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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY
NATIONAL IRANIAN OIL ENGINEERING
& CONSTRUCTION COMPANY

NIOEC SP

NIOEC SPECIFICATION FOR RECIPROCATING PUMPS

FIRST EDITION

JULY, 2005

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IN THE NAME OF GOD**FOREWORD**

By their very nature, technical Specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such Specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international Standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant Specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design and Engineering Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design and Engineering Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design and Engineering Director of NIOEC for evaluation and approval.

REVISION INDEX

REV. PAGE	1	2	3	4	5	REV. PAGE	1	2	3	4	5	REV. PAGE	1	2	3	4	5	REV. PAGE	1	2	3	4	5
1						26						51						76					
2	X					27						52						77					
3	X					28						53						78					
4	X					29						54						79					
5	X					30						55						80					
6	X					31						56						81					
7	X					32						57						82					
8	X					33						58						83					
9	X					34						59						84					
10	X					35						60						85					
11						36						61						86					
12						37						62						87					
13						38						63						88					
14						39						64						89					
15						40						65						90					
16						41						66						91					
17						42						67						92					
18						43						68						93					
19						44						69						94					
20						45						70						95					
21						46						71						96					
22						47						72						97					
23						48						73						98					
24						49						74						99					
25						50						75						100					

NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 3) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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CONTENTS:	PAGE NO.
INTRODUCTION.....	2
1. SCOPE.....	2
2. REFERENCES.....	2
3. UNITS.....	3
4. DEFINITION & TERMINOLOGY	3
5. MODIFICATION TO API 674.....	3

INTRODUCTION

To satisfy the requirements of this NIOEC Specification, API 674 with the modifications as specified herein after shall be strictly followed.

The following annotations, as specified hereunder, have been used at the bottom right hand side of each clause or paragraph to indicate the type of change made to the equivalent clause or paragraph of API.

Substitution: The clause in API shall be deleted and replaced by the new clause in this Standard.

Addition: The new clause with the new number shall be added to the relevant section of API.

Modification: Part of the clause or paragraph in API shall be modified and/or the new description

1. SCOPE

NIOEC Specifications cover the minimum requirements for detailed engineering, procurements, testing inspection & construction of refinery/ oil plant, distribution depots, pump stations and pipelines.

Deviations from this specification will only be permitted on obtaining written approval from NIOEC.

Resolution on cases not explicitly stipulated in this Specification, or on cases where conflicts may arise among the requirements of the referenced IPS and the international standards, shall be made through written consent and approval of NIOEC.

Unless specific exception accompanied by a description of the proposed substitute is recorded under the heading "Exception" in the manufacturers proposal it, shall be mutually understood that the proposal is based on equipment which complies strictly with the requirements of these Specifications.

This Specification supplements the Specification sheets for each individual pump on which the operating conditions and special requirements are listed in detail.

Compliance with the provisions of this Specification does not relieve the Contractor and/or Vendor/Contractor of the responsibility of furnishing pumps and accessories of proper design, mechanically suited to meet operating guarantees at the specified service conditions.

This Specification covers the minimum requirements of reciprocating pumps for water and other general refinery services which shall conform to the American petroleum Institute standard 674 as supplemented and modified herein.

2. REFERENCES

The following standards, codes, and specifications, to the extent specified hereinafter, shall constitute a part of this NIOEC Specification. Latest edition of the undated referenced documents and the cited edition of the dated references shall apply. The applicability of changes made to the dated references, after the cited date shall be mutually agreed upon between NIOEC and the Vendor /Contractor.

API (AMERICAN PETROLEUM INSTITUTE)

API 674 "Position Displacement pump-Reciprocating", Third Edition– 2010

ASME (THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Boiler and Pressure Vessel Code, Section VIII, Div 1

OSHA (OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION)

NIOEC SP (NIOEC SPECIFICATION)

NIOEC-SP-00-10	"NIOEC Specification for Units"
NIOEC-SP-00-11	"NIOEC Specification for Civil Design Criteria"
NIOEC-SP-00-01	"NIOEC Specification for Site Condition"
NIOEC-SP-00-50	"NIOEC Specification for Design Criteria for Process and Mechanics"
NIOEC-SP-40-03	"NIOEC Specification for Spare Parts Requirements"
NIOEC-SP-40-04	"NIOEC Specification for Lubricating, Sealing and Controlling Oil"
NIOEC-SP-46-02	"NIOEC Specification for General Purpose Steam Turbines"
NIOEC-SP-47-10	"NIOEC Specification for Noise Control and Vibration"
NIOEC-SP-60-02	"NIOEC Specification for Low Voltage Induction Motors"

3. UNITS

International system of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

4. DEFINITION & TERMINOLOGY

This section contains definitions for the terms as they are used in this document.

Employer: National Iranian Oil Engineering and Construction Company (NIOEC).

Contractor: The person, firm, Company or consortium whose tender has been accepted by the Employer or legal successors in title to such person.

Purchaser: National Iranian Oil Engineering & Construction Company in cases where this Specification is part of a direct purchase by National Iranian Oil Engineering & Construction Company; In cases where this Specification is part of Contract Documents, "Purchaser" means the Contractor.

Vendor: The manufacturer's from which the equipment is to be purchased.

5. MODIFICATION TO API 674

The paragraph numbering follows API standard 674 and each paragraph denotes an addition, substitution or alteration. Those optional section not covered in the text are included in the pump data sheets.

2.1. (Modification)

Add the following sentence to the end of paragraph:

For Motors see NIOEC'S Specification NIOEC-SP-60-2. For turbines see NIOEC'S Specification NIOEC-SP-46-02.

6.1.5. (Substitution)

For control of the sound level refer to NIOEC Specification NIOEC-SP-47-10.

6.2.1. (Addition)

Side pot type piston pumps will be acceptable up to 27.58 bar(g) and 176.6°C. Plunger pumps shall be used for pressures greater than 34.48 bar (g) for all temperatures, and when pumping amines, caustics, and glycols.

6.2.2. (Addition)

Unless otherwise specified all power pumps shall be plunger pumps. Triplex power pumps are preferred.

6.4.1. (Modification)

Pressure casings and pressure retaining parts shall be of such thickness as will be suitable for the specified design and test pressure and pumping temperature with a 3 mm minimum corrosion allowance, the stress used in design for any given material shall not be in excess of the values given in section VIII, Div.1 of the ASME Boiler and Pressure Vessel Code for the same material.

All pumps in the process area which are pumping hydrocarbons shall have cast steel cylinders.

Cast iron or ductile iron shall not be used for pressure retaining parts handling flammable or toxic fluids.

6.4.8. (Addition)

Drive end cylinders shall be designed for at least 2 bar and 10°C over the design conditions of the driving medium. The manufacturer shall indicate the maximum safe working pressure and temperature of the drive end.

6.4.9. (Addition)

Pump used for tar, asphalt, and heavy oils may require steam jacketed rigid cylinders.

