

DIN EN ISO 13709

ICS 23.080; 75.180.20

Ersatz für
DIN EN ISO 13709:2005-07**Kreiselpumpen für den Einsatz in der Erdöl-, petrochemischen und Erdgasindustrie (ISO 13709:2009);
Englische Fassung EN ISO 13709:2009, nur auf CD-ROM**

Centrifugal pumps for petroleum, petrochemical and natural gas industries
(ISO 13709:2009);
English version EN ISO 13709:2009, only on CD-Rom

Pompes centrifuges pour les industries du pétrole, de la pétrochimie et du gaz naturel
(ISO 13709:2009);
Version anglaise EN ISO 13709:2009, seulement en CD-ROM

Gesamtumfang 204 Seiten

Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN
Normenausschuss Maschinenbau (NAM) im DIN

Nationales Vorwort

Dieses Dokument (EN ISO 13709:2009) wurde vom Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ erarbeitet, dessen Sekretariat von AFNOR (Frankreich) gehalten wird. Es handelt sich dabei um eine unveränderte Übernahme von ISO 13709:2009, erarbeitet von ISO/TC 115 „Pumps“, Subkomitee SC 3 „Installation and special application“.

Für Deutschland hat hieran der Arbeitsausschuss NA 109-00-01 AA „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie - Spiegelausschuss zu CEN/TC 12 und ISO/TC 67“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO Norm.

Diese Norm enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“, „°R“, „ft“, „gal“, „in (inch)“, „lb (pound)“, „lbf“, „mil“, „NPS“, „ppm“, „psi“, „(psig)“, „r/min“, „oz (ounce)“, die im Deutschen Normenwerk nicht zugelassen sind. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung	
°F	°C	°C	= (5/9) (°F-32)
°R	°C	1 ° R	= 1,25 °C
ft	m	1 ft	= 0,304 8 m
gal (galone)	l	1 gal	= 3,785 l
hp	kW	1 hp	= 0,74 kW
in (inch)	mm	1 inch	= 25,4 mm
lb (pound)	kg	1 lb	= 0,453 592 37 kg
lbf	N	1 lbf	= 4,448 222 N
mil	µm	1 mil	= 26 µm
NPS	DN	1 NPS	= DN 25
ppm	mg/kg	1 ppm	= 1 mg/kg
psi (psig)	kPa	1 psi	= 6,894 757 kPa
r/min	min ⁻¹	1 r/min	= 1 min ⁻¹
oz (ounce)	g	1 oz	= 28,35 g

Für die in diesem Dokument zitierte Internationale Norm wird im Folgenden auf die entsprechenden Deutsche Norm hingewiesen:

ISO 7-1	siehe	DIN EN 10226-1
ISO 228-1	siehe	DIN EN ISO 228-1
ISO 261	siehe	DIN ISO 261
ISO 262	siehe	DIN ISO 262
ISO 281	siehe	DIN ISO 281
ISO 286-1	siehe	DIN ISO 286-1
ISO 286-2	siehe	DIN ISO 286-2
ISO 724	siehe	DIN ISO 724
ISO 965-1	siehe	DIN ISO 965-1
ISO 965-2	siehe	DIN ISO 965-2
ISO 965-3	siehe	DIN ISO 965-3
ISO 965-4	siehe	DIN ISO 965-4
ISO 965-5	siehe	DIN ISO 965-5
ISO 1940-1	siehe	DIN ISO 1940-1
ISO 4200	siehe	DIN EN 10220, DIN 2460, DIN EN 10224, DIN EN 10311
ISO 8501-1	siehe	DIN EN ISO 8501-1
ISO 8501-2	siehe	DIN EN ISO 12944-4, DIN EN ISO 8501-2
ISO 8501-3	siehe	DIN EN ISO 8501-3
ISO 8501-4	siehe	DIN EN ISO 8501-4
ISO 9606-1	siehe	DIN EN 287-1
ISO 9606-2	siehe	DIN EN ISO 9606-2
ISO 9606-3	siehe	DIN EN ISO 9606-3
ISO 9606-4	siehe	DIN EN ISO 9606-4
ISO 9606-5	siehe	DIN EN ISO 9606-5
ISO 9906	siehe	DIN EN ISO 9906
ISO 10438-1	siehe	DIN EN ISO 10438-1
ISO 10438-2	siehe	DIN EN ISO 10438-2
ISO 10438-3	siehe	DIN EN ISO 10438-3
ISO 10438-4	siehe	DIN EN ISO 10438-4
ISO 10441	siehe	DIN EN ISO 10441
ISO 10721-2	siehe	DIN 18800-7, DIN EN 1090-2
ISO 11342	siehe	DIN ISO 11342
ISO 14120	siehe	DIN EN 953
ISO 14691	siehe	DIN EN ISO 14691
ISO 15156-1	siehe	DIN EN ISO 15156-1
ISO 15609-1	siehe	DIN EN ISO 15609-1
ISO 15609-2	siehe	DIN EN ISO 15609-2
ISO 15609-3	siehe	DIN EN ISO 15609-3
ISO 15609-4	siehe	DIN EN ISO 15609-4
ISO 15609-5	siehe	DIN EN ISO 15609-5
ISO 21049	siehe	DIN EN ISO 21049
IEC 60034-1	siehe	DIN EN 60034-1
IEC 60034-2-1	siehe	DIN EN 60034-2-1
IEC 60079 (all parts)	siehe	DIN EN 60079-1 (alle Teile)

Änderungen

Gegenüber DIN EN ISO 13709:2005-07 wurden folgende Änderungen vorgenommen:

- a) zusätzlicher Hinweis zur Kosteneffizienz im Anwendungsbereich;
- b) Aktualisierung der normativen Referenzen;
- c) Aufnahme von Begriffsdefinitionen zu „Classically stiff“, „design“, „hydraulic power recovery turbine“, „identical pump“, „maximum operating temperature“ und „multistage pump“;
- d) aktualisierung von Bild 18 „Pump type VS7“;
- e) neuer Abschnitt 5 „Requirements“;
- f) neue Bilder: Bild 20 „Typical gusset design“, Bild 27 „Seal chamber concentricity“, Bild 28 „Seal chamber face runout“, Bild 29 „Torsional analysis flow chart“ und Bild 33 „Locations for taking vibration readings on a) vertical in-line (OH3) and b) high-speed integrally geared (OH6) pumps“;
- g) aktualisierte Bilder: Bild 21 „Coordinate system for the forces and moments in Table 5 – Vertical in-line pumps“, Bild 22 „Coordinate system for the forces and moments in Table 5 – Vertical suspended, double-casing pumps“, Bild 23 „Coordinate system for the forces and moments in Table 5 – Horizontal pumps with side suction and side discharge nozzles“, Bild 24 „Coordinate system for the forces and moments in Table 5 – Horizontal pumps with end suction and top discharge nozzles“, Bild 25 „Coordinate system for the forces and moments in Table 5 – Horizontal pumps with top nozzles“;
- h) Aufnahme von Tabelle 14 „Pressure casing material inspection requirements“;
- i) neue Teilbilder in Bild C.1: „Typical HPRT arrangements“ zu a) „Pump drive at motor speed“ und b) „Pump drive at greater than motor speed“;
- j) neuer informativer Anhang K „Shaft stiffness and bearing system life“;
- k) neuer informativer Anhang N „Pump datasheet and electronic data exchange“;
- l) aktualisierte Literaturhinweise;
- m) Norm wurde redaktionell überarbeitet.

Frühere Ausgaben

DIN EN ISO 13709: 2005-07

Nationaler Anhang NA (informativ)

Begriffe

Folgende Begriffe werden in der Norm verwendet:

3.1

axiale Teilung

Teilung mit der Hauptnaht parallel zur Wellenachse

3.2

zulässiger Betriebsbereich

vom Hersteller festgelegter Teil des hydraulischen Bereichs einer Pumpe, in dem die Pumpe betrieben werden darf, basierend auf der oberen Grenze, die in dieser Internationalen Norm für Schwingungen oder den Temperaturanstieg festgelegt wurde oder einer anderen Begrenzung

3.3

Fasspumpe

horizontale Pumpe in Doppelgehäuse-Ausführung

3.4

Sperrfluid

extern zugeführtes Fluid, mit einem höheren Druck als dem Druck im Dichtungsraum der Pumpe, das in eine Dichtung der Anordnung 3 (druckbeaufschlagte Doppel-Gleitringdichtung) eingebracht wird, um die Pumpen-Prozessflüssigkeit vollständig von der Umgebung zu trennen

3.5

Punkt des besten Wirkungsgrads (Bestwirkungsgrad)

BEP (en: best efficiency point)

Durchfluss, bei dem eine Pumpe beim Nenn-Laufrad-Durchmesser ihren höchsten Wirkungsgrad erreicht

ANMERKUNG Der Bestförderstrom beim maximalen Laufrad-Durchmesser wird zur Bestimmung der spezifischen Dreh- und Saugzahl einer Pumpe verwendet. Der Bestförderstrom bei reduzierten Laufrad-Durchmessern ist in Bezug auf den Wert beim maximalen Laufrad-Durchmesser in gleicher Weise reduziert.

3.6

Pufferfluid

extern zugeführtes Fluid, mit einem geringeren Druck als dem Druck im Dichtungsraum der Pumpe, das als Schmiermittel und/oder Verdünnungsmittel in einer Dichtung der Anordnung 2 (nicht-druckbeaufschlagte Doppel-Gleitringdichtung) dient

3.7

Cartridge-Element

Baugruppe aus sämtlichen Teilen der Pumpe außer dem Gehäuse

3.8

drehsteif

charakterisiert durch die erste trockene kritische Drehzahl, die über der maximalen Dauerdrehzahl liegt, und zwar folgendermaßen:

- 20 % bei Rotoren, die nur für Nasslauf konstruiert sind;
- 30 % bei Rotoren, die trocken laufen können.

3.9

kritische Drehzahl

Wellendrehzahl, bei der das Rotorlager-Stützsystem eine Resonanzfrequenz entwickelt

3.10

Bezugshöhe

Höhe, auf die sich die NPSH-Werte beziehen (siehe 6.1.8)

vgl. **Haltedruckhöhe** (3.33)

3.11

Konstruktion

berechneter Parameter des Herstellers

ANMERKUNG „Konstruktion“ ist ein Begriff, der vom Hersteller der Ausrüstung zur Beschreibung verschiedener Parameter verwendet werden kann, wie beispielsweise Konstruktions-Leistung, Konstruktions-Druck, Konstruktions-Temperatur oder Konstruktions-Drehzahl. Dieser Begriff sollte ausschließlich durch den Hersteller der Ausrüstung verwendet werden, aber nicht in den Bestellerspezifikationen.

3.12

Doppelgehäuse

eine Gehäuseausführung einer Pumpe, bei der das äußere Druckgehäuse ein von den Pumpenelementen im Gehäuse völlig separates Bauteil ist

ANMERKUNG Beispiele für Pumpenelemente sind Diffusoren, Membranen, Trommeln und Spiral-Innengehäuse.

3.13

Bauteil des Antriebssystems

Einheit der Einrichtung, die in Reihe verwendet wird, um die Pumpe anzutreiben

BEISPIELE Motor, Getriebe, Turbine, Triebwerk, Fluidantrieb, Kupplung.

