API 610 NINTH EDITION HIGHLIGHTS

by

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Mr. Sanders received his B.S. degree (Mechanical Engineering) from The University of New Mexico. He is a registered Professional Engineer in the State of Texas, and he represents his company on the API Subcommittee on Mechanical Equipment and is a member of API 610, API 611, and API 671 taskforces.

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Mr. Jones received his B.S. and M.S. degrees (Mechanical Engineering) from Kansas State University, and is a registered Professional Engineer in the State of Texas. He represents his company on the API Subcommittee as its Vice-Chairman and as the Chairman of the Steering Committee. Mr. Jones is the taskforce chairman of API 610 and the ISO Convenor for ISO tag 13709. He is a former member of the International Pump Users Symposium Advisory Committee.

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Mr. Heald received his B.S. degree (Mechanical Engineering) from the University of Maine. During his 35 years of service with Ingersoll-Rand and Ingersoll-Dresser Pump Company, he held various pump engineering positions. He is a Life Member of ASME and has participated in American Petroleum Industry programming since 1963, serving as Chairman of the Centrifugal Pump Manufacturers Subcommittee and on numerous API committees and taskforces, including 610, 682, and Standard Paragraphs.

This paper varies in style from other published papers due to the fact that it heavily represents an actual API Standard. There has been minimal editing of actual API Standard verbiage. Editorial notes for redesignated Figure and Table numbers are within brackets.

ABSTRACT

API Standard 610, "Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services," has been revised from the Eighth Edition to the Ninth Edition and developed into an International Standard, ISO 13709.

The process of how the standard was changed, the participants involved, and the schedule for the new document is covered. The change in format is discussed to provide the user information on where certain information is now located.

The authors discuss specific major changes in the design section covering issues such as working pressure, vibration, and baseplates. The user is provided with information regarding API 610 Eighth Edition requirements and what the new Ninth Edition

change is and where it is located. The user of the document is advised of not only what the changes are but also the reasoning behind the changes.

In conclusion, insight is provided as to the future of API 610/ISO 13709 as an international document and the plan for its maintenance.

INTRODUCTION

The American Petroleum Institute (API) publication, "Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services," API Standard 610 Eighth Edition (which will be referred to as the Eighth Edition) was published in August of 1995. The Eighth Edition (1995) has been used by end users and engineering contractors worldwide to purchase pumps for refineries, chemical and petrochemical plants, and the petroleum and gas industries. This document has been used successfully to obtain pumping equipment of high quality that will provide long service life and satisfactory run times between failures, when applied correctly. All API documents are currently on a five to eight year review cycle and are required to be updated within that time span.

Mission Statement

The API 610 Ninth Edition Taskforce Mission Statement was stated as follows:

> The API 610 9th edition Taskforce is charted to update API 610 to the 9th edition. Our mission includes accomplishing the following:
> a) Update 610 to the newest version of the standard paragraphs.
> b) Correct all known errors.
> c) Address all technical inquiries to the 8th edition
> d) Test all clauses for cost effectiveness and where appropriate either modify or eliminate onerous requirements.
> e) Test all clauses for clarity and where necessary reword (API 610, 2001).

Vision

The vision of the API 610 Ninth Edition Taskforce was stated:

> It is the vision of the 9th Edition Taskforce that the 9th Edition of API 610 will be accepted by ISO with no changes whatsoever and that the vast majority of users will choose to use API 610 with no user company or contractor overlay specifications (API 610, 2001).

The Ninth Edition Taskforce became both the Ninth Edition Taskforce and the International Organization for Standardization (ISO) Working Group Tag 13709.

TASKFORCE AND UPDATE PROCESS

Participants

The following individuals have participated in taskforce and working group meetings, presentations to the API Subcommittee on Mechanical Equipment, and have otherwise contributed to the successful completion of API 610, Ninth Edition/ISO 13709 (2001):

Chairman	
Roger Jones	Shell Oil
Vice Chairman	
Joseph Thorp	Aramco Services Co.
Secretary	
Charles Heald	Flowserve
Members	
Daniel Batten	Texaco
Rene Barbarulo	Textron
William Beekman	Floway Pumps
Fred Blumentrath	CPC Pumps International
Stephen Brown	Sundstrand Fluid Handling
Jim Bryant	Halliburton KBR
Daniel Clark	Lawrence Pumps Inc.
Michael S. Cropper	Sulzer Pumps
Rick Eickhoff	Exxon Mobil
Brian Ellis	European Sealing
Frank Ennenbach	ABS
Patrick Flach	Chesterton
Ralph Gabriel	John Crane
Bill Goodman	ITT Goulds
Thomas Graham	BP
Angus Grant	Weir Pumps
Bryan Gudgel	Floway Pumps
Mike Huebner	Flowserve Seals
Bill Jones	Flowserve
Norbert Kastrup	KSB Group
Fran Kludt	Celanese Chemical
Todd Lindrew	Jacobs Engineering
Bill Litton	Williams Co.
Jon R. Mancuso	Kop-Flex
J. Terry McGuire	Flowserve
David Mikalonis	SKF
Richard O'Donnell	ITT Goulds
Ron Palgrave	Textron—David Brown Union
Rasik Patel	Burgmann Seals
Peter S. Petrunich	Fluid Sealing Association
David Redpath	BP
Jack D. Sanders	Fluor Daniel
Winfried Schoeffler	Sulzer Weise
Steve Schofield	BPMA
Jan Schutte	Envirotech
John Sidelko	Sundstrand
Peter Simmons	EEMUA
Joe Spiller	Shell Oil
Jim Steiger	Textron—David Brown Union
Bill Tipton	Flowserve
Paul Wareham	Sundstrand
Neil Wallace	Flexibox

Schedule

The first meeting of the taskforce was held in Lake Buena Vista, Florida, on September 25, 1998. Work had started before the meeting with each section of the standard being reviewed by a section coordinator. During this meeting, screening and functionality factors were assigned to each paragraph. These screening and functionality factors are called "Stickel factors" for John Stickel, retired from Exxon. The purpose of this review was to determine if each paragraph was of value, needed to be changed, or, in some cases, deleted.

Also at this meeting was the start of updating the Ninth Edition document to the API Subcommittee on Mechanical Equipment (SOME) standard paragraphs. The SOME has a compilation of standard paragraphs that are used for all API standards, if the standard paragraph is applicable to that standard. One who is familiar with the API mechanical standards will note that there are identical paragraphs from standard to standard. In some cases the standard paragraph has to be changed to apply to the equipment to which that standard applies. In some cases the standard paragraph is not applicable, and is not used. The SOME current standard paragraphs are currently in revision 22.

Taskforce meetings were held in Houston, Texas, on December 10 and 11, 1998. During these meetings, the taskforce reviewed the "Stickel factors," proposed technical changes, technical inquires that had been submitted to the Eighth Edition, and standard paragraph changes. The taskforce also discussed the changes that would be required to have the document default to API 682 (1994) for mechanical seals and to API 614 (1999) for instrumentation and lube oil systems.

Taskforce meetings were again held in Houston, Texas, on February 4 and 5, 1999. During these meetings, the taskforce continued the reviews of each section created by the changes started in December. Discussions also included API 614 changes, appendices changes, and British Pump Manufacturers Association (BPMA) comments. The main focus of this meeting was to prepare the first draft of the Ninth Edition for review by the SOME. On March 8, the first draft of the Ninth Edition was sent out for comment to the SOME. This draft listed in four columns the existing edition paragraph, the new edition paragraph, if changed, the source for the change, and the reason for the change.

A meeting was held in Chicago, Illinois, on April 29 and 30, 1999, to review the Ninth Edition document on a paragraph by paragraph basis and to address the comments received to the first draft. In May, the second draft of the document was distributed by E-mail for further comments.

On September 2 and 3, 1999, an ISO/API 610 working group meeting was held in Frankfurt, Germany, to review ISO publication requirements, Ninth Edition significant changes, ISO editing, and additional input by ISO. On September 15 through 17, 1999, a follow up meeting was held in Houston, Texas, to review comments to the second draft and to prepare the document for presentation to the SOME in October 1999.

On October 13, 1999, the proposed Ninth Edition sections 2 and 5 were presented to the SOME in New Orleans, Louisiana. The presentation discussed the comments received to the document, the disposition of each comment, and major changes that had been made to the document. A follow up taskforce meeting was held after the SOME presentation on October 14 and 15 to resolve the issues raised during the SOME presentation and to prepare the third draft of the document.

A taskforce meeting was held on March 1 through 3, 2000, in Houston, Texas. The purpose of this meeting was to address comments received to the third draft, resolve outstanding issues, and complete the presentation of the document for the SOME meeting in San Diego, California. On March 3, 2001, a combined API 610 and API 682 taskforce meeting was held to assure harmony between these documents.

Sections 1, 3, 4, and 6, and the appendices were presented to the SOME on May 24, 2000, in San Diego, California. A follow up taskforce meeting was held on May 25 and 26 to resolve the comments received during the presentation.

On August 22 through 24, 2000, a combined ISO/API 610 taskforce meeting was held in London, to review the work plan required for acceptance of the document by ISO and to review the ISO formatted draft. In May and June 2001, the final ISO draft was reviewed by the taskforce. The final comments are to be resolved in early 2002.

Please note that this chronology of meetings does not include all the telephone meetings that the taskforce held and the hours spent individually that all the taskforce members spent in producing the Ninth Edition document.

ISO 13709

Sections

The first time a "veteran" user of API standards picks up the new document, there will be immediate frustration and anxiety, because the document has changed format from the Eighth Edition. The new document is based on the ISO standard format arrangement. In order to familiarize people with this new arrangement, Table 1 is a list of the new section numbers in ISO format as they relate to the Eighth Edition paragraphs.

The changes will be reviewed on a section-by-section basis, and author comments are shown in italics.

All paragraph (in ISO terminology, they are referred to as clauses, not paragraphs) references are to the ISO/DIS 13709.2 draft (2001). The ISO 13709 document, the standard that is finally published, may have revisions to these numbers.

Table 1. ISO Format Section Numbers.

ISO 13709	API 610 Eighth Edition Section
Section 1 Scope	Section 1 Scope and Pump Designations
Section 2 Normative References	Section 1.5 and Appendix A
Section 3 Terms and Definitions	Section 1.4 Definitions of Terms
Section 4 Classifications and Designations	Section 1.1.2
Pump Designations	Section 1.1.2
Alternative Standards	New
Section 5 Basic Design	Section 2 Basic Design
Section 6 Accessories	Section 3 Accessories
Section 7 Inspection, Testing, and Preparation for Shipment	Section 4 Inspect Testing and Preparation for Shipment
Section 8 Specific Pump Types	Section 5 Specific Pump Types
Section 9 Vendor's Data	Section 6 Vendor's Data

Section 1 Scope

This International Standard is applicable to overhung pumps, between bearings pumps, and vertically suspended pumps (see Table 1 *[Table 2]*).

Table 1 [Table 2] is a modification of the centrifugal pump types flow chart in the Eighth Edition that shows the pump classification type identification used throughout this standard.

Table 2. Pump Classification Type Identification.

Centrifugal Pumps	Overhung	Flexibly Coupled	Horizontal	Foot Mounted	OH1
				Centerline Supported	OH2
			Vertical Inline with Bearing Bracket		OH3
		Rigidly Coupled	Vertical Inline		OH4
		Close Coupled	Vertical Inline		OH5
			High Speed Integrally Geared		OH6
	Between Bearings	1 and 2 Stage	Axially Split		BB1
			Radially Split		BB2
		Multistage	Axially Split		BB3
			Radially Split	Single Casing	BB4
				Double Casing	BB5
	Vertically Suspended	Single Casing	Discharge Through Column	Diffuser	VS1
				Volute	VS2
				Axial Flow	VS3
			Separate Discharge	Line Shaft	VS4
				Cantilever	VS5
		Double Casing	Diffuser		VS6
			Volute		VS7

Process and utility services exist within most facilities that do not require pumps of the robustness and intrinsic reliability of those covered in this standard. For such services, that do not exceed ANY of the following limits, i.e. less rigorous services, the user may want to consider pumps designed in compliance with other standards such as ISO 5199 or ANSI/ASME B73.1M.

Maximum discharge pressure:	19 bar	(275 psig)
Maximum suction pressure:	5 bar	(75 psig)
Maximum pumping temperature:	150°C	(300°F)
Maximum rotative speed:	3600 r/min	(3600 rpm)
Maximum rated total head:	120 m	(400 ft)

Maximum impeller diameter,
overhung pumps: 330 mm (13 in)

This clause states the same service limits that were invoked in paragraph 1.1.4. of the Eighth Edition. The Eighth Edition paragraph also had the requirement that the services be nonflammable and nonhazardous. The decision to use non-API pumps in flammable and hazardous service is determined by the user. It should be noted that users are currently applying non-API pumps in flammable and hazardous service successfully and have done so for years.

Section 2 Normative references

Section 2 is a listing of the normative references. All references are either "normative" (required) or "informative" (for information only). The references were contained in Appendix A in the Eighth Edition. All ISO references are listed first with other references listed second.

Section 3 Terms and definitions

Section 3 lists the terms and definitions used in the document. Since this standard addresses pumps, several definitions were changed to include the word "pump" instead of the word "equipment."

3.18
maximum allowable working pressure (MAWP)
maximum continuous pressure for which the manufacturer has designed the pump (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature

This definition changes the maximum allowable working pressure to the maximum continuous pressure for which the manufacturer has designed the pump at the maximum operating temperature specified by the user. In the Eighth Edition the design pressure is the same maximum continuous pressure that the manufacturer has designed for, but at the maximum allowable temperature. The Eighth Edition would allow the manufacturer to derate the temperature in order to raise the allowable working pressure. This led to confusion and disagreement.

3.30
net positive suction head required
NPSH3
NPSH that results in a 3% loss of head (first stage head in a multistage pump) determined by the vendor by testing with water.

The NPSH required is now designated using NPSH3 instead of NPSHR. This nomenclature is consistent with that used by the Hydraulic Institute and other standards.

3.31
nominal pipe size
NPS (followed by size designation number)
A designation corresponding to the outside diameter of pipe established by various ASTM standards

A definition has been added for nominal pipe size (NPS).

3.34
observed
inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled if the purchaser or his representative is not present
NOTE For observed tests the purchaser should expect to be in the factory longer than for a witness test.

The definition of "observed" is now in the definition section, where it should be, and not in inspection and testing.

3.48
shall
used to state a mandatory requirement

3.49
should
used to state a non-mandatory requirement.