6.5.11. (Substitution)

Inlet and outlet connections shall be flanged and oriented as specified in the data sheets. Flanges that are not forged or cast integral with the cylinder shall be socket welded to the pump cylinder. Screwed and seal welded flanges are not acceptable.

6.5.15. (Addition)

All pumps shall be provided with flanged and valved vent and drain connections.

6.5.16. (Addition)

Tapped connections shall be provided for completely draining pump case of horizontal pumps.

6.5.17. (Addition)

All vents, lantern rings or case drains shall be ½ inch NPS as minimum.

6.7.1.3. (Modification)

d) Liners held in by follower and set screw require Purchaser's approval.

6.7.2.4. (Modification)

Solid plungers are preferred. Hollow plungers shall be water cooled for operating temperature 232.2° C and over.

6.7.2.6. (Addition)

Body and follower type pistons are preferred. Piston packing of the snap ring type is preferred, but sectional rings with expander springs tempered to hold tension under maximum operating temperature will be considered.

6.7.2.7. (Addition)

All components including driver and gears shall be suitable for a plunger loading of 1.15 time the design discharge pressure, or 3.45 bar (g) over the design discharge pressure, whichever is greater. Vendor shall indicate the maximum allowable plunger loading.

6.7.3. (Modification)

Valve seats shall be renewable. Valve seats shall be held by threads for pressures up to 27.58 bar (g) and temperatures less than 65.5° C, and press fit for all pressures when temperature exceeds 65.5°C, for non-corrosive services. For corrosive, services, valve seats shall not be threaded. Valve seats shall have sufficient metal to allow resurfacing.

6.7.3.1. (Addition)

Valves may be disc, ball, or wing guided as recommended by manufacturer for each specific service. Recommendation shall be based on pressure, NPSH requirement, velocities, viscosity of fluid, etc., and subject to Purchaser's approval. In general wing guided valves are preferred. Valves shall be arranged to eliminate gas pockets.

6.7.4. (Substitution)

Gaskets shall be one piece and of suitable material. For operating temperatures above 315.5°C, gaskets shall be steel jacketed asbestos-free. When pressure exceeds 27.58 bar (g) (and temperature above 148.9°C), soft steel gaskets shall be required. Gaskets shall be confined for operating pressure in excess of 17.24 bar (g).

6.7.5.1.5. (Addition)

Quench type glands requirement shall be specified in the data sheets.

6.7.5.1.6. (Addition)

Glands shall be bushed with a non-sparking material for liquid and gas ends.

6.7.5.3. (Modification)

Stuffing boxes shall have square end gland packing and shall be provided with lantern ring. Stuffing boxes shall be extra deep to accommodate sufficient packing to prevent leakage and be so dimensioned to accommodate standard size packing. The pump Vendor's recommendation for packing for the specified service is desired. Minimum number of packing rings shall be 6. All stuffing boxes shall be tapped for connection to a lantern ring.

Glands shall be easily removable and must permit replacement of packing without removal or disassembly of any other part of the pump. Pumps operating on high vacuum require liquid seal stuffing boxes.

6.8.1. (Substitution)

The provisions specified in 6.8.1a through 6.8.1d shall apply.

6.8.14. (Modification)

The power end shall be provided with a filtered vent and 1/4 NPT (minimum) connection for purging. An accessible drain 1/2 NPT (minimum) shall be provided at the lowest point of the sump. When an oil heater is required a drilled, tapped and plugged connection shall be provided for insertion of an oil heater.

6.8.15. (Addition)

Connecting rods on power frame reciprocating pumps shall have replaceable babbitt lined bearings.

6.8.16. (Addition)

Power frame pumps shall not be operated at more than 75% of their maximum allowable speed. Frame loading limitations, NPSH requirements, packing life and overall maintenance problems must all be considered in manufacturer recommended speed of these units.

6.10.2.1. (Modification)

For pressures over 68.9 bar (g) forced feed packing lubrication is required.

6.10.2.5. (Modification)

Pump Vendor shall supply force feed lubricator of Manzel Type or equivalent and all necessary piping and accessories for correct packing lubrication.

6.11.2.11. (Modification)

The presence of hydrogen sulfide shall be specified in the data sheets.

6.11.6.4. (Modification)

Inspection requirement of welds if required will be specified on the Data Sheets.

6.11.7.3. (Modification)

Carbon steels shall have an impact strength test at the lowest specified ambient temperature(-28°C) sufficient to qualify under the minimum Charpy V-notch impact energy requirements of the ASME Code, Section VIII, Division 1, paragraph UG-84.

6.12.4. (Modification)

In addition to the information which is indicated in API-item 6.12.4 the following information shall be also stamped or embossed.

m) Specific gravity of Liquid to be pumped.

n) Hydrostatic test pressure.

7.1.1.1. (Modification)

The type of driver shall be as specified in the Data Sheets.

Motor drivers shall conform to NIOEC- SP-60-02.

See also item 6.7.2.9 of this Specification.

7.1.1.2. (Modification)

Process conditions and variations if any will be as specified on the Data Sheets.

7.1.1.3. (Modification)

Starting conditions for the driven equipment will be as specified on the Data Sheets.

7.1.2.2. (Modification)

The type of motor and the electrical characteristics, type of enclosure, sound pressure level, area classification, type of insulation, ambient temperature and elevation all will be specified on the Data Sheets.

7.1.3.1. (Modification)

Steam turbine drivers shall conform to NIOEC-SP-46-02.

Drivers may be coupled or flanged.

7.2.6. (Substitution)

The Vendor shall mount and align the driver in his shop, unless otherwise specified on the data sheets.

7.2.8. (Modification)

Removable coupling guards shall be supplied by the Vendor. Coupling guards shall be of equal to or better than the requirements of (OSHA).

7.2.9. (Addition)

The coupling shall be dynamically balanced when the coupling size speed relationship is such that balancing is recommended by the coupling manufacturer.

7.3.1. (Modification)

Belt or chain drive pumps are not acceptable.

7.4.2.6. (Modification)

Delete "one hole" in 2nd. sentence and insert "two holes".

7.4.2.12. (Addition)

Shaft centerlines of turbine driven pumps shall be sufficiently raised on the baseplate to allow piping of turbine steam inlet end drain and leakage connections.

7.5.2.5. (Modification)

A constant speed governor and governor valve shall be furnished if specified on the Data Sheets.

7.5.4.4.2. (Modification)

Relief valves shall be set to relieve fully at not more than the maximum allowable working pressure of the cylinder but at not less than the 115% of the rated discharge pressure or 1.72 bar (g) Whichever is higher.

7.5.4.4.5. Stroke Counters (Addition)

5 digit stroke counters of the non-resetting type shall be fitted.

7.6.4. (Addition)

The Vendor shall review all piping, appurtenances such as pulsation suppression devices, and vessels immediately upstream or downstream of the equipment and supports. The Vendor shall advise the Purchaser on the basis of his knowledge and experience of any hazards in the use, sizing, arrangement, or the like, that may result in damage to the equipment.