3.14

trockene kritische Drehzahl

kritische Drehzahl des Läufers, bei deren Berechnung davon ausgegangen wird, dass keine Einwirkungen durch Flüssigkeiten vorhanden sind, der Läufer nur in den Lagern gestützt wird und die Lager eine unendliche Steifigkeit besitzen

3.15

Element

Paket

Baugruppe aus dem Läufer und den innenliegenden ortsfesten Teilen einer Kreiselpumpe

3.16

hydraulische Entspannungsturbine

HPRT

Strömungsmaschine, die zur Rückgewinnung von Energie aus einem Fluidstrom bestimmt ist

3.17

hydrodynamisches Lager

Lager, das nach den Grundsätzen hydrodynamischer Schmierung funktioniert

3.18

identische Pumpe

Pumpe mit der gleichen Größe, hydraulischen Bemessung, derselben Anzahl von Stufen, der gleichen Drehzahl, dem gleichen Spiel, der gleichen Art Wellendichtung (Gleitring oder Wellenschutzbuchse), der gleichen Lagerart, Kupplungsmasse, dem gleichen Kupplungsüberhang und die zum Fördern derselben Flüssigkeit dient

3.19**maximal zulässige Drehzahl**

höchste Drehzahl, bei der die Konstruktion des Herstellers einen Dauerbetrieb zulässt

3.20**maximal zulässige Temperatur**

höchste Dauertemperatur, für die der Hersteller die Pumpe (oder ein Teil, auf das sich die Benennung bezieht) unter Berücksichtigung der festgelegten Flüssigkeit und des festgelegten maximalen Betriebsdrucks ausgelegt hat (umfasst nicht die Gleitringdichtung)

vgl. **Druckgehäuse** (3.43)

3.21**maximal zulässiger Betriebsdruck****MAWP**

höchster Dauerdruck, für den der Hersteller die Pumpe (oder ein Teil, auf das sich die Benennung bezieht) ausgelegt hat, wenn die festgelegte Flüssigkeit bei der festgelegten maximal zulässigen Temperatur gefördert wird (umfasst nicht die Gleitringdichtung)

3.22**maximaler Förderdruck**

höchster festgelegter Saugdruck zuzüglich des maximalen Differenzdrucks den die Pumpe mit dem vorhandenen Laufrad erreichen kann, wenn sie bei Nenndrehzahl mit einer Flüssigkeit der festgelegten normalen relativen Dichte (spezifisches Gewicht) betrieben wird

3.23**maximaler dynamischer Wellendichtungsdruck**

der an den Wellendichtungen zu erwartende höchste Überdruck bei den jeweiligen festgelegten Betriebsbedingungen sowie während des Anfahr- und Abfahrbetriebs

ANMERKUNG Sowohl dynamische als auch statische Wellendichtungsdrücke sind bei der Auswahl der mechanischen Dichtung (Gleitringdichtung) wichtig. Sie hängen vom Saugdruck der Pumpe, dem Arbeitspunkt und dem Spiel der Pumpe ab. Außerdem werden sie durch den Druck der Dichtungsspülung beeinflusst. Dieser Druck wird durch den Verkäufer der Dichtung angegeben. Siehe ISO 21049 oder ANSI/API Std 682/ISO 21049.

3.24**maximale Betriebstemperatur**

höchste Temperatur der Förderflüssigkeit, unter Berücksichtigung von Betriebsstörungen, der die Pumpe ausgesetzt ist

ANMERKUNG Diese Temperatur wird durch den Verkäufer der Dichtung angegeben. Siehe ISO 21049 oder ANSI/API Std 682/ISO 21049.

3.25**maximaler statischer Dichtungsdruck**

höchster Druck, mit Ausnahme von Drücken, die während hydrostatischer Prüfung auftreten, denen die Dichtungen beim Abschalten der Pumpe ausgesetzt werden können

3.26**maximaler Saugdruck**

höchster Saugdruck, dem die Pumpe während des Betriebes ausgesetzt ist (dauerhaft; dabei ist kein Druckstoß berücksichtigt)

3.27**kleinste zulässige Drehzahl**

niedrigste Drehzahl, bei der die Konstruktion des Herstellers einen Dauerbetrieb zulässt

ANMERKUNG Die Drehzahl wird in der Einheit Umdrehungen je Minute angegeben.

3.28

minimaler stabiler Dauerförderstrom

kleinster Förderstrom, bei dem die Pumpe betrieben werden kann, ohne die in dieser Internationalen Norm festgelegten Schwingungsgrenzen zu überschreiten

3.29

minimaler thermischer Dauerförderstrom

kleinster Förderstrom, bei dem die Pumpe betrieben werden kann, ohne dass ihr Betrieb durch den Temperaturanstieg der Förderflüssigkeit beeinträchtigt wird

3.30

niedrigste Auslegungswandtemperatur

tiefste mittlere Wandtemperatur (durch die Dicke hindurch), die während des Betriebs erwartet wird, unter Berücksichtigung von Betriebsstörungen, Selbstkühlung und der Temperatur der Umgebung, für die die Anlage ausgelegt ist

3.31

Mehrstufenpumpe

Pumpe mit drei oder mehr Stufen

Siehe 4.2.

3.32

Nennweite des Rohres

NPS

Bezeichnung, normalerweise mit einer nachfolgenden Größenbezeichnung, die annähernd dem Außendurchmesser des Rohres entspricht

ANMERKUNG Die NPS wird in Inch angegeben.

3.33

NPSH

Haltedruckhöhe

absolute Energiehöhe im Eintrittsquerschnitt der Pumpe oberhalb der dem Dampfdruck entsprechenden Höhe bezogen auf das NPSH-Bezugsniveau

ANMERKUNG NPSH wird in Metern (Fuß) der Energiehöhe der Förderflüssigkeit angegeben.

3.34

verfügbare Haltedruckhöhe der Anlage

NPSHA

vom Käufer für die Pumpenanlage bestimmte NPSH, mit der Flüssigkeit bei Auslegungsförderstrom und normaler Fördertemperatur

3.35

erforderliche Haltedruckhöhe der Pumpe

NPSH3

NPSH, der zu einem Abfall der Förderhöhe von 3 % führt (Energiehöhe der ersten Stufe bei einer Mehrstufenpumpe) und vom Verkäufer durch Prüfung mit Wasser bestimmt wird

3.36

üblicher Betriebspunkt

Punkt, an dem die Pumpe unter normalen Prozessbedingungen betrieben werden soll

3.37

Teil mit normalem Verschleiß

Teil, das bei jeder Überholung der Pumpe repariert oder ersetzt wird

BEISPIELE Verschleißringe, Zwischenbuchsen, Auswuchtgerät, Drosselbuchse, Dichtflächen, Lager und Dichtungen.

3.38**Überwachungsinspektion****Überwachungsprüfung**

Inspektion oder Prüfung, bei der der Käufer über den Zeitpunkt der Inspektion bzw. Prüfung unterrichtet ist und die Inspektion bzw. Prüfung planmäßig durchgeführt wird, unabhängig davon, ob der Käufer oder dessen Vertreter anwesend ist

3.39**Ölnebelschmierung**

Schmierung mittels Ölnebel, der durch Zerstäubung erzeugt und dem Lagergehäuse oder den Gehäusen mittels Druckluft zugeführt wird

3.40**Betriebsbereich**

Teil des hydraulischen Bereichs einer Pumpe, in dem die Pumpe betrieben wird

3.41**fliegend gelagerte Pumpe**

Pumpe, deren Laufrad durch eine einseitig gelagerte, freitragende Welle gestützt wird

3.42**bevorzugter Betriebsbereich**

Teil des hydraulischen Bereichs einer Pumpe, innerhalb dessen sich die Schwingung der Pumpe innerhalb der Untergrenze dieser Internationalen Norm befindet

3.43**Druckgehäuse**

Umgrenzung für sämtliche ortsfesten drucktragenden Teile der Pumpe, einschließlich sämtlicher Stutzen, Stopfbuchsen, Dichtungsräume und Hilfsanschlüsse, aber ausschließlich der stationären und umlaufenden Teile von Gleitringdichtungen

ANMERKUNG Die Atmosphärenseite der Stopfbuchse, die Dichtungsspülung (Rohrleitung), Hilfsrohre und Ventile sind nicht Teil des Druckgehäuses.

3.44**Käufer**

Eigentümer oder Vertreter des Eigentümers, der dem Verkäufer die Bestellung erteilt und die Leistungsbeschreibung übermittelt

3.45**reine Ölnebelschmierung**

(Trockensumpf-)System, in dem der Nebel sowohl das/die Lager schmiert als auch das Gehäuse reinigt und sich im Sumpf kein Öl befindet

3.46**Ölnebelschmierung mit Nasssumpf**

(Nasssumpf-)Systeme, in denen der Nebel nur das Lagergehäuse reinigt

3.47**radial geteilt**

Teilung mit der Hauptnaht rechtwinklig zur Wellenachse

3.48**Nennarbeitspunkt**

Punkt, für den der Verkäufer bescheinigt, dass die Pumpenleistung innerhalb der in dieser Internationalen Norm festgelegten Toleranzen liegt

ANMERKUNG Normalerweise entspricht der Nennarbeitspunkt dem festgelegten Arbeitspunkt mit dem größten Förderstrom.

3.49

relative Dichte

spezifisches Gewicht (*veraltet*)

Eigenschaft einer Flüssigkeit, die als Verhältnis zwischen der Dichte der Flüssigkeit und der Dichte von Wasser bei Standardtemperatur angegeben wird

ANMERKUNG Die Standardtemperatur entspricht 4 °C (39,2 °F).

3.50

Rotor

Baugruppe aus sämtlichen rotierenden Teilen einer Kreiselpumpe

3.51

baugleiche Pumpe

Pumpe, bei der unter Berücksichtigung der Faktoren, die für eine identische Pumpe (3.18) aufgeführt sind, aufgrund einer Vereinbarung zwischen Käufer und Hersteller davon ausgegangen wird, dass sie hinreichend ähnlich ist, so dass keine laterale Analyse erforderlich ist

3.52

spezifische Drehzahl

Kennzahl in Bezug auf den Förderstrom, die Gesamthöhe und die Drehzahl bei Pumpen mit ähnlicher Geometrie

3.53

Stufe

ein Laufrad und dessen zugehöriger Diffusor bzw. Spirale und Rückführkanal

3.54

spezifische Saugzahl

Kennzahl in Bezug auf den Förderstrom, die erforderliche Haltedruckhöhe der Pumpe (NPSH3) und die Drehzahl bei Pumpen mit ähnlicher Geometrie

3.55

Drosselbuchse

Einrichtung mit engem Spiel um die Wellenhülse (oder Welle) zwischen der Dichtung oder Innendichtung einer Doppel-Gleitringdichtung und dem Laufrad

3.56

Gesamtanzeige

gesamte Rundlaufabweichung

TIR

Differenz zwischen den maximalen und minimalen abgelesenen Werten eines Skalenzeigers oder eines ähnlichen Gerätes zur Überwachung einer Fläche oder zylindrischen Oberfläche während einer vollständigen Umdrehung der überwachten Oberfläche

ANMERKUNG Bei einer vollständig zylindrischen Oberfläche entspricht die Exzentrizität der Hälfte des Indikatorwertes. Bei einer vollständig ebenen Fläche entspricht die vom Indikatorwert angegebene Abweichung von der Rechtwinkligkeit dem angezeigten Wert. Ist der betreffende Durchmesser nicht vollständig zylindrisch oder eben, dann ist die Interpretation der Bedeutung von TIR komplexer und kann Ovalität oder Keulenförmigkeit darstellen.

3.57

Abschaltdrehzahl

bei elektrischen motorgetriebenen Antrieben: Synchrondrehzahl des Motors bei der maximalen Frequenz der elektrischen Energieversorgung

3.58

Abschaltdrehzahl

bei drehzahlvariablen Antrieben: Drehzahl, bei der ein unabhängiger Notfall-Überdrehzahlschutz den Hauptantrieb abschaltet

3.59**Anlagenverantwortlichkeit**

Verantwortung für die Koordinierung der Dokumentation, Lieferung sowie der technischen Aspekte der Ausrüstung und sämtlicher Hilfssysteme, die zum Auftragsumfang gehören

ANMERKUNG Zu den zu berücksichtigenden technischen Aspekten zählen beispielsweise Faktoren wie Leistungsanforderungen, Drehzahl, Drehrichtung, allgemeine Anordnung, Kupplungen, Dynamik, Schmierung, Dichtungssysteme, Materialprüfberichte, Instrumentierung, Verrohrung, Übereinstimmung mit Spezifikationen und die Prüfung von Bauteilen.

