

DIN EN ISO 10439-1

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Mit DIN EN ISO 10439-2:2015-05,
DIN EN ISO 10439-3:2015-05
und
DIN EN ISO 10439-4:2015-05
Ersatz für
DIN EN ISO 10439:2004-02

**Erdöl-, petrochemische und Erdgasindustrie –
Axial- und Radialkompressoren und Expanderkompressoren –
Teil 1: Allgemeine Anforderungen (ISO 10439-1:2015);
Englische Fassung EN ISO 10439-1:2015, nur auf CD-ROM**

Petroleum, petrochemical and natural gas industries –
Axial and centrifugal compressors and expander-compressors –
Part 1: General requirements (ISO 10439-1:2015);
English version EN ISO 10439-1:2015, only on CD-ROM

Industries du pétrole, de la pétrochimie et du gaz naturel –
Compresseurs axiaux et centrifuges et compresseurs-détenteurs –
Partie 1: Exigences générales (ISO 10439-1:2015);
Version anglaise EN ISO 10439-1:2015, seulement en CD-ROM

Gesamtumfang 153 Seiten

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

Nationales Vorwort

Dieses Dokument (EN ISO 10439-1:2015) wurde vom Technischen Komitee ISO/TC 118 „Compressors and pneumatic tools, machines and equipment“, Sub committee SC 1 / Working group WG 1 „Joint TC 118/SC 1 — TC 67/SC 6 WG: Turbo compressors/expanders for petroleum, chemical and gas industry services“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erarbeitet.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-06 AK „Verfahrenstechnische Anlagen und Ausrüstungen“ im DIN-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“, „ft“, „in (inch)“, „lb (pound)“, „lb/ft³“, „lbf“, „mil“, „NPS“, „oz (ounce)“, „psi“ und „r/min“ die in Deutschland 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. Die Angabe dieser Einheiten dient lediglich als Hilfe im amtlichen und geschäftlichen Verkehr (z. B. bei Einfuhr und Ausfuhr) mit solchen Staaten, die diese Einheiten anwenden.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung	
°F	°C	°C	= (5/9) (°F-32)
ft	m	1 ft	= 0,304 8 m
in (inch)	mm	1 inch	= 25,4 mm
lb (pound)	kg	1 lb	= 0,453 592 37 kg
lb/ft ³	kg/m ³	1 lb/ft ³	= 4,882 kg/m ³
lbf	N	1 lbf	= 4,448 222 N
mil	µm	1 mil	= 26 µm
NPS	DN	1 NPS	= DN 25
oz (ounce)	g	1 oz	= 28,35 g
psi (psig)	kPa	1 psi	= 6,894 757 kPa
r/min	min ⁻¹	1 r/min	= 1 min ⁻¹

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 261	siehe	DIN ISO 261
ISO 6708	siehe	DIN EN ISO 6708
ISO 10438 (all parts)	siehe	DIN EN ISO 10438 (alle Teile)
ISO 10441	siehe	DIN EN ISO 10441
ISO 15156-3	siehe	DIN EN ISO 15156-3
ISO 21940-32	siehe	DIN EN ISO 21940-32
IEC 60079-10-1	siehe	DIN EN ISO 60079-10-1

Änderungen

Gegenüber DIN EN ISO 10439:2004-02 wurden folgende Änderungen vorgenommen:

- a) DIN EN ISO 10439:2004-02 wird überarbeitet in 4 separaten Teilen der Reihe DIN EN ISO 10439 (Teil 1 bis Teil 4) veröffentlicht.

Frühere Ausgaben

DIN EN ISO 10439: 2004-02

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen sind identisch mit der Benummerung in der englischen Fassung.

3 Begriffe und Abkürzungen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

3.1.1

Verankerungsschrauben Fundamentschrauben Ankerbolzen

Schrauben zur Befestigung der Montageplatten an der Stützkonstruktion (dem Betonfundament oder der Stahlkonstruktion)

vgl. Halteschrauben (3.1.13)

3.1.2

axial geteilte Verbindung

Verbindung, die so geteilt ist, dass die Hauptfläche parallel zur Mittellinie der Welle liegt

3.1.3

Baugruppe mit austauschbarer Patrone

<radiale> Baueinheit, die aus einer vollständigen Kompressoreinheit ohne Gehäuse besteht

Anmerkung 1 zum Begriff: Zu ihr gehören die komplette Innentrommel, die Kopfstücke (Deckel), die Dichtungen, die Lagergehäuse und die Lager. Die Rotor-Baugruppe gehört ebenfalls dazu. Um die Montagearbeiten auf dem Bohrfeld zu minimieren, ist diese Baugruppe fertig vormontiert, so dass sie unter Werkstattbedingungen in das Gehäuse einzubringen ist.

3.1.4

zertifizierter Arbeits- oder Betriebspunkt

Punkt, auf den die Leistungstoleranzen angewendet werden müssen

Anmerkung 1 zum Begriff: Der zertifizierte Punkt ist der übliche Betriebspunkt; die Lieferanten verlangen im Allgemeinen, dass dieser Punkt in dem von ihnen bevorzugten Bereich liegt.

3.1.5

komplexe Steifigkeit

Bezeichnung zur Angabe der gesamten äquivalenten Steifigkeit und Dämpfung unter Einbeziehung von Kreuzkupplungen, die für hydrodynamische Lager oder Einpressfilm-Dämpfungen erforderlich sind

3.1.6

nachgiebige Dichtung

Dichtung, die so ausgeführt ist, dass Kontakte zum Rotor oder zur Baugruppe Rotor-Hülse sowie eine mögliche Penetration eines Statorelements ohne größere Verluste der Dichtleistung möglich sind

3.1.7**Betriebspunkt (Arbeitspunkt) des Kompressors**

Schnittstelle mit der 100 %-Drehzahlkurve, die dem jeweils festgelegten Betriebspunkt mit der größten Belastbarkeit entspricht

3.1.8**Kompressorteil****Verdichterstufe**

Reihe von einem oder mehreren Laufrädern, mit festgelegten äußeren Prozessbedingungen (d. h. Seitenströmungen, Umführung oder Injektion)

Anmerkung 1 zum Begriff: Das ist im Allgemeinen anstelle des tatsächlichen Betriebspunkts der abgeleitete Betriebspunkt (siehe graphische Darstellung im Bild 1 in ISO 10439-2:2015).