7.7.1.2. (Modification)

When suction and /or discharge pulsation dampeners are specified on the Data sheets, these shall be furnished by the pump manufacturer. Dampeners of the volume bottle type are preferred. Dampeners shall preferably be arranged for direct connection to the pump and shall have connections matching the corresponding pump connections.

8.2. (Modification)

All tests and inspections shall be performed in accordance with the relevant NIOEC inspection and test procedures including Shop Inspection Procedure (SIP).

8.2.1.3. (Modification)

Parts and types of inspection required shall be specified on the data sheets.

8.2.1.5. (Addition)

The purchaser shall have the opportunity to witness all tests. The vendor shall notify the purchaser no less than 4 weeks before the date that the equipment will be ready for testing regardless of which type of witnessed or observed is specified. If the testing is rescheduled, the vendor shall notify the purchaser not less than 4 weeks before the new date.

8.2.2.1.1. (Modification)

All material shall be subject to inspection by the Purchaser or his appointed representative.

8.3.1.1. (Modification)

The tests which shall be performed on the pump shall be specified on the data sheets.

8.3.1.3. (Addition)

All motor and turbine drivers, gear units and auxiliary equipment furnished by the pump Vendor shall be given the approved manufacturer's procedure for shop running test.

8.3.1.4. (Addition)

The pump and driver shall be mounted on the base and tested as a complete unit unless otherwise approved by the Purchaser.

8.3.1.5. (Addition)

All pumps shall be given hydrostatic and running tests on water.

8.3.8. (Modification)

NPSH test are not required unless indicated otherwise on the data sheet. NPSH shall be based on water. Vendor's maximum allowable pump speed shall be stated in the proposal. Vendor shall recommend lower speeds if required by specified NPSH available, more viscous liquid or pump design.

8.4.3.1. (Substitution)

After all tests are completed and inspection is made, all exterior surfaces with the exception of machined surfaces shall be given a coat of manufacturer's standard nonlead and nonchromate paint.

8.4.3.8. (Modification)

Each pump shall be properly identified as required by the purchase order. No material shall be shipped separately. Miscellaneous parts shall be properly tagged or marked with the item number for which they are intended. All such parts shall be suitably boxed, firmly attached to the base plate, and shipped with the unit.

8.4.9. (Addition)

Packing used in tests shall be removed from the pump and new packing furnished for installation in the field.

9.1.1. (Addition)

Information to be supplied by Vendor:

Type and size of pump with descriptive brochure.

Capacity of pump at operating speed and 90% volumetric efficiency.

Operating speed

Driver H.P.

Required NPSH

Suction valve velocity fpm

Outline drawing of installation indicating direction of rotation, and nozzle position.

Max. allowable working pressure bar(g)

Max. hydrostatic pressure bar(g)

Required cooling water consumption.

Weight of pump and base plate separately.

Exploded view of pump.

Priced list of spares required for startup and 2 years continuous operation.

Vendor shall supply for a service discharge pressure in excess of 68.9 bar (g), a detailed drawing indicating methods of internal gasketing to prevent leakage from high pressure side.

9.2.2. (Modification)

Vendor may proceed with manufacturing while the Purchaser reviews the drawings, provided that Vendor accept in written to carry out all changes requested by Purchaser without any charges.

9.2.2.1. (Addition)

The number of prints and/or reproducibles required, and the time within which they are to be submitted by Vendor will be specified on Vendor Data Commitment Form.

Following information shall be provided on the drawings additionally to App.D:

The Purchaser's order number (on every drawing).

The Purchaser's equipment item number (on every drawing).

The weight of the complete unit or of each major assembly, the weight of the heaviest piece of equipment that must be handled for erection, and the weights of significant items to be handled for maintenance.

All principal dimensions, including those required for the Purchaser's foundation, piping design, maintenance clearances, and dismantling clearances.

The direction and magnitude of all unbalanced forces and couples and the location of center of gravity shall be provided on the drawing by the Vendor.

The direction of rotation.

The size, type, location, and identification of all Purchaser's connections, including vents, drains, lubricating oil, conduits, and instruments. (The Vendor's plugged connections shall be identified)

When applicable, the manufacturer, size and type of couplings and the location of guards and their coverage.

Complete bill(s) of material covering the Vendor's entire scope of supply.

Special weather protection and climatization features, if any.

9.2.3. (Modification)

The Vendor shall make available to the Purchaser physical and chemical data, and certified copies of test data prior to shipment. (The Vendor shall maintain a record of shop test data for at least 18 months from date of shipment)

SECTION 10: GUARANTEE AND WARRANTY (Addition)**10.1. (Addition)**

All material and workmanship shall be guaranteed by the Vender for the period specified on the purchase Order.

Clauses 10.1, 10.2 and 10.3 shall apply in cases where these items in condition of contract as laid out in the purchase order are not covered. In case of conflict, conditions of contract shall govern.

10.2. (Addition)

A complete pumping unit performance test (including auxiliaries and driver) under the specified conditions of service may be conducted by the Purchaser after initial starting of the process. If a unit fails to perform as specified, the Vendor shall be responsible for enforcing the guarantees provided in accordance with the condition of the Contract.

10.3. (Addition)

Equipment, parts and materials which have defects, show improper fabrication, or that are not in accordance with the requirements of this Specification, shall be subject to rejection. They shall also be subject to rejection if such conditions are discovered after acceptance of the items at the manufacturer's works.

Positive Displacement Pumps— Reciprocating

API STANDARD 674
THIRD EDITION, DECEMBER 2010



AMERICAN PETROLEUM INSTITUTE

Positive Displacement Pumps— Reciprocating

Downstream Segment

API STANDARD 674
THIRD EDITION, DECEMBER 2010



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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

Page

1	Scope	1
2	Normative References	1
3	Terms and Definitions	4
4	General	8
4.1	Units of Measurement	8
4.2	Subvendor control	9
5	Statutory Requirements	9
6	Basic Design	9
6.1	General	9
6.2	Selection of Pump Type	12
6.3	Ratings	12
6.4	Pressure-Containing and Pressure-Retaining Parts	15
6.5	Cylinder Connections	16
6.6	External Forces and Moments	18
6.7	Liquid End Features	19
6.8	Power End Running Gear	21
6.9	Direct-Acting Pump	23
6.10	Lubrication	24
6.11	Materials	25
6.12	Nameplates and Rotation Arrows	31
7	Accessories	32
7.1	Drivers	32
7.2	Couplings and Guards	34
7.3	Belt Drives	35
7.4	Mounting Plates	36
7.5	Controls and Instrumentation	38
7.6	Auxiliary Piping	40
7.7	Pulsation and Vibration Control Requirements	43
7.8	Special Tools	44
8	Inspection, Testing, and Preparation for Shipment	44
8.1	General	44
8.2	Inspection	45
8.3	Testing	46
8.4	Preparation for Shipment	50
9	Vendor's Data	51
9.1	General	51
9.2	Proposals	52
9.3	Contract Data	54
	Annex A (informative) Pump Material Specifications	56
	Annex B (informative) Vendor Drawing and Data Requirements (VDDR) (Typical)	61
	Annex C (informative) Pulsation and Vibration Control Techniques	66
	Annex D (informative) Reciprocating Positive-Displacement Data Sheets	70