3.60**Verkäufer****Lieferant**

Hersteller oder Vertreter des Herstellers, der die Ausrüstung liefert und normalerweise für die Betreuung von Kunden verantwortlich ist

3.61**vertikale Inlinepumpe**

einstufige, fliegend gelagerte Pumpe mit vertikaler Achse, deren Saug- und Druckanschlüsse eine gemeinsame Mittelachse aufweisen, die die Wellenachse schneidet

ANMERKUNG Die Typen VS6 und VS7 werden nicht als Inlinepumpen angesehen.

3.62**vertikal hängende Pumpe**

Vertikalachs-Pumpe, deren Hydraulikteil an einem Tragrohr und einer Montageplatte befestigt ist

ANMERKUNG Der Dosierkopf der Pumpe ist normalerweise in die Förderflüssigkeit getaucht.

3.63**feuchte kritische Drehzahl**

Rotor-Resonanzdrehzahl, berechnet unter Berücksichtigung der zusätzlichen Unterstützung und Dämpfung, die durch die Wirkung der Förderflüssigkeit bei den Betriebsbedingungen in den internen Laufspielen entsteht und die Steifigkeit und Dämpfung in den Lagern mit einbezieht

3.64**Prüfung unter Zeugen****Inspektion unter Zeugen**

Inspektion oder Prüfung, bei der der Käufer über den Zeitpunkt der Inspektion bzw. Prüfung unterrichtet ist und die Inspektion bzw. Prüfung erst dann durchgeführt wird, wenn der Käufer oder dessen Vertreter vor Ort ist

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN 2460, *Stahlrohre und Formstücke für Wasserleitungen*

DIN 18800-7, *Stahlbauten — Teil 7: Ausführung und Herstellerqualifikation*

DIN EN 287-1, *Prüfung von Schweißern — Schmelzschweißen — Teil 1: Stähle*

DIN EN 953, *Sicherheit von Maschinen — Trennende Schutzeinrichtungen — Allgemeine Anforderungen an Gestaltung und Bau von feststehenden und beweglichen trennenden Schutzeinrichtungen*

DIN EN 1090-2, *Ausführung von Stahltragwerken und Aluminiumtragwerken — Teil 2: Technische Regeln für die Ausführung von Stahltragwerken*

DIN EN 10220, *Nahtlose und geschweißte Stahlrohre — Allgemeine Tabellen für Maße und längenbezogene Masse*

DIN EN 10224, *Rohre und Fittings aus unlegiertem Stahl für den Transport von Wasser und anderen wässrigen Flüssigkeiten — Technische Lieferbedingungen*

DIN EN 10311, *Verbindungen für Stahlrohre und Fittings für den Transport von Wasser und anderen wässrigen Flüssigkeiten*

DIN EN 10226-1, *Rohrgewinde für im Gewinde dichtende Verbindungen — Teil 1: Kegelige Außengewinde und zylindrische Innengewinde — Maße, Toleranzen und Bezeichnung*

DIN EN 60034-1, *Drehende elektrische Maschinen — Teil 1: Bemessung und Betriebsverhalten*

DIN EN 60034-2-1, *Drehende elektrische Maschinen — Teil 2-1: Standardverfahren zur Bestimmung der Verluste und des Wirkungsgrades aus Prüfungen (ausgenommen Maschinen für Schienen- und Straßenfahrzeuge)*

DIN EN 60079-1 (alle Teile), *Explosionsfähige Atmosphäre*

DIN EN ISO 228-1, *Rohrgewinde für nicht im Gewinde dichtende Verbindungen — Teil 1: Maße, Toleranzen und Bezeichnung*

DIN EN ISO 8501-1, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen - Visuelle Beurteilung der Oberflächenreinheit — Teil 1: Rostgrade und Oberflächenvorbereitungsgrade von unbeschichteten Stahloberflächen und Stahloberflächen nach ganzflächigem Entfernen vorhandener Beschichtungen*

DIN EN ISO 8501-2, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Visuelle Beurteilung der Oberflächenreinheit — Teil 2: Oberflächenvorbereitungsgrade von beschichteten Oberflächen nach örtlichem Entfernen der vorhandenen Beschichtungen*

DIN EN ISO 8501-3, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Visuelle Beurteilung der Oberflächenreinheit — Teil 3: Vorbereitungsgrade von Schweißnähten, Kanten und anderen Flächen mit Oberflächenunregelmäßigkeiten*

DIN EN ISO 8501-4, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Visuelle Beurteilung der Oberflächenreinheit — Teil 4: Ausgangszustände, Vorbereitungsgrade und Flugrostgrade in Verbindung mit Hochdruck-Wasserwaschen*

DIN EN ISO 9606-2, *Prüfung von Schweißern — Schmelzschweißen — Teil 2: Aluminium und Aluminiumlegierungen*

DIN EN ISO 9606-3, *Prüfung von Schweißern — Schmelzschweißen — Teil 3: Kupfer und Kupferlegierungen*

DIN EN ISO 9606-4, *Prüfung von Schweißern — Schmelzschweißen — Teil 4: Nickel und Nickellegierungen*

DIN EN ISO 9606-5, *Prüfung von Schweißern — Schmelzschweißen — Teil 5: Titan und Titanlegierungen, Zirkonium und Zirkoniumlegierungen*

DIN EN ISO 9906, *Kreiselpumpen — Hydraulische Abnahmeprüfung — Klasse 1 und 2*

DIN EN ISO 10438-1, *Erdöl-, petrochemische und Erdgasindustrie — Schmieröl-, Sperröl- und Regelölversorgungsanlagen und Hilfsanlagen — Teil 1: Allgemeine Anforderungen*

DIN EN ISO 10438-2, *Erdöl-, petrochemische und Erdgasindustrie — Schmieröl-, Sperröl- und Regelölversorgungsanlagen und Hilfsanlagen — Teil 2: Ölversorgungsanlagen für besondere Anwendungsfälle*

DIN EN ISO 10438-3, *Erdöl-, petrochemische und Erdgasindustrie — Schmieröl-, Sperröl- und Regelölversorgungsanlagen und Hilfsanlagen — Teil 3: Ölversorgungsanlagen für allgemeine Anwendungsfälle*

DIN EN ISO 10438-4, *Erdöl-, petrochemische und Erdgasindustrie — Schmieröl-, Sperröl- und Regelölversorgungsanlagen und Hilfsanlagen — Teil 4: Sperrgasversorgungsanlagen*

DIN EN ISO 10441, *Erdöl- und Erdgasindustrie — Nachgiebige Kupplungen zur mechanischen Kraftübertragung — Besondere Anwendungsfälle*

DIN EN ISO 12944-4, *Beschichtungsstoffe — Korrosionsschutz von Stahlbauten durch Beschichtungssysteme — Teil 4: Arten von Oberflächen und Oberflächenvorbereitung*

DIN EN ISO 14691, *Erdöl-, petrochemische und Erdgasindustrie — Flexible Kupplungen für mechanische Kraftübertragung — Allgemeine Anwendungsfälle*

DIN EN ISO 15156-1, *Erdöl- und Erdgasindustrie — Werkstoffe für den Einsatz in H₂S-haltiger Umgebung bei der Öl- und Gasgewinnung — Teil 1: Allgemeine Grundlagen für die Auswahl von gegen Rissbildung beständigen Werkstoffen*

DIN EN ISO 15609-1, *Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe — Schweißanweisung — Teil 1: Lichtbogenschweißen*

DIN EN ISO 15609-2, *Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe — Schweißanweisung — Teil 2: Gasschweißen*

DIN EN ISO 15609-3, *Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe — Schweißanweisung — Teil 3: Elektronenstrahlschweißen*

DIN EN ISO 15609-4, *Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe — Schweißanweisung — Teil 4: Laserstrahlschweißen*

DIN EN ISO 15609-5, *Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe — Schweißanweisung — Teil 5: Widerstandsschweißen*

DIN EN ISO 21049, *Pumpen — Wellendichtungssysteme für Kreiselpumpen und rotierende Verdrängerpumpen*

DIN ISO 261, *Metrisches ISO-Gewinde allgemeiner Anwendung — Übersicht*

DIN ISO 262, *Metrisches ISO-Gewinde allgemeiner Anwendung — Auswahlreihen für Schrauben, Bolzen und Muttern*

DIN ISO 281, *Wälzlager — Dynamische Tragzahlen und nominelle Lebensdauer*

DIN ISO 965-1, *Metrisches ISO-Gewinde allgemeiner Anwendung — Toleranzen — Teil 1: Prinzipien und Grundlagen*

DIN ISO 286-1, *ISO-System für Grenzmaße und Passungen — Grundlagen für Toleranzen, Abmaße und Passungen*

DIN ISO 286-2, *ISO-System für Grenzmaße und Passungen — Tabellen der Grundtoleranzgrade und Grenzabmaße für Bohrungen und Wellen*

DIN ISO 724, *Metrische ISO-Gewinde allgemeiner Anwendung — Grundmaße*

DIN ISO 965-1, *Metrisches ISO-Gewinde allgemeiner Anwendung — Toleranzen — Teil 1: Prinzipien und Grundlagen*

DIN ISO 965-2, *Metrisches ISO-Gewinde allgemeiner Anwendung — Toleranzen — Teil 2: Grenzmaße für Außen- und Innengewinde allgemeiner Anwendung; Toleranzklasse mittel*

DIN ISO 965-3, *Metrisches ISO-Gewinde allgemeiner Anwendung — Toleranzen — Teil 3: Grenzabmaße für Konstruktionsgewinde*

DIN ISO 965-4, *Metrisches ISO-Gewinde allgemeiner Anwendung — Toleranzen — Teil 4: Grenzmaße für feuerverzinkte Außengewinde, passend für Innengewinde der Toleranzfeldlagen H oder G nach Aufbringung des Überzuges*

DIN ISO 965-5, *Metrisches ISO-Gewinde allgemeiner Anwendung — Toleranzen — Teil 5: Grenzmaße für Innengewinde, passend für feuerverzinkte Außengewinde mit Höchstmaßen der Toleranzfeldlage h vor Aufbringung des Überzuges*

DIN ISO 1940-1, *Mechanische Schwingungen — Anforderungen an die Auswuchtgüte von Rotoren in konstantem (starrem) Zustand — Teil 1: Festlegung und Nachprüfung der Unwuchttoleranz*

DIN ISO 11342, *Mechanische Schwingungen — Verfahren und Kriterien für das mechanische Auswuchten nachgiebiger Rotoren*

English Version

Centrifugal pumps for petroleum, petrochemical and
natural gas industries
(ISO 13709:2009)

Pompes centrifuges pour les industries du pétrole, de la
pétrochimie et du gaz naturel
(ISO 13709:2009)

Kreiselpumpen für den Einsatz in der Erdöl-,
petrochemischen und Erdgasindustrie
(ISO 13709:2009)

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Foreword

This document (EN ISO 13709:2009) has been prepared by Technical Committee ISO/TC 115 “Pumps” in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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Endorsement notice

The text of ISO 13709:2009 has been approved by CEN as a EN ISO 13709:2009 without any modification.

Introduction

It is necessary that users of this International Standard be aware that further or differing requirements can be needed for individual applications. This International Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This can be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, it is necessary that the vendor identify any variations from this International Standard and provide details.

A bullet (•) at the beginning of a clause or subclause indicates that either a decision is required or the purchaser is required to provide further information. It is necessary that this information should be indicated on data sheets or stated in the enquiry or purchase order (see examples in Annex N).

In this International Standard, where practical, US Customary, or other, units are included in parentheses for information.

1 Scope

This International Standard specifies requirements for centrifugal pumps, including pumps running in reverse as hydraulic power recovery turbines, for use in petroleum, petrochemical and gas industry process services.

This International Standard is applicable to overhung pumps, between-bearings pumps and vertically suspended pumps (see Table 1). Clause 9 provides requirements applicable to specific types of pump. All other clauses of this International Standard are applicable to all pump types. Illustrations are provided of the various specific pump types and the designations assigned to each specific type.