3.1.9**kritische Drehzahl**

Rotationsgeschwindigkeit der Welle, bei der das Stützsystem für Rotor-Lager Resonanz erreicht

3.1.10**Auslegung**

vom Hersteller errechnete Parameter

Anmerkung 1 zum Begriff: Der Kompressorhersteller verwendet diese Benennung zur Beschreibung verschiedener Kennwerte, z. B. Auslegungsleistung, Auslegungsdruck, Auslegungstemperatur oder Auslegungsdrehzahl. Es ist nicht vorgesehen, dass der Käufer diese Benennung verwendet.

3.1.11**Großrad****Getrieberad**

in einem Getriebe das Laufrad (der Rotor) mit der niedrigsten Drehzahl

vgl. Ritzel (3.1.34)

3.1.12**Zahnradgetriebe****Getriebeeingriff**

Kombination(en) von Ritzel(n) und Getrieberad

Anmerkung 1 zum Begriff: Ein Zahneingriff (Kämen des Getriebes) erfolgt, wenn Ritzel und Getrieberad ineinander greifen. Ein Getrieberad darf mit mehreren Ritzeln kämmen, d. h. an mehreren Getriebeeingriffen beteiligt sein.

3.1.13**Halteschrauben**

Schrauben zur Befestigung des Kompressors an der Montageplatte

vgl. Ankerschrauben (3.1.1)

3.1.14**hydrodynamische Lager**

Lager, die Prinzipien der hydrodynamischen Schmierung anwenden

Anmerkung 1 zum Begriff: Die Lagerflächen sind so ausgerichtet, dass durch die relative Bewegung ein oder mehrere Ölkeil(e) gebildet wird/werden, wodurch eine Lastaufnahme ohne Kontakt Welle-Lager erfolgt.

3.1.15**Hysteresedämpfung**

<innere Reibung> Hysteresedämpfung verursacht in allen Werkstoffen, die einer Dauerschwingbeanspruchung ausgesetzt sind, eine Phasendifferenz zwischen Spannung und Dehnung; diese Phasendifferenz erzeugt im Spannungs-Dehnungs-Diagramm die charakteristische Hystereseschleife und bewirkt eine potentielle Destabilisierung der Dämpfungskraft

3.1.16

Volumenstrom am Eintritt

der in Einheiten des Volumenstroms unter festgelegten Bedingungen für Druck, Temperatur, Kompressibilität und Gaszusammensetzung sowie für den Feuchtegehalt am Einlassstutzen des Kompressors angegebene Durchsatz (Strömungsrate)

Anmerkung 1 zum Begriff: Der Eintrittsvolumenstrom ist ein spezifisches Beispiel für den tatsächlichen Betriebsvolumenstrom. Dieser tatsächliche Betriebsvolumenstrom ist der Volumenstrom, der an bestimmten Stellen auftritt, z. B. an der Zwischenstufe, am Eintritt oder Austritt des Laufrads oder am Einlass- oder am Auslassstutzen des Kompressors. Die Benennung „tatsächlicher Volumenstrom“ sollte daher nicht synonym zu der Benennung „Eintrittsvolumenstrom“ angewendet werden.

3.1.17

Innentrommel-Baugruppe

<radiale> Baugruppe, die aus den fest stehenden und aus dem Strömungsweg zu entfernenden Innenteilen besteht, einschließlich der Innentrommel, der Membranen, der Labyrinth an der Laufradnabe und an der Membran

3.1.18

Einsatz bei niedriger Temperatur

Einsatz, bei dem die festgelegte kleinste Auslegungswandtemperatur unter -29 °C (-20 °F) liegt

3.1.19

maximal zulässige Temperatur

die höchste kontinuierliche Temperatur, für die der Hersteller den Kompressor (oder einen Teil des Kompressors, auf den sich diese Benennung bezieht) ausgelegt hat

Anmerkung 1 zum Begriff: Die maximal zulässige Temperatur wird im Allgemeinen in Abhängigkeit vom Werkstoff festgelegt.

3.1.20

maximal zulässiger Betriebsdruck

der höchste kontinuierliche Druck, für den der Hersteller den Kompressor (oder einen Teil des Kompressors, auf den sich diese Benennung bezieht) ausgelegt hat

Anmerkung 1 zum Begriff: Die normalerweise erwarteten Betriebsbedingungen können auf den Ausgleichsdruck, den maximalen Saugdruck zuzüglich des bei der maximalen Drehzahl (Abschaltdrehzahl) auftretenden maximalen Differenzdrucks zurückgeführt werden, oder sie dürfen durch den Regeldruck des Sicherheitsventils (Entlastungsventils) oder durch andere Einrichtungen eingegrenzt werden.

3.1.21

maximale kontinuierliche Drehzahl

höchste Dauerdrehzahl

höchste Rotationsgeschwindigkeit (Umdrehungen je Minute), bei der die Arbeitsmaschine im installierten und geprüften Zustand dauernd betrieben werden darf

3.1.22

maximaler Eintrittsdruck

höchster festgelegter Eintrittsdruck, dem der Kompressor ausgesetzt werden muss

3.1.23

maximaler Abdichtungsdruck

höchster Druck, bei dem die Dichtungen unter festgelegten statischen oder betrieblichen Bedingungen sowie beim Anlaufen und Abschalten dicht bleiben müssen

3.1.24

kleinste zulässige Drehzahl

niedrigste Rotationsgeschwindigkeit (Umdrehungen je Minute), bei der entsprechend der vom Hersteller ausgewählten Auslegung Dauerbetrieb möglich sein muss

3.1.25**kleinste Auslegungswandtemperatur**

niedrigste (über die Wanddicke) gemittelte Wandtemperatur, die unter Berücksichtigung betrieblicher Störungen, Eigenkühlung und der Umgebungstemperatur erwartet wird

3.1.26**Rotor in Modulbauweise****Lauftrad-Element**

Rotor, der unter Verwendung von Wellenstümpfen oder ähnlichen Elementen aufgebaut ist und mit Hilfe einer oder mehrerer Durchsteckschrauben zusammengehalten wird

3.1.27**Momentensimulator**

Hilfseinrichtung zur Simulierung des Moments für die Masse einer Kupplungshälfte

Anmerkung 1 zum Begriff: Der Momentensimulator kann auch als Leerlaufadapter (Fußplatte) gestaltet sein.