Definitions were added for "shall" and "should," in order to distinguish between requirements.

3.51
specific speed
index relating flow, total head, and rotative speed for pumps of similar geometry, expressed mathematically by the following equation:

$N_S = N(Q)^{0,5}/(H)^{0,75}$

Where:
N_S is the specific speed;
Q is the total pump flow, expressed in cubic metres per second;

Specific speed derived using SI Units multiplied by a factor of 51,64 is equal to specific speed in US Customary Units.

The definition of specific speed has returned to the classical one of N_s instead of N_q.

3.53
suction specific speed
index relating flow, NPSH3, and rotative speed for pumps of similar geometry, expressed mathematically by the following equation:

. $S = N(Q)^{0,5}/(NPSH3)^{0,75}$

Where:
S is the suction specific speed, dimensionless;
Q is the flow per impeller eye, expressed in cubic metres per second; equals the total flow for single suction impellers, equals the one half total flow for double suction impellers.

The definition of suction specific speed has returned to the classical one of S instead of n_{qs}.

3.61
witnessed
<inspection or test>
where the purchaser is notified of the timing of the inspection or test and a hold point is placed on the inspection or test until the purchaser or his representative is in attendance

Like the definition for "observed," the definition for "witnessed" is now in the definition section, where it should be.

Section 4.2 Alternative standards

This is a new section that was added to conform to the ISO formatting.

4.2.1
Thirteen subclauses in this document contain more than one reference or set of references, with the first being an ISO/IEC reference and the other(s) being non-ISO/IEC references or set of references. In each of these cases, the two references are not identical, but both yield results that are technically acceptable. The relevant subclauses are noted in Table 2 *[Table 3]*.

4.2.2
The purchaser shall specify whether machines shall comply with system 1 or system 2.

4.2.3
Drawings and maintenance dimensions of pumps shall be in SI dimensions or US dimensions as specified by the purchaser.

4.2.4
Where requirements specific to a particular pump in clause 8 conflict with the general sections, the requirements of clause 8 govern.

The user specifies in 4.2.2 whether the pump is built to ISO standards, or US customary references. In 4.2.3 the user specifies the units for the drawings and maintenance dimensions. 4.2.4 provides an order of preference between the specific pump section and the general design section.

Table 3. Alternative Standard References.

Clause	Reference 1	Reference 2
5.1.24	IEC 60079	NFPA 70, Articles 500, 501, 502, 504 and 505
5.1.31 a)	ISO 261, ISO 262, ISO 724, and ISO 965	ASME B1.1
5.10.1.4	ISO 5753 Group 3	ABMA Group 3
6.1.4 e)	IED 60079	API RP 500
6.1.6 a)	ISO 281-1	ANSI/ABMA Standard 9
6.1.6 d)	ISO 5753 Group 3	ABMA Group 3
6.1.8	ISO 10436	API 611
6.3.17	ISO 8501 Grade Sa2	SSPC SP6
6.4.1	ISO 10438	API 614
7.3.1.1	ISO 9906	Hydraulic Institute Standards
7.3.4.2.1	ISO 9906	Hydraulic Institute Standards: ANSI/HI 1.6 – Centrifugal Pumps, 2.6 – Vertical Pumps
8.1.3.7	ISO 10438	API 614

Section 5 Basic design

5.1 General

5.1.6
Pumps shall be capable of operating at least up to the maximum continuous speed. The maximum continuous speed shall be:
a) equal to the speed corresponding to the synchronous speed at maximum supply frequency for electrical motors;
b) at least 105% of rated speed for variable speed pumps, and any fixed speed pump sparing or spared by a pump whose driver is capable of exceeding rated speed.

In the Eighth Edition all pumps, regardless of driver, had to be rated for a speed increase of 105 percent speed. This change recognizes that motor driven fixed speed pumps, that are not spared by steam turbine driven pumps, do not need this overspeed requirement.

5.1.12
Pumps that handle liquids more viscous than water shall have their water performance corrected in accordance with the Centrifugal Pump Section of the Hydraulic Institute Standards. Correction factors shall be submitted with proposal and test curves.

The requirement was added to have the correction factors submitted with the proposal and with the test curves.

● 5.1.16
If specified, the vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment. Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor having unit responsibility. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified.
NOTE ISO 3740, ISO 3744 and ISO 3746 may be consulted for guidance.

The "if specified" was added since many pumps are small and do not require sound level data to be routinely furnished.

5.1.30
Unless otherwise specified, equipment, including all auxiliaries, shall be designed for outdoor installation and the specified site environmental conditions. The vendor shall advise any equipment protection required for the jobsite location (i.e. winterisation for low ambient temperatures, unusual humidity, dusty or corrosive conditions, etc.).

The standard now defaults to the pump being located outdoors. The vendor must now take into account the site conditions and advise any equipment protection requirements.

5.1.31
Bolting for pressure casings shall conform with 5.1.31.a) through 5.1.31.f).

e) Fasteners (excluding washers and headless set screws). Shall have the material grade and manufacturers identification symbols applied to one end of studs 10 mm (3/8 in) in diameter and larger and to the heads of bolts 6 mm (1/4 in) in diameter and larger. If the available area is inadequate, the grade symbol may be marked on one end and the manufacturers identification symbol marked on the other end. For studs, the marking shall be on the exposed end (reference ASTM A 193).

This is a new clause, not previously in the Eighth Edition. It protects the user from having fasteners supplied that do not comply with material requirements of the standard. It also provides the ability to trace the manufacture of fasteners.

5.3 Pressure casings

This section was reorganized into a more concise and understandable format. The individual new clauses are:

5.3.1
The maximum discharge pressure shall be the maximum suction pressure plus the maximum differential pressure the pump is able to develop when operating with the furnished impeller at the rated speed and specified normal relative density (specific gravity).
NOTE The basis of determining maximum discharge pressure is an application issue.

This is a repeat of the definition, but it is necessary to provide a logical flow of information required for the calculation of maximum allowable working pressure (MAWP). The maximum discharge pressure in the Eighth Edition was equal to the maximum suction pressure plus the maximum differential pressure using the rated impeller, at rated speed and maximum specified relative density. The significant change in the definition is the use of the normal density instead of the maximum specified density.

If the user wants to account for maximum relative density, maximum impeller size, maximum number of impellers, or operation to trip speed, these options are available in clause 5.3.2.

The basic design does not account for these maximums because they are considered to be excursions to nonnormal operating conditions covered by the safety factor in the applicable design code pressure calculations. In the case of maximum impeller diameter or maximum number of impellers, these are future cases that could be considered as preinvestment items. The user is advised to consider all these items closely and to change the calculation of maximum discharge pressure to suit specific application requirements.

● 5.3.2
If specified, the maximum discharge pressure shall be increased by the additional differential pressure developed during one or more of the following operating circumstances:

a) the maximum specified relative density (specific gravity) at any specified operating condition.
b) installation of the maximum diameter impeller and/or number of stages that the pump can accommodate.
c) operation to trip speed.
NOTE 1 The purchaser should assess the likelihood of the circumstances above occurring before specifying them.
NOTE 2 The additional differential pressure developed at trip speed is normally a momentary excursion to be absorbed by the hydro test margin.

5.3.3
The pressure casing shall be designed to:
a) operate without leakage or internal contact while subject simultaneously to the MAWP (and corresponding temperature) and the worst case combination of two times the allowable nozzle loads of Table 5A (Table 5B) applied through each nozzle;
b) withstand the hydrostatic test (see 7.3.2).
NOTE The two times nozzle load requirement is a pressure casing design criterion. Allowable nozzle loads for piping designers are the values given in Table 5A and Table 5B. Other factors such as casing support or baseplate stiffness affect allowable nozzle loads.

This is a new clause added to emphasize the fact that the pump must not only operate at the MAWP condition, but must operate without leakage or internal rotor contact with two times the allowable nozzle loads applied. This is a design criterion and is not intended that it be proven on test.

5.3.4
The tensile stress used in the design of the pressure casing for any material shall not exceed 0,25 times the minimum ultimate tensile strength for that material at the maximum specified operating temperature. Casting factors shall be as shown in Table 3 *[Table 4]*. The manufacturer shall state the source of the material properties, such as ASTM, as well as the casting factors applied in his proposal.
NOTE 1 In general the criteria in 5.3.4 result in deflection (strain) being the determining consideration in the design of pump casings. Ultimate tensile or yield strength is seldom the limiting factor.
NOTE 2 For bolting, the allowable tensile stress is used to determine the total bolting area based on hydrostatic load or gasket preload. It is recognised that to provide the initial load required to obtain a reliable bolted joint, the bolting will be tightened to produce a tensile stress higher than the design tensile stress. Values in the range of 0,7 times yield are common.

Table 4. 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

In the Eighth Edition, the stress used in design was based on the values given in Section II of the ASME code, with a factor for cast materials as specified in Section VIII, Division 1 of the code. This new clause is intended to make "all pressure design codes equal" worldwide. It removes specific reference to the ASME Boiler & Pressure Vessel Code (2001) and places the conventional values for stress and casting factors in this standard. The design rules of the pressure vessel codes do not apply to pumps and the calculated maximum stresses become a function of the calculation methods employed. Please read note 1, which advises that the case thickness is typically determined from what is required to limit strain (distortion) rather than to limit hoop stresses resulting from internal pressure.

5.3.6
Unless otherwise specified, vertically suspended, double casing, integral gear driven (type OH6) and horizontal multistage pumps (pumps with three or more stages) may be designed for dual pressure ratings. For example regions of these pumps that are subject only to suction pressure need not be designed for the maximum allowable working pressure of the higher pressure sections.

Integrally gear driven pumps were added to this Eighth Edition clause, recognizing that these pumps also apply.

5.3.7
The pressure casing shall be designed with a corrosion allowance to meet the requirements of 5.1.1. Unless otherwise specified the minimum corrosion allowance shall be 3 mm (0,12 in).
NOTE The vendor is encouraged to propose alternative corrosion allowances for consideration when materials of construction with superior corrosion resistance are employed if they result in lower cost without affecting safety and reliability.

The note was added to encourage vendors to propose better materials for service.

5.3.9
Unless otherwise specified, pumps with radially split casings are required for any of the following operating conditions.
a) A pumping temperature of 200°C (400°F) or higher (a lower temperature limit should be considered when thermal shock is probable).
b) A flammable or hazardous pumped liquid with a relative density (specific gravity) of less than 0,7 at the specified pumping temperature.
c) A flammable or hazardous pumped liquid at a rated discharge pressure above 100 bar (1450 psi).
NOTE The above limits are based on conservative refinery practice. Axially split casings have been used successfully beyond the limits given above, generally for off plot applications at higher pressure or lower specific gravity. The success of such applications depends on the margin of design pressure over rated, the manufacturer's experience with similar applications, the design and manufacture of the split joint, and the owner's ability to correctly remake the split joint in the field. The purchaser should take these factors into account before specifying an axially split casing for conditions beyond the above limits.

The note, which was previously in the Seventh Edition of API 610 (1995), has been restored to recognize the fact that axially split pumps are frequently used for liquids with relative densities substantially less than 0.7. The user is cautioned to review his own and the vendor's experience and capabilities before applying axially split pumps that exceed these limits.

5.3.11
Centreline supported pump casings shall be used for all horizontal pumps except as allowed in 8.2.1.2.

Clause 8.2.1.2 allows BB1-BB5 pumps to be foot mounted if the service temperature is below 150°C (300°F).

5.3.14
The use of threaded holes in pressure parts shall be minimised. To prevent leakage in pressure sections of casings, metal, equal in thickness to at least half the nominal bolt or stud diameter, plus the allowance for corrosion, shall be left around and below the bottom of drilled and threaded holes.

a) Internal bolting shall be of a material fully resistant to corrosive attack by the pumped liquid.
b) Studs shall be supplied on all main casing joints unless cap screws are specifically approved by the purchaser.

In the Eighth Edition of API 610, there was also a requirement that the depth of tapped holes be at least 1.5 times the nominal bolt or stud diameter. This requirement has been eliminated. This requirement was not in the Seventh Edition of API 610 or any previous editions of API 610. This is important on small compact process pumps where shallow taps are utilized to minimize weight and bulk as well as on single stage double suction pumps and multistage pumps that utilize shallow taps where the parting flange bolting is close to internal hydraulic passageways.

5.4 Nozzles and pressure casing connections

5.4.1 Casing opening sizes

5.4.1.2
Casing connections other than suction and discharge nozzles shall be at least 1/2 NPS for pumps with discharge nozzle openings DN 50 (2 NPS) and smaller. Connections shall be at least DN 20 (3/4 NPS) for pumps with discharge nozzle openings DN 75 (3 NPS) and larger, except that connections for seal flush piping and gauges may be DN 12 (1/2 NPS) regardless of pump size.

The reference to a lantern ring connection was deleted, since the standard now defaults to mechanical seals only.

5.4.2 Suction and discharge nozzles

5.4.2.2
Cast iron flanges shall be flat faced and conform to the dimensional requirements of ISO 7005-2 and the flange finish requirements of ANSI/ASME B16.1 or 16.42. Class 125 flanges shall have a minimum thickness equal to Class 250 for sizes DN 200 (8 NPS) and smaller.

5.4.2.3
Unless otherwise specified, flanges other than cast iron shall as a minimum conform to the dimensional requirements of ISO 7005-1 PN50 and the flange finish requirements of ANSI/ASME B16.5 or B16.47.
NOTE For the purpose of dimensional requirements ANSI/ASME B16.5 or B16.47 are equivalent to ISO 7005-1.

Both clauses add the flange finish requirement from referenced ANSI/ASME standards. The Eighth Edition paragraph 2.3.2.6 had special flange finish requirements beyond the previous standard flange requirements of ANSI/ASME. This requirement has been deleted, because the flange finish specifications in the ANSI/ASME standards have been revised.

5.4.3 Auxiliary connections

5.4.3.4
For flammable or hazardous liquids, auxiliary connections to the pressure casing, except seal gland, shall be socket welded, butt welded, or integrally flanged. Purchaser interface connections shall terminate in a flange.

The "except seal gland" was added to this clause to recognize the standard practice in industry of having seal gland connections threaded for ease of maintenance.

5.4.3.5
Connections welded to the casing shall meet or exceed the material requirements of the casing, including impact values, rather than the requirements of the connected piping. All connection welding shall be completed before the casing is hydrostatically tested (see 7.3.2).

The phrase, "or exceed," was added for practical reasons and the requirement to complete connection welds before hydrostatic tests.