Relevant industry operating experience suggests pumps produced to this International Standard are cost effective when pumping liquids at conditions exceeding any one of the following:

— discharge pressure (gauge)	1 900 kPa (275 psi; 19,0 bar)
— suction pressure (gauge)	500 kPa (75 psi; 5,0 bar)
— pumping temperature	150 °C (300 °F)
— rotative speed	3 600 r/min
— rated total head	120 m (400 ft)
— impeller diameter, overhung pumps	330 mm (13 in)

NOTE For sealless pumps, reference can be made to API Std 685. For heavy duty pump applications in industries other than petroleum, petrochemical and gas processing, reference can be made to ISO 9905.

2 Normative references

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

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 261, *ISO general purpose metric screw threads — General plan*

ISO 262, *ISO general purpose metric screw threads — Selected sizes for screws, bolts and nuts*

ISO 281:2007, *Rolling bearings — Dynamic load ratings and rating life*

ISO 286 (all parts), *ISO system of limits and fits*

ISO 724, *ISO general-purpose metric screw threads — Basic dimensions*

ISO 965 (all parts), *ISO general-purpose metric screw threads — Tolerances*

ISO 1940-1, *Mechanical vibration — Balance quality requirements for rotors in a constant (rigid) state — Part 1: Specification and verification of balance tolerances*

ISO 3117, *Tangential keys and keyways*

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

ISO 5753, *Rolling bearings — Radial internal clearance*

ISO 7005-1, *Metallic flanges — Part 1: Steel flanges for industrial and general service piping systems*

ISO 7005-2, *Metallic flanges — Part 2: Cast iron flanges*

ISO 8501 (all parts), *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness*

ISO 9606 (all parts), *Approval testing of welders — Fusion welding*¹⁾

ISO 9906, *Rotodynamic pumps — Hydraulic performance acceptance tests*²⁾

ISO 10438:2007 (all parts), *Petroleum, petrochemical and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries*

ISO 10441, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — Special-purpose applications*

ISO 10721-2, *Steel structures — Part 2: Fabrication and erection*

ISO 11342, *Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors*

ISO 14120, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14691, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — General-purpose applications*

ISO 15156-1, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials*

ISO 15609 (all parts), *Specification and qualification of welding procedures for metallic materials — Welding procedure specification*

ISO 15649, *Petroleum and natural gas industries — Piping*

ISO/TR 17766, *Centrifugal pumps handling viscous liquids — Performance corrections*

ISO 21049:2004, *Pumps — Shaft sealing systems for centrifugal and rotary pumps*

IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

IEC 60034-2-1, *Rotating electrical machines — Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*³⁾

EN 953, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

1) Some parts of ISO 9606 are under revision and some revised parts have been published with *Qualification test of welders* as the main title.

2) To be published. (Revision of ISO 9906:1999)

3) Many parts of this standard have *Explosive atmospheres* as the main title.

EN 13445 (all parts), *Unfired pressure vessels*

EN 13463-1, *Non-electrical equipment for use in potentially explosive atmospheres — Part 1: Basic method and requirements*

ANSI/ABMA 7, *Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plan* ⁴⁾

ANSI/AGMA 9000, *Flexible Couplings — Potential Unbalance Classification* ⁵⁾

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

ANSI/AMT B15.1, *Safety Standard for Mechanical Power Transmission Apparatus* ⁶⁾

ANSI/API Std 541, *Form-Wound Squirrel-Cage Induction Motors — 500 Horsepower and Larger*

ANSI/API Std 611, *General-Purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

ANSI/API Std 670, *Machinery Protection Systems*

ANSI/API Std 671/ISO 10441, *Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services*

ANSI/ASME B1.1, *Unified Inch Screw Threads, UN and UNR Thread Form* ⁷⁾

ANSI/ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125 and 250*

ANSI/ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard*

ANSI/ASME B16.11, *Forged Steel Fittings, Socket-Welding and Threaded*

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

ANSI/ASME B16.47, *Larger Diameter Steel Flanges: NPS 26 Through NPS 60*

ANSI/ASME B18.18.2M, *Inspection and Quality Assurance for High-Volume Machine Assembly Fasteners*

ANSI/ASME B31.3, *Process Piping*

ANSI/HI 1.6, *Centrifugal Tests* ⁸⁾

ANSI/HI 2.6, *American National Standard for Vertical Pump Tests*

API Std 547, *General-Purpose Form-Wound Squirrel Cage Induction Motors — 250 Horsepower and Larger*

API Std 677, *General-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services*

ASME, *Boiler and pressure vessel code BPVC, Section V, Nondestructive Examination*

ASME, *Boiler and pressure vessel code BPVC, Section VIII, Rules for Construction of Pressure Vessels*

ASME, *Boiler and pressure vessel code BPVC, Section IX, Welding and Brazing Qualifications*

⁴⁾ American Bearing Manufacturers Association, 2025 M Street, NW, Suite 800, Washington, DC 20036, USA.

⁵⁾ American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314, USA.

⁶⁾ American National Standards Institute, 1819 L Street, Suite 600, Washington, D.C. 20036, USA.

⁷⁾ American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA.

⁸⁾ Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ 07054, USA.

DIN 910, *Heavy-duty hexagon head screw plugs*⁹⁾

IEEE 841, *IEEE Standard for Petroleum and Chemical Industry — Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors — Up to and Including 500 hp*¹⁰⁾

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components — Visual Method for Evaluation of Surface Irregularities*¹¹⁾

NACE MR0103, *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*¹²⁾

NFPA 70:2008, *National Electrical Code*¹³⁾

SSPC SP 6, *Commercial Blast Cleaning*¹⁴⁾

3 Terms and definitions

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

3.1

axially split

split with the principal joint parallel to the shaft centreline

3.2

allowable operating region

portion of a pump's hydraulic coverage over which the pump is allowed to operate, based on vibration within the upper limit of this International Standard or temperature rise or other limitation, specified by the manufacturer

3.3

barrel pump

horizontal pump of the double-casing type

3.4

barrier fluid

externally supplied fluid, at a pressure above the pump seal chamber pressure, introduced into an Arrangement 3 seal (pressurized dual mechanical seal) to completely isolate the pump process liquid from the environment

3.5

best efficiency point

BEP

flowrate at which a pump achieves its highest efficiency at rated impeller diameter

9) Deutsches Institut für Normung, Burggrafenstrasse 6, Berlin, Germany D-10787.

10) Institute of Electrical & Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA.

11) Manufacturers Standardization Society of The Valve and Fittings Industry Inc., 127 Park Street N.E., Vienna, VA 22180-4602, USA.

12) National Association of Corrosion Engineers, Houston, Texas, USA.

13) National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, USA.

14) Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4643, USA.

NOTE The best efficiency point flowrate at maximum impeller diameter is used to determine pump specific speed and suction specific speed. The best efficiency point flowrate at reduced impeller diameters is similarly reduced from the value at maximum impeller diameter.

3.6
buffer fluid

externally supplied fluid, at a pressure lower than the pump seal chamber pressure, used as a lubricant and/or to provide a diluent in an Arrangement 2 seal (unpressurized dual mechanical seal)

3.7
cartridge-type element
assembly of all the parts of the pump except for the casing

3.8
classically stiff
characterized by the first dry critical speed being above the pump's maximum continuous speed by the following:

20 % for rotors designed for wet running only

30 % for rotors designed to be able to run dry

3.9
critical speed
shaft rotational speed at which the rotor-bearing-support system is in a state of resonance

3.10
datum elevation
elevation to which values of NPSH are referred (see 6.1.8)

cf. **net positive suction head** (3.33)

3.11
design
manufacturer's calculated parameter

NOTE "Design" is a term that may be used by the equipment manufacturer to describe various parameters, such as design power, design pressure, design temperature, or design speed. This term should be used only by the equipment manufacturer and not in the purchaser's specifications.

3.12
double casing
type of pump construction in which the pressure casing is separate from the pumping elements contained in the casing

NOTE Examples of pumping elements include diffuser, diaphragms, bowls and volute inner casings.

3.13
drive-train component
item of the equipment used in series to drive the pump

EXAMPLES Motor, gear, turbine, engine, fluid drive, clutch.

3.14
dry critical speed
rotor critical speed calculated assuming that there are no liquid effects, that the rotor is supported only at its bearings and that the bearings are of infinite stiffness

3.15

**element
bundle**

assembly of the rotor plus the internal stationary parts of a centrifugal pump

3.16

hydraulic power recovery turbine

HPRT

turbomachine designed to recover power from a fluid stream

3.17

hydrodynamic bearing

bearing that uses the principles of hydrodynamic lubrication

3.18

identical pump

pump of the same size, hydraulic design, number of stages, rotational speed, clearances, type of shaft seal (axial face or breakdown bushing), type of bearings, coupling mass, coupling overhang, and pumping the same liquid

3.19

maximum allowable speed

highest speed at which the manufacturer's design permits continuous operation

3.20

maximum allowable temperature

maximum continuous temperature for which the manufacturer has designed the pump (or any part to which the term is referred) when pumping the specified liquid at the specified maximum operating pressure (does not include mechanical seal)

cf. **pressure casing** (3.43)

3.21

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 pumping the specified liquid at the specified maximum operating temperature (does not include mechanical seal)

3.22

maximum discharge pressure

maximum specified suction pressure plus the maximum differential pressure the pump with the furnished impeller is able to develop when operating at rated speed with liquid of the specified normal relative density (specific gravity)

3.23

maximum dynamic sealing pressure

highest pressure expected at the seals during any specified operating condition and during start-up and shut-down

NOTE Both dynamic and static sealing pressures are important to selection of the mechanical seal. They are dependent on the pump suction pressure, operating point and pump clearances. They are also affected by the pressure of the seal flush. This pressure is specified to the seal vendor. See ISO 21049 or ANSI/API Std 682/ISO 21049.

3.24

maximum operating temperature

highest temperature of the pumped liquid, including upset conditions, to which the pump is exposed

NOTE This temperature is specified to the seal vendor. See ISO 21049 or ANSI/API Std 682/ISO 21049.

3.25

maximum static sealing pressure

highest pressure, excluding pressures encountered during hydrostatic testing, to which the seals can be subjected while the pump is shut down

3.26

maximum suction pressure

highest suction pressure to which the pump is subjected during operation (non-transient; does not include waterhammer)

3.27

minimum allowable speed

lowest speed at which the manufacturer's design permits continuous operation

NOTE The speed is expressed in units of revolutions per minute.

3.28

minimum continuous stable flow

lowest flow at which the pump can operate without exceeding the vibration limits imposed by this International Standard

3.29

minimum continuous thermal flow

lowest flow at which the pump can operate without its operation being impaired by the temperature rise of the pumped liquid

3.30

minimum design metal temperature

lowest mean metal temperature (through the thickness) expected in service, including operation upsets, auto-refrigeration and temperature of the surrounding environment, for which the equipment is designed

3.31

multistage pump

pump with three or more stages

See 4.2.

3.32

nominal pipe size

NPS

designation, usually followed by a size designation number, corresponding approximately to the outside diameter of the pipe

NOTE The NPS is expressed in inches.

3.33

NPSH

net positive suction head

absolute inlet total head above the head equivalent to the vapour pressure referred to the NPSH datum plane

NOTE NPSH is expressed in metres (feet) of head of the pumped liquid.

3.34

net positive suction head available

NPSHA

NPSH determined by the purchaser for the pumping system with the liquid at the rated flow and normal pumping temperature

3.35

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

3.36

normal operating point

point at which the pump is expected to operate under normal process conditions

3.37

normal-wear part

part normally restored or replaced at each pump overhaul

EXAMPLES Wear rings, inter-stage bushings, balancing device, throat bushing, seal faces, bearings and gaskets.