Contents

	Page
Annex E (informative) Net Positive Suction Head Versus Net Positive Inlet Pressure	82
Annex F (informative) Inspector's Checklist	85
Annex F (informative) Lubrication System	87
Bibliography	90
Figures	
1 Kinematic Viscosities	13
C.1 Discharge Pressure Pulsations	69
G.1 Lube Oil System Schematic	87
Tables	
1 Maintenance and Wear Parts	9
2 Cooling Water System Design Requirements	10
3 Speed Ratings for Power Pumps in Continuous Service	12
4 Speed Ratings for Direct-Acting Pumps in Continuous Service	12
5 Casting Factors	15
6a Forces and Moments on Process Connections (SI)	18
6b Forces and Moments on Process Connections (US Customary)	19
7 Bearing Selection	22
8 Maximum Severity of Defects in Steel Castings	26
9 Welding Requirements	30
10 Minimum Requirements for Piping Materials	41
11 Materials Inspection Standards	46
12 Maximum Severity of Defects in Castings	46
13 Test Tolerances	49
A.1 Materials Specifications for Reciprocating Pump Parts	57
B.1 Vendor Drawing and Data Requirements (VDOR) (Typical)	62
G.1 Lube Oil System Schematic	88

Positive Displacement Pumps—Reciprocating

1 Scope

This standard covers the minimum requirements for reciprocating positive displacement pumps and pump units for use in the petroleum, petrochemical, and gas industry services. Both direct-acting and power-frame types are included. Controlled-volume pumps, hydraulically driven pumps, and rotary pumps are not included.

Note: See API 675 for controlled-volume pumps and API 676 for rotary pumps.

2 Normative References

2.1 The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5L: 2004, *Specification for Line Pipe*

API Standard 526:2002, *Flanged Steel Pressure Relief Valves*

API Standard 541:2002, *Form-wound Squirrel Cage Induction Motors — 250 Horsepower and Larger*

API Standard 546:1997, *Brushless Synchronous Machines — 500 kVA and Larger*

API Standard 611:1997, *General-purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

API Standard 677:1997, Reaffirmed: 2000, *General-purpose Gear Units for Petroleum, Chemical and Gas Industry Services*

API Recommended Practice 500A, *Classification of Locations for Electrical Installations in Petroleum Refineries*

API Recommended Practice 686:1996, *Machinery Installation and Installation Design*

ANSI/ABMA 7:1995 ¹, *Shaft and Housing Fits for Metric Radial Ball And Roller Bearings (Except Tapered Roller Bearings) Conforming To Basic Boundary Plan*

ANSI/AGMA 2015-1:2001 ², *Accuracy Classification System — Tangential Measurements for Cylindrical Gears*

ANSI/AGMA 6010:2003, *Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives*

ANSI/AGMA 6009:2000, *Standard for Gearmotor, Shaft Mounted, and Screw Conveyor Drives*

ANSI/AGMA 9002:2001, *Bores and Keyways for Flexible Couplings (Inch Series)*

ASA S2.19:1999 ³, *Mechanical Vibration — Balance Quality Requirements of Rigid Rotors — Part 1: Determination of Permissible Residual Unbalance, Including Marine Applications*

ASME Boiler and Pressure Vessel Code ⁴, Section V:2001, *Non-destructive Examination*

ASME Boiler and Pressure Vessel Code, Section VIII:2001, *Rules for Construction of Pressure Vessels, Division 1*

¹ American Boiler Manufacturers Association, 8221 Old Courthouse Road, Suite 207, Vienna, Virginia 22182, www.abma.com.

² American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314, www.agma.org.

³ Acoustical Society of America, 35 Pinelawn Road, Suite 114 East, Melville, NY 11747, <http://asa.aip.org>.

⁴ ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

ASME Boiler and Pressure Vessel Code, Section IX:2001, *Welding and Brazing Qualifications*

ASME B1.1:2003, *Unified Inch Screw Threads, UN and UNR Thread Form*

ASME B16.1:1998, *Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250*

ASME B16.5:2003, *Pipe flanges and flanged fittings NPS 1/2 through NPS 24*

ASME B16.11:2001, *Forged Fittings Socket Welding and Threaded*

ASME B16.42:1998, *Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300*

ASME B16.47:1996, *Large Diameter Steel Flanges NPS 26 Through NPS 60*

AWS D1.1:2003 ⁵, *Structural Welding Code — Steel*

DIN 910:2004 ⁶, *Heavy-duty Hexagon Head Screw Plugs*

EN 287:1997 (all parts) ⁷, *Qualification Test of Welders — Fusion Welding*

EN 288:1997 (all parts), *Specification and Approval of Welding Procedures for Metallic Materials*

EN 13445:2002 (6 parts), *Unfired Pressure Vessels*

HI 6.6:2000 ⁸, *Reciprocating Pump Tests*

HI 8.1-8.5:2000, *Direct Acting (Steam) Pumps — Nomenclature, Definitions, Applications, and Operation*

IEC 60034 (all parts: latest editions published prior to June 1, 2004) ⁹, *Rotating Electrical Machines*

IEC 60079 (all parts: latest editions published prior to June 1, 2004), *Electrical Apparatus for Explosive Gas Atmospheres*

IEEE 841:2001 ¹⁰, *Standard for the Petroleum and Chemical Industry — Severe Duty Totally Enclosed Fan-cooled (TEFC) Squirrel Cage Induction Motors — Up To and Including 370 kW (500 hp)*

ISO 7; part 1:1994; part 2: 2000 ¹¹, *Pipe Threads Where Pressure-tight Joints are Made On the Threads*

ISO 228-1:2000, *Pipe Threads Where Pressure-tight Joints are Not Made On the Threads — Part 1: Dimensions, Tolerances And Designation*

ISO 261:1998, *ISO General-purpose Metric Screw Threads — General Plan*

ISO 262:1998, *ISO General-purpose Metric Screw Threads — Selected Sizes for Screws, Bolts, and Nuts*

ISO 281:1990; Amendment 1:2000; Amendment 2:2000, *Rolling Bearings. Dynamic Load Ratings, and Rating Life*

⁵ American Welding Society, 550 NW LeJeune Road, Miami, Florida 33126, www.aws.org.

⁶ Deutsches Institut für Normung E.V., Burggrafenstrasse 6, 10787 Berlin, Germany.

⁷ European Committee for Standardization, Avenue Marnix 17, B-1000, Brussels, Belgium, www.cen.eu.

⁸ Hydraulic Institute, 6 Campus Drive, First Floor North, Parsippany NJ, 07054-4406, www.pumps.org.

⁹ International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211, Geneva 20, Switzerland, www.iec.ch.

¹⁰ Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08854, www.ieee.org.

¹¹ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.