5.4.3.7
Threaded openings not connected to piping are only allowed in seal glands (5.8.7) and in pumps of material classes I-1 and I-2. When supplied they shall be plugged. Taper threaded plugs shall be (long shank) solid round head bar stock plugs in accordance with ANSI/ASME B16.11. If cylindrical threads are specified in 5.4.3.3, plugs shall be solid hexagon head plugs in accordance with DIN 910. These plugs shall meet the material requirements of the casing. An anaerobic (or other suitable high temperature) lubricant/sealant shall be used to ensure that the threads are vapour tight. Plastic plugs are not permitted.

In the Eighth Edition, paragraph 2.3.3.7 allowed tapped openings not connected to piping to be plugged. This new clause only allows plugs to be used at the seal gland and for I-1 and I-2 pumps. It also adds technical requirements for the plugs.

• 5.4.3.8
Machined and studded customer connections require specific purchaser approval. When approved, they shall conform to the facing and drilling requirements of ISO 7005-1 or ISO 7005-2. Studs and nuts shall be furnished installed. The first 1,5 threads at both ends of each stud shall be removed.
NOTE For the purpose of this clause ANSI/ASME B16.1 and B16.5 is equivalent to ISO 7005-1 and ISO 7005-2.

The phrase "require specific purchaser approval" was added to allow the user the option to approve use. This was not in the Eighth Edition.

5.4.3.11
All of the purchaser's connections shall be accessible for disassembly without requiring the pump, or any major part of the pump, to be moved.

This is a new clause based on standard paragraph. This is a new requirement that was not in Eighth Edition.

5.6 Rotors

5.6.2
Impellers shall be single-piece castings, forgings or fabrications.
NOTE Impellers made as forgings or fabrications have machined waterways, which may offer improved performance for low N_s designs.

The Eighth Edition paragraph 2.5.1 required impellers to be single piece castings; fabricated impellers required specific purchaser approval. The new clause allows impellers to be fabricated and allows fully machined impellers to be offered for improved performance.

5.6.6
The shaft to seal sleeve fit(s) shall be h6/G7 in accordance with ISO 286.

This is a new clause. The Eighth Edition paragraph 2.5.5 describing shaft sleeve construction has been deleted because all sleeve information is now contained in API 682.

5.6.7
Areas of shafts that may be damaged by setscrews shall be relieved to facilitate the removal of sleeves or other components.

This is a new clause detailing shaft construction.

5.6.11
If the shaft is made of material that exhibits inconsistent electrical properties, the shaft sensing areas may be produced by shrink fitting sleeves or "target rings" to the shaft. Target rings shall be finished in accordance with 5.6.10. The use of target rings requires specific purchaser approval.

NOTE Materials known to exhibit inconsistent electrical properties are high chrome alloys such as 17-4 PH, duplex stainless steel and ASTM A 479 grade XM-19.

This is a new clause added to recognize the problem of excessive electrical runout exhibited by certain alloy materials.

● 5.6.12

If it is specified that equipment shall have provisions for mounting non-contacting vibration probes in the future (6.4.2.1), the shaft shall be prepared in accordance with the requirements of 5.6.10 and API Standard 670.

This is a new clause based on standard paragraph to provide a shaft suitable for future probes.

5.6.14

All shaft keyways shall have fillet radii conforming to ANSI/ASME B17.1.

NOTE This requirement applies to all shaft keyways, not just those at the coupling(s).

This is a new clause that adds the keyway radii requirement.

5.6.15

The rotor of one- and two-stage pumps shall be designed so its first dry bending critical speed is at least 20% above the pump's maximum continuous operating speed.

This is a new clause used to define the requirement for critical speed margin.

5.7 Wear rings and running clearances

5.7.1

Radial running clearances shall be used to limit internal leakage and, where necessary, balance axial thrust. Impeller pumping vanes or close axial clearances shall not be used to balance axial thrust. Renewable wear rings shall be provided in the pump casing. Impellers may have integral wear surfaces or renewable wear rings.

Integral wear surfaces are now allowed. This was addressed in the Eighth Edition as a note to 2.6.1 and required purchasers approval.

5.7.3

Renewable wear rings, when used, shall be held in place by a press fit with locking pins, screws (axial or radial) or by tack welding. The diameter of a hole in a wear ring for a radial pin or threaded dowel shall not be more than one-third the width of the wear ring.

In the Eighth Edition, tack welding of wear rings required purchaser approval. Tack welding of wear rings is a common accepted practice and is so recognized.

5.7.4

Running clearances shall meet the requirements of 5.7.4.a) through 5.7.4.c).

c) For non-metallic wear ring materials with very low or no galling tendencies (see Annex G, Table G4), clearances less than those given in Table 6 may be proposed by the vendor. Factors such as distortion and thermal gradients shall be considered to be sure clearances are sufficient to assure dependability of operation and freedom from seizure under all specified operating conditions.

This is a new clause addressing nonmetallic wear rings such as PEEK and graphite materials (such as Graphalloy®) supplied with tighter running clearances than API 610 standard clearances. The user should review the application service requirements when approving tighter clearances.

5.8 Mechanical Shaft Seals

5.8.1

Pumps shall be equipped with mechanical seals and sealing systems in accordance with API Standard 682, including pump and seal interface dimensions. The purchase shall specify the category of seal required.

The default is for all mechanical seal information to be contained in API 682 and for the mechanical seal to be an API 682 seal. Nearly all the paragraphs in section 2.7.3 (2.7.3.1 through 2.7.3.23) have been deleted and are covered in API 682. API 682 is to be published simultaneously with API 610 Ninth Edition to form a complete pump standard. The only remaining paragraphs from the Eighth Edition are the seal chamber dimensions paragraph 2.7.3.6 now covered by 5.8.3, and centering provisions in 2.7.3.11 now covered by 5.8.4.

5.8.2

The seal cartridge shall be removable without disturbing the driver.

This is a new clause requiring that the coupling spacer length be sufficient to allow removal of the total seal cartridge (package) without disturbing either the driver or the pump when installed in the field.

5.8.3

The seal chamber shall conform to the dimensions shown in Figure 25 and Table 7 *[please refer to APPENDIX A for Figure A-1 and Table A-1]*. For pumps with flange and pressure ratings in excess of the minimum values in 5.3.5, the gland stud size and circle may increase. Larger studs shall be furnished only if required to meet the stress requirements of 5.3.4 or to sufficiently compress spiral wound gaskets in accordance with manufacturer's specifications.

The Eighth Edition note referring to the possible need for larger gland stud size and circle diameter for higher pressure pumps is now included in the clause.

● 5.8.9

If specified, jackets shall be provided on seal chambers for heating. Heating requirements shall be agreed upon by the purchaser, vendor, and seal manufacturer for high melting point products

Optional cooling inserts or jackets for seal chambers have been deleted. The use of cooling jackets on seal chambers is no longer an option and should not be applied.

Throat Bushing

The Eighth Edition paragraph 2.7.3.18 requiring a throat bushing has been deleted. The requirement for a throat bushing is left to the pump designer. If the seal chamber pressure has to be maintained, then a throat bushing will probably be furnished. Throat bushings were initially used to contain packing.

5.9 Dynamics

5.9.2.4

If torsional resonances are calculated to fall within the margin specified in 5.9.2.3 (and the purchaser and the vendor have agreed that all efforts to remove the critical from within the limiting frequency range have been exhausted), a stress analysis shall be performed to demonstrate that the resonances have no adverse effect on the complete train. The assumptions made in this analysis regarding the magnitude of excitation and the degree of damping shall be clearly stated. The acceptance criteria for this analysis shall be agreed upon by the purchaser and the vendor.

The requirement to have the pump vendor supply the assumptions made in the analysis regarding the magnitude of excitation and the degree of damping has been added.

5.9.3 Vibration

5.9.3.4

Bearing housing overall vibration measurements shall be made in root mean square (RMS) velocity, millimetres per second (inches per second).

The requirement to supply true peak velocity readings during the performance test has been deleted. A database has not been established from which meaningful true peak vibration limits for pumps can be determined.

5.9.3.6

The vibration measured during the performance test shall not exceed the values shown in the following *[refer to Table 5 and 6 and Figure 1]:*

Table 5. Vibration Limits for Overhung and Between Bearings Pumps.

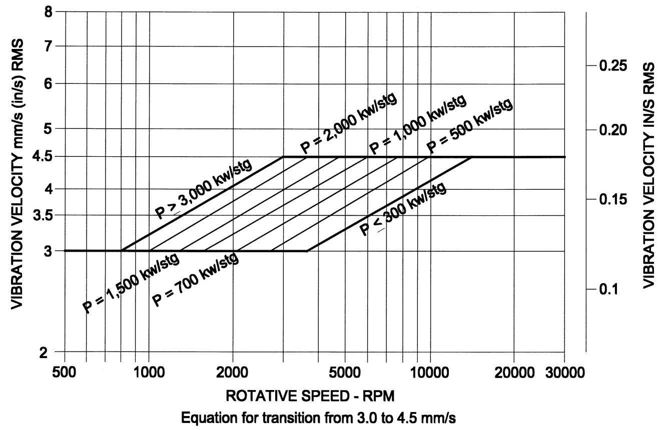
Item	Location of vibration measurement	
	Bearing housing (see Figure 27)	**Pump shaft (adjacent to bearing)**
Pump bearing type	**All**	**Hydrodynamic journal bearings**
Vibration at any flow within the pump's preferred operating region:		
Overall	V_u < 3,0 mm/s RMS (0,12 in/s RMS) (1) For pumps running at up to 3600 r/min and absorbing up to 300 kW (400 hp) per stage(2). See Figure 29 for pumps running above 3600 r/min or absorbing more than 300 kW (400 hp) per stage.	$A_u < (5,2x10^6/N)^{0,5}$ µm peak to peak $(8000 / N)^{0,5}$ mils peak to peak **Not to exceed:** A_u < 50 µm (peak to peak) (1) 2,0 mils (peak to peak)
Discrete frequencies	V_f < 2,0 mm/s RMS (0,08 in/s RMS)	for f < N: A_f < 33 % of A_u
Increase in allowable vibration at flows beyond the preferred operating region but within the allowable operating region	30%	30%

NOTE 1 Values calculated from the basic limits shall be rounded off to two significant figures.
NOTE 2 Calculated for BEP of rated impeller with liquid RD (SG) = 1.0
Where:
V_u is the unfiltered velocity;
V_f is the filtered velocity determined by FFT;
A_u is the unfiltered displacement;
A_f is the filtered displacement determined by FFT;
N is the rotational speed, expressed in revolutions per minute.

Table 6. Vibration Limits for Vertically Suspended Pumps.

Item	Location of vibration measurement	
	Pump thrust bearing housing Or Motor mounting flange (see Figure 28)	**Pump shaft (adjacent to bearing)**
Pump bearing type	**All**	**Hydrodynamic guide bearing adjacent to accessible region of shaft**
Vibration at any flow within the pump's preferred operating region:		
Overall	V_u < 5,0 mm/s RMS (0,20 in/s RMS)	$A_u < (6,2x10^6/N)^{0,5}$ peak to peak $(10\,000/N)^{0,5}$ mils (peak to peak) **Not to exceed:** A_u < 100 µm (peak to peak) 4,0 mils (peak to peak)
Discrete frequencies	V_f < 3,4 mm/s RMS (0,13 in/s RMS)	for A_f : 75% of A_u
Increase in allowable vibration at flows beyond the preferred operating region but within the allowable operating region	30%	30%

NOTE Values calculated from the basic limits shall be rounded off to two significant figures.
Where:
V_u is the unfiltered velocity;
V_f is the filtered velocity determined by FFT;
A_u is the unfiltered displacement;
A_f is the filtered displacement determined by FFT;
N is the rotational speed, expressed in revolutions per minute.



$$Vu = 3.0 \left(\frac{N}{3600}\right)^{0.30} \left(\frac{kw/stage}{300}\right)^{0.21}$$

Figure 1. Vibration Limits for Horizontal Pumps Running Above 3600 r/min or Absorbing More than 200 kW (400 hp) Per Stage.

The allowable vibration levels have been increased for higher speed and higher energy pumps, recognizing the existing limits were too low for these applications. In Tables 4 and 5, the values for unfiltered displacement determined by fast Fourier transform (FFT) for hydrodynamic bearings have been corrected from the Eighth Edition.

5.9.4

5.9.4 Balancing

5.9.4.1

Impellers, balancing drums, and similar major rotating components shall be dynamically balanced to ISO 1940 Grade 2.5. The weight of the arbor used for balancing shall not exceed the weight of the component being balanced.

The balance grade in Eighth Edition paragraph 2.8.4.1 was ISO grade G1.0. The maximum allowable imbalance has been changed to that required to achieve the specified vibration levels.

If the user desires a higher degree of balance, this can be added by invoking the following clause.

● 5.9.4.4

If specified, impellers, balancing drums and similar rotating components shall be dynamically balanced to ISO 1940 Grade 1.0 or 4W/N.

5.10.1 Bearings

5.10.1.1

Each shaft shall be supported by two radial bearings and one double-acting axial (thrust) bearing which may or may not be combined with one of the radial bearings. Bearings shall be one of the following arrangements: rolling element radial and thrust, hydrodynamic radial and rolling element thrust or hydrodynamic radial and thrust. Unless otherwise specified, the bearing type and arrangement shall be selected in accordance with the limitations in Table 9.

The first sentence has been added to conform to actual pump construction.

5.10.1.5

Ball thrust bearings shall be of the paired single row, 40° (0,7 radian) angular contact type (7000 series) with machined brass cages. Unless otherwise specified, bearings shall be mounted in a paired arrangement installed back-to-back. The need for bearing clearance or preload shall be determined by the vendor to suit the application and meet the bearing life requirements of Table 8.

NOTE There are applications where alternate bearing arrangements may be preferable particularly where bearings operate continuously with minimal axial loads.

The note has been added to allow other bearing arrangements for lightly loaded thrust bearings.

5.10.1.6

If loads exceed the capability of paired angular contact bearings as described in 5.10.1.5, alternative rolling element arrangements may be proposed.

This is a new clause allowing the use of roller-type bearings for higher axial load capability.

5.10.2 Bearing housings

5.10.2.2

Bearing housings for oil-lubricated non-pressure-fed bearings shall be provided with threaded and plugged fill and drain openings at least DN 15 (1/2 NPS). The housings shall be equipped with constant level sight feed oilers at least 12 dl (4 oz) in volume, with a positive level positioner (not an external screw), heat-resistant glass containers, and protective wire cages. Means shall be provided, such as a bulls-eye or an overfill plug, for detecting overfilling of the housings. A permanent indication of the proper oil level shall be accurately located and clearly marked on the outside of the bearing housing with permanent metal tags, marks inscribed in the castings, or other durable means.