3.38

observed inspection

observed test

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, regardless of whether the purchaser or his representative is present

3.39

oil-mist lubrication

lubrication provided by oil mist produced by atomization and transported to the bearing housing, or housings, by compressed air

3.40

operating region

portion of a pump's hydraulic coverage over which the pump operates

3.41

overhung pump

pump whose impeller is supported by a cantilever shaft from its bearing assembly

3.42

preferred operating region

portion of a pump's hydraulic coverage over which the pump's vibration is within the base limit of this International Standard

3.43

pressure casing

composite of all stationary pressure-containing parts of the pump, including all nozzles, seal glands, seal chambers and auxiliary connections but excluding the stationary and rotating members of mechanical seals

NOTE The atmospheric side of the seal gland, the seal flush (piping) plan, auxiliary piping and valves are not part of the pressure casing.

3.44

purchaser

owner, or owner's agent, who issues the order and specification to the vendor

3.45

pure oil-mist lubrication

(dry sump) system in which the mist both lubricates the bearing(s) and purges the housing and there is no oil level in the sump

3.46

purge oil-mist lubrication

〈wet sump〉 systems in which the mist only purges the bearing housing

3.47

radially split

split with the principal joint perpendicular to the shaft centreline

3.48

rated operating point

point at which the vendor certifies that pump performance is within the tolerances stated in this International Standard

NOTE Normally, the rated operating point is the specified operating point with the highest flow.

3.49

relative density

specific gravity

property of a liquid expressed as the ratio of the liquid's density to that of water at standard temperature

NOTE Standard temperature is 4 °C (39,2 °F).

3.50

rotor

assembly of all the rotating parts of a centrifugal pump

3.51

similar pump

pump that is accepted, by agreement between purchaser and manufacturer as sufficiently similar to not require a lateral analysis, taking into account the factors listed for an **identical pump** (3.18)

3.52

specific speed

index relating flow, total head and rotational speed for pumps of similar geometry

3.53

stage

one impeller and associated diffuser or volute and return channel, if required

3.54

suction-specific speed

index relating flow, NPSH3 and rotative speed for pumps of similar geometry

3.55

throat bushing

device that forms a restrictive close clearance around the sleeve (or shaft) between the seal or inner seal of a dual seal cartridge and the impeller

3.56

total indicator reading

total indicated runout

TIR

difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface, during one complete revolution of the monitored surface

NOTE For a perfectly cylindrical surface, the indicator reading implies an eccentricity equal to half the reading. For a perfectly flat face the indicator reading gives an out-of-squareness equal to the reading. If the diameter in question is not perfectly cylindrical or flat, interpretation of the meaning of TIR is more complex and can represent ovality or lobing.

3.57

trip speed

(electric motor driver) electric motor driver-synchronous speed at maximum supply frequency

3.58

trip speed

(variable-speed driver) variable-speed driver-speed at which the independent emergency over-speed device operates to shut down the driver

3.59

unit responsibility

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

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

3.60

vendor

supplier

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

3.61

vertical in-line pump

vertical-axis, single-stage overhung pump whose suction and discharge connections have a common centreline that intersects the shaft axis

NOTE Types VS6 and VS7 are not considered in-line pumps.

3.62

vertically suspended pump

vertical-axis pump whose liquid end is suspended from a column and mounting plate

NOTE The pump's liquid end is usually submerged in the pumped liquid.

3.63

wet critical speed

rotor critical speed calculated considering the additional support and damping produced by the action of the pumped liquid within internal running clearances at the operating conditions and allowing for stiffness and damping within the bearings

3.64

witnessed test

witnessed inspection

inspection or test for which the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or his representative is in attendance

4 General

4.1 Unit responsibility

Unless otherwise specified, the pump vendor shall have unit responsibility. The pump vendor shall ensure that all sub-vendors comply with the requirements of this International Standard and all reference documents.

4.2 Classification and designation

4.2.1 Description of codes

The pumps described in this International Standard are classified and designated by type codes, as shown in Table 1.

Table 1 — Pump classification type identification

Pump type ^a			Orientation		Type code
Centrifugal pumps	Overhung	Flexibly coupled	Horizontal	Foot-mounted	OH1
				Centreline-supported	OH2
			Vertical in-line with bearing bracket	—	OH3
		Rigidly coupled	Vertical in-line	—	OH4
		Close-coupled	Vertical in-line	—	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

^a Illustrations of the various types of pump are provided in 4.2.2.

^a Illustrations of the various types of pump are provided in 4.2.2.

4.2.2 Pump designations and descriptions

4.2.2.1 Pump type OH1

Foot-mounted, single-stage overhung pumps shall be designated pump type OH1. (This type does not meet all the requirements of this International Standard; see Table 3.)

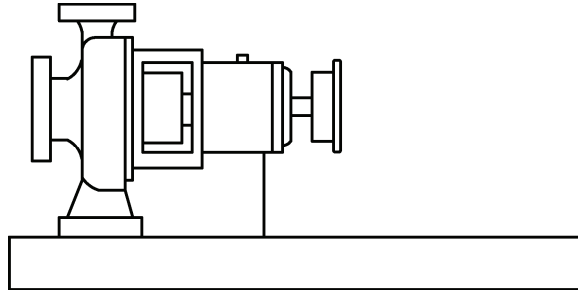


Figure 1 — Pump type OH1

4.2.2.2 Pump type OH2

Centreline-mounted, single-stage overhung pumps shall be designated pump type OH2. They have a single bearing housing to absorb all forces imposed upon the pump shaft and maintain rotor position during operation. The pumps are mounted on a baseplate and are flexibly coupled to their drivers.

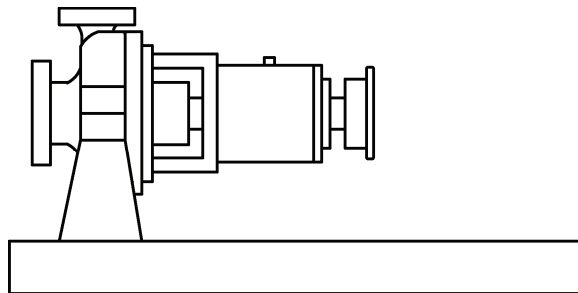


Figure 2 — Pump type OH2

4.2.2.3 Pump type OH3

Vertical, in-line, single-stage overhung pumps with separate bearing brackets shall be designated pump type OH3. They have a bearing housing integral with the pump to absorb all pump loads. The driver is usually mounted on a support integral to the pump. The pumps and their drivers are flexibly coupled.

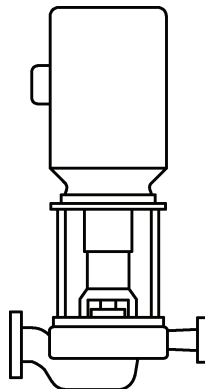


Figure 3 — Pump type OH3

4.2.2.4 Pump type OH4

Rigidly coupled, vertical, in-line, single-stage overhung pumps shall be designated pump type OH4. Rigidly coupled pumps have their shaft rigidly coupled to the driver shaft. (This type does not meet all the requirements of this International Standard; see Table 3.)

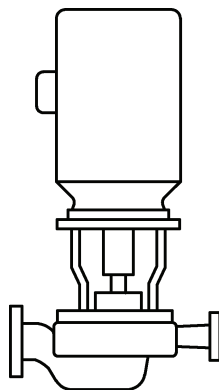


Figure 4 — Pump type OH4

4.2.2.5 Pump type OH5

Close-coupled, vertical, in-line, single-stage overhung pumps shall be designated pump type OH5. Close-coupled pumps have their impellers mounted directly on the driver shaft. (This type does not meet all the requirements of this International Standard; see Table 3.)

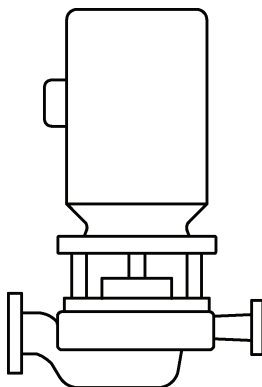


Figure 5 — Pump type OH5

4.2.2.6 Pump type OH6

High-speed, integral, gear-driven, single-stage overhung pumps shall be designated pump type OH6. These pumps have a speed-increasing gearbox integral with the pump. The impeller is mounted directly to the gearbox output shaft. There is no coupling between the gearbox and pump; however, the gearbox is flexibly coupled to its driver. The pumps may be oriented vertically or horizontally.

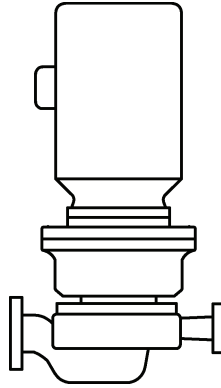


Figure 6 — Pump type OH6

4.2.2.7 Pump type BB1

Axially split, one- and two-stage, between-bearings pumps shall be designated pump type BB1.

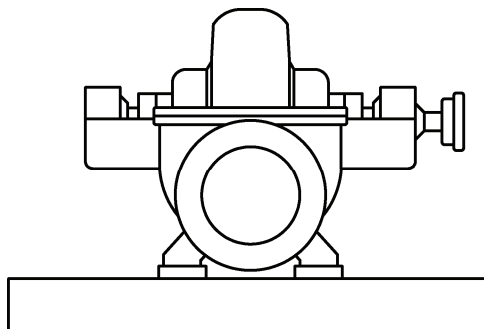


Figure 7 — Pump type BB1

4.2.2.8 Pump type BB2

Radially split, one- and two-stage, between-bearings pumps shall be designated pump type BB2.

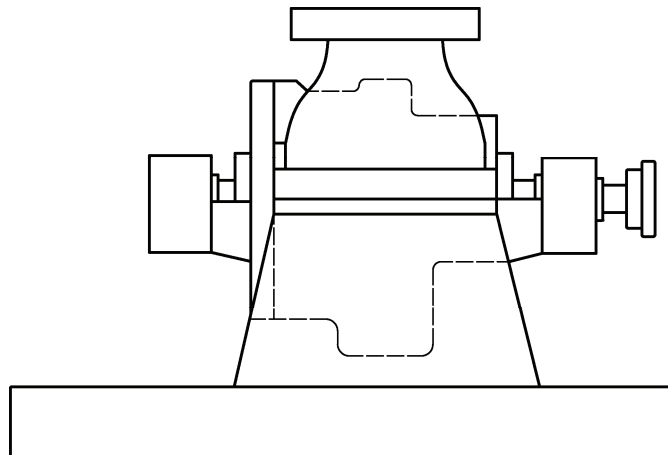


Figure 8 — Pump type BB2

4.2.2.9 Pump type BB3

Axially split, multistage, between-bearings pumps shall be designated pump type BB3.

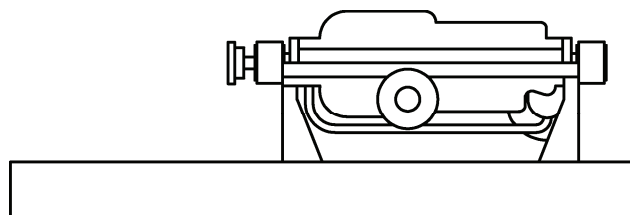


Figure 9 — Pump type BB3

4.2.2.10 Pump type BB4

Single-casing, radially split, multistage, between-bearings pumps shall be designated pump type BB4. These pumps are also called ring-section pumps, segmental-ring pumps or tie-rod pumps. These pumps have a potential leakage path between each segment. (This type does not meet all the requirements of this International Standard; see Table 3.)

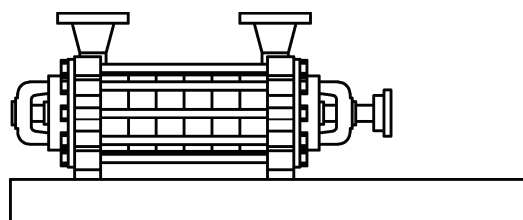


Figure 10 — Pump type BB4

4.2.2.11 Pump type BB5

Double-casing, radially split, multistage, between-bearings pumps (barrel pumps) shall be designated pump type BB5.

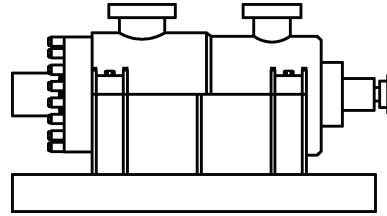


Figure 11 — Pump type BB5

4.2.2.12 Pump type VS1

Wet pit, vertically suspended, single-casing diffuser pumps with discharge through the column shall be designated pump type VS1.