3.1.28**Montageplatte(n)**

Einrichtung, die zur Befestigung des Kompressors auf Betonfundamenten verwendet wird; es handelt sich bei den Montageplatten entweder um eine/mehrere Grundplatte(n) oder Fußplatten

3.1.29**normaler Betriebspunkt**

Punkt, an dem der übliche Betrieb erwartet und optimale Effizienz gewünscht wird

Anmerkung 1 zum Begriff: Im Allgemeinen bescheinigt der Lieferant für diesen Punkt, dass die Leistung innerhalb der in diesem Teil von ISO 10439 angegebenen Toleranzen liegt.

3.1.30**normale Drehzahl**

Drehzahl, die den Anforderungen unter üblichen Betriebsbedingungen entspricht

3.1.31**NW****Nennweite eines Rohrs**

[en.: NPS = nominal pipe size]

dimensionslose Kenngröße, die ungefähr dem in Zoll angegebenen Durchmesser entspricht

BEISPIEL NW 3/4

Anmerkung 1 zum Begriff: Übernommen aus ASME B 31.3-2002, Absatz 300.2.

Anmerkung 2 zum Begriff: Die nach den Buchstaben NW angegebene Zahl stellt keinen gemessenen Wert dar.

Anmerkung 3 zum Begriff: „NW“ dient lediglich zur Bezeichnung der Rohrgröße. Das Rohrende darf mit Gewinde oder einem Schweißfitting versehen werden.

3.1.32**Beobachtung**

<Prüfungen und Inspektionen> Inspektion oder Prüfung, bei der dem Käufer der zeitliche Ablauf der Inspektion oder Prüfung angekündigt wird, die Inspektion oder Prüfung jedoch wie geplant durchgeführt wird, auch wenn der Käufer oder sein Vertreter nicht anwesend ist

3.1.33**Überlast**

Punkt mit dem höchsten Durchsatz, bei dem die vorausgesagte Lastkurve an einer Drehzahllinie endet

3.1.34

Ritzel

in einem Getriebe das/die mit hoher Drehzahl laufende Rad/laufenden Räder

vgl. Großrad (3.1.11)

3.1.35

PN

Nenndruck

zahlenmäßige Bezeichnung für den Druck, die eine vorteilhaft gerundete Zahl ist und als Referenzgröße angewendet wird

BEISPIEL PN 100 [ISO 7268]

Anmerkung 1 zum Begriff: Der zulässige Betriebsdruck, der einer PN-Bezeichnung zuzuordnen ist, hängt von den verwendeten Werkstoffen, der Gestaltung und der Betriebstemperatur ab und muss aus den Zuordnungstabellen für Druck-Temperatur in den jeweils zutreffenden Normen ausgewählt werden.

3.1.36

Druckgehäuse

Hülle für alle fest stehenden drucktragenden Teile des Kompressors einschließlich aller Stutzen und sonstiger Teile, zur Trennung des Prozessgases von der Atmosphäre

3.1.37

Käufer

Institution, die dem Lieferanten den Auftrag und Festlegungen erteilt

Anmerkung 1 zum Begriff: Der Käufer darf der Eigentümer der Anlage sein, in der die Arbeitsmaschine zu installieren ist oder der vom Eigentümer benannte Vertreter.

3.1.38

radial geteilt

Verbindung mit einer Teilung rechtwinklig zur Mittellinie der Welle

3.1.39

Nenndrehzahl

100 %-Drehzahl

höchste Rotationsgeschwindigkeit (Umdrehungen je Minute), die erforderlich ist, um den jeweils festgelegten Betriebsbedingungen zu entsprechen

3.1.40

Regeldruck (Einstelldruck) des Sicherheitsventils (Entlastungsventils)

Druck, bei dem das Sicherheitsventil abzuheben beginnt

Anmerkung 1 zum Begriff: Angaben zu Sicherheitsventilen, siehe API RP 520.

3.1.41

Überlastfaktor

Betriebsbeiwert

<Getriebe> Faktor, der in Abhängigkeit von den Kennwerten des treibenden und des getriebenen Systems zur Berücksichtigung von Differenzen der Kennwerte durch mögliche Überlast, Stoßlast und/oder kontinuierlich schwingende Drehmomente auf den Zahnteilungsindex und die Biegespannungszahl angewendet wird

3.1.42

Ausgleichsdruck

der höchste auf den nicht arbeitenden Kompressor nach Erreichen des Gleichgewichtszustands wirkende Druck

Anmerkung 1 zum Begriff: Zur Bestimmung des Ausgleichsdrucks muss das im gesamten Kompressorsystem und im angeschlossenen Rohrleitungssystem eingeschlossene Gasvolumen berücksichtigt werden. Dazu wird nach Abschalten des Kompressors das gesamte Gas erfasst, das zwischen dem vor- und dem nachgeschalteten Ventil eingeschlossen ist.

3.1.43**Wellenenddichtung**

Wellendichtung, die den Austritt von Prozessgas in die Atmosphäre begrenzt

3.1.44**langsame Rollbewegung**

Bewegung mit einer Drehzahl, niedriger als 5 % von der normalen Betriebsdrehzahl oder von der niedrigsten, durch die Drehzahlregelung zulässigen Drehzahl

3.1.45**Fußplatte****Grundplatte**

am Fundament angebrachte Platte, mit einer Montagefläche für die Aufstellung des Kompressors oder zur Anbringung einer Grundplatte

3.1.46**Sonderanwendung****Anwendung für Sonderzwecke**

Anwendung unter kritischen Einsatzbedingungen, für die ein besonderer Kompressor, für den im Allgemeinen kein Ersatzgerät installiert ist, für ununterbrochenen Dauerbetrieb ausgelegt ist

3.1.47**Sonderwerkzeug; Spezialwerkzeug**

Werkzeug, das nicht handelsüblich aus einem Katalog zu beziehen ist

3.1.48**Stabilitätsanalyse**

Bestimmung der Eigenfrequenzen und der entsprechenden logarithmischen Dekremente (log Dec) des gedämpften Rotor-Stützsystems unter Anwendung einer umfassenden Wertanalyse

