005 (1350)	11,076 (2490)	5057 (3730)	814 (600)	814 (600)	8763 (1970)	6005 (1350)	27,757 (6240)	895 (660)	895 (660)	895 (660)
A70	4 × 3 × 8	12,010 (2700)	6005 (1350)	8185 (1840)	5057 (3730)	475 (350)	475 (350)	8985 (2020)	6005 (1350)	27,757 (6240)	1980 (1460)	1980 (1460)	936 (690)
A05	2 × 1 × 10	10,409 (2340)	4270 (960)	4270 (960)	4936 (3640)	298 (220)	298 (220)	8985 (2020)	6005 (1350)	27,757 (6240)	895 (660)	895 (660)	895 (660)
A50	3 × 1.5 × 10	12,010 (2700)	6005 (1350)	8496 (1910)	5057 (3730)	569 (420)	569 (420)	8630 (1940)	6005 (1350)	27,757 (6240)	502 (370)	502 (370)	502 (370)
A60	3 × 2 × 10	12,010 (2700)	6005 (1350)	6583 (1480)	5057 (3730)	420 (310)	420 (310)	8985 (2020)	6005 (1350)	27,757 (6240)	759 (560)	759 (560)	759 (560)
A70	4 × 3 × 10	10,231 (2300)	6005 (1350)	7295 (1640)	5057 (3730)	420 (310)	420 (310)	8985 (2020)	6005 (1350)	27,757 (6240)	1980 (1460)	1980 (1460)	936 (690)
A80	6 × 4 × 10	12,010 (2700)	6005 (1350)	27,757 (6240)	5057 (3730)	1491 (1100)	1491 (1100)	8985 (2020)	6005 (1350)	27,757 (6240)	4203 (3100)	4203 (3100)	936 (690)
A20	3 × 1.5 × 13	12,010 (2700)	6005 (1350)	13,612 (3060)	5057 (3730)	908 (670)	908 (670)	8985 (2020)	6005 (1350)	27,757 (6240)	719 (530)	719 (530)	719 (530)
A30	3 × 2 × 13	8541 (1920)	5471 (1230)	5471 (1230)	5057 (3730)	475 (350)	475 (350)	8985 (2020)	6005 (1350)	27,757 (6240)	1980 (1460)	1980 (1460)	936 (690)
A40	4 × 3 × 13	12,010 (2700)	6005 (1350)	10,631 (2390)	5057 (3730)	542 (400)	542 (400)	8985 (2020)	6005 (1350)	27,757 (6240)	2346 (1730)	2346 (1730)	936 (690)
A80	6 × 4 × 13	12,010 (2700)	6005 (1350)	27,757 (6240)	5057 (3730)	6752 (4980)	1491 (1100)	8985 (2020)	6005 (1350)	27,757 (6240)	2915 (2150)	2915 (2150)	936 (690)
A90	8 × 6 × 13	28,291 (6360)	14,145 (3180)	22,597 (5080)	12,162 (8970)	1586 (1170)	1586 (1170)	28,291 (6360)	14,145 (3180)	59,873 (13,460)	9192 (6780)	5220 (3850)	3851 (2840)
A100	10 × 8 × 13	28,291 (6360)	14,145 (3180)	59,873 (13,460)	12,162 (8970)	3322 (2450)	2915 (2150)	28,291 (6360)	14,145 (3180)	59,873 (13,460)	12,162 (8970)	9789 (7220)	3851 (2840)
A110	8 × 6 × 15	28,291 (6360)	14,145 (3180)	29,714 (6680)	12,162 (8970)	2007 (1480)	2007 (1480)	28,291 (6360)	14,145 (3180)	59,873 (13,460)	8894 (6560)	5044 (3720)	3851 (2840)
A120	10 × 8 × 15	28,291 (6360)	14,145 (3180)	22,819 (5130)	12,162 (8970)	1532 (1130)	1532 (1130)	28,291 (6360)	14,145 (3180)	59,873 (13,460)	12,162 (8970)	12,284 (9060)	3851 (2840)

^a This is not an ASME size. It is included here as a special Group 1 size that is common among manufacturers.