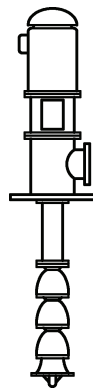


Figure 12 — Pump type VS1

4.2.2.13 Pump type VS2

Wet pit, vertically suspended, single-casing volute pumps with discharge through the column shall be designated pump type VS2.

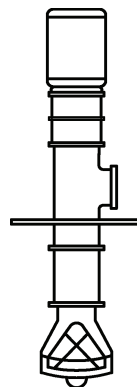


Figure 13 — Pump type VS2

4.2.2.14 Pump type VS3

Wet pit, vertically suspended, single-casing axial-flow pumps with discharge through the column shall be designated pump type VS3.



Figure 14 — Pump type VS3

4.2.2.15 Pump type VS4

Vertically suspended, single-casing, volute, line-shaft-driven sump pumps shall be designated pump type VS4.

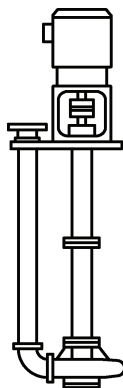


Figure 15 — Pump type VS4

4.2.2.16 Pump type VS5

Vertically suspended, cantilever sump pumps shall be designated pump type VS5.

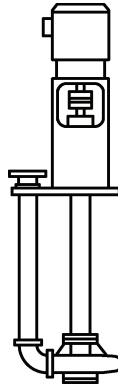


Figure 16 — Pump type VS5

4.2.2.17 Pump type VS6

Double-casing, diffuser, vertically suspended pumps shall be designated pump type VS6.

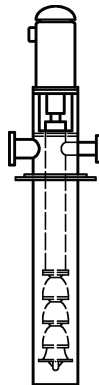


Figure 17 — Pump type VS6

4.2.2.18 Pump type VS7

Double-casing, volute, vertically suspended pumps shall be designated pump type VS7.

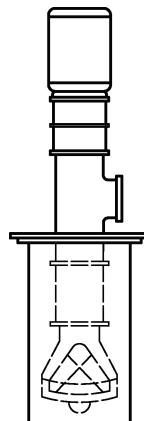


Figure 18 — Pump type VS7

5 Requirements

5.1 Units

- The purchaser shall specify whether data, drawings, and maintenance dimensions of pumps shall be in the SI or US Customary (USC) system of measurements. Use of an SI data sheet (see N.3.1) indicates the International Standard System of measurements shall be used. Use of a USC data sheet (see N.3.2) indicates the USC system of measurements shall be used.

5.2 Statutory requirements

The purchaser and the vendor shall mutually determine the measures necessary to comply with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment, its packaging and preservation.

5.3 Requirements

5.3.1 In case of conflict between this International Standard and the inquiry, the inquiry shall govern. At the time of the order, the order shall govern.

5.3.2 Where requirements specific to a particular pump type in Clause 9 conflict with any other clauses, the requirements of Clause 9 shall govern.

6 Basic design

6.1 General

6.1.1 The equipment (including auxiliaries) covered by this International Standard shall be designed and constructed for a minimum service life of 20 years (excluding normal-wear parts as identified in Table 19) and at least 3 years of uninterrupted operation. Shutting down the equipment to perform vendor-specified maintenance or inspection does not meet the continuous uninterrupted operation requirement. It is recognized that these requirements are design criteria and that service or duty severity, mis-operation or improper maintenance can result in a machine failing to meet these criteria.

- **6.1.2** The purchaser shall specify the operating conditions, the liquid properties, site conditions and utility conditions, including all data shown on the process data sheet (Annex N). The purchaser shall specify whether the pump is intended for use as an HPRT and whether Annex C shall apply.

6.1.3 The equipment shall be capable of operation at the normal and rated operating points and any other anticipated operating conditions specified by the purchaser.

6.1.4 Pumps shall be capable of at least a 5 % head increase at rated conditions by replacement of the impeller(s) with one(s) of larger diameter or different hydraulic design, variable-speed capability or use of a blank stage.

This requirement is intended to prevent a change in selection caused by refinement of hydraulic requirements after the pump has been purchased. It is not intended to accommodate future expandability. If there is a future operating requirement, it should be specified separately and considered in selection.

6.1.5 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.

6.1.6 Variable-speed pumps shall be designed for excursions to trip speed without damage.

6.1.7 The conditions in the seal chamber required to maintain a stable film at the seal faces, including temperature, pressure and flow, as well as provisions for assuring the adequacy of the design for sealing against atmospheric pressure when pumps are idle in vacuum service, shall be agreed upon by the pump vendor and the seal manufacturer, approved by the purchaser, and noted on the data sheet.

Provision for sealing against atmospheric pressure in vacuum service is especially important when handling liquids near their vapour pressure (such as liquefied petroleum gases). During operation, the seal chamber pressure shall be at least a gauge pressure of 35 kPa (0,35 bar; 5 psi); see ISO 21049.

6.1.8 The vendor shall specify on the data sheets the NPSH3 based on water [at a temperature of less than 55 °C (130 °F)] at the rated flow and rated speed. A reduction or correction factor for liquids other than water (such as hydrocarbons) shall not be applied.

The purchaser should consider an appropriate NPSH margin in addition to the NPSH3 specified. An NPSH margin is the NPSH that exists in excess of the pump's NPSH3. It is usually desirable to have an operating NPSH margin that is sufficient at all flows (from minimum continuous stable flow to maximum expected operating flow) to protect the pump from damage caused by flow recirculation, separation and cavitation. The vendor should be consulted about recommended NPSH margins for the specific pump type and intended service.

In establishing the NPSHA, the purchaser and the vendor should recognize the relationship between minimum continuous stable flow and the pump's suction-specific speed. In general, minimum continuous stable flow increases as suction-specific speed increases. However, other factors, such as the pump's energy level and hydraulic design, the pumped liquid and the NPSH margin, also affect the pump's ability to operate satisfactorily over a wide flow range. Pump design that addresses low-flow operation is an evolving technology, and selection of suction-specific speed levels and NPSH margins should take into account current industry and vendor experience.

Unless otherwise specified, the datum elevation shall be the shaft centreline for horizontal pumps, the suction-nozzle centreline for vertical in-line pumps, and the top of the foundation for vertically suspended pumps.

- **6.1.9** The pump suction-specific speed shall be calculated in accordance with Annex A and, if specified, limited as stated on the data sheet.

6.1.10 Pumps that handle liquids more viscous than water shall have their water performance corrected in accordance with ISO/TR 17766. Correction factors used for viscous liquid shall be submitted with both sales proposal curves and final test curves.

NOTE For the purpose of this provision, ANSI/HI 9.6.7 is equivalent to ISO/TR 17766.

- **6.1.11** Pumps that have stable head/flowrate curves (continuous head rise to shutoff) are preferred for all applications and are required if parallel operation is specified. If parallel operation is specified, the head rise from rated point to shutoff shall be at least 10 %. If a discharge orifice is used as a means of providing a continuous rise to shutoff, this use shall be stated in the proposal.

6.1.12 Pumps shall have a preferred operating region of 70 % to 120 % of best efficiency flowrate of the pump as furnished. Rated flow shall be within the region of 80 % to 110 % of best efficiency flowrate of the pump as furnished.

Setting limits for the preferred operating region and the location of rated flow is not intended to lead to the development of additional sizes of small pumps or preclude the use of high-specific-speed pumps. Small pumps that are known to operate satisfactorily at flows outside the specified limits and high-specific-speed pumps that may have a narrower preferred operating region than specified should be offered, where appropriate, and their preferred operating region clearly shown on the proposal curve. The pump specific speed shall be calculated in accordance with Annex A.

NOTE "Best efficiency flowrate of the pump as furnished" refers to the pump with the impeller diameter properly selected to meet head-flowrate performance requirements as stated on the data sheet.

It is recognized that very low-specific-speed pumps might not be able to reach flowrates beyond 105 % to 110 % of BEP. In such cases, the expected flow limitations shall be indicated on the proposal curves (see 10.2.4).

6.1.13 The best efficiency point flowrate for the pump as furnished should preferably be between the rated point and the normal point.

- **6.1.14** 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 who has unit responsibility. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified. ISO 3740^[7], ISO 3744^[8] and ISO 3746^[9] may be consulted for guidance.

6.1.15 Pumps with heads greater than 200 m (650 ft) per stage and with more than 225 kW (300 hp) per stage shall be deemed high-energy pumps and can require special provisions to reduce vane passing-frequency vibration and low-frequency vibration at reduced flowrates. For these pumps, the radial clearance between the diffuser vane or volute tongue (cutwater) and the periphery of the impeller blade shall be at least 3 % of the maximum impeller blade-tip radius for diffuser designs and at least 6 % of the maximum blade-tip radius for volute designs. The maximum impeller blade-tip radius is the radius of the largest impeller that can be used within the pump casing (see 6.1.6). The clearance, P , expressed as a percentage, is calculated as given in Equation (1):

$$P = 100(R_2 - R_1) / R_1 \quad (1)$$

where

R_2 is the radius of volute or diffuser inlet tip;

R_1 is the maximum impeller blade tip radius.

It is common practice for the impellers of pumps covered by this clause to be modified after initial test to correct hydraulic performance by underfiling, overfiling or "V"-cutting; see 8.3.3.7 c). Any such modifications shall be documented in accordance with 10.3.4.1.

6.1.16 Pumps operating above 3 600 r/min and absorbing more than 300 kW (400 hp) per stage can require even larger clearances and other special construction features. For these pumps, specific requirements should be agreed upon by the purchaser and the vendor, considering actual operating experience with the specific pump types.

- **6.1.17** The need for cooling shall be determined by the vendor, and the method shall be agreed upon by the purchaser. Fan cooling should be the first choice. If fan cooling is inadequate, one of the plans in Annex B shall be selected. The cooling system shall be suitable for operation with the coolant type, pressure and temperature specified by the purchaser. The vendor shall specify the required flow. To avoid condensation, the minimum temperature at the cooling-water inlet to bearing housings should be above the ambient air temperature.

6.1.18 Jackets, if provided, shall have clean-out connections arranged so that the entire passageway can be mechanically cleaned, flushed and drained.

6.1.19 Jacket systems, if provided, shall be designed to prevent the process stream from leaking into the jacket. Jacket passages shall not open into casing joints.

6.1.20 Unless otherwise specified, water-cooling systems shall be designed for the conditions on the water side as given in Table 2.

Table 2 — Water-cooling systems — Conditions on the water side

Parameter	SI units	USC and other units
Velocity over heat exchange surfaces	1,5 m/s to 2,5 m/s	5 ft/s to 8 ft/s
Maximum allowable working pressure (MAWP), gauge shall be as a minimum	700 kPa	100 psi; 7 bar
Test pressure (> 1,5 MAWP), gauge	1 050 kPa	150 psi; 10,5 bar
Maximum pressure drop	100 kPa	15 psi, 1 bar
Maximum inlet temperature	30 °C	90 °F
Maximum outlet temperature	50 °C	120 °F
Maximum temperature rise	20 K	30 °F
Fouling factor on water side	0,35 m ² K/kW	0,002 h-ft ² -°R/Btu
Shell corrosion allowance (not for tubes)	3,0 mm	0,125 in

Provisions shall be made for complete venting and draining of the system.

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

- **6.1.22** Motors, electrical components and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser and shall meet the requirements of the applicable sections of IEC 60079 (all parts) or NFPA 70:2008, Articles 500, 501, 502, 504 and 505 as well as any local codes specified and furnished on request by the purchaser.

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

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

6.1.25 Except for vertically suspended pumps and integrally geared pumps, pumps shall be designed to permit removal of the rotor or inner element without disconnecting the suction or discharge piping or moving the driver.

6.1.26 The pump and its driver shall perform on their test stands and on their permanent foundation within the vibration acceptance criteria specified in 6.9.3. After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the vendor who has unit responsibility.