3.1.49**üblicher Volumenstrom****genormter Volumendurchfluss**

in Einheiten des Volumenstroms unter den folgenden genormten Bedingungen angegebene Strömungsrate:

Nach ISO-Normen (übliche) Bedingungen

Volumenstrom:	Normkubikmeter je Stunde (Nm ³ /h) Normkubikmeter je Minute (Nm ³ /min)
Druck:	1,013 bar absolut
Temperatur:	0 °C
Feuchte:	0 %

Im US-Sprachraum gebräuchliche Bedingungen:

Volumenstrom:	Kubikfuß je Minute (scfm) Million Kubikfuß je Tag (mmscfd)
Druck:	14,7 psia
Temperatur:	60 °F
Feuchte:	0 %

Anmerkung 1 zum Begriff: Es gibt keine allgemein gültigen Bedingungen für Norm- oder Standardkubikmeter; aus diesem Grund sollten der Referenzdruck und die Referenztemperatur stets genannt werden, d. h. m³/h, 0 °C, 1,013 bar a.

Anmerkung 2 zum Begriff: Da keine einheitlichen Normbedingungen existieren, ist der Normvolumenstrom keine bevorzugte Größe; falls er festgelegt ist, sollte er, um Verwechslungen zu vermeiden, zusammen mit dem tatsächlichen Massenstrom angegeben werden.

3.1.50

Steifigkeit und Dämpfung der Konstruktion

Lagergehäuse zur Gründung der äquivalenten komplexen Steifigkeit

3.1.51

„Pump“vorgänge

Druckwelle

Schwing„pump“bewegung

Instabilität, die in Radial- oder Axialkompressoren bei niedrigen Volumenströmen auftritt

3.1.52

Koeffizienten für synchrone Kippsegmente

komplexe frequenzabhängige Koeffizienten mit einer Frequenz gleich der Wellendrehzahl

3.1.53

Verkäufer

Anbieter

Lieferant

der mit der Lieferung des Kompressors beauftragte Hersteller oder ein Vertreter des Herstellers

3.1.54

Steifigkeit und Dämpfung der Abstützungen

äquivalenter Schmierfilm zur Gründung der Kennwerte für die komplexe Steifigkeit; die Steifigkeit des Drehgelenks sollte nicht in die Schmierfilm-Eigenschaften einbezogen werden

3.1.55

Zahnteilungsindex

Faktor zur Bewertung der Beständigkeit der Oberfläche, der durch die tangentielle Last, den Teilungsdurchmesser, die Zahnbreite und das Übersetzungsverhältnis bestimmt wird

3.1.56

TIR

(en: total indicator reading)

Mittigkeitsausschlag

Gesamtmessuhrausschlag

Gesamtrundlaufabweichung

Differenz zwischen dem größten und dem kleinsten Ausschlag einer Messuhr oder einer ähnlichen Messeinrichtung beim Messen einer ebenen oder zylindrischen Fläche während einer vollständigen Umdrehung der untersuchten Fläche

Anmerkung 1 zum Begriff: Bei zylindrischen Flächen enthält der angezeigte Abweichungswert eine Exzentrizität, die der Hälfte des abgelesenen Werts entspricht. Bei ebenen Flächen enthält der angezeigte Abweichungswert eine Rechtwinkligkeitsabweichung, die gleich dem abgelesenen Wert ist. Wenn die untersuchten Flächen weder zylindrisch noch eben sind, darf der TIR komplizierter ausgewertet werden, weil er möglicherweise auch Ovalitäten oder Oberflächenunregelmäßigkeiten repräsentiert.

3.1.57

(Schnell-)Abschaltdrehzahl

Unterbrechungs-Drehzahl

<Elektromotorantrieb> Drehzahl, die der synchronen Motordrehzahl entspricht, wenn an den Motorklemmen die maximale Netzfrequenz anliegt

3.1.58

(Schnell-)Abschaltdrehzahl

Unterbrechungs-Drehzahl

<Turbine, Antriebsmaschine, Expansionsmaschine, Hydrostatiktrieb>

Drehzahl, bei der die unabhängige Notfall-Überdrehzahleinrichtung ausgelöst wird, um den Antrieb abzuschalten

3.1.59**Zurückfahren****Durchsatzverringern**

prozentuale Änderung der Belastbarkeit (bezogen auf die Nennbelastbarkeit) zwischen der Nennbelastbarkeit und der Belastbarkeit bei Erreichen der Pumpgrenze für die Nennförderhöhe, wenn der Kompressor bei der Nennsaugtemperatur und bei der Nenngaszusammensetzung arbeitet

3.1.60**Grenzbelastungswert**

<für hydrodynamische Axialdrucklager> Last, bei der die kleinste zulässige Schmierschichtdicke erzeugt werden muss, ohne dass das Lager bei Dauerbetrieb versagt, oder aber die Last, bei der in dem für das Lager verwendeten Weißmetall/Lagerwerkstoff am Stützlager an der Stelle mit der höchsten Temperatur nicht die Werte zum Auslösen von Kriechvorgängen oder zum Erreichen der Streckgrenze überschritten werden dürfen, wobei die jeweils kleinere Last anzuwenden ist

3.1.61**Verantwortung für das Kompressorsystem**

der Verantwortliche für das Kompressorsystem ist verpflichtet, die Dokumentation, die Lieferung und alle technischen Aspekte des Kompressors und alle im Bestellumfang enthaltenen Hilfssysteme zu koordinieren

3.1.62**Bezeugung oder Bestätigung**

<von Prüfungen und Inspektionen> Inspektion oder Prüfung, bei der dem Käufer der zeitliche Ablauf der Inspektion oder Prüfung angekündigt wird und die Inspektion oder Prüfung ausgesetzt wird, bis der Käufer oder sein Vertreten anwesend sind