ISO 286-2:1998, *ISO System of Limits and Fits — Part 2: Tables of Standard Tolerance Grades and Limit Deviations For Holes and Shafts*

ISO 724:1993, *ISO General-purpose Metric Screw Threads — Basic Dimensions*

ISO 965:2000 (5 parts), *ISO General-purpose Metric Screw Threads — Tolerances*

ISO 1328-1:1995, *Cylindrical Gears — ISO System of Accuracy — Part 1: Definitions and Allowable Values of Deviations Relevant To Corresponding Flanks of Gear Teeth*

ISO 1940-1:2003, *Mechanical Vibration — Balance Quality Requirements of Rigid Rotors — Part 1: Determination of Permissible Residual Imbalance*

ISO 3448:1992, *Industrial Liquid Lubricants — ISO Viscosity Classification*

ISO 3744, *Acoustics — Determination of Sound Power Levels of Noise Sources Using Sound Pressure — Engineering Method in an Essentially Free Field Over a Reflecting Plane*

ISO 5753:1991, *Rolling bearings — Radial Internal Clearance*

ISO 6708:1995, *Pipework Components — Definition and Selection of DN (nominal size)*

ISO 7005-1:1992, *Metallic Flanges — Part 1: Steel Flanges*

ISO 7005-2:1998, *Metallic Flanges — Part 2: Cast Iron Flanges*

ISO 8501-1:1988 (supplement:1994), *Preparation of Steel Substrates Before Application of Paints and Related Products — Visual Assessment Of Surface Cleanliness — Part 1: Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates After Overall Removal of Previous Coatings*

ISO 10438:2003 (all parts), *Petroleum and Natural Gas Industries — Lubrication, Shaft-sealing and Control-oil Systems and Auxiliaries*

ISO 15649:2001, *Petroleum and Natural Gas Industries — Piping*

NACE MR0175/ISO15156:2003 (3 parts) ¹², *Petroleum and Natural Gas Industries — Materials for Use in H₂S-Containing Environments In Oil and Gas Production*

NFPA 70:2002 ¹³, *National Electrical Code*

SSPC SP 6:2000 ¹⁴, *Commercial Blast Cleaning*

2.2 All referenced standards, to the extent specified in the text, are normative.

2.3 Notes following a paragraph are informative.

2.4 The editions of standards, codes, and specifications that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard.

The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed upon by the Purchaser and the Vendor.

¹² NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.

¹³ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

¹⁴ The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, Pennsylvania 15222, www.sspc.org.

3 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1

acoustical simulation

Process whereby the acoustical characteristics of fluids and the reciprocating pump dynamic flow influence are modeled.

3.2

alarm point

Preset value of a measured parameter at which an alarm is activated to warn of a condition that requires corrective action.

3.3

anchor bolt

Bolt used to attach the mounting plate to the support structure (concrete foundation or steel structure).

Refer to 3.6 for definition of hold down bolt.

3.4

direct-acting pump

Reciprocating pump consisting of a piston-powered drive end connected directly to a liquid end to which power is directly transmitted by the action of the motive fluid on the piston.

NOTE A direct-acting pump may use steam, air, or gas as the motive fluid.

3.5

flammable liquid

Liquid that has a closed-cup flash point below 37.8 °C (100 °F), as determined by recommended test procedures and apparatus.

NOTE Suitable test procedures are e.g., those set forth in NFPA 30.

3.6

hold down bolt

mounting bolt

Bolt holding the equipment to the mounting plate.

3.7

inlet reference point

Position, upstream of any pulsation suppression device, at which the Purchaser's connection is made.

NOTE Point at which the specified inlet conditions, such as inlet pressure, inlet temperature, and NPIP apply.

3.8

local

<of a device>

Mounted on the equipment mounting plate.

3.9

maximum allowable speed

Highest speed permitted by the Manufacturer's design for continuous operation.

NOTE cf. speed (3.40).

3.10**maximum allowable temperature**

Maximum continuous liquid temperature permitted by the Manufacturer's design when handling the specified liquid at the specified maximum operating pressure.

3.11**maximum allowable working pressure (MAWP)**

Maximum continuous pressure permitted by the Manufacturer's design when handling the specified liquid at the specified maximum operating temperature.

3.12**maximum continuous speed**

Highest speed at which the machine, as built and tested, is capable of continuous operation with the specified liquid at each of the specified operating conditions.

NOTE cf. speed (3.40).

3.13**minimum allowable liquid temperature**

Lowest liquid temperature permitted by the Manufacturer's design.

3.14**minimum allowable speed**

Lowest speed at which the Manufacturer's design permits continuous operation.

NOTE This is measured in revolutions per minute for power pumps and strokes per minute for direct acting pumps.

3.15**mounting plate**

Baseplate, skid, or soleplate on which the equipment is mounted.

NOTE See 7.4 for mounting plate specifications.

3.16**net positive inlet pressure****NPIP**

Minimum instantaneous pressure determined at the pump inlet reference point during pulsating pressure, minus the vapor pressure of the liquid at the maximum operating temperature.

3.17**net positive inlet pressure available****NPIPA**

NPIP determined by the Vendor from the NPSHA and system data.

3.18**net positive inlet pressure required****NPIPR**

Minimum NPIP required by the pump to achieve the required performance with the specified liquid.

3.19**NPIPR test**

Running test conducted to validate the NPIPR.

3.20**net positive suction head****NPSH**

Total absolute suction pressure determined at the underside of the mounting plate, minus the vapor pressure of the liquid.

NOTE It is expressed as head of water, in meters (ft).

3.21**net positive suction head available****NPSHA**

Minimum value of NPSH determined to be available under any specified operating condition at the underside of the mounting plate, based on steady state flow.

NOTE NPSHA is a value provided by the Purchaser and which the Supplier will use to calculate the NPIPA (see 3.17). NPSHA is a function only of the system upstream of the pump and the operating conditions, and is independent of pump design.

3.22**observed [test]**

Inspection [test] for which the Purchaser is notified of the timing, and the inspection [test] is performed as scheduled irrespective of whether the Purchaser or Purchaser's representative is present.

3.23**panel**

Enclosure used to mount, display and protect gauges, switches and other instruments.

3.24**performance test**

Running test conducted to confirm the pump's mechanical and volumetric efficiency.

3.25**piston pump**

Reciprocating pump having a seal attached to the piston and moving within a cylinder.

3.26**piston load****plunger load**

Force acting on one piston or plunger during any portion of the pumping cycle.

3.27**plunger pump**

Reciprocating pump having a uniform-section plunger that moves in a static seal.

3.28**power pump**

Reciprocating pump consisting of a power end and a liquid end connected by a frame or distance piece.

NOTE 1 The power end of a power pump transmits energy from a rotating shaft to pistons or plungers by means of a crankshaft, connecting rods, and crossheads.

NOTE 2 The liquid end of a power pump consists of the cylinders, the pistons or plungers, and the valves.

3.29**preliminary anticipated system acceleration head**

The estimated pressure change due to changes in velocity in the piping system.