6.1.27 Spare and all replacement parts for the pump and all furnished auxiliaries shall, as a minimum, meet all the criteria of this International Standard.

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

6.1.29 Bolting and threads

- **6.1.29.1** The details of threading shall conform to ISO 261, ISO 262, ISO 724 and ISO 965 (all parts), or to ANSI/ASME B1.1. The vendor shall advise the type of bolting used on the pump.

6.1.29.2 When ANSI/ASME B1.1 threads have been specified, the thread series shall be the variable-pitch series UNC. The threads shall be Class 2 for bolting, studs and nuts. For other threads and nuts, they shall be Class 2 or 3.

6.1.29.3 When ISO 261 and ISO 262 have been specified, the thread series shall be coarse. Threads shall be Class 6g for bolting and studs, and Class 6H for nuts.

6.1.30 Commercial fasteners shall be manufactured in accordance with the requirements of ANSI/ASME B18.18.2M or shall be procured from distributors having quality plans in accordance with ANSI/ASME B18.18.2M.

6.1.31 Adequate clearance shall be provided at all bolting locations to permit the use of socket or box wrenches.

6.1.32 Unless otherwise specified or agreed, studs shall be supplied on all main casing joints, and all other joints and connections shall be supplied with external hexagon-head bolting.

6.1.33 Fasteners (excluding washers and headless set-screws) shall have the material grade and manufacturer's 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 manufacturer's identification symbol marked on the other end. Studs shall be marked on the exposed end.

NOTE A set-screw is a headless screw with a hexagonal socket in one end.

6.1.34 Pressure casing fasteners shall be not less than 12 mm (0,5 in) diameter.

6.2 Pump types

The pump types listed in Table 3 have special design features and shall be furnished only if specified by the purchaser and if the manufacturer has proven experience for the specific application. Table 3 lists the features requiring special consideration for these pump types, and gives in parentheses the relevant subclause(s) of this International Standard.

Table 3 — Special design features of particular pump types

Pump type	Features requiring special consideration
Horizontal foot-mounted overhung, OH1	a) Pressure rating (6.3.5) b) Casing support (6.3.11)
Rigidly coupled vertical in-line, OH4	a) Motor construction (7.1.7, 7.1.8) b) Rotor stiffness (6.9.1.3) c) Product-lubricated guide bearing (6.10.1.1) d) Shaft runout at seal (6.6.9, 6.8.5)
Close-coupled (impeller mounted on motor shaft), OH5	a) Motor construction (7.1.7, 7.1.8) b) Motor bearing and winding temperature at high pumping temperatures c) Seal removal (6.8.2)
Two-stage overhung	a) Rotor stiffness (6.9.1.3)
Double-suction overhung	a) Rotor stiffness (6.9.1.3)
Ring-section casing (multistage), BB4	a) Pressure containment (6.3.3, 6.3.10) b) Dismantling (6.1.24)
Built-in mechanical seal (no separable seal gland)	a) Seal removal (6.8.2)

6.3 Pressure casings

6.3.1 The maximum discharge pressure shall be the maximum suction pressure plus the maximum differential pressure that 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.

- **6.3.2** Maximum discharge pressure shall be stated on the data sheet. 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) maximum specified relative density at any specified operating condition;
- b) installation of an impeller of the maximum diameter and/or number of stages that the pump can accommodate;
- c) operation to trip speed.

The purchaser should assess the likelihood of the occurrence of a), b) and/or c) before specifying any of them.

NOTE Rare occurrences can be taken as excursions into the hydrotest margin.

The additional differential pressure developed at trip speed is normally a momentary excursion that is absorbed by the hydrotest margin.

6.3.3 The pressure casing shall be designed to

- a) operate without leakage or internal contact between rotating and stationary components while subject simultaneously to the MAWP (and maximum operating temperature) and the worst-case combination of twice the allowable nozzle loads of Table 5 applied through each nozzle;
- b) withstand the hydrostatic test (see 8.3.2).

NOTE The twice-nozzle-load requirement is a pressure-casing design criterion. Allowable nozzle loads for piping designers are the values given in Table 5, which, in addition to pressure casing design, include other factors that affect allowable nozzle loads, such as casing support and baseplate stiffness.

6.3.4 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 or 0,67 times the minimum yield strength for that material, whichever is lower, across the full range of specified operating temperatures. For castings, the design tensile stress values shall be multiplied by the appropriate casting factor, as shown in Table 4. The manufacturer, in his proposal, shall state the source of the material properties from those listed in Table H.2 (i.e. ISO, ASTM, UNS, EN, JIS), as well as the casting factors applied. National material standards other than those listed in Table H.2, may be used with specific purchaser approval.

NOTE 1 In general, the criteria in 6.3.3 result in deflection (strain) being the determining consideration in the design of pump casings with respect to pressure retention and nozzle loads. 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 recognized that to provide the initial load required to obtain a reliable bolted joint, it is necessary that the bolting be tightened to produce a tensile stress higher than the design tensile stress. Values in the range of 0,7 to 0,9 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

6.3.5 Except as noted in 6.3.6, the MAWP shall be at least the maximum discharge pressure (see 6.3.1 and 6.3.2) plus 10 % of the maximum differential pressure, and shall not be less than

- a) for axially split, one- and two-stage, between-bearings pumps and single-casing, vertically suspended pumps: a pressure rating equal to that of an ISO 7005-2 PN20 cast iron or ISO 7005-1 PN20 steel flange of a material grade corresponding to that of the pressure casing;

NOTE 1 For the purpose of this provision, ANSI/ASME B16.1 Class 125 is equivalent to ISO 7005-2 PN20; ANSI/ASME B16.5 Class 150 and EN 1759-1 Class 150 are equivalent to ISO 7005-1 PN20.

- b) for all other pumps: a gauge pressure rating equal to at least 4 MPa (40 bar; 600 psi) at 38 °C (100 °F).

NOTE 2 This subclause provides minimum requirements consistent with designs existing at the time of publication of this International Standard. For the next edition, all OH, BB1, and BB2 pumps with ISO 7005-1 PN50 flanges will be required to have a casing MAWP equivalent to their flanges.

The pump-seal chamber and seal gland shall have a pressure-temperature rating at least equal to the maximum allowable working pressure and temperature of the pump casing to which it is attached, in accordance with ISO 21049:2004, 3.41.

NOTE 3 The 10 % differential pressure margin is intended to accommodate head increases (6.1.4), higher speed in variable-speed pumps (6.1.5) and head (testing) tolerance [see 8.3.3.3 b)].

NOTE 4 For the purposes of this provision, ANSI/ASME B16.5 Class 300 and EN 1759-1 Class 300 are equivalent to ISO 7005-1 PN50.

- **6.3.6** Unless otherwise specified, vertically suspended, double-casing, integral gear-driven (type OH6) and horizontal, multistage pumps may be designed for dual pressure ratings. If specified, suction regions shall be designed for the same MAWP as the discharge section. The purchaser should consider installation of relief valves on the suction side of such installations.

6.3.7 The pressure casing shall be designed with a corrosion allowance to meet the requirements of 6.1.1. Unless otherwise specified, the minimum corrosion allowance shall be 3 mm (0,12 in).

The vendor is encouraged to propose alternative corrosion allowances for consideration if materials of construction with superior corrosion resistance are employed and if they result in lower cost without affecting safety and reliability.

6.3.8 The inner casing of double-casing pumps shall be designed to withstand the maximum differential pressure or 350 kPa (3,5 bar; 50 psi), whichever is greater.

6.3.9 Unless otherwise specified, pumps with radially split casings are required in services for any of the following operating conditions:

- a) pumping temperature of 200 °C (400 °F) or higher (a lower temperature limit should be considered if thermal shock is probable);
- b) liquids with a relative density of less than 0,7 at the specified pumping temperature;
- c) liquids at a rated discharge gauge pressure above 10 MPa (100 bar; 1 450 psi).

Axially split casings have been used successfully beyond the limits given above, generally for off-plot applications at higher pressure or lower relative density (specific gravity). The success of such applications depends on the margin between design pressure and rated pressure, the manufacturer's experience with similar applications, the design and manufacture of the split joint, and the user'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.

- **6.3.10** Radially split casings shall have metal-to-metal fits, with confined controlled-compression gaskets, such as an O-ring or a spiral-wound type. Gaskets other than spiral-wound may be proposed and furnished if proven suitable for service and approved by the purchaser. Radially split pressure casing joints and bolting shall be designed to seat a spiral-wound gasket (see 9.3.2.3 for VS type pumps).

NOTE Table H.1 shows only spiral-wound gaskets for casing joints. Spiral-wound gaskets are generally preferred because they are perceived by users to have had better availability, are more conducive to material identification, have a broader chemical compatibility and temperature range, contact a wider sealing surface (are less susceptible to leakage because of sealing surface irregularities) and are easier to handle and store than O-rings. ISO 21049 and ANSI/API Std 682/ISO 21049, specifically require O-ring gaskets on low-temperature [$< 175\text{ °C}$ (350 °F)] pressure-seal gland plates.

6.3.11 Centreline-supported pump casings shall be used for all horizontal pumps except as allowed in 9.2.1.2.

6.3.12 O-ring sealing surfaces, including all grooves and bores, shall have a maximum surface roughness average value, R_a , of 1,6 μm (63 μin) for static O-rings and 0,8 μm (32 μin) for the surface against which dynamic O-rings slide. Bores shall have a minimum 3 mm (0,12 in) radius or a minimum 1,5 mm (0,06 in) chamfered lead-in for static O-rings and a minimum 2 mm (0,08 in) chamfered lead-in for dynamic O-rings. Chamfers shall have a maximum angle of 30°.

6.3.13 Jackscrews shall be provided to facilitate disassembly of the casing. One of the contacting faces shall be relieved (counterbored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face.

6.3.14 The use of threaded holes in pressure parts shall be minimized. 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.

6.3.15 Internal bolting shall be of a material fully resistant to corrosive attack by the pumped liquid.

6.3.16 If the manufacture of cast pressure-casing parts requires the use of openings for core support, core removal or waterway inspection and cleaning, these openings shall be designed so they can be closed by welding, using an appropriate, qualified weld procedure, during the completion of casting manufacture.

6.4 Nozzles and pressure casing connections

6.4.1 Casing opening sizes

6.4.1.1 Openings for nozzles and other pressure casing connections shall be standard pipe sizes. Openings of DN 32, DN 65, DN 90, DN 125, DN 175 and DN 225 (NPS 1 1/4, NPS 2 1/2, NPS 3 1/2, NPS 5, NPS 7 and NPS 9) shall not be used.

- **6.4.1.2** Casing connections other than suction and discharge nozzles shall be at least DN 15 (NPS 1/2) for pumps with discharge nozzle openings DN 50 (NPS 2) and smaller. Connections shall be at least DN 20 (NPS 3/4) for pumps with discharge nozzle openings DN 80 (NPS 3) and larger, except that connections for seal flush piping and gauges may be DN 15 (NPS 1/2) regardless of pump size.

6.4.2 Suction and discharge nozzles

6.4.2.1 Suction and discharge nozzles shall be flanged, except those on pumps with forged casings, which shall be flanged or machined and studded. One- and two-stage pumps shall have suction and discharge flanges of equal rating. If the pump is supplied with machined and studded connections, the pump vendor shall provide drawings showing the dimensions of break-out spool pieces to allow the pump to be conveniently removed from the piping.

6.4.2.2 Cast iron flanges shall be flat-faced and, except as noted in 6.4.2.4, conform to the dimensional requirements of ISO 7005-2 and the flange finish requirements of ANSI/ASME B16.1 or ANSI/ASME B16.42. PN20 (Class 125) flanges shall have a minimum thickness equal to that of PN40 (Class 250) flanges for sizes DN 200 (NPS 8) and smaller.

6.4.2.3 Flanges other than cast iron shall, as a minimum requirement, conform to the dimensional requirements of ISO 7005-1 PN50 except as noted in 6.4.2.4 and the flange finish requirements of ANSI/ASME B16.5 or ANSI/ASME B16.47.