3.2 Abkürzungen

A_{c1}	Amplitude bei N_{c1} , μm (mil)	(en: amplitude at N_{c1} , μm (mil))
A_{max}	maximale Amplitude des Schwingungsaufnehmers (p-p) unter Berücksichtigung aller Schwingungsaufnehmer im von N_{ma} bis N_{mc} , für das Ausmaß der Unwucht/für den jeweils betrachteten Fall, μm (mil)	(en: maximum probe response amplitude (p-p) considering all vibration probes, over the range of N_{ma} to N_{mc} , for the unbalance amount/case being considered, μm (mil))
AF	Verstärkungsfaktor (siehe API RP 684 und Bild 2)	(en: amplification factor (refer to API RP 684 and Figure 2))
AF_1	Verstärkungsfaktor für die 1. kritische Drehzahl, definiert als: $AF_1 = N_{c1} / (N_2 - N_1)$	(en: amplification factor of the first critical speed, defined as: $AF_1 = N_{c1} / (N_2 - N_1)$)
AMB	Aktives Magnetlager	(en: active magnetic bearing)
API	Amerikanisches Erdöl-Institut	(en: American Petroleum Institute)
ASME	Amerikanischer Berufsverband der Maschinenbauingenieure	(en: American Society of Mechanical Engineers)
ASME-Vorschrift	ASME Boiler and Pressure Vessel Code; ASME-Druckgeräte-Richtlinie	(en: ASME boiler and pressure vessel code)
ASTM	Amerikanische Gesellschaft für Materialprüfungen	(en: American Society for Testing and Materials)

Avl	Vibrationsgrenze bei der mechanischen Prüfung, festgelegt in 4.8.2.10, μm (mil)	(en: the mechanical test vibration limit defined in 4.8.2.10, μm (mil))
AWS	Amerikanischer Schweiß-Verband	(en: American Welding Society)
CCW	(Drehung) entgegen dem Uhrzeigersinn	(en: counter clockwise (rotation))
CSR	Verhältnis der kritischen Geschwindigkeit, definiert als: $\text{CSR} = N_{\text{mc}} / \text{FCSR}$	(en: critical speed ratio, defined as: $\text{CSR} = N_{\text{mc}} / \text{FCSR}$)
CW	(Drehung) im Uhrzeigersinn	(en: clockwise (rotation))
cf (lat. conferre)	vergleiche — Querverweisung	(en: (Latin conferre) confer or compare — cross reference)
DN	Nenndurchmesser	(en: nominal diameter)
δ	logarithmisches Dekrement	(en: logarithmic decrement)
δ_A	kleinstes logarithmisches Dekrement bei der anzunehmenden Kreuzkupplung für entweder des kleinste oder das größte Spiel des Bauteils	(en: minimum log decrement at the anticipated cross coupling for either minimum or maximum component clearance)
δ_b	grundlegendes logarithmisches Dekrement nur des Rotor- und des Stützsystems	(en: basic log decrement of the rotor and support system only)
δ_f	logarithmisches Dekrement des kompletten Rotor-Stützsystems aus der Analyse für Level II	(en: log decrement of the complete rotor support system from the Level II analysis)
FCSR	erste ungedämpfte kritische Drehzahl bei starren Stützsystemen, min^{-1}	(en: first undamped critical speed on rigid supports, r/min)
IEC	Internationale Elektrotechnische Kommission	(en: International Electrotechnical Commission)
ISO	Internationale Organisation für Standardisierung	(en: International Organization for Standardization)
MAWP	maximal zulässiger Betriebsdruck	(en: maximum allowable working pressure)
MCS	maximale Dauerdrehzahl	(en: maximum continuous speed)
N	Betriebsdrehzahl, min^{-1}	(en: operating speed, r/min)
N_{cn}	n-te kritische Drehzahl des Rotors, min^{-1}	(en: rotor nth critical speed, r/min)
N_{c1}	1. kritische Drehzahl des Rotors, min^{-1}	(en: rotor first critical speed, r/min)
N_{ma}	kleinste zulässige Drehzahl, min^{-1}	(en: minimum allowable speed, r/min)
N_{mc}	maximale Dauerdrehzahl, min^{-1}	(en: maximum continuous speed, r/min)

N_1	(kleinere) Anfangsdrehzahl bei $0,707 \times \text{Peakamplitude, min}^{-1}$	(en: initial (lesser) speed at $0,707 \times \text{peak amplitude, r/min}$)
N_2	(höhere) Enddrehzahl bei $0,707 \times \text{Peakamplitude, min}^{-1}$	(en: final (greater) speed at $0,707 \times \text{peak amplitude, r/min}$)
NACE, international	Nationaler (amerikanischer) Verband von Korrosionsingenieuren	(en: National Association of Corrosion Engineers)
NFPA	Amerikanische Brandschutzvereinigung	(en: National Fire Protection Association)
PPM	Präventive proaktive Wartung	(en: proactive preventive maintenance)
OEM	Originalausrüstungshersteller; Erstausrüster	(en: Original Equipment Manufacturer)
Q_A	anzunehmende Kreuzkupplung für den Rotor, kN/mm (klbf/in.), definiert als $Q_A = \sum_{i=1}^S q_{Ai}$	(en: anticipated cross coupling for the rotor, kN/mm (klbf/in.), defined as: $Q_A = \sum_{i=1}^S q_{Ai}$)
Q_0	kleinste notwendige Kreuzkupplung, um ein log dec von Null für entweder das kleinste oder größte Spiel des Bauteils zu erreichen, kN/mm (klbf/in.)	(en: minimum cross coupling needed to achieve a log decrement equal to zero for either minimum or maximum component clearance, kN/mm (klbf/in.))
q_a	Kreuzkupplung, definiert in Gleichung (7) oder (8) für jede Stufe oder jedes Laufrad, kN/mm (klbf/in.)	(en: cross coupling defined in Formula (7) or (8) for each stage or impeller, kN/mm (klbf/in.))
R_{out}	kombinierte mechanische und elektrische Rundlaufabweichung, μm (mil)	(en: combined mechanical and electrical runout, μm (mil))
ρ_{ave}	mittlere Gasdichte quer über den Rotor, kg/m^3 (lb/ft^3)	(en: average gas density across the rotor, kg/m^3 (lb/ft^3))
S	Anzahl der Stufen oder Laufräder	(en: number of stages or impellers)
S_{an}	tatsächliche Trennung für die n-te kritische Drehzahl, min^{-1}	(en: actual separation for nth critical speed, r/min)
S_{a1}	tatsächliche Trennung für die 1. kritische Drehzahl, min^{-1}	(en: actual separation for 1st critical speed, r/min)
SM	Trenngrenze (siehe Bild 2)	(en: separation margin (see Figure 2))
SM_a	tatsächliche Trenngrenze für die Analyse mit erzwungenen Frequenzen, %	(en: forced response analysis actual separation margin, %)
SM_{an}	Trenngrenze für die n-te kritische Drehzahl, %	(en: separation margin for nth critical speed, %)
SM_r	erforderliche Trenngrenze für die erzwungene Analyse mit erzwungenen Frequenzen, %	(en: forced response analysis required separation margin, %)