The requirement for a bulls-eye or an overfill plug has been added.

5.10.2.4

Where water cooling is required, cooling coils are preferred. The coils (including fittings) shall be of nonferrous material or austenitic stainless steel and shall have no internal pressure joints. Tubing or pipe shall have a minimum thickness of 1,0 mm (0,040 in) and shall be at least 12 mm (0,50 in) outside diameter. Water jackets, if used, shall have only external connections between upper and lower housing jackets and shall have neither gasketed nor threaded connection joints which may allow water to leak into the oil reservoir. Water jackets shall be designed to cool the oil rather than the outer bearing ring.

NOTE Cooling the outer ring can reduce bearing internal clearance and cause bearing failure.

This clause replaces the API 610 Eighth Edition paragraph 2.9.24, which referenced the use of water jackets as the means to cooling bearing housings. The new clause defaults to using cooling coils instead of water jackets.

5.10.2.7

Bearings and bearing housings shall meet the requirements of 5.10.2.7.a) through 5.10.2.7.e) if oil mist lubrication is specified (see 5.11 3).

a) An oil mist inlet connection, DN 6 (1/4 NPS), shall be provided in the top half of the bearing housing. Pure oil mist fitting connections shall be located so that oil mist will flow through rolling element bearings. If bearing housing design is such that short circuiting cannot be avoided, directional oil mist reclassifiers may be furnished to ensure positive oil mist circulation through the bearings.

The last sentence allows the use of reclassifiers if the oil mist may short-circuit the bearings.

The Eighth Edition paragraph 2.9.2.9 stating, "when specified the vendor shall furnish oil heaters," has been deleted since users are not requesting oil heaters.

5.11 Lubrication

5.11.2

The operation and maintenance manual shall describe how the lubrication system circulates oil.

There are several methods used to deliver oil to the bearings: oil rings, flingers, disks, and flood. It is the pump designer's responsibility to provide an effective lubrication method that meets the performance requirements of this standard. This clause completely replaces Eighth Edition paragraph 2.10.2, which dictated flingers or oil rings and defined submergence level. The method for mounting oil rings was also stated.

• 5.11.4

If specified, rolling element bearings shall be grease lubricated in accordance with 5.11.4.a) through 5.11.4.d):

a) Grease lubrication shall not be used if the estimated grease life is less than 2000 h.

b) If the estimated grease life is 2000 h or greater but less than 25000 h, provision shall be made for re-greasing the bearings in service and for the effective discharge of old or excess grease and the vendor shall advise the purchaser of the required re-greasing interval.

c) If the estimated grease life is 25000 h or more, grease nipples or any other system for the addition of grease in service shall not be fitted.

d) Grease life (re-lubrication interval) shall be estimated using the method recommended by the bearing manufacturer or an alternative method approved by the purchaser.

New clauses have been added allowing grease lubrication and listing criteria for this lubrication method.

5.12 Materials

5.12.1.1

Materials for pump parts shall be in accordance with Annex H, except that superior or alternative materials recommended for the service by the vendor shall be listed on the data sheets. Table G.1, Annex G is a guide showing material classes that may be appropriate for various services. Pump parts designated as full compliance materials in Table H.1 of Annex H shall meet the requirements of the industry specifications listed for materials in Table H.2. Pump parts not designated as full compliance materials in Table H.1 shall be made from materials with the applicable chemical composition but need not meet the other requirements of the listed industry specification. Auxiliary piping materials are covered in 6.5

5.12.1.2

The materials of construction of all major components shall be clearly stated in the vendor's proposal. Materials shall be identified by reference to applicable international standards, including the material grade (see Annex H). When no such designation is available, the vendor's material specification, giving physical properties, chemical composition, and test requirements shall be included in the proposal.

NOTE Where international standards are not available, internationally recognised national or other standards may be used.

These clauses were rewritten and material's Tables H.4 through H.6 in Annex H have been updated and revised. Table H.1 now contains recommendations for super duplex material and the materials listed are normative. Table H.2 contains international corresponding materials that may be used with the purchaser's approval. This material list is informative. [Please refer to APPENDIX A for Tables A-2, A-3, A-4, and A-5.]

• 5.12.1.8

If specified, coatings of a type agreed between the purchaser and the vendor shall be applied to impellers and other wetted parts to minimise erosion. If coatings are applied to rotating components, the acceptance balance shall be performed after coatings have been applied. The sequence of procedures for balancing and coating of rotating components shall be agreed.

NOTE It is advisable to pre-balance in order to minimise balance corrections to coated areas. By minimising the area to be recoated, a final check balance after coating repair may not be required.

This is a new clause recognizing the use of coatings to minimize erosion.

5.12.1.10
The purchaser shall specify if reduced hardness materials in accordance with NACE MR0175 shall be provided. If reduced hardness materials are specified, ferrous materials not covered by NACE MR0175 shall not have a yield strength exceeding 620 N/mm2 (90 000 psi) nor a hardness exceeding HRC 22. Components that are fabricated by welding shall be postweld heat treated, if required, so that both the welds and the heat-affected zones meet the yield strength and hardness requirements.
NOTE 1 It is the responsibility of the purchaser to determine the amount of wet H2S that may be present, considering normal operation, startup, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.
NOTE 2 Application of MR0175 is a two step process. First the need for special materials is determined and second the materials are selected. Specification of this clause assumes the user has determined the need and results in limited hardness materials.
NOTE 3 In many applications, small amounts of wet H_2S are sufficient to require materials resistant to sulfide stress corrosion cracking. When there are trace quantities of wet H_2S known to be present or if there is any uncertainty about the amount of wet H_2S that may be present, the purchaser should automatically note on the data sheets that materials resistant to sulfide stress corrosion cracking are required.

5.12.1.10.1
As a minimum, the requirements of 5.12.1.10 apply to the following components:
a) the pressure casing;
b) shafting (including wetted shaft nuts);
c) pressure retaining mechanical seal components (excluding seal faces);
d) wetted bolting;
e) bowls.
NOTE Double-casing pump inner casing parts that are in compression, such as diffusers, are not considered pressure casing parts. In some applications it may be desirable to apply this requirement to impellers.

5.12.1.10.2
Renewable impeller wear rings that must be through-hardened above HRC 22 for proper pump operation are not acceptable in sour services. Wear rings may be surface hardened or coated with a suitable coating. When approved by the purchaser, in lieu of furnishing renewable wear rings, wear surfaces may be surface hardened or hardened by the application of a suitable coating.

This is a major change in philosophy of material selection in the new standard. In the Eighth Edition, paragraph 2.11.1.11, the purchaser specified the presence of H_2S and water in the process liquid. The standard then dictated the material requirements in regard to yield strength and hardness levels for certain components.
It is now the purchaser's responsibility to determine if reduced hardness materials in accordance with NACE MR0175 (2000) shall be provided.

5.12.1.12
The vendor shall select materials to avoid conditions that may result in galvanic corrosion. Where such conditions cannot be avoided, the purchaser and the vendor shall agree on the material selection and any other precautions necessary.

NOTE When dissimilar materials with significantly different electrochemical potentials are placed in contact in the presence of an electrolytic solution, galvanic couples that can result in serious corrosion of the less noble material may be created. The NACE *Corrosion Engineer's Reference Book* is one source for selection of suitable materials in these situations.

This standard clause replaces the note in paragraph 2.11.1.9 in the Eighth Edition. This clause recognizes a known material problem.

5.12.2 Castings

● 5.12.2.5
If specified, for casting repairs made in the vendor's shop, repair procedures including weld maps shall be submitted for purchaser's approval. The purchaser shall specify if approval is required before proceeding with repair. Repairs made at the foundry level shall be controlled by the casting material specification ("producing specification").

This clause is a replacement to the Eighth Edition paragraph 2.11.2.5. The clause has been expanded to recognize the difference between repair welds and foundry production welds.

5.12.3 Welding

● 5.12.3.1
Welding and weld repairs shall be performed and inspected by operators and procedures qualified in accordance with the requirements of Table 11 *[Table 7]*. If specified, alternate codes or standards may be used. These alternate codes shall be specified using the welding and material inspection datasheet in Annex O.

Table 7. Welding Requirements.

Requirement	Applicable Code or Standard
Welder/operator qualification	ASME IX
Welding procedure qualification	Applicable material specification or, where weld procedures are not covered by the material specification ASME IX
Non-pressure retaining structural welding such as baseplates or supports	ANSI/AWS D1.1
Magnetic particle or liquid penetrant examination of the plate edges	ASME VIII, Division 1, UG-93(d)(3
Postweld heat treatment	Applicable material specification or ASME VIII, Division 1, UW 40
Postweld heat treatment of casing fabrication welds	Applicable material specification or ASME VIII, Division I

This is a new clause that contains the same information that was detailed in section 2.11.3 of the Eighth Edition. The new standard defaults to ASME/ANSI/AWS codes with the option for other international codes to be used if defined by the user.

5.12.4 Low temperature

5.12.4.2
To avoid brittle failures, materials of construction for low temperature service shall be suitable for the minimum design metal temperature (see 5.12.4.5) in accordance with the codes and other requirements specified. The purchaser and the vendor shall agree on any special precautions necessary with regard to conditions that may occur during operation, maintenance, transportation, erection, commissioning and testing.

NOTE Good design practice should be followed in the selection of fabrication methods, welding procedures, and materials for vendor furnished steel pressure retaining parts that may be subject to temperatures below the ductile-brittle transition temperature. The published design-allowable stresses for metallic materials in internationally recognised standards such as the ASME Code and ANSI standards are based on minimum tensile properties. Some standards do not differentiate between rimmed, semi-killed, fully killed hot-rolled and normalised material, nor do they take into account whether materials were produced under fine- or course-grain practices. The vendor should exercise caution in the selection of materials intended for services between −30°C (−20°F) and 40°C (100°F).

Clause 5.12.4.2 in ISO 13709 is the same as 2.11.4.1 in API 610 Eighth Edition. The note has been added to encourage the user to be cautious in material selection.

5.12.4.5
Carbon steel and low alloy steel pressure retaining parts applied at a specified minimum design metal temperature (5.12.4.5) between −30°C (−20°F) and 40°C (100°F) shall require impact testing in accordance with 5.12.4.3.a) and 5.12.4.3.b).
a) Impact testing is not required for parts with a governing thickness (5.12.4.4) of 25 mm (1 in) or less.
b) Impact testing exemptions for parts with a governing thickness (5.12.4.4) greater than 25 mm (1 in) shall be established in accordance with paragraph UCS-66 in Section VIII, Division 1 of the ASME Code. Minimum design metal temperature without impact testing may be reduced as shown in figure UCS-66.1. If the material is not exempt, Charpy V-notch impact test results shall meet the minimum impact energy requirements of paragraph UG-84 of the ASME Code.

This is the same clause as 2.11.4.3.2 in the Eighth Edition, except reference to curve B for carbon steel and low alloy steel has been deleted. This change was made because UCS-66 now includes these materials.

5.13 Nameplates and rotation arrows

5.13.2
The nameplate shall be stamped with the following information in units consistent with the data sheet:
h) manufacturer's bearing identification numbers (if applicable);

The phrase "in units consistent with the data sheet" was added to have the nameplate and the data sheet in the same units. The words "(if applicable)" were added to cover bearings that do not have identity numbers.

6 Accessories

6.1 Drivers

6.1.5
The driver's starting torque capabilities shall exceed the speed-torque requirements of the driven equipment. Unless otherwise specified, the motor shall be capable of accelerating the pump to rated speed at 80% voltage against a closed discharge valve.
NOTE Some pumps are equipped with bypasses and alternate starting conditions must be used.

The default requirement for 80 percent voltage drop and closed discharge valve was added.

6.1.6
Rolling element bearings in the drive systems designed for radial or axial loads transmitted from the pump shall meet the following requirements.
b) Bearings shall be selected to give a basic rating life, L_{10h}, of at least 16000 h when carrying the maximum loads (radial or axial or both) imposed with internal pump clearances at twice the design values and when operating at any point between minimum continuous stable flow and rated flow. Vertical motors 750 kW (1000 hp) and larger that are equipped with spherical or taper roller bearings may have less than 16000 hour L_{10h} life at worst conditions to avoid skidding in normal operation. In such cases, the vendor will state the shorter design life in the proposal.

The last sentence was added for vertical motors equipped with rolling element bearings where the requirement to design to a minimum 16,000 hours life at worst conditions might result in bearing skidding and reduced actual bearing life.

6.1.8
Unless otherwise specified, steam turbine drivers shall conform to ISO 10436 or API Standard 611. Steam turbine drivers shall be sized to deliver continuously 110% of the pump rated power at normal steam conditions.

The Eighth Edition paragraph 3.1.9 required the purchaser to specify which steam conditions were to be supplied. The default is now the normal steam conditions.

6.1.10
Unless otherwise specified, for drive train components that have a mass greater than 250 kg (500 lb), the equipment feet shall be provided with vertical jackscrews.

The Eighth Edition paragraph 3.1.11 required vertical jackscrews for components that weighed more than 450 kg (1000 lb).

6.2 Couplings and guards

API Eighth Edition paragraph 3.2.7, which required a component balance to 4 W/N for couplings operating below 3800 rpm, has been deleted. The requirement to meet AGMA class 9 has been retained.

6.2.5
Flexible couplings shall be keyed to the shaft. Keys, keyways, and fits shall conform to AGMA 9002, Commercial Class.

6.2.7
If the shaft diameter is greater than 60 mm (2,5 in) and/or the coupling hub must be removed to service the mechanical seal, the hub shall be mounted with a taper fit. The coupling fit taper for keyed couplings shall be 1 in 16 (0,75 in/ft, diametral). Other mounting methods shall be agreed upon by the purchaser and the vendor. Coupling hubs with cylindrical bores may be supplied with slip fits to the shaft and set screws that bear on the key.
NOTE 1 Appropriate assembly and maintenance procedures should be used to assure that taper fit couplings have an interference fit. Slip fits on cylindrical bores allow adjustment of the coupling axial position in the field without application of heat.
NOTE 2 Alternate tapers are acceptable when agreed to. Previously referenced standards ISO 773 and ISO 775 have been withdrawn.

The Eighth Edition paragraph 3.2.4 required that cylindrical bores have an interference fit. The type of fit is now defaulted to the user or pump supplier, who will determine the type of coupling to shaft fit required. Pump vendors have been meeting Eighth Edition vibration limits with slip fit couplings.