Table 9.6.2.1.4d — Maximum forces and moments for use with Equation Set 3 to assess applied loads

Pump Group	Suction						Discharge					
	Forces, N (lbf)			Moments, N•m (lbf•ft)			Forces, N (lbf)			Moments, N•m (lbf•ft)		
		$F_{ys\ max}$		$M_{xs\ max}$	$M_{ys\ max}$	$M_{zs\ max}$		$F_{yd\ max}$		$M_{xd\ max}$	$M_{yd\ max}$	$M_{zd\ max}$
Group 1		–8896 (–2000)		1220 (900)	1627 (1200)	1695 (1250)		6672 (1500)		–678 (–500)	2034 (1500)	1695 (1250)
Group 2		–15,569 (–3500)		1763 (1300)	1763 (1300)	4067 (3000)		11,120 (2500)		–1627 (–1200)	2034 (1500)	4067 (3000)
Group 3		–22,241 (–5000)		2034 (1500)	2712 (2000)	5423 (4000)		4067 (3000)		–1695 (–1250)	6780 (5000)	5423 (4000)

Table 9.6.2.1.4e — Maximum forces and moments for use with Equation Set 4 to assess applied loads

Pump Group	Suction						Discharge					
	Forces, N (lbf)			Moments, N•m (lbf•ft)			Forces, N (lbf)			Moments, N•m (lbf•ft)		
	$F_{xs\ max}$		$F_{zs\ max}$	$M_{xs\ max}$	$M_{ys\ max}$	$M_{zs\ max}$	$F_{xd\ max}$	$F_{yd\ max}$	$F_{zd\ max}$	$M_{xd\ max}$	$M_{yd\ max}$	$M_{zd\ max}$
Group 1	4671 (1050)		–5560 (–1250)	2034 (1500)	1627 (1200)	–3390 (–2500)	3559 (800)	8896 (2000)	–13,345 (–3000)	2034 (1500)	1356 (1000)	–3390 (–2500)
Group 2	15,569 (3500)		–6672 (–1500)	2034 (1500)	1763 (1300)	–4745 (–3500)	6228 (1400)	11,121 (2500)	–14,457 (–3250)	2034 (1500)	2915 (2150)	–4745 (–3500)
Group 3	15,569 (3500)		–8896 (–2000)	2034 (1500)	5559 (4100)	–5423 (–4000)	15,569 (3500)	17,793 (4000)	–15,569 (–3500)	2034 (1500)	6779 (5000)	–5423 (–4000)

9.6.2.1.4.2 Composite pumps

By reducing the values in Tables 9.6.2.1.4b through 9.6.2.1.4e to 90% of their original values, the values are applicable for pumps mounted on a grouted metal baseplate with anchor bolts. Use Equation Sets 1 – 5 with these adjusted values.

If mounting the pump on a base other than a fully grouted metal baseplate with anchor bolts, refer to Section 9.6.2.1.6 for adjustment factor.

9.6.2.1.5 ANSI/ASME B73.3 sealless pump assessment of applied nozzle loads

Assessment of nozzle loads applied to pumps built to ASME B73.3, *Specification for Sealless Horizontal End Suction Centrifugal Pumps for Chemical Process* is identical to ASME B73.1 pumps. Refer to Section 9.6.2.1.4.

9.6.2.1.6 Nozzle load adjustment factors

The loads in the tables must be multiplied by adjustment factors when applicable. The lowest correction factor should be applied when more than one adjustment factor is involved. For example, if the pump is an ASME B73.1 pump (90% reduction factor) mounted on a fully grouted nonmetallic baseplate (80% reduction factor), then the reduction factor for Tables 9.6.2.1.4b through 9.6.2.1.4e would be 80%.

There may be cases where one adjustment factor is applied to Table 9.6.2.1.4c and another adjustment factor is applied to Tables 9.6.2.1.4d and 9.6.2.1.4e. These cases are denoted in the text.

Refer to Appendix A for further discussion of nozzle load reduction factors.