SM_1	Trenngrenze für die 1. kritische Drehzahl, %, $= 100 \times S_{a1}/N_{ma}$	(en: separation margin for the 1st critical speed, %, $= 100 \times S_{a1}/N_{ma}$)
STD	Standard	(en: standard)
U_a	Eingangsunwucht des Rotors bei der dynamischen Analyse, g-mm (oz-in.), $= 2 \times U_r$	(en: input unbalance for the rotordynamic response analysis, g-mm (oz-in.), $= 2 \times U_r$)
U_r	maximal zulässige Restunwucht, g-mm (oz-in.)	(en: maximum allowable residual unbalance, g-mm (oz-in.))
VDDR	Lieferanten-Zeichnung und Daten-Anforderungen	v(en: endor (supplier) drawing and data requirements)
VFD	Antrieb mit veränderlicher Frequenz bzw. Drehzahl	(en: variable frequency drive (variable speed motor drive))

Nationaler Anhang NB (informativ)

Literaturhinweise

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

DIN EN ISO 6708, *Rohrleitungsteile — Definition und Auswahl von DN (Nennweite)*

DIN EN ISO 10438 (alle Teile), *Erdöl-, petrochemische und Erdgasindustrie — Schmieröl-, Sperröl- und Regelölversorgungsanlagen und Hilfsanlagen*

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

DIN EN ISO 15156-3, *Erdöl- und Erdgasindustrie — Werkstoffe für den Einsatz in H₂S-haltiger Umgebung bei der Öl- und Gasgewinnung — Teil 3: Hochlegierte Stähle (CRAs) und andere Legierungen*

DIN EN ISO 21940-32, *Mechanische Schwingungen — Auswuchten von Rotoren — Teil 32: Behandlung von Passfederverbindungen*

DIN EN ISO 60079-10-1, *Explosionsfähige Atmosphäre — Teil 10-1: Einteilung der Bereiche — Gasexplosionsgefährdete Bereiche*

— Leerseite —

English Version

Petroleum, petrochemical and natural gas industries —
Axial and centrifugal compressors and expander-compressors —
Part 1: General requirements
(ISO 10439-1:2015)

Industries du pétrole, de la pétrochimie et du gaz naturel —
Compresseurs axiaux et centrifuges et compresseurs-
détenteurs —
Partie 1: Exigences générales
(ISO 10439-1:2015)

Erdöl-, petrochemische und Erdgasindustrie —
Axial- und Radialkompressoren und
Expanderkompressoren —
Teil 1: Allgemeine Anforderungen
(ISO 10439-1:2015)

This European Standard was approved by CEN on 8 November 2014.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN ISO 10439-1:2015) has been prepared by Technical Committee ISO/TC 118 "Compressors and pneumatic tools, machines and equipment" 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 August 2015, and conflicting national standards shall be withdrawn at the latest by August 2015.

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.

This document supersedes EN ISO 10439:2002.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 10439-1:2015 has been approved by CEN as EN ISO 10439-1:2015 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 118, *Compressors and pneumatic tools, machines and equipment*, Subcommittee SC 1, *Process compressors*.

This first edition, together with ISO 10439-2, ISO 10439-3, and ISO 10439-4, cancels and replaces ISO 10439:2002.

ISO 10439 consists of the following parts, under the general title *Petroleum, petrochemical and natural gas industries — Axial and centrifugal compressors and expander-compressors*:

- *Part 1: General requirements*
- *Part 2: Non-integrally geared centrifugal and axial compressors*
- *Part 3: Integrally geared centrifugal compressors*
- *Part 4: Expander-compressors*

Introduction

This International Standard is based on the 7th edition of the American Petroleum Institute standard API 617.

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

An asterisk (*) at the beginning of the paragraph of a clause or subclause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on data sheets or stated in the enquiry or purchase order (see examples in ISO 10439-2:2015, Annex A, ISO 10439-3:2015, Annex A, and ISO 10439-4:2015, Annex A).

This International Standard includes the following annexes:

- Annex A: Procedure for the determination of residual unbalance;
- Annex B: Typical shaft end seals;
- Annex C: Requirements for lateral analysis reports;
- Annex D: Requirements for torsional analysis reports;
- Annex E: Magnetic bearings;
- Annex F: Dry gas seal testing at manufacturer's shop;
- Annex G: Guidelines for anti-surge systems;
- Annex H: Typical bid tab template.

Annex A, Annex C, Annex D, Annex E, and Annex F form a normative part of this part of ISO 10439. Annex B, Annex G, and Annex H are for information only.

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

Petroleum, petrochemical and natural gas industries — Axial and centrifugal compressors and expander- compressors —

Part 1: General requirements

1 Scope

This International Standard specifies minimum requirements and gives recommendations for axial compressors, single-shaft, and integrally geared process centrifugal compressors, and expander-compressors for special purpose applications that handle gas or process air in the petroleum, petrochemical, and natural gas industries. This part of ISO 10439 specifies general requirements applicable to all such machines.

This International Standard does not apply to fans (these are covered by API 673) or blowers that develop less than 34 kPa (5 psi) pressure rise above atmospheric pressure. This International Standard also does not apply to packaged, integrally geared centrifugal plant, and instrument air compressors, which are covered by API 672. Hot gas expanders over 300 °C (570 °F) are not covered by this International Standard.

This part of ISO 10439 contains information pertinent to all equipment covered by the other parts of ISO 10439. It shall be used in conjunction with the following parts of ISO 10439, as applicable to the specific equipment covered:

- ISO 10439-2;
- ISO 10439-3;
- ISO 10439-4.

2 Normative references

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

NOTE Typical documents submitted as a user inquiry or order are user specifications, industry specifications, (such as ISO and API specifications), data sheets, meeting notes, and supplemental agreements.