• 6.2.10
If specified, couplings shall be fitted with a proprietary clamping device. Acceptable clamping devices may include tapered bushes, frictional locking assemblies and shrink discs. The vendor responsible for the final machining of the hub bores shall select a suitable rating/size device to suit the coupling and the application.

NOTE Care should be exercised in the selection of these devices as some are not inherently self-centring and may introduce eccentricity and unbalance into the coupling assembly. This effect must be evaluated and allowed for when determining coupling potential unbalance

This is a new clause that allows proprietary clamping devices. This is a bulleted clause, requiring the user to specify the type of device.

6.2.11
Provision shall be made for the attachment of alignment equipment without the need to remove the spacer or dismantle the coupling in any way.
NOTE One way of achieving this is to provide at least 25 mm (1 in) of bare shaft between the coupling hub and the bearing housing where alignment brackets may be located.

This is a new clause, requiring the supplier to make provisions for the mounting of alignment equipment.

6.2.13
Each coupling shall have a coupling guard which is removable without disturbing the coupled elements and shall meet the following requirements:
a) Coupling guards shall enclose the coupling and the shafts to prevent personnel from contacting moving parts during operation of equipment train. Allowable access dimensions shall comply with specified standards, such as ISO 14120, EN 953 or ANSI/ASME B15.1.
b) Guards shall be constructed with sufficient rigidity to withstand a 900 N (200 lbf) static point load in any direction without the guard contacting moving parts.
c) Guards shall be fabricated from solid sheet or plate with no openings. Guards fabricated from expanded metal or perforated sheets may be used if the size of the openings does not exceed 10 mm (0,375 in). Guards shall be constructed of steel, brass or nonmetallic (polymer) materials. Guards of woven wire shall not be used. If specified non-sparking guards of agreed material shall be supplied.

The coupling guard section has been greatly expanded to provide requirements for dimensions with specific material requirements. The user can specify other materials for guards.

6.3.4
All pads for drive train components shall be machined to allow for the installation of shims at least 3 mm (0,12 in) thick under each component. When the vendor mounts the components, a set of stainless steel shims at least 3 mm (0,12 in) thick shall be furnished. Shim packs shall not be thicker than 13 mm (0,5 in.) nor contain more than 5 shims. All shim packs shall straddle the hold down bolts and vertical jackscrews and extend at least 5 mm (1/4 in) beyond the outer edges of the equipment feet. When the vendor does not mount the components, the pads shall not be drilled, and shims shall not be provided. Unless otherwise specified, shims shall not be used under the pump.

The requirements for the mounting pads from the Eighth Edition has not changed from paragraph 3.3.4. The addition is the requirement that "Shim packs shall not be thicker than 13 mm (0,5 in.) nor contain more than 5 shims. All shim packs shall straddle the hold down bolts and vertical jackscrews and extend at least 5 mm (1/4 in) beyond the outer edges of the equipment feet." Also added: "Unless otherwise specified, shims shall not be used under the pump." This will hopefully stop the shimming of pumps, which should only be done when a gearbox is part of the drive train.

6.3.11
The bottom of the baseplate between structural members shall be open if the baseplate is designed to be installed and grouted to a concrete foundation. Accessibility shall be provided for grouting under all load carrying members. The bottom of the baseplate shall be in one plane to permit use of a single level foundation.

The Eighth Edition paragraph 3.3.8 requiring "J" hooks to be seal welded to the underside of the baseplate has been deleted. The baseplate members provide enough locking area to the grout.

6.3.17
Unless otherwise specified, the vendor shall commercially sand blast, in accordance with ISO 8501 Grade Sa2 or SSPC SP 6, all grout contact surfaces of the baseplate, and coat those surfaces with a primer compatible with epoxy grout.
NOTE Grouts other than epoxy may require alternative surface preparation. Full bond strength of epoxy is not generally necessary (6.3.7).

The Eighth Edition paragraph 3.3.17 defaulted to an inorganic zinc silicate primer on the base underside for epoxy grouts. The user and vendor should agree on the proper primer.

The Eighth Edition paragraph 3.3.18, which specified when baseplates would be installed with cementitious grout, has been deleted. The default is to install baseplates with epoxy grout, which matches API 686 (1996).

• 6.3.20
All lifting devices shall be designed and fabricated to meet the safety requirements of ANSI/ASME B30.20. For lifting lugs that are attached to the equipment being lifted the applicable requirements are found in ANSI/ASME B30.20-1.2.2 General Construction. The maximum allowable stress shall be one third of yield. If specified the vendor shall submit detail drawings for all lifting devices.

This is a new clause adding requirements for lifting devices and lugs and the option to have detailed drawings submitted for approval.

6.4 Instrumentation

6.4.1 Gauges
If furnished, temperature indicators and pressure gauges shall be provided in accordance with ISO 10438 or API Standard 614.

The instrumentation requirements have now been deferred to API 614 and are not included in API 610.

6.5 Piping and appurtenances

All the piping and appurtenances design, fabrication, and material requirements have been deferred to API 614. The minimum requirements for piping materials Table 3-4 has been retained and is now in Table 14.

7 Inspection, testing, and preparation for shipment

• 7.1.4
The purchaser shall specify the extent of his participation in the inspection and testing.
a) When shop inspection and testing have been specified, the purchaser and the vendor shall coordinate manufacturing hold points and inspector's visits.
b) The expected dates of testing shall be communicated at least 30 days in advance and the actual dates confirmed as agreed. Unless otherwise specified, the vendor shall give at least (5) working days advanced notification of a witnessed or observed inspection or test.
NOTE 1 For smaller pumps where setup and test time is short, (5) days notice may require the pump to be removed from the test stand between preliminary and witness tests.
NOTE 2 All witnessed inspections and tests are hold points. For observed tests, the purchaser should expect to be in the factory longer than for a witnessed test (see 3.34 and 3.62).
c) If specified, witnessed mechanical and performance tests shall require a written notification of a successful preliminary

test. The vendor and purchaser shall agree if the machine test set up is to be maintained or if the machine can be removed from the test stand between the preliminary and witnessed tests.
NOTE Many users prefer not to have preliminary tests prior to witnessed tests to understand any difficulties encountered during testing. If this is the case users should make it clear to the vendor.

Clauses b and c and notes have been added to provide the advanced notice required, and to add the option of providing written notification of a successful test, before the witnessed test.

7.2 Inspection

7.2.1 General

● 7.2.1.1
The vendor shall keep the following data available for at least 20 years.
c) If specified, details of all repairs and records of all heat treatment performed as part of a repair procedure.
f) Other data specified by the purchaser or required by applicable codes and regulations (see 9.3.1 and 9.3.2)

Options have been added to the data retention by the vendor for repair records and any other specified data.

7.2.2 Material inspection

● 7.2.2.1
NDE shall be performed as required by the material specification. If additional radiographic, ultrasonic, magnetic particle or liquid penetrant examinations of welds or materials specified by the purchaser, the methods and acceptance criteria shall be in accordance with the standards shown in Table 15 *[Table 8]* or as indicated on the datasheet in Annex O.

Table 8. Acceptance Standards for Materials Inspections.

Type of inspection	Methods	For fabrications	Castings
Radiography	ASTM E 94 and ASTM E 142	Section VIII, Division 1, UW-51 (for 100% radiography) and UW-52 (for spot radiography) of the ASME Code	Section VIII, Division 1, Appendix 7 of the ASME Code
Ultrasonic inspection	Section V, Articles 5 and 23 of the ASME Code	Section VIII, Division 1, Appendix 12, of the ASME Code	Section VIII, Division 1, Appendix 7, of the ASME Code
Magnetic particle inspection	ASTM E 709	Section VIII, Division 1, Appendix 6 and Section V, Article 25, of the ASME Code	Section VIII, Division 1, Appendix 7, of the ASME Code, Maximum defect severity per Table 13.x
Liquid penetrant inspection	Section V, Article 6 of the ASME Code	Section VIII, Division 1, Appendix 8, and Section V, Article 24, of the ASME Code	Section VIII, Division 1, Appendix 7, of the ASME Code

The material inspection standards are now tabulated and there is an option to indicate alternate codes as specified by the user on the welding and material inspection datasheet in the annex.

7.3 Testing

7.3.2.1 Hydrostatic test

All pressure casing components shall be hydrostatically tested with liquid at a minimum of 1,5 times the maximum allowable working pressure, with the special provisions specified below.
a) Double-casing pumps, horizontal multistage pumps, integral gear pumps (as described in 5.3.6), and other special design pumps as approved by the purchaser may be segmentally tested at 1,5 times the section maximum allowable working pressure.

This clause is the same as the Eighth Edition paragraph 4.3.2.1 a), except integral gear pumps have been added to a, since these pumps can have two different pressure levels.

7.3.2.5
The hydrostatic test liquid shall include a wetting agent to reduce surface tension when one or more of the following conditions exists.
a) The liquid pumped has a relative density (specific gravity) of less than 0,7 at the pumping temperature.
b) The pumping temperature is higher than 260°C (500°F).
c) The casing is cast from a new or altered pattern.
d) The materials are known to have poor castability.

In the Eighth Edition, this was paragraph 4.3.2.5 and was a "when specified" paragraph. It now defaults to requiring a wetting agent when any of these conditions exist.

7.3.3.2
The requirements of 7.3.3.2.a) through 7.3.3.2.h) shall be met before the performance test is performed.
c) The seal (or seals) shall not have a leakage rate during any phase of the pump performance test that is visible or in excess of that specified in ISO 21049 or as otherwise agreed by the vendor and purchaser. Any unacceptable leakage during the pump performance test requires a disassembly and repair to the seal. If the seal is disassembled or removed, the seal shall be retested with an air test of the pump using the criteria defined in 7.3.3.5 d).
NOTE 1 For the purpose of this clause API 682 is equivalent to ISO 21049.
NOTE 2 When the pump is on the test stand and water is used as the test fluid, liquid seals suitable for testing on water will exhibit a maximum average liquid leakage rate of less than 5,6 g/h (2 drops per minute). For most seals, this means there will be no visible signs of leakage. Lack of visible seal leakage does not necessarily indicate satisfactory seal performance under the specified operating conditions. Factors such as test fluid, pressure, temperature, and system cleanliness have an appreciable effect on seal leakage.
d) If specified, seal leakage during test shall require the assembled pump and seal to be rerun to demonstrate satisfactory seal performance.

Clauses c and d have been added to cover seal leakage. Seal leakage was covered in the Eighth Edition, paragraph 4.3.3.1.3, but no limits were provided for leakage rates.

7.3.3 Performance Test

7.3.3.3
Unless otherwise specified, the performance test shall be conducted as specified in 7.3.3.3.a) through 7.3.3.3.d).
a) The vendor shall take test data, including head, capacity, power, appropriate bearing temperature(s), and vibration, at a minimum of five points. These points will normally be (1) shutoff (no vibration data required), (2) minimum continuous stable flow, (3) midway between minimum and rated flow, (4) rated flow, and (5) maximum allowable flow (as a minimum, 120% of BEP). The test point for rated flow shall be within a tolerance band of ±5% of rated flow.

A tolerance on the test point flow rate has been added of ± 5 percent of rated flow.

● e) If specified, in addition to formal submittal of final data in accordance with 9.3.2.2, curves and test data (corrected for speed, specific gravity and viscosity) shall be submitted within 24 h after completion of performance testing for Purchaser's engineering review and acceptance prior to shipment.

Item e has been added as a bulleted clause to allow for expedited submittal of test data to the purchaser.

7.3.3.4
During the performance test, the requirements of 7.3.3.4.a) through 7.3.3.4.d) shall be met.

• d) If specified, True Peak bearing housing velocities shall also be recorded for information only.

In the Eighth Edition paragraph 4.3.3.3.1, the default requirement was to provide true peak bearing housing velocities. This clause applies only if specified. Before requesting these data, the user should identify the purpose for having these data taken and submitted.

7.3.4 Optional Tests

All the optional test clauses have been modified by adding "if specified" to emphasize the fact that they are indeed optional tests that will be performed only "if specified" by the purchaser.

7.4 Preparation for shipment

7.4.2
The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up which should be in accordance with API 686.

This is a new clause added to invoke the requirements of API 686 (1996).

8 Specific Pump Types

8.1.2 Vertical in-line (Type OH3)

8.1.2.3
Pumps shall be designed so that they may either float with the suction and discharge pipe, or be bolted to a pad or foundation.
NOTE Flange loading on the pump may increase if the user elects to bolt the unit down. This should be addressed in the piping design.

In the Eighth Edition, paragraph 5.1.2.4, the pump was required to be designed to be bolted to a pad or foundation only when specified. The requirement now is that the pump is to be designed to meet both requirements at all times.

8.1.3 Integral gear driven (Type OH6)

8.1.3.2
Integral gear pumps may require removal of the driver to allow disassembly of the rotor and the seal assembly.

This is a new clause added to this section allowing for the need to remove the driver to service the rotor and seal, since this is the way this type of pump is manufactured.

8.1.3.8
Inducers, impellers, and similar major rotating components shall be dynamically balanced to ISO 1940 Grade 2.5, or to a residual unbalance of 7 g-mm (0,01 oz-in) whichever is greater. Whenever possible, the weight of the arbor used for balancing shall not exceed the weight of the component being balanced. The resulting vibration measured during the performance test shall not exceed the levels in Table 8.

This clause is new and applies specifically to integral gear pumps.

8.2 Between bearings pumps (Types BB1-BB5)

8.2.2.1
Impellers of multistage pumps shall be individually located along the shaft by a shoulder or captive split ring in the direction of normal hydraulic thrust.

In the Eighth Edition, this was paragraph 5.2.2.1 and it did not specify how the impellers should be located. This is now stated. The reference to interference fit has been deleted.

8.2.2.2
Rotors with clearance fit impellers shall have mechanical means to limit impeller movement in the direction opposite to normal hydraulic thrust to 0,75 mm (0,030 in) or less.

This is a new clause added to reflect current practice and to clarify clause 8.2.2.1.

• 8.2.2.3
If specified, rotors with shrink fit impellers shall have mechanical means to limit movement in the direction opposite to normal hydraulic thrust to 0,75 mm (0,030 in) or less.

This is a new clause added to allow for impellers mounted with an interference fit, if specified. This clause replaces Eighth Edition paragraph 5.2.2.2.

8.2.3 Running clearances

8.2.3.2
Running clearances associated with components used to balance axial thrust or to serve as product lubricated internal bearings may be the manufacturer's standard, provided these clearances are stated as exceptions to this International Standard (see 5.7.4.2) in the proposal and are approved by the purchaser. When the manufacturer's standard clearances are based on material combinations exhibiting superior wear characteristics, supporting data shall be included in the proposal.