NOTE This is an important factor in the application of reciprocating pumps because of the pulsating nature of the flow in the pump suction line. For additional information on acceleration head, refer to Hydraulic Institute standards. For additional information on acceleration head, see Annex E.

3.30**pressure-containing part**

Part that acts as a barrier between process or motive fluid and the atmosphere

EXAMPLE Liquid cylinder, discharge manifold, suction manifold, the stuffing box, cylinder plugs and covers (when in contact with process fluid), valve seats (when a portion is in contact with the atmosphere), the power cylinder, the gas cylinder head, the valve chest, and the valve chest cover and heads.

3.31**pressure-limiting valve accumulation pressure**

Pressure at which a pressure-limiting valve discharges the pump rated flow.

3.32**pressure-limiting valve set pressure**

Pressure at which a pressure-limiting valve starts to release pressure.

3.33**pressure-retaining part**

Part whose failure would allow process or motive fluid to escape to the atmosphere.

EXAMPLE Liquid and gas cylinder bolting, stuffing box bolting, gland bolting, glands, and covers that constrain plugs and valve stops, but not parts such as packing, gaskets, pistons, plungers, piston rings, rods, valves, seats (when completely surrounded by pressure-containing parts), and internal bolting.

3.34**pump efficiency****pump mechanical efficiency**

Ratio of the pump's hydraulic power to its power input.

3.35**Purchaser**

Issuer of the order and specification to the Vendor.

NOTE The Purchaser can be the Owner of the plant in which the equipment is to be installed or the Owner's appointed agent.

3.36**rated flow**

Total volume of liquid actually delivered per unit time at rated operating conditions normalized to inlet conditions.

NOTE Rated flow includes liquid and any dissolved or entrained gasses or solids specified.

3.37**remote**

<of a control device>

When located away from the equipment or console, typically in a control room.

3.38**shutdown set point**

Preset value of a measured parameter at which automatic or manual shutdown of the system or equipment is required.

3.39**special tool**

Tool that is not commercially available, e.g. from a catalogue.

3.40**speed**

<power pump>

Number of revolutions of the crankshaft in a given unit of time.

NOTE It is expressed as revolutions per minute.

speed

<direct acting pump>

Number of strokes of the piston in a given unit of time.

NOTE It is expressed in strokes per minute.

3.41**unit responsibility**

Responsibility for coordinating the documentation, delivery, and technical aspects of the equipment and all auxiliary systems included in the scope of the order.

NOTE The technical aspects to be considered include, but are not limited to, such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubrication, sealing system, material test reports, instrumentation, piping, conformance to specifications and testing of components.

3.42**Vendor****Supplier**

Manufacturer or Manufacturer's agent that supplies the equipment and is normally responsible for service support.

3.43**volumetric efficiency**

Ratio of the pump rated flow to the total piston or plunger displacements per unit time.

NOTE Volumetric efficiency is normally expressed as a percentage.

3.44**witnessed [test]**

Inspection [test] for which the Purchaser is notified of the timing of the inspection [test] and a hold is placed on the inspection [test] until the Purchaser or his representative is in attendance.

4 General**4.1 Units of Measurement**

Drawings and maintenance dimensions of pumps shall be in SI units or U.S. Customary (USC) units. Use of an ISO Standards datasheet (e.g. Annex D, Figure D.1) indicates SI units shall be used. Use of a USC datasheet (e.g. Annex D, Figure D.2) indicates USC units shall be used.

4.2 Subvendor control

The Vendor who has unit responsibility shall ensure that all Subvendors comply with the requirements of the International Standard.

5 Statutory Requirements

The Purchaser and the Vendor shall mutually determine the measures that must be taken to comply with any governmental codes, regulations, ordinances or rules that are applicable to the equipment.

6 Basic Design

6.1 General

6.1.1 The equipment (including auxiliaries, but excluding normal maintenance and wear parts as identified in Table 1) shall be designed and constructed for a minimum service life of 20 years and at least 3 years of uninterrupted operation.

It is recognized that these requirements are design criteria, and that service or duty severity, misoperation, or improper maintenance can result in a machine failing to meet these criteria.

The term 'design' shall apply to parameters or features of the equipment supplied by the Manufacturer. The term 'design' should not be used in the Purchaser's enquiry or specification because it can cause confusion in understanding the order.

Table 1—Maintenance and Wear Parts

Item	Life (months)
Packings	4 to 12
Valves	9 to 24
Valve Seats	9 to 24
Plungers	12 to 36
NOTE The Purchaser and Vendor should discuss the frequency of replacement of these parts at the time of inquiry to determine the value added using life cycle cost analysis, delivery, and parts availability.	

6.1.2 The Vendor shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order.

- **6.1.3** The Purchaser shall specify the normal operating point and all other required operating points.

6.1.4 Equipment driven by fixed-speed induction motors shall be rated at the actual motor speed for the rated load condition.

- **6.1.5** Control of the sound pressure level (SPL) of all equipment supplied shall be a joint effort of the Purchaser and the Vendor having unit responsibility. The equipment supplied by the Vendor shall conform to the maximum allowable sound pressure level specified. In order to determine compliance, the Vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment.

6.1.6 Unless otherwise specified, cooling water system or systems shall be designed for the following conditions given in Table 2.

Table 2—Cooling Water System Design Requirements

	SI Units	US Customary Units
Velocity over heat exchange surfaces	1.5 m/sec to 2.5 m/sec	5 f/sec to 8 f/sec
Maximum allowable working pressure (MAWP), gauge pressure	≥7.0 barg	≥100 psig
Test pressure (≥ 1.5 MAWP)	≥10.5 barg	≥150 psig
Maximum pressure drop	1 bar	15 psi
Maximum inlet temperature	30 °C	90 °F
Maximum outlet temperature	50 °C	120 °F
Maximum temperature rise	20 K	30 °F
Minimum temperature rise	10 K	20 °F
Fouling factor on water side	0.35 m ² K/kW	0.002 hr-ft ² -°F/BTU
Shell corrosion allowance	3 mm	1/8 in.
The Vendor shall notify the Purchaser if the criteria for minimum temperature rise and velocity over heat exchange surfaces result in a conflict. The criterion for velocity over heat exchange surfaces is intended to minimize water-side fouling; the criterion for minimum temperature rise is intended to minimize the use of cooling water. If such a conflict exists, the Purchaser will approve the final selection. NOTE To avoid condensation, the minimum inlet water temperature to water-cooled bearing housings should preferably be above the ambient air temperature.		

6.1.7 Provision shall be made for complete venting and draining of the pump and systems provided by the Vendor.

6.1.8 Equipment shall be selected to run to the pressure-limiting accumulation pressure and at trip speed without suffering damage.

NOTE There might be insufficient driver power to operate under these conditions.

6.1.9 For direct driven equipment the equipment's maximum continuous operating speed shall be not less than 105 % of the rated speed for variable speed machines and shall be equal to the rated speed for constant speed motor drives.