NOTE For the purpose of this provision, ANSI/ASME B16.5 Class 300 and ANSI/ASME B16.47 Class 300 and EN 1759-1 Class 300 are equivalent to ISO 7005-1 PN50.

6.4.2.4 Flanges in all materials that are thicker or have a larger outside diameter than required by the relevant ISO or ASME standards in this International Standard are acceptable. Non-standard (oversized) flanges shall be completely dimensioned on the arrangement drawing. If oversized flanges require studs or bolts of non-standard length, this requirement shall be identified on the arrangement drawing.

6.4.2.5 Flanges shall be full faced or spot faced on the back and shall be designed for through bolting, except for jacketed casings.

6.4.2.6 To minimize nozzle loading and facilitate installation of piping, machined faces of pump flanges shall be parallel to the plane as shown on the general arrangement drawing within 0,5°. Bolt holes or studs shall straddle centrelines parallel to the main axes of the pump.

6.4.3 Auxiliary connections

- **6.4.3.1** All auxiliary connections to the pressure casing, except the seal gland, shall terminate in a flange meeting the requirements of 6.4.2.2. or 6.4.2.3. These connections shall be integrally flanged, socket welded or butt welded as specified by the purchaser. Seal welding of threaded connections is not permitted. Purchaser interface connections shall terminate in a flange.
- **6.4.3.2** If specified, for pumps in pipeline service with a maximum operating temperature of 55 °C (130 °F) or less, auxiliary connections may be threaded.
- **6.4.3.3** If specified, special threaded fittings for transitioning from the casing to tubing for seal flush piping may be used provided that a secondary sealing feature, such as O-rings, are used and that the joint does not depend on the thread contact alone to seal the fluid. The connection boss shall have a machined face suitable for sealing contact.

6.4.3.4 Connections, including gusseting, welded to the casing shall meet or exceed the material and the pressure-temperature requirements of the casing, including impact values, rather than the requirements of the connected piping.

6.4.3.5 All connection welding shall be completed before the casing is hydrostatically tested (see 8.3.2).

6.4.3.6 Auxiliary connections to cast iron pressure casings may be threaded.

6.4.3.7 Unless otherwise specified, pipe threads shall be tapered threads in accordance with ISO 7-1. Openings and bosses for pipe threads shall conform to ANSI/ASME B16.5.

NOTE For the purpose of this provision, ANSI/ASME B1.20.1 is equivalent to ISO 7-1.

- **6.4.3.8** If specified, cylindrical threads in accordance with ISO 228-1 shall be used. If cylindrical threads are used, they shall be sealed with a contained face gasket, and the connection boss shall have a machined face suitable for gasket containment (see Figure 19).

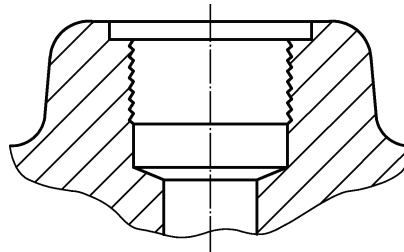


Figure 19 — Machined face suitable for gasket containment if using cylindrical threads

6.4.3.9 The first segment of piping screwed or welded to the casing should not be more than 150 mm (6 in) long and shall be a minimum of schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of schedule 80 for DN 40 (NPS 1 1/2). The first segment of piping (nipple) should be straight, if practical, to allow connections such as drains to be cleaned. The first segment can attach axially to avoid increasing centreline height (see 7.3.4). On small pumps, if this causes interference with the suction nozzle, for example, this requirement is considered impractical.

- **6.4.3.10** If specified, piping shall be gusseted in two orthogonal planes to increase the rigidity of the piped connection, in accordance with the following stipulations.
 - a) Gussets shall be of a material compatible with the pressure casing and the piping and shall be made of either flat bar with a minimum cross section of 25 mm by 3 mm (1 in by 0,12 in) or round bar with a minimum diameter of 9 mm (0,38 in).

- b) Gusset design shall be as shown in Figure 20.

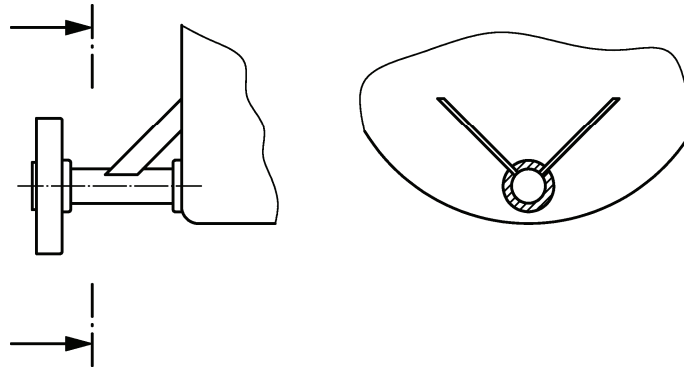


Figure 20 — Typical gusset design

- c) Gussets shall be located at or near the connection end of the piping and fitted to the closest convenient location on the casing to provide maximum rigidity. The long width of gussets made with bar shall be perpendicular to the pipe and shall be located to avoid interference with the flange bolting or any maintenance areas on the pump.
- d) Gusset welding shall meet the fabrication requirements (see 6.12.3), including PWHT when required, and the inspection requirements (see 8.2.2) of this International Standard.
- e) Gussets may also be bolted to the casing if drilling and tapping is done prior to hydrotest.
- f) Proposals to use clamped or bolted gusset designs shall be submitted to the purchaser for approval.

6.4.3.11 Threaded openings not connected to piping are allowed only in seal glands and in pumps furnished of material classes I-1 and I-2 (see Annex H). If supplied, they shall be plugged. Taper-threaded plugs shall be long-shank solid round-head, or long-shank hexagon-head, bar stock plugs in accordance with ANSI/ASME B16.11. If cylindrical threads are specified in 6.4.3.7, plugs shall be solid hexagon-head plugs in accordance with DIN 910. These plugs shall meet the material requirements of the casing. A lubricant/sealant that is suitable for high-temperature duty shall be used to ensure that the threads are vapour-tight. Plastic plugs are not permitted.

- **6.4.3.12** If specified, auxiliary connections to the pressure casing shall be machined and studded. These connections 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 provision, ANSI/ASME B16.1 and ANSI/ASME B16.5 are equivalent to ISO 7005-2 and ISO 7005-1, respectively.

6.4.3.13 All connections shall be suitable for the hydrostatic test pressure of the region of the casing to which they are attached.

6.4.3.14 All pumps shall be provided with vent and drain connections, except that vent connections may be omitted if the pump is made self-venting by the arrangement of the nozzles. Pumps that are not self-venting shall be provided with vent connections in the pressure casing, as required (see 6.8.10). If the pump cannot be completely drained for geometrical reasons, this shall be stated in the proposal. The operating manual shall include a drawing indicating the quantity and location(s) of the liquid remaining in the pump.

As a guide, a pump is considered functionally self-venting if the nozzle arrangement and the casing configuration permit sufficient venting of gases from the first-stage impeller and volute area to prevent loss of prime during the starting sequence.

6.4.3.15 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.

6.5 External nozzle forces and moments

6.5.1 Steel and alloy-steel horizontal pumps and their baseplates, vertical in-line pumps with supports anchored to the foundation, and vertically suspended pumps shall be designed for satisfactory performance if subjected to the forces and moments in Table 5 applied simultaneously to both suction and discharge nozzles in the worst-case combination for the pump in question. For horizontal pumps, two effects of nozzle loads are considered: distortion of the pump casing (see 6.3.3 and 6.3.4) and misalignment of the pump and driver shafts (see 7.3.20).

6.5.2 Allowable forces and moments for vertical in-line pumps with supports not anchored to the foundation may be twice the values in Table 5 for side nozzles.

6.5.3 For pump casings constructed of materials other than steel or alloy steel or for pumps with nozzles larger than DN 400 (NPS 16), the vendor shall submit allowable nozzle loads corresponding to the format in Table 5.

Table 5 — Nozzle loadings

Location/orientation	Nozzle-loading force as a function of flange size — SI units N								
	Nominal size of flange (DN)								
	50	80	100	150	200	250	300	350	400
Each top nozzle									
F_X	710	1 070	1 420	2 490	3 780	5 340	6 670	7 120	8 450
F_Y	580	890	1 160	2 050	3 110	4 450	5 340	5 780	6 670
F_Z	890	1 330	1 780	3 110	4 890	6 670	8 000	8 900	10 230
F_R	1 280	1 930	2 560	4 480	6 920	9 630	11 700	12 780	14 850
Each side nozzle									
F_X	710	1 070	1 420	2 490	3 780	5 340	6 670	7 120	8 450
F_Y	890	1 330	1 780	3 110	4 890	6 670	8 000	8 900	10 230
F_Z	580	890	1 160	2 050	3 110	4 450	5 340	5 780	6 670
F_R	1 280	1 930	2 560	4 480	6 920	9 630	11 700	12 780	14 850
Each end nozzle									
F_X	890	1 330	1 780	3 110	4 890	6 670	8 000	8 900	10 230
F_Y	710	1 070	1 420	2 490	3 780	5 340	6 670	7 120	8 450
F_Z	580	890	1 160	2 050	3 110	4 450	5 340	5 780	6 670
F_R	1 280	1 930	2 560	4 480	6 920	9 630	11 700	12 780	14 850
Moment N·m									
Each nozzle									
M_X	460	950	1 330	2 300	3 530	5 020	6 100	6 370	7 320
M_Y	230	470	680	1 180	1 760	2 440	2 980	3 120	3 660
M_Z	350	720	1 000	1 760	2 580	3 800	4 610	4 750	5 420
M_R	620	1 280	1 800	3 130	4 710	6 750	8 210	8 540	9 820

Table 5 (continued)

Location/orientation	Nozzle-loading force as a function of flange size — USC units								
	lbf								
	Nominal size of flange (NPS)								
	2	3	4	6	8	10	12	14	16
Each top nozzle									
F_X	160	240	320	560	850	1 200	1 500	1 600	1 900
F_Y	130	200	260	460	700	1 000	1 200	1 300	1 500
F_Z	200	300	400	700	1 100	1 500	1 800	2 000	2 300
F_R	290	430	570	1 010	1 560	2 200	2 600	2 900	3 300
Each side nozzle									
F_X	160	240	320	560	850	1 200	1 500	1 600	1 900
F_Y	200	300	400	700	1 100	1 500	1 800	2 000	2 300
F_Z	130	200	260	460	700	1 000	1 200	1 300	1 500
F_R	290	430	570	1 010	1 560	2 200	2 600	2 900	3 300
Each end nozzle									
F_X	200	300	400	700	1 100	1 500	1 800	2 000	2 300
F_Y	160	240	320	560	850	1 200	1 500	1 600	1 900
F_Z	130	200	260	460	700	1 000	1 200	1 300	1 500
F_R	290	430	570	1 010	1 560	2 200	2 600	2 900	3 300
Moment ft·lbf									
Each nozzle									
M_X	340	700	980	1 700	2 600	3 700	4 500	4 700	5 400
M_Y	170	350	500	870	1 300	1 800	2 200	2 300	2 700
M_Z	260	530	740	1 300	1 900	2 800	3 400	3 500	4 000
M_R	460	950	1 330	2 310	3 500	5 000	6 100	6 300	7 200
NOTE 1 See Figures 21 through 25 for orientation of nozzle loads (X, Y and Z).									
NOTE 2 Each value shown above indicates range from minus that value to plus that value; for example 160 indicates a range from -160 to +160.									

6.5.4 The coordinate system(s) shown in Figures 21 through 25 shall be used to apply the forces and moments in Table 5.

- **6.5.5** Annex F gives methods of qualifying nozzle loads in excess of those in Table 5. The purchaser should be aware that the use of the methods in Annex F can result in a misalignment up to 50 % greater than that based on the loads given in Table 5 and can impact equipment installation criteria. The use of the methods in Annex F requires approval by the purchaser and specific direction to the piping designers for its use.