The Eighth Edition paragraph 5.2.3.2 has been modified to eliminate reference to interstage bushings and to be more precise.

8.2.5 Bearing and bearing housings

8.2.5.1.4
When the shaft contains more than 1,0 % chromium and the journal surface speed is above 20 m/s (65 ft/s), the shaft's journal shall be hard chromium plated, hard coated, or sleeved with carbon steel.
NOTE This construction is necessary to avoid damage to the bearing from "wire wooling."

This is a new clause added to reflect the standard practice in pumps with chrome steel and higher alloy shafts to avoid "wire wooling."

• 8.2.5.2.4
Thrust bearings shall be sized for the maximum continuous applied load (see 5.10.1.2). At this load, and the corresponding rotative speed, the following parameters shall be met.
a) minimum oil film thickness of 8 mm (0,000 3 in)
b) maximum unit pressure (load divided by area) of 3,5 MPa (500 psi), and
c) maximum calculated babbit surface temperature of 130°C (265°F).
If specified, thrust bearing sizing shall be reviewed and approved by the purchaser.
NOTE 1 The limits given above correspond to a design factor of 2 or more based on the bearing's ultimate capacity. The calculated babbit surface temperature is a design value.
NOTE 2 Bearings sized to meet the above criteria have the following allowable metal temperatures on shop test and in the field:
shop test (7.3.3.4.b): 93°C (200°F);
in-field trip: 115°C (240°F).

This is a complete rewrite of Eighth Edition paragraph 5.2.5.2.4. The babbit temperature was raised, after consulting with bearing manufacturers. The allowable trip and alarm values were added.

8.2.6 Lubrication

8.2.6.2
External pressure lubrication systems shall comply with the requirements of ISO 10438-3 and Annex C, Figure C.12 and Table C.1 *[please refer to APPENDIX A for Figure A-2 and Table A-6].*

External pressure lubrication systems for API 610 pumps are now located in API 614, Chapter 3. The minimum requirements are described in Annex C, Figure C.12, and Table C.1 of the Ninth Edition (ISO 13709). This means that the lube oil system is no longer described in detail in this standard. Figure C.12 in Annex C and Table C.1 list the minimum requirements for a pressure lubrication system. The minimum requirements are comparable to the Eighth Edition system. Optional items are also listed for the user to specify.

8.2.8 Preparation for shipment

8.2.8.2
Spare rotors and cartridge-type elements shall be prepared for vertical storage. A rotor shall be supported from its coupling end with a fixture designed to support 1,5 times the rotor's weight without damaging the shaft. A cartridge type element shall be supported from the casing cover (with the rotor hanging from the thrust bearing) in an alignment and shipping fixture. Instructions on the use of the fixtures shall be included in the installation, operation, and maintenance manual.

Spare rotors now default to vertical storage. In the Eighth Edition, this was a "when specified" paragraph (5.2.9.2).

8.3 Vertically suspended pumps

8.3.1 General
Specified discharge pressure shall be at the customer discharge connection. Hydraulic performance shall be corrected for column static and friction head losses. Bowl or pump casing performance curves shall be furnished with the correction indicated.

This is a new clause added to avoid confusion with bowl performance curves.

8.3.8.2.2
Vertical pumps without integral thrust bearings require rigid adjustable type couplings.

This is a new clause to cover vertical pumps without thrust bearings.

Eighth Edition paragraph 5.3.7.3.2, requiring single casing vertical pumps to have the manufacturer's standard mounting arrangement, was deleted. There was no reason to dictate something that is a manufacturer's standard.

Eighth Edition paragraph 5.3.7.3.2 requiring that the pump-to-motor mounting surface have a rabbeted fit, was deleted because the motors still need to be aligned to the pump. The requirement to provide a rabbeted fit gave a false impression that alignment was not required.

8.3.10 Single case diffuser (VS1) and volute (VS2) pumps

8.3.10.6
Unless otherwise specified, integral bushing spiders and rabbetted fits shall be used for all columns.

In the Eighth Edition, this requirement only applied to column sizes of 300 mm (12 in) or larger.

8.3.13 Double casing diffuser (VS6) and volute (VS7) pumps

• 8.3.13.2
If specified, bowls and column pipe shall be hydrostatically tested with liquid at a minimum of 1,5 times the maximum differential pressure developed by the bowl assembly. Hydrostatic testing shall be conducted in accordance with the requirements of 7.3.2.

This is a new clause allowing for the option for hydro testing the bowl assembly.

9 Vendor's data

• 9.1.3
If specified, a coordination meeting shall be held, preferably at the vendor's plant, within 4 to 6 weeks after order commitment. Unless otherwise specified, the vendor shall prepare and distribute an agenda prior to this meeting, which as a minimum shall include a review of the following items:
a) The purchase order, scope of supply, unit responsibility, and sub vendor items.
b) The data sheets.
c) Applicable specifications and previously agreed-upon exceptions.
d) Schedules for transmittal of data, production, and testing.
e) The quality assurance program and procedures.
f) Inspection, expediting, and testing.
g) Schematics and bills of material for auxiliary systems.
h) The physical orientation of the equipment, piping, and auxiliary systems.
i) Coupling selection and rating.
k) Thrust and journal bearing sizing, estimated loadings and specific configurations.
l) Rotor dynamic analyses (lateral, torsional and transient torsional, as required; commonly not available for 10-12 weeks).).
m) Equipment performance, alternate operating conditions, startup, shutdown and any operating limitations.
n) Scope and details of any pulsation or vibration analysis.
o) Instrumentation and controls.
p) Identification of items for stress analysis or other design reviews.
q) Other technical items.

The standard paragraph is now used, note the requirement for the vendor to prepare and distribute the agenda. Also several new items have been added.

9.2 Proposals

9.2.3 Technical data
The following data shall be included in the proposal:
h) A description of any special weather protection and winterization required for start-up, operation, and periods of idleness, under the site conditions specified on the data sheets. This description shall clearly indicate the protection to be furnished by the purchaser as well as that included in the vendor's scope of supply.

This is a new clause requiring the vendor to advise special protection requirements.

9.3 Contract data

9.3.2 Drawings and technical data

9.3.2.1
The drawings and data furnished by the vendor shall contain sufficient information so that together with the manuals specified in 9.3.5, the purchaser can properly install, operate, and maintain the equipment covered by the purchase order. All contract drawings and data shall be clearly legible (8-point minimum font size even if reduced from a larger size drawing), shall cover the scope of the agreed VDDR form, and shall satisfy the applicable detailed descriptions in Annex K.

Dimensional outline drawings shall indicate the tolerance for pump suction and discharge nozzle face and centreline locations referenced from the centreline of the nearest baseplate anchor bolt hole. The centreline of baseplate anchor bolt hole locations shall indicate the tolerance from a common reference point on the baseplate.

The first clause is the same as 6.3.2 from the Eighth Edition. The second clause is a new requirement for dimensional tolerances on the major dimensions.

9.3.5.3 Operating, maintenance, and technical data manual
A manual containing operating, maintenance and technical data shall be sent at the time of shipment. In addition to covering

operation at all specified process conditions, this manual shall include a section that provides special instructions for operation at specified extreme environmental conditions. The manual shall also include sketches that show the location of the centre of gravity and rigging provisions to permit the removal of the top half of the casings, rotors, and any subassemblies having a mass greater than 135 kg (300 lb). As a minimum, the manual shall also include all of the data listed in ANNEX K that are not uniquely related to installation.

This is the same as Eighth Edition paragraph 6.3.6.3, except the added requirement for sketches for rigging and lifting.

Annex

The new ISO format replaces the appendices with Annexes. The disposition of the Eighth Edition Appendices is as follows:

- *Appendix A:* The referenced publications and international standards are now included in Section 1.
- *Appendix B:* The pump datasheets are new datasheets, specifically arranged for each pump type (overhung, between bearings, vertically suspended); these are now located in Annex O.
- *Appendix C:* The appendix covering packing has been eliminated.
- *Appendix D:* The seal piping plans have been deleted and are now deferred to API 682. The cooling water piping schematics and lube oil system schematic are now located in Annex B.
- *Appendix E:* The information covering hydraulic power recovery turbines has been updated and is located in Annex C.
- *Appendix F:* The appendix covering criteria for piping design has been revised and is now located in Annex F.
- *Appendix G:* The appendix covering material class selection guide has been updated and is now in Annex G.
- *Appendix H:* The appendix covering materials and material specifications has been updated and is now in Annex H.
- *Appendix I:* The appendix covering lateral analysis has not changed and is now located in Annex I.
- *Appendix J:* The appendix for residual unbalance has been updated and is now located in Annex J.
- *Appendix K:* The appendix for seal chamber runout has not changed and is now located in Annex K.
- *Appendix L:* The appendix on grouting has been eliminated.
- *Appendix M:* The appendix covering standard baseplates has been revised by eliminating the anchor bolt length and is now Annex D.
- *Appendix N:* The appendix covering the inspectors checklist has been updated and is now Annex E.
- *Appendix O:* The appendix for vendor drawing and data requirements has been updated and is now Annex L.
- *Appendix P:* The appendix for purchaser checklist has been eliminated.
- *Appendix Q:* The appendix covering standardized electronic data exchange file specification is now Annex A.
- *Appendix R:* The appendix for SI to US units conversion factors is now Annex M.
- *Appendix S:* The appendix covering calibration and performance verification of true peak and RMS measurement instruments has been eliminated
- *Appendix T:* The appendix for test data summary has been revised and is in now Annex N.
- *Appendix U:* The appendix covering seal chamber dimensions, basic philosophy, has been eliminated.

THE FUTURE

After publication, it is planned to convene the Taskforce/ Working Group on an annual basis to consider all technical inquiries received that year. Agreed upon modifications to the standard will then be issued as an addendum. On the regular review cycle for the standard, these addenda will be considered and compiled along with any other changes deemed necessary to update the standard and will comprise the next standard publication draft. This draft will then be submitted to the balloting process for approval to publish the next edition of the standard. By following this annual process, the standard will be able to consider improvements more responsively, and the review process that now occurs approximately every five years will be supplemented with an annual event. It is envisioned that this process will simplify and expedite the lengthy review process currently required to update and issue new editions of the standard.

APPENDIX A

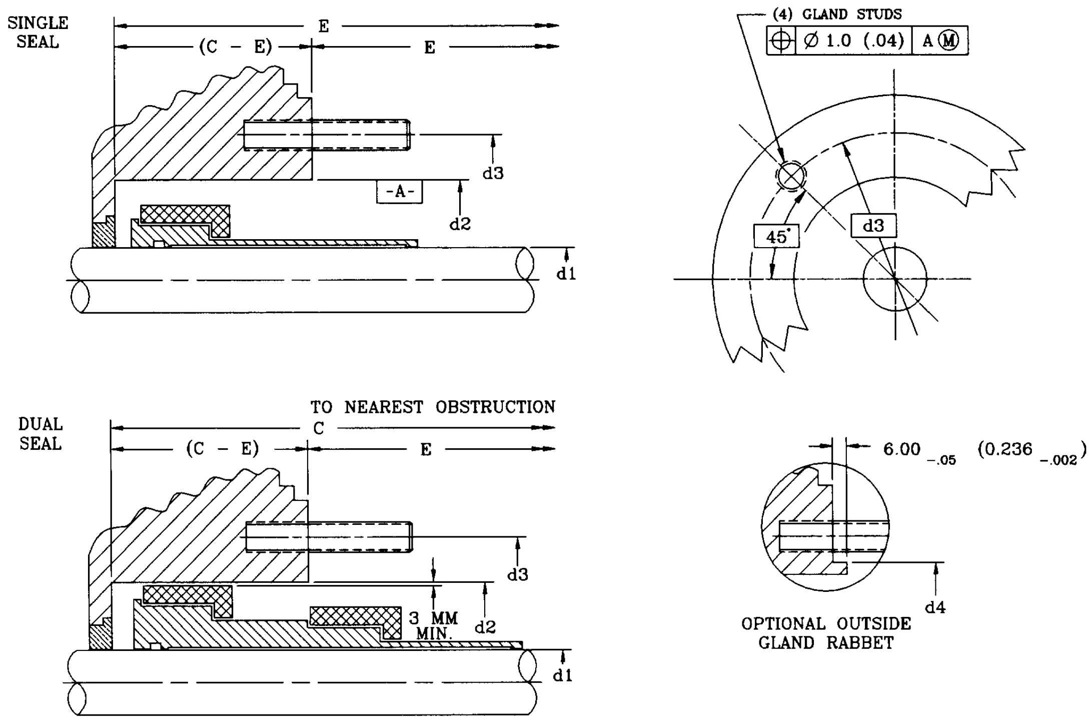


Figure A-1. Seal Chamber Dimensions.

Table A-1. Standard Dimensions for Seal Chambers, Seal Gland Attachments, and Cartridge Mechanical Seal Sleeves (mm/in).

Seal chamber size	Shaft diameter (max) (Note 1)	Seal chamber bore (Note 2)	Gland stud circle	Outside gland rabbet (Note 2)	Total length (min) (Note 3)	Clear length (min) (Note 3)	Stud size	Stud size
	(d1)	**(d2)**	**(d3)**	**(d4)**	**(C)**	**(E)**	**(SI Std)**	**(US Std)**
1	20,00 (0,787)	70,00 (2,756)	105 (4,13)	85,00 (3,346)	150 (5,90)	100 (3,94)	M12x1,75	1/2”-13
2	30,00 (1,181)	80,00 (3,150)	115 (4,53)	95,00 (3,740)	155 (6,10)	100 (3,94)	M12x1,75	1/2”-13
3	40,00 (1,575)	90,00 (3,543)	125 (4,92)	105,00 (4,134)	160 (/6,30)	100 (3,94)	M12x1,75	1/2”-13
4	50,00 (1,968)	100,00 (3,937)	140 (5,51)	115,00 (4,528)	165 (6,50)	110 (4,33)	M16x2,0	5/8”-11
5	60,00 (2,362)	120,00 (4,724)	160 (6,30)	135,00 (5,315)	170 (6,69)	110 (4,33)	M16x2,0	5/8”-11
6	70,00 (2,756)	130,00 (5,118)	170 (6,69)	145,00 (5,709)	175 (6,89)	110 (4,33)	M16x2,0	5/8”-11
7	80,00 (3,150)	140,00 (5,512)	180 (7,09)	155,00 (6,102)	180 (7,09)	110 (4,33)	M16x2,0	5/8”-11
8	90,00 (3,543)	160,00 (6,299)	205 (8,07)	175,00 (6,890)	185 (7,28)	120 (4,72)	M20x2,5	3/4”-10
9	100,00 (3,937)	170,00 (6,693)	215 (8,46)	185,00 (7,283)	190 (7,48)	120 (4,72)	M20x2,5	3/4”-10
10	110,00 (4,331)	180,00 (7,087)	225 (8,86)	195,00 (7,677)	195 (7,68)	120 (4,72)	M20x2,5	3/4”-10

NOTE 1 Dimensions to Tolerance Grade G7/h6.