6.1.10 For gear-driven equipment the gearbox input shaft maximum continuous operating speed shall not be less than 105 % of the rated speed for variable speed machines and shall be equal to the rated speed for constant speed motor drives.

6.1.11 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the Purchaser and the Vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

6.1.12 Motors, electrical components, and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the Purchaser and shall meet the requirements of the applicable sections of IEC 60079, or NFPA 70, Articles 500, 501, 502, 504, and 505 as specified, as well as any local codes specified and supplied by the Purchaser.

6.1.13 Oil reservoirs and housings that enclose moving lubricated parts such as bearings, shaft seals, highly polished parts, instruments, and control elements shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation and idleness.

6.1.14 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as cylinder components and bearing housings shall be designed to ensure accurate alignment on reassembly. This may be accomplished by the use of shouldering, cylindrical dowels, or keys.

6.1.15 The equipment (machine, driver, and auxiliary equipment) shall perform on the test stand and on its permanent foundation within the specified test tolerances (see 8.3.6). After installation, the performance of the combined units shall be the joint responsibility of the Purchaser and the Vendor who has unit responsibility. The Vendor shall review and comment on the Purchaser's piping and foundation drawings in order to minimize adverse effects.

NOTE Many factors can adversely affect performance of the pump at site. These factors include piping layout, piping connection loads, alignment at operating conditions, support structure, handling during shipment and handling and assembly on site.

- **6.1.16** The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified by the Purchaser. The environmental conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, unusual humidity, dusty, or corrosive conditions, and with available utilities.

6.1.17 Spare and replacement parts for the machine and all supplied auxiliaries shall meet all the criteria of this standard.

6.1.18 Bolting shall conform to 6.1.18.a) through 6.1.18.f).

- a) Details of threading shall conform to ISO 261, ISO 262, ISO 724, and ISO 965, or to ASME B1.1.
- b) Adequate clearance shall be provided at all bolting locations to permit the use of socket spanners (wrenches).
- c) External or internal hexagon head bolting is required unless otherwise agreed.
- d) Mounting bolts shall be not less than 12 mm (0.5 in.) diameter.
- e) Manufacturer's markings shall be located on all fasteners 6mm (¹/₄ in.) and larger (excluding washers and headless screws). For studs, the marking shall be on the nut end of the exposed stud end.

NOTE A set screw is a headless screw with an internal hex opening on one end.

- f) Metric fine and UNF threads shall not be used.

6.1.19 Mounting surfaces shall meet the following criteria.

- a) They shall be machined to a finish of 6.3 µm (250 µin.) arithmetic average roughness (Ra) or smoother.
- b) To prevent a soft foot, they shall be in the same horizontal plane within 25 µm (0.001 in.).
- c) Each mounting surface shall be machined within a flatness of 1:24,000. Corresponding surfaces shall be in the same plane within 150 µm/m (0.002 in./ft).
- d) The upper machined or spot faced surface shall be parallel to the mounting surface.

- e) Hold-down bolt holes shall be drilled perpendicular to the mounting surface or surfaces, machined or spot faced to a diameter three times that of the hole and to allow for equipment alignment, be 15 mm ($1/2$ in.) larger in diameter than the hold down bolt.

6.1.20 Glands shall be bolted or threaded to the stuffing box. Gland studs shall pass through holes (not slots) in the gland. Axially-split glands shall be bolted together. Threaded gland bolts in slots are not acceptable.

6.2 Selection of Pump Type

6.2.1 Unless otherwise specified a piston pump shall not be used in applications requiring continuous operation where the differential pressure across the piston is in excess of 15 MPa (150 bar) (2175 psi).

NOTE Operation above these pressures may result in a significant reduction in piston seal and liner life and some reduction in pump performance (due to piston seal leakage).

6.3 Ratings

6.3.1 Table 3 and Table 4 represent the maximum allowable speed ratings for reciprocating pumps in continuous service.

Table 3—Speed Ratings for Power Pumps in Continuous Service

Stroke Length		Revolutions per minute	Revolutions per minute
mm	(in.)		
50	2	450	140
75	3	400	127
100	4	350	116
125	5	310	108
150	6	270	100
175	7	240	94
200	8	210	88
250	10	168	83
300	12	140	78
350	14	120	74
400	16	105	70

Table 4—Speed Ratings for Direct-Acting Pumps in Continuous Service

Stroke Length		Per Minute
mm	(in.)	
100	4	52
150	6	44
200	8	38
250	10	34
300	12	30
350	14	28
400	16	26
450	18	24
500	20	22
600	24	20

NOTE 1 Factors such as viscosity, specific gravity, abrasiveness, vapor pressure, gas solubility or evolution in the pumped liquid, specified pressures and temperatures, or system acceleration (resulting NPIP) head may require further speed limitations.

NOTE 2 For installations where the NPIPA is less than 0.15 bar (2.25 psi) above the NPIPR consideration should be given to speeds lower than those in Table 3 and Table 4.

6.3.2 Refer to Figure 1 when using plug and plate valves in services in which the kinematic viscosities are above 65 mm² (65 cSt) (300 Saybolt Seconds Universal) at pumping temperatures. For other valve designs, refer to Manufacturer's data. The speeds given in Table 3 and Table 4 shall be reduced using the correction factors given in Figure 1. These corrections apply only to pumps with plate and plug valves; for other valve designs, refer to Manufacturers' data.

NOTE The correction factors apply only above 65 mm²/s (65 cSt).