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

ISO 6708, *Pipework components — Definition and selection of DN (nominal size)*

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

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

ISO 8068, *Lubricants, industrial oils and related products (class L) — Family T (Turbines) — Specification for lubricating oils for turbines*

ISO 21940-32, *Mechanical vibration — Rotor balancing — Part 32: Shaft and fitment key convention*

ISO 10438 (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 14839-3, *Mechanical vibration — Vibration of rotating machinery equipped with active magnetic bearings — Part 3: Evaluation of stability margin*

ISO 15156-3, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys*

IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

EN 55011, *Industrial scientific and medical (ISM) radio-frequency equipment — Electromagnetic disturbance characteristics — Limits and methods of measurement*

EN 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

API 613, *Special purpose gear units for petroleum, chemical, and gas industry services*

ASME B1.1, *Unified inch screw threads (UN and UNR thread form)*

ASME B16.1, *Grey iron pipe flanges and flanged fittings (Classes 25, 125, and 250)*

ASME B16.11, *Forged fittings, socket-welding and threaded*

ASME B16.42, *Ductile iron pipe flanges and flanged fittings (Classes 150 and 300)*

ASME B16.47, *Large diameter steel flanges NPS 26 through NPS 60 metric/inch standard*

ASME B16.5, *Pipe flanges and flanged fittings NPS ½ through NPS 24 metric/inch standard*

ASME B1.20.1, *Pipe threads, General purpose (Inch)*

ASTM A247, *Standard test method for evaluating the microstructure of graphite in iron castings*

ASTM A395, *Standard specification for ferritic ductile iron pressure-retaining castings for use at elevated temperatures*

ASTM E125, *Standard reference photographs for magnetic particle indications on ferrous castings*

ASTM E165, *Standard practice for liquid penetrant examination for general industry*

ASTM E709, *Standard guide for magnetic particle testing*

AWS D1.1, *Structural welding code*

NACE MR0103, *Standard material requirements — Material resistant to sulfide stress cracking in corrosive petroleum refining environments*

NACE SP0472, *Methods and controls to prevent in-service environmental cracking of carbon steel weldments in corrosive petroleum refining environments*

NFPA 70, *National electrical code*

SAE J518, *Hydraulic flanged tube, pipe, and hose connections, four-bolt split flange type*

3 Terms, abbreviated terms and definitions

3.1 Terms and definitions

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

3.1.1

anchor bolts

bolts used to attach the mounting plates to the support structure (concrete foundation or steel structure)
cf. *hold-down bolts* (3.1.11)

3.1.2

axially split joint

joint split with the principal face parallel to the shaft centreline

3.1.3

cartridge bundle assembly

<centrifugal> assembly consisting of the complete compressor assembly minus the casing

Note 1 to entry: It includes the inner barrel assembly, end heads, seals, bearing housings, and bearings. It also includes the rotor assembly. It is designed to be shop assembled, ready for insertion into the casing to minimize installation work in the field.

3.1.4

certified point

point to which the performance tolerances shall be applied

Note 1 to entry: This is usually the normal operating point and suppliers will normally require that this point is within their preferred selection range.

3.1.5

complex stiffness

notation for the total equivalent stiffness and damping expression, including the cross-coupled terms as required for the hydrodynamic bearing or squeeze damper oil film

3.1.6

compliant seal

seal design that allows rotor or rotor sleeve contact and possible stator element penetration without excessive loss of sealing performance

3.1.7

compressor rated point

intersection on the 100 % speed curve corresponding to the highest capacity of any specified operating point

3.1.8

compressor section

series of one or more impellers with defined external process conditions (i.e. side streams, bypassing, or injection)

Note 1 to entry: This is generally a derived point rather than an actual operating point (see Figure 1 in ISO 10439-2:2015 for a graphical representation).

3.1.9

critical speed

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

3.1.10

design

manufacturers' calculated parameter

Note 1 to entry: This is a term used by the equipment manufacturer to describe various parameters such as design power, design pressure, design temperature, or design speed. It is not intended for the purchaser to use this term.

3.1.11

bull gear gear wheel

lowest speed rotor in a gearbox cf. *pinion(s)* (3.1.34)

3.1.12

gearing

pinion(s) and gear wheel combination(s)

Note 1 to entry: A gear mesh is a pinion and gear wheel that operates together. A gear wheel may mesh with more than one pinion and, therefore, be part of more than one gear mesh.

3.1.13

hold-down bolts

bolts holding the equipment to the mounting plate cf. *anchor bolts* (3.1.1)

3.1.14

hydrodynamic bearings

bearings that use the principles of hydrodynamic lubrication

Note 1 to entry: The bearing surfaces are oriented so that relative motion forms an oil wedge, or wedges, to support the load without shaft-to-bearing contact.

3.1.15

hysteresis damping

<internal friction> causes a phase difference between the stress and strain in any material under cyclic loading; this phase difference produces the characteristic hysteric loop on a stress-strain diagram and, thus, a potentially destabilizing damping force

3.1.16

inlet volumetric flow

flow rate expressed in volume flow units at the conditions of pressure, temperature, compressibility, and gas composition, including moisture content, at the machine inlet flange

Note 1 to entry: Inlet volumetric flow is a specific example of actual volumetric flow. Actual volumetric flow is the volume flow at any particular location such as interstage impeller inlet or discharge or machine inlet or discharge. Actual volumetric flow should not be used interchangeably therefore with inlet volumetric flow.

3.1.17

inner barrel assembly

<centrigugal> assembly consisting of the internal stationary parts that make up the removable portion of the flowpath, including the inner barrel, the diaphragms, the impeller eye labyrinths, and the diaphragm labyrinths

3.1.18

low temperature service

service where the specified minimum design metal temperature is below $-29\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$)

3.1.19

maximum allowable temperature

maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred)

Note 1 to entry: The maximum allowable temperature is usually set by material considerations.

3.1.20

maximum allowable working pressure

maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred)

Note 1 to entry: Normally expected operating conditions can be based on settling-out pressure, maximum suction pressure plus the maximum developed differential pressure at the maximum speed (trip speed) or may be limited by relief valve set pressure or other means.