NOTE 2 Dimensions to tolerance Grade H7/h6; for axially split pumps, an additional tolerance to allow for gasket thickness: ± 75 micrometres / 0,003 in.

NOTE 3 Shaft deflection criteria (5.6.9) may require (C) and (E) dimensions on size 1 and 2 seal chambers to be reduced below the minimum values listed, depending on specific pump construction and casing design.

Table A-2. Material for Pump Parts (Normative).

Material Class and Material Abbreviations [1]

PART	Full Com-pliance Materials [2]	I-1 CI / CI	I-2 CI / BRZ	S-1 STL / CI	S-3 STL / NI-RESIST	S-4 STL / STL	S-5 STL / STL 12% CHR	S-6 STL / 12% CHR	S-8 [12] STL / 316 AUS	S-9 [12] STL / MONEL	C-6 12% CHR / 12% CHR	A-7 AUS / AUS [3&4]	A-8 316 AUS / 316 AUS [4]	D-1 [10] DUPLEX / DUPLEX	D-2 [10] Super Duplex / Super Duplex
Pressure Casing	Yes	Cast Iron	Cast Iron	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	12% CHR	AUS	316 AUS	Duplex	Super Duplex
Inner Case parts: (bowls, diffusers, diaphragms)	No	Cast Iron	Bronze	Cast Iron	Ni-Resist	Cast Iron	Carbon Steel	12% CHR	316 AUS	Monel	12% CHR	AUS	316 AUS	Duplex	Super Duplex
Impeller	Yes	Cast Iron	Bronze	Cast Iron	Ni-Resist	Carbon Steel	Carbon Steel	12% CHR	316 AUS	Monel	12% CHR	AUS	316 AUS	Duplex	Super Duplex
Case Wear Rings [11]	No	Cast Iron	Bronze	Cast Iron	Ni-Resist	Cast Iron	12% CHR Hardened	12% CHR Hardened	Hard-faced 316AUS [5]	Monel	12% CHR Hardened	Hard-faced AUS [5]	Hard-faced 316 AUS [5]	Hard-faced Duplex [5]	Hard-faced Super Duplex [5]
Impeller Wear Rings [11]	No	Cast Iron	Bronze	Cast Iron	Ni-Resist	Cast Iron	12% CHR Hardened	12% CHR Hardened	Hard-faced 316AUS [5]	Monel	12% CHR Hardened	Hard-faced AUS [5]	Hard-faced 316 AUS [5]	Hard-faced Duplex [5]	Hard-faced Super Duplex [5]
Shaft [4]	Yes	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	AISI 4140	AISI 4140 [6]	316 AUS	K-Monel	12% CHR	AUS	316 AUS	Duplex	Super Duplex
Throat bushings [11]	No	Cast Iron	Bronze	Cast Iron	Ni-Resist	Cast Iron	12% CHR Hardened	12% CHR Hardened	316 AUS	Monel	12% CHR Hardened	AUS	316 AUS	Duplex	Super Duplex
Interstage Sleeves [11]	No	Cast Iron	Bronze	Cast Iron	Ni-Resist	Cast Iron	12% CHR Hardened	12% CHR Hardened	Hard-faced 316AUS [5]	Monel	12% CHR Hardened	Hard-faced AUS [5]	Hard-faced 316 AUS [5]	Hard-faced Duplex [5]	Hard-faced Super Duplex [5]
Interstage Bushings [11]	No	Cast Iron	Bronze	Cast Iron	Ni-Resist	Cast Iron	12% CHR Hardened	12% CHR Hardened	Hard-faced 316AUS [5]	Monel	12% CHR Hardened	Hard-faced AUS [5]	Hard-faced 316 AUS [5]	Hard-faced Duplex [5]	Hard-faced Super Duplex [5]
Case and Gland Studs	Yes	Carbon Steel	Carbon Steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	K Monel Hardened [9]	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	Duplex [9]	Super Duplex [9]
Case Gasket	No	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	316 AUS Spiral Wound [7]	Monel, Spiral Wound, PTFE filled [7]	AUS, Spiral Wound [7]	AUS, Spiral Wound [7]	316 AUS Spiral Wound [7]	Duplex SS Spiral Wound [7]	Duplex SS Spiral Wound [7]
Discharge Head/ Suction Can	Yes	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	AUS	AUS	316 AUS	Duplex	Super Duplex
Column / Bowl shaft bushings	No	Nitrile [8]	Bronze	Filled Carbon	Nitrile [8]	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon	Filled Carbon
Wetted Fasteners(Bolts)	Yes	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	316 AUS	316 AUS	316 AUS	K Monel	316 AUS	316 AUS	316 AUS	Duplex	Super Duplex

NOTES FOR TABLE H.1

1 The abbreviation above the diagonal line indicates the case material; the abbreviation below the diagonal line indicates trim material. Abbreviations are as follows: BRZ = bronze, STL = steel, 12% CHR = 12% chrome, AUS = austenitic stainless steel, CI = cast iron, 316 AUS = Type 316 austenitic stainless steel

2 See 5.12.1.1

3 Austenitic stainless steels include ISO Types 683-13-10/19 (AISI Standard Types 302, 303, 304, 316, 321, and 347).

4 For vertically suspended pumps with shafts exposed to liquid and running in bushings, the standard shaft material is 12 % chrome, except for Classes S-9, A7, A-8, and D- 1. The standard shaft material for cantilever pumps (Type VS5) is AISI 4140 where the service liquid allows (see Annex G, Table G.1).

5 Unless otherwise specified, the need for hard-facing and the specific hard-facing material for each application is determined by the vendor and described in the proposal. Alternatives to hard-facing may include opening running clearances (5.7.4) or the use of non-galling materials, such as Nitronic 60, Waukesha 88, or non-metallic materials, depending on the corrosiveness of the pumped liquid.

6 For Class S-6, the standard shaft material for boiler feed service and for liquid temperatures above 175 °C (350 °F) is 12 % chrome (see Annex G. Table G-1).

7 If pumps with axially split casings are furnished, a sheet gasket suitable for the service is acceptable. Spiral wound gaskets should contain a filler material suitable for the service. Gaskets other than spiral wound, may be proposed and furnished if proven suitable for service and specifically approved by the purchaser.

8 Alternate materials may be substituted for liquid temperatures greater than 45 °C (110 °F) or for other special services.

9 Unless otherwise specified, AISI 4140 steel may be used for non-wetted case and gland studs.

10 Some applications may require alloy grades higher than the Duplex materials given in Table H-2.

"Super Duplex " material grades with pitting resistance equivalency values greater than 40 may be necessary.

PRE $\geq$ 40 Where PRE is based on actual chemical analysis.

PRE = Cr_{free} + (3,3 x % Molybdenum) + (2 x % Copper) + (2 x % Tungsten) + (16 x % Nitrogen)

PRE = [(%Chromium-14,5) x %Carbon] + (3.3 x % Molybdenum) + (2x % Copper) + (2x % Tungsten) + (16 x % Nitrogen)

Note that alternative materials such as "super austenitic" may also be considered.

11 Non-metallic wear part materials, proven to be compatible with the specified process fluid, may be proposed within the applicable limits shown in Table H-3. Also see 6.7.4.3.

The vendor must consider the effects of differential material expansion between casing and rotor and confirm suitability when operating temperatures are to exceed 95°C (200°F).

Table A-3. International Materials for Pump Parts (Informative).

Material Class	Applications	U.S.A. ASTM	U.S.A. UNS	International ISO	Europe EN Std	Europe Symbol	Europe Material No	Japan JIS
Cast Iron	Pressure Castings	A 278 Class 30	F 12401	185/ Gr. 250	EN 1561	EN-GJL-250	JL 1040	G 5501, FC 300
	General Castings	A 48 Class 25/30/40	F 11 701/ F 12 101	185/ Gr. 300	EN 1561	EN-GJL-250 EN-GJL-300	JL 1040 JL 1050	G 5501, FC 250/300
Carbon Steel	Pressure Castings	A216 Gr WCB	J 03 002	4991 C23-45 AH	EN 10213-2	GP 240 GH	1.0619	G 5151, C1 SCPH 2
	Wrought / Forgings	A 266 Class 2	K 03506	683-18-C25	EN 10222-2	P 280 GH	1.0426	G3202, C1 SFVC 2A
	Bar Stock: Pressure	A 696 Gr B40	G 10 200	683-18-C 25	EN 10273	P 295 GH	1.0481	G 4051, C1 S25C
	Bar Stock: General	A 576 Gr 1045	G 10 450	683-18-C 45e	EN 10083-2	C 45	1.0503	G 4051, C1 S45C
	Bolts and Studs (General)	A 193 Gr B7	G 41 400	2604-2-F31	EN 10269	42 Cr Mo 4	1.7225	G 4107, C1 SNB7
	Nuts(General)	A 194 Gr 2H	K 04 002	683-1-C35e	EN 10269	C 35 E	1.1181	G 4051, C1 S45C
	Plate	A 516 Gr 65/70	K 02 403/ K 02 700		EN 10028-2	P 295 GH	1.0481	G 3106, Gr SM400B
	Pipe	A 106 GrB	K 03 006		EN 10208-1	L 245 GA	1.0459	G3456, Gr. STPT 370/410
	Fittings	A 105	K 03 504			See National Standards		G 4051, C1 S25C
AISI 4140 Steel	Bar Stock	A 434 Class BB A 434 Class BC	G 41 400[c]	683-2-3	EN 10083-1	42 Cr Mo 4	1.7225	G 4105, C1 SCM 440
	Bolts and Studs	A 193 Gr B7	G 41 400		EN 10269	42 Cr Mo 4	1.7225	G 4107, C1 SNB16
	Nuts	A 194 Gr 2H	K 04 002	2604-2-F31	EN 10269	C 35 E	1.1181	G 4051, C1 S45C
12% Chrome Steel	Pressure Castings	A 217 Gr CA 15	J 91 150		EN 10213-2	GX 8 Cr Ni 12	1.4107	G5121, C1 SCS 1
		A 487 Gr CA6NM	J 91 540		EN 10213-2	GX 4 Cr Ni 13-4	1.4317	G5121, C1 SCS 6
	General Castings	A 743 Gr CA 15	J 91 150		EN 10283	GX 12 Cr 12	1.4011	
		A 743 Gr CA6NM	J 91 540		EN 10283-2	GX 4 Cr Ni 13-4	1.4317	
	Wrought / Forgings: Pressure	A 182 Gr F6a Cl 1 A 182 Gr F 6 NM	S 41 000 S 41 500	683-13-3	EN 10222-5	X 3 Cr NiMo 13-4-1	1.4313	G3214, C1 SUS F6 B G3214, C1 SUS F6NM
	Wrought / Forgings: General	A 473 Type 410	S 41 000	683-13-2	EN 10088-3	X 12 Cr 13	1.4006	G3214, C1 SUS F6 NM
	Bar Stock: Pressure	A 479 Type 410	S 41 000	683-13-3	EN 10272	X12 Cr 13	1.4006	G4303 or 410
	Bar Stock: General	A 276 Type 410	S 41 400	683-13-3	EN 10088-3	X 12 Cr 13	1.4006	G4303, Grl SUS 403 or 420
	Bar Stock:Forgings[a]	A 276 Type 420 A 473 Type 416 A582 Type 416	S 42 000	683-13-4	EN 10088-3	X 20 Cr 13 X 20 Cr S 13 X 20 Cr S 13	1.4021 1.4005 1.4005	G4303, Grl SUS 403 or 420
	Bolts and Studs[b]	A 193 Gr B6	S 41 000		EN 10269	X22CrMoV 12-1	1.4923	G4303, Gr SUS 403 or 420
	Nuts[b]	A 194 Gr 6	S 41 000		EN 10269	X22CrMoV 12-1	1.4923	G4303, Gr SUS 403 or 420
	Plate	A 240 Type 410	S 41 000	683-13-3	EN 10088-2	X 12 Cr 13	1.4006	G4304/4305 or 410

Table A-3. International Materials for Pump Parts (Informative). (Continued)