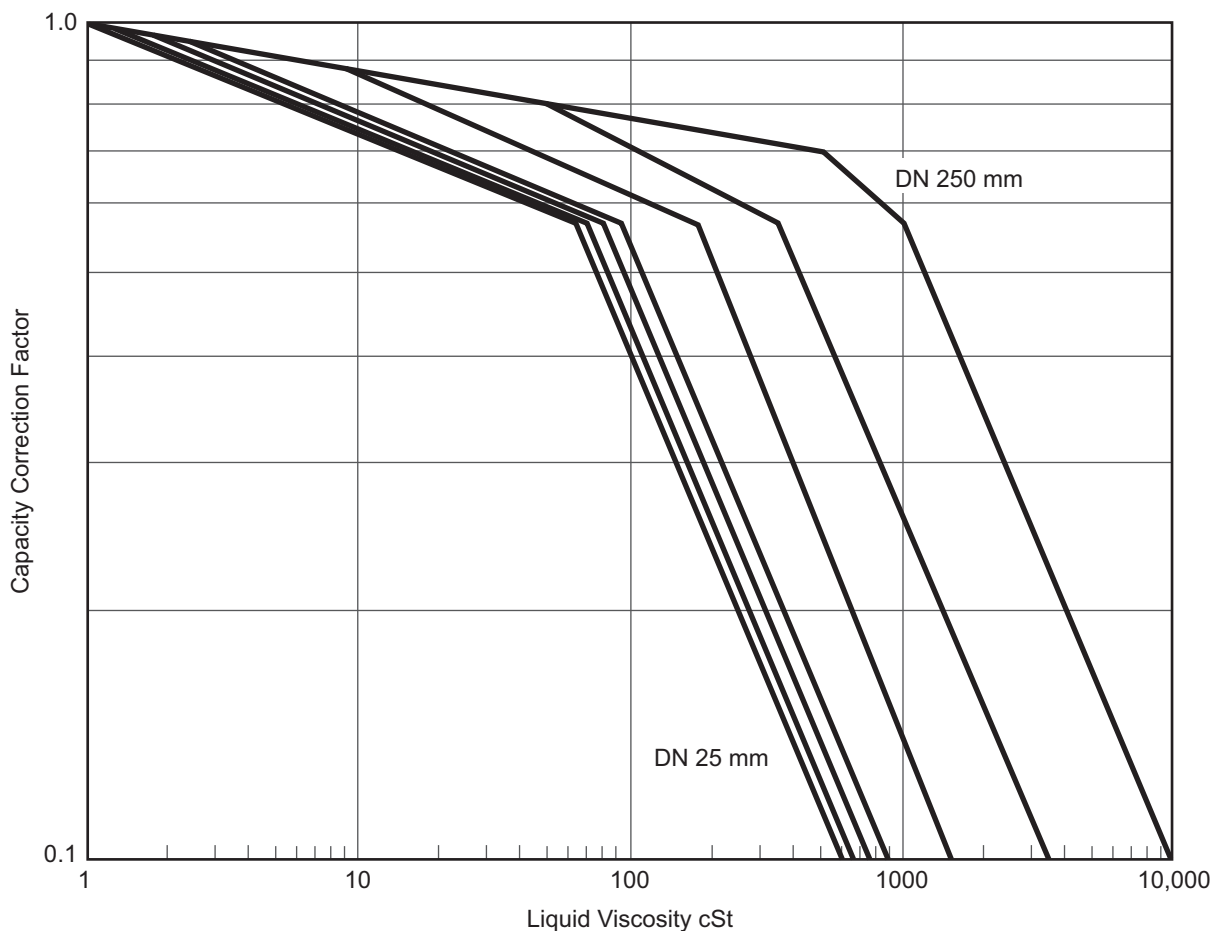


Figure 1—Kinematic Viscosities

- **6.3.3** The Purchaser shall supply liquid properties. Based on these properties, the Vendor shall state the volumetric efficiency.

6.3.4 In the determination of power-pump power requirements, the value of pump efficiency used shall be that value determined by the Vendor for the specified operating conditions.

NOTE The power requirement is used for driver sizing.

6.3.5 For power pumps, the Vendor shall include in the proposal the rated and maximum allowable continuous piston or plunger load. The allowable peak or momentary load, if different from the continuous rating, shall also be specified.

6.3.6 For direct-acting piston pumps, without liquid end tail rods, the Vendor shall include in the proposal the maximum process liquid outlet stall pressure, the maximum of the two values calculated as follows:

$$p_{st} = \frac{(d_m^2 \times p_m) + ((d_p^2 - d_r^2) \times p_1) - ((d_m^2 - d_r^2) \times p_e)}{d_p^2}$$

$$p_{st} = \frac{(d_p^2 \times p_1) + ((d_m^2 - d_r^2) \times p_m) - (d_m^2 \times p_e)}{d_p^2 - d_r^2}$$

where

d_m is the motive piston diameter,

d_p is the liquid end piston or plunger diameter,

d_r is the rod diameter,

p_e is the lowest motive fluid exhaust pressure,

p_m is the highest motive fluid supply pressure,

p_1 is the highest process liquid inlet pressure,

p_{st} is the maximum process liquid outlet stall pressure.

NOTE Direct-acting pumps may require protection by pressure-limiting valves, in the process liquid and motive fluid circuits, if pressures greater than design can occur.

6.3.7 For direct-acting plunger pumps, without liquid end tail rods, the Vendor shall include in the proposal the maximum process liquid outlet stall pressure, the maximum of the two values calculated as follows:

$$p_{st} = \frac{(d_m^2 \times p_m) - ((d_m^2 - d_r^2) \times p_e)}{d_p^2}$$

where

d_m is the motive piston diameter,

d_p is the liquid end piston or plunger diameter,

d_r is the rod diameter,

p_e is the lowest motive fluid exhaust pressure,

p_m is the highest motive fluid supply pressure,

p_{st} is the maximum process liquid outlet stall pressure.

NOTE Direct-acting pumps may require protection by pressure-limiting valves, in the process liquid and motive fluid circuits, if pressures greater than design can occur.

6.4 Pressure-Containing and Pressure-Retaining Parts

6.4.1 The pressure-containing parts shall be designed in accordance with 6.4.1.1 (or 6.4.1.2, as selected by the Vendor) and 6.4.1.3 to achieve the following:

a) operate without leakage or internal contact between rotating and stationary components (other than bearings and seals) while subject simultaneously to the MAWP (and corresponding temperature) and the worst case combination of maximum allowable nozzle loads applied to all nozzles;

b) withstand the hydrostatic test.

6.4.1.1 The allowable tensile stress used in the design of the pressure-containing parts for any material shall not exceed 0.25 times the minimum ultimate tensile strength for that material at the maximum specified operating temperature and, for castings, multiplied by the appropriate casting factor for the type of non-destructive examination (NDE) as given in Table 5. The Manufacturer shall state which material specification is being used as the source of the material properties, see Annex A, as well as the casting factors applied.

Table 5—Casting Factors

Type of NDE	Casting factor
Visual, magnetic particle, and/or liquid penetrant	0.8
Spot radiography	0.9
Ultrasonic	0.9
Full radiography	1.0
NOTE Application of these criteria seldom results in ultimate tensile strength or yield strength governing the design; fatigue strength usually governs the design.	

6.4.1.2 Pressure-containing parts may be designed with the aid of finite-element analysis. The value of the stress intensity and deflections shall be assessed for acceptability at 150 % of MAWP. The allowable tensile stress used in the design of the pressure components for any material shall not exceed 0.25 times the minimum ultimate tensile strength for that material at the maximum specified operating temperature.

6.4.1.3 The allowable stress for bolts shall be used to determine the total bolting area based on hydrostatic load and gasket preload, as applicable. The preload stress shall not exceed 0.75 times the bolting material minimum yield strength.

NOTE Preloading is performed to prevent bolt fatigue failure under cyclic loading.

6.4.2 The pressure-limiting valve accumulation pressure shall not exceed the maximum allowable working pressure of the cylinder and shall not exceed 110 % of the specified pressure-limiting valve set pressure.

6.4.3 Cylinders and other pressure-retaining parts and supports shall be designed to prevent detrimental distortion caused by the worst combination of temperature, pressure, torque, and allowable external forces and moments based on the specified operating conditions.

6.4.4 The use of threaded holes in pressure-retaining parts shall be minimized. To prevent leakage in these parts, metal, equal in thickness to at least half the nominal bolt diameter, in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and threaded holes. The depth of the threaded holes shall be at least 1.5 times the stud diameter.