3.1.21

maximum continuous speed

highest rotational speed (revolutions per minute) at which the machine, as-built and tested, is capable of continuous operation

3.1.22

maximum inlet pressure

highest specified inlet pressure the equipment shall be subject to

3.1.23

maximum sealing pressure

highest pressure the seals are required to seal during any specified static or operating conditions and during start-up and shutdown

3.1.24

minimum allowable speed

lowest speed (revolutions per minute) at which the manufacturer's design shall permit continuous operation

3.1.25

minimum design metal temperature:

lowest mean metal temperature (through the thickness) expected, including operation upsets, auto refrigeration, and temperature of the surrounding environment

3.1.26

modular rotor

rotor which is built up using stub shafts or similar devices and held together by one or more through bolts

3.1.27

moment simulator

auxiliary device intended to simulate the moment of the mass of a half coupling

Note 1 to entry: A moment simulator can also be designated to serve as an idling adapter (solo plate).

3.1.28

mounting plate(s)

device used to attach equipment to concrete foundations; this is either baseplate(s) or soleplates

3.1.29

normal operating point

point at which usual operation is expected and optimum efficiency is desired

Note 1 to entry: This point is usually the point at which the supplier certifies that performance is within the tolerances stated in this part of ISO 10439.

3.1.30

normal speed

speed corresponding to the requirements of the normal operating condition

3.1.31

NPS

nominal pipe size

dimensionless value approximately equal to the diameter in inches

EXAMPLE NPS 3/4

Note 1 to entry: Adapted from ASME B 31.3–2002, 300.2.

Note 2 to entry: The number following the letters NPS does not represent a measurable value.

Note 3 to entry: NPS is a designation of pipe size only. The pipe end may be threaded or prepared for a welded fitting.

3.1.32

observed

<tests and inspections> 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 even if the purchaser or his representative is not present

3.1.33

overload

highest flow point at which the predicted curve terminates on a speed line

3.1.34

pinion(s)

high-speed rotor(s) in a gearbox cf. *bull gear* (3.1.11)

3.1.35

PN

nominal pressure

numerical designation relating to pressure that is a convenient round number for reference purposes

EXAMPLE PN 100 [ISO 7268]

Note 1 to entry: The permissible working pressure associated with a PN designation depends upon the materials, design, and working temperature and has to be selected from the pressure/temperature rating tables in corresponding standards.

3.1.36

pressure casing

composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts that isolates process gas from the atmosphere

3.1.37

purchaser

agency that issues the order and specification to the supplier

Note 1 to entry: The purchaser may be the owner of the plant in which equipment is to be installed or the owner's appointed agent.

3.1.38

radially split

split with the joint perpendicular to the shaft centreline

3.1.39

rated speed

100 % speed

highest rotational speed (revolutions per minute) required to meet any of the specified operating conditions

3.1.40

relief valve set pressure

pressure at which a relief valve starts to lift

Note 1 to entry: For information on relief valves, see API RP 520.

3.1.41

service factor

<gear> factor that is applied to the tooth pitting index and the bending stress number, depending upon the characteristics of the driver and the driven equipment, to account for differences in potential overload, shock load, and/or continuous oscillatory torque characteristics

3.1.42

settling-out pressure

highest pressure which the compressor experiences when the compressor is not running and equilibrium has been reached

Note 1 to entry: Determination of settling-out pressure requires consideration of the trapped volume of gas throughout the compressor and its associated piping system. This includes all gas trapped between the downstream valve and the upstream valve after a compressor is shut down.

3.1.43

shaft end seal

process gas seal on the shaft which restricts leakage of process gas to the atmosphere

3.1.44

slow roll

speed less than 5 % of the normal operating speed or the minimum speed permitted by the speed control

3.1.45

soleplate

plate attached to the foundation, with a mounting surface for equipment or for a baseplate

3.1.46

special purpose application

application for which the equipment is designed for uninterrupted, continuous operation in critical service and for which there is usually no installed spare equipment

3.1.47

special tool

tool which is not a commercially available catalogue item

3.1.48

stability analysis

determination of the natural frequencies and the corresponding logarithmic decrements (log decs) of the damped rotor/support system using a complex value analysis

3.1.49

standard volume flow

flow rate expressed in volume flow units at standard conditions as follows:

ISO standard (normal) conditions

flow: normal cubic meters per hour (Nm³/h)
 normal cubic meters per min (Nm³/min)

pressure: 1,013 bar absolute

temperature: 0 °C

humidity: 0 %

US customary standard conditions

flow: standard cubic ft per min (scfm)
 million standard cubic ft per day (mmscfd)

pressure: 14,7 PSIA

temperature: 60 °F

humidity: 0 %

Note 1 to entry: There are no universally accepted conditions for normal or standard cubic meters; therefore, their reference pressure and temperature should always be spelled out, i.e. m³/h 0 °C, 1,013 bar absolute.

Note 2 to entry: Due to the lack of uniformity on standard conditions, standard volume flow is not a preferred unit and, if specified, should be given in conjunction with actual mass flow to avoid confusion.

3.1.50

structure stiffness and damping

bearing housing to ground equivalent complex stiffness

3.1.51

surge

instability which occurs in a centrifugal or axial compressor at low volumetric flow

3.1.52

synchronous tilt-pad coefficients

complex frequency dependent coefficient with the frequency equal to the rotational speed of the shaft

3.1.53

supplier

manufacturer or manufacturer's agent that supplies the equipment

3.1.54

support stiffness and damping

equivalent oil film to ground complex stiffness characteristics; pivot stiffness should be included in the oil film characteristics

3.1.55

tooth pitting index

surface durability rating factor that is determined by the tangential load, pitch diameter, face width, and gear ratio

3.1.56

TIR

total indicator reading

total indicator runout

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 1 to entry: For a cylindrical surface, the indicated runout implies an eccentricity equal to half the reading. For a flat face, indicated runout implies an out-of-squareness equal to the reading. If the diameter in question is not cylindrical or flat, the interpretation of the meaning of TIR is more complex and may represent ovality or surface irregularities.

3.1.57

trip speed

<electric motor driver> speed corresponding to the synchronous speed of the motor at maximum supply frequency at the motor terminals

3.1.58

trip speed

<turbine, engine, expander, hydrostatic driver> speed at which the independent emergency overspeed device operates to shut down the driver

3.1.59

turndown

percentage of change in capacity (referred to rated capacity) between the rated