Austenitic Stainless Steel	Pressure Castings	A 351 Gr CF3	J 92 500	683-13-10	EN 10213-4	GX2 Cr Ni 19-11	1.4309	G 5121, C1 SCSI 3A
		A 351 Gr CF3M	J 92 800	683-13-19	EN 10213-4	GX2 Cr Ni Mo 19-11-2	1.4409	G 5121, C1 SCS I 4A 02M
	General Castings	A 743 Gr CF3	J 92 500		EN 10283	GX2 Cr Ni 19-11	1.4309	
		A 743 Gr CF3M	J 92 800		EN 10283	GX2 Cr Ni Mo 19-11-2	1.4409	
	Wrought / Forgings	A 182 Gr F 304L	S 30 403	683-13-10	EN 10222-5 EN 10250-4	X2 Cr Ni 19-11	1.4306	G 3214, C1 SUS F 304 L
		A 182 Gr F 316L	S 31 603	683-13-19	EN 10222-5 EN 10250-4	X2 Cr Ni Mo 17-12-2	1.4404	G 3214, C1 SUS F 316 L
	Bar Stock [e]	A 479 Type 304L A 479 Type 316L	S 30 403 S 31 603	683-13-10 683-13-19	EN 10088-3 EN 10088-3	X2 Cr Ni 19-11 X2 Cr Ni Mo 17-12-2	1.4306 1.4404	G 4303, SUS F 304L G 4303, SUS F 316L
		A 479 Type XM19[d]	S 20910			See National Standards		
	Plate	A 240 Gr 304L / 316L	S 30 403 S 31 603	683-13-10 683-13-19	EN 10028-7 EN 10028-7	X2 Cr Ni 19-11 X2 Cr Ni Mo 17-12-2	1.4306 1.4404	G 4304/5, Gr 304L/ 316L
	Pipe	A 312 Type 304L 316L	S 30 403 S 31 603	683-13-10 683-13-19		See National Standards		G 3459, Gr 304 LTP/ 316LTP
	Fittings	A 182 Gr F304L Gr 316L	S 30 403 S 31 603	683-13-10 683-13-19	EN 10222-5	X2 Cr Ni 19-11 X2 Cr Ni Mo 17-12-2	1.4306 1.4404	G 3214, Dr SUS 304L 316L
	Bolts and Studs	A 193 Gr B 8 M	S 31 600	683-1-21	EN 10250-4	X6 Cr Ni Mo Ti 17-12-2	1.4571	G 4303, Grl SUS 316
	Nuts	A 194 Gr B 8 M	S 31 600	682-1-21	EN 10250-4	X6 Cr Ni Mo Ti 17-12-2	1.4571	G 4303, Grl SUS 316
Duplex Stainless Steel	Pressure Castings	A 351 Gr CD4 MCu A 890 Gr 1 B	J93370 J 93372		EN 10213-4	GX2 CrNiMoCuN 25-6-3-3	1.4517	
		A 890 Gr 3A	J93371			See National Standards		G 5121, C1 SCS 11
		A 890 Gr 4A	J92205		EN 10213-4	GX2 CrNiMoCuN 25-6-3-3	1.4517	
	Wrought / Forgings	A 182 Gr F 51	S 31803		EN 10250-4 EN 10222-5	X2 Cr Ni Mo N 22-5-3	1.4462	G 4319, C1 SUS 329
		A 479 (German proposal)	S 32550		EN 10088-1	X2 Cr Ni Mo Cu N 25-6-3	1.4507	
	Bar Stock	A276-S31803	S 31 803		EN 10088-3	X2 Cr Ni Mo N 22-5-3	1.4462	G 4303, Grl SUS 329 Gr SUS 329
	Plate	A240-S31803	S 31 803		EN 10028-7	X2 Cr Ni Mo N 22-5-3	1.4462	G 4303, Gr SUS 329
	Pipe	A790-S31803	S 31 803			See National Standards		G 3459, Gr SUS 329
	Fittings	A 182 Gr F 51	S 31803		EN 10250-4 EN 10222-5	X2 Cr Ni Mo N 22-5-3	1.4462	
	Bolts and Studs	A276-S31803	S 31 803		EN 10088-3	X2 Cr Ni Mo N 22-5-3	1.4462	G 4303, Gr SUS 329
	Nuts	A276-S31803	S 31 803		EN 10088-3	X2 Cr Ni Mo N 22-5-3	1.4462	G 4303, Gr SUS 329
Super Duplex Stainless Steel [f]	Pressure Castings	A 351 Gr CD3MWCuN	J93380			See National Standards		
		A 890 Gr 5A	J93404		EN 10213-4	GX2 Cr Ni Mo N 26-7-4	1.4469	
		A 890 Gr 6A	J93380			See National Standards		
	Wrought / Forgings	A 182 Gr 55	S 32 760		EN 10250-4 EN 10088-3	X2 Cr Ni Mo Cu WN 25-7-4	1.4501	
	Bar Stock	A276-S32760 A479-S32760	S 32 760		EN 10088-3	X2 Cr Ni Mo Cu WN 25-7-4	1.4501	
	Plate	A240-S32760	S 32 760		EN 10028-7	X2 Cr Ni Mo Cu WN 25-7-4	1.4501	
	Pipe	A790-S32760	S 32 760			See National Standards		
	Fittings	A 182 Gr F55	S 32 760		EN 10250-4 EN 10088-3	X2 Cr Ni Mo Cu WN 25-7-4	1.4501	
	Bolts and Studs	A276-S32760	S 32 760		EN 10088-3	X2 Cr Ni Mo Cu WN 25-7-4	1.4501	
	Nuts	A276-S32760	S 32 760		EN 10088-3	X2 Cr Ni Mo Cu WN 25-7-4	1.4501	

NOTE 1 This table lists corresponding (not necessarily equivalent) International Materials which may be acceptable with the purchaser's approval. These materials represent family/type and grade only. Final condition or hardness level (where appropriate) is not specified.

NOTE 2 Materials listed for pressure applications may be utilised for non-pressure applications.

NOTE 3 When approved by the purchaser, alternate materials of the same nominal chemistry and mechanical properties may be substituted.

NOTE 4 All wear part material combinations must be selected in accordance with the requirements of 5.7.4.

[a] Do not use for shafts in the hardened condition (over 302HB).

[b] Special, normally use AISI 4140.

[c] UNS (unified numbering system) designation for chemistry only.

[d] Nitronic 50 or equivalent.

[e] For shafts, standard grades of 304 and 316 may be substituted in place of low carbon (L) grades

[f] Super duplex stainless steel classified with pitting resistance equivalent (PRE) number greater than or equal to 40

PRE = Cr_{free} +3.3 x % Molybdenum + 2 x % Copper + 2 x %Tungsten + 16 x % Nitrogen

PRE = (%Chromium-14.5 x %Carbon) +3.3 x % Molybdenum + 2x % Copper + 2x %Tungsten + 16 x %Nitrogen

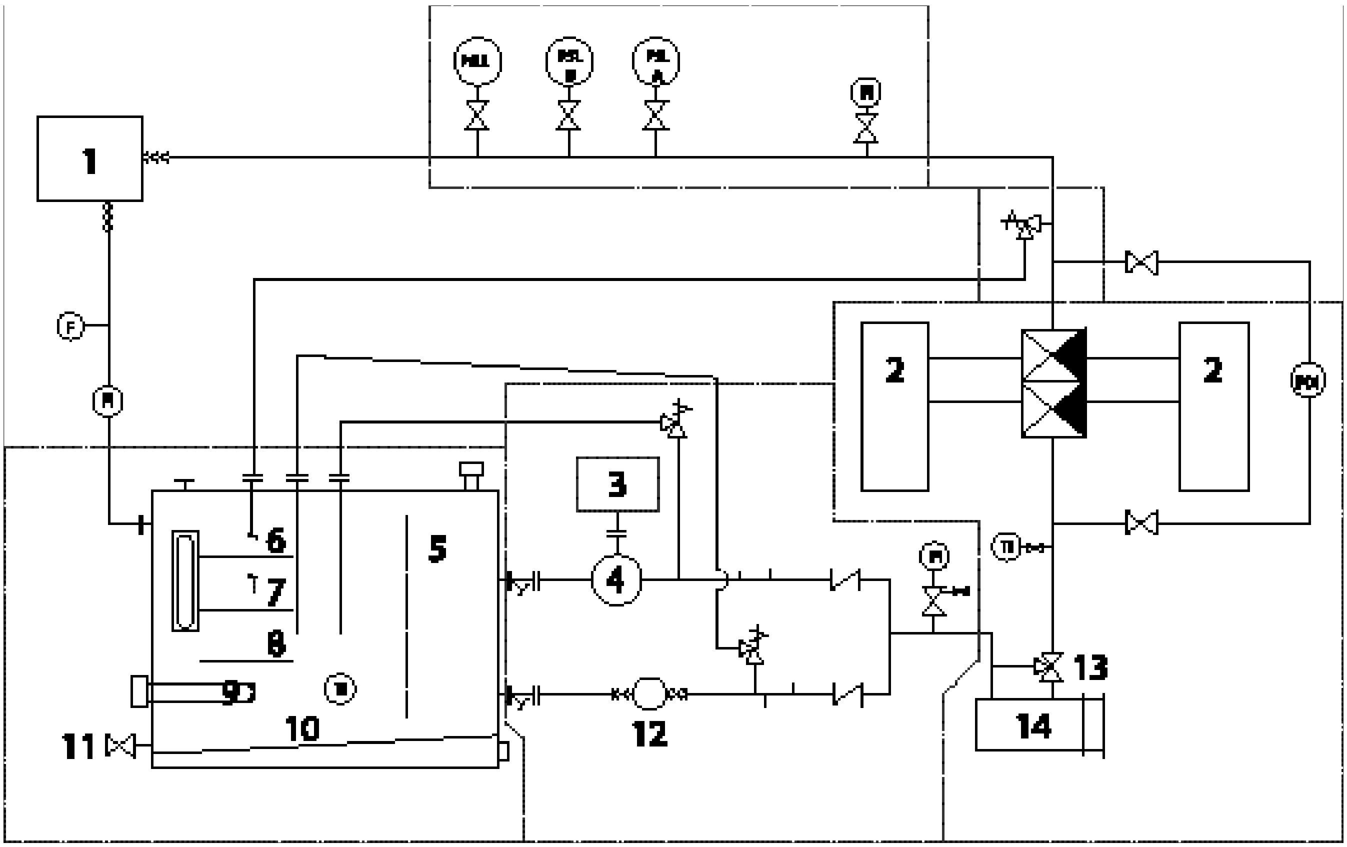
Table A-4. International Materials for Pump Parts, National Standards (Informative).

Material Class	Applications	U.S.A.		International	Germany-DIN		Great Britain	France	Japan
		ASTM	UNS	ISO	17007	17006	BSI	AFNOR	JIS
Carbon Steel	Fittings	A 105	K 03 504		1.0308	St. 35.0	1503 221 490	AE 250	G 4051, C1 S25C
Austenitic Stainless Steel	Bar Stock	A 479 Type XM19[d]	S 34 565		1.3974	X3CrNiMnMoNNb 23-17-6-3			
	Pipe	A 312 Type 304L / 316L	S 30 403 S 31 603	683-13-10 683-13-19	1.4306 1.4404	X2 Cr Ni 19-11 X2 Cr Ni Mo 17 13 2	3605 304 S11 3605 316 S11	TU Z2 CN 18-10 TU Z2 CND 17-12-02	G 3459, Gr 304 LTP/ 316LTP
Duplex Stainless	Pressure Castings	A 890 Gr 3A	J93371		1.4468	G-X 2 Cr Ni Mo N 25 6 3			G 5121, C1 SCS 11
Steel	Pipe	A790-S31803	S 31 803		1.4462	X 2 Cr Ni Mo N 22-5-3		TU Z2 CND 22-05-03	G 3459, Gr SUS 329
Super Duplex Stainless Steel [f]	Pressure Castings	A 351 Gr CD3MWCuN	J93380		1.4471	G-X3 Cr Ni Mo W Cu N 27-6-3-1			
		A 890 Gr 6A	J93380		1.4471	G-X3 Cr Ni Mo W Cu N 27-6-3-1			
	Pipe	A790-S32760	S 32 760		1.4501	X2 Cr Ni Mo N Cu WN 25-7-4			

Table A-5. Nonmetallic Wear Part Materials (Normative).

Material	Temperature limits		Limiting pressure differential	Application
	Min	Max		
PEEK Chopped carbon fibre	-30 ºC (-20 ºF)	135 ºC (275 ºF)	2 MPa (20 bar) (300 psi)	Stationary parts
PEEK Continuous carbon fibre wound	-30 ºC (-20 ºF)	230 ºC (450 ºF)	3,5 MPa (35 bar) (500 psi) 4 MPa (140 bar) (2 000 psi) possible when suitably supported	Stationary or rotating
Polyamide	Need information relative to experience.			
Carbon graphite Resin impregnated Babbit impregnated Nickel impregnated Copper impregnated	 -50 ºC (-55 ºF) -100 ºC (-150 ºF) -195 ºC (-320 ºF) -100 ºC (-450 ºF)	 285 ºC (550 ºF) 150 ºC (300 ºF) 400 ºC (750 ºF)	 2 MPa (20 bar) (300 psi) 2,75 MPa (27,5 bar) (400 psi) 3,5 MPa (35 bar) (500 psi)	Stationary parts
NOTE 1 Non-metallic wear part materials, which are proven to be compatible with the specified process fluid, may be proposed within the following limits. See 6.7.4.3. NOTE 2 Such materials may be selected as wear components to be mated against a suitably selected metallic component such as hardened 12 % Chr steel or hardfaced Austenitic stainless steel. Materials may be used beyond these limits when proven application experience can be provided, and when approved by the customer.				

Figure A-2. Lube-Oil System Schematic.



Key

1. Rotating equipment
2. Filter
3. Electric motor
4. Pump
5. Internal baffle
6. Max operating lever
7. Min operating level
8. Pump suction level
9. Heater (optional)
10. Sloped bottom
11. Drain
12. Shaft-driven oil pump with integral pressure relief
13. TCV (optional)
14. Cooler

Table A-6. Lube-Oil System Schematic.

ISO 10438-3 sub-clause	Note/Option	Comments
3A-1 Minimum requirements for general purpose oil systems	Add	TI, FI on oil return lines from pump (and driver)
3A-2 Reservoir	Option 1	A level switch is not required
	Option 2	A temperature indicator with thermowell is required
	Option 3	An electric immersion or steam heater is optional
	Option 4	Additional connections are required for 1. Shaft-driven oil pump relief valve return (not required with integral relief valve) 2. Motor-driven oil pump relief valve return (not required with integral relief valve) 3. System PCV return 4. Aux. oil pump to have independent suction w/ strainer
	Option 5	One tapped grounding lug is required
	Option 6	Gauge glass may be armoured and extended
	Add	A vent (breather) with screen is required
	Add	The reservoir shall have a sloped bottom
	Add	A flanged drain connection with valve and blind at least 2" in size shall be included
	Add	A level glass shall be provided in accordance with ISO 10438-3
	Add Additional item	(If so, the return line from the system RV shall be located below the minimum operating oil level.)
3A-3 Pumps	Option 1	A 100% capacity motor-driven auxiliary pump is required
	Option 2	Block valves are not required
	Option 3	A pre/post lube oil pump is not required
	Option 4	Pressure switches are required for low pressure trip, alarm, and aux. pump start
	Option 5	The pressure transmitter is not required
	Additional item	The pressure switches shall be located in accordance with Figure A.5
3A-4 Pumps and coolers (and filters)	Option 1	One oil cooler is required
	Option 2	Duplex filters are required
	Option 3	A three-way constant temperature control valve with bypass line is optional
	Option 4	A two or three way variable temperature control valve with bypass line is not required
	Option 5	A temperature switch is required. Temperature switch is not represented in Figure A.5.
	Option 6	A single transfer valve with cooler and filter in parallel with separate TCV is not required. Valve is not represented in Figure A.5.
	Option 7	A pressure differential indicator is required
	Add	A single transfer valve for the duplex filters is required
	Additional item	The replaceable filter shall be in accordance with ISO 10438-3
3A-5 Pressure control	Option 1	A pressure regulator (relief valve) is required
	Option 2	A back-pressure control valve - direct acting is not required
	Option 3	Block valves around the PCV / regulator are not required
	Option 4	A globe bypass valve is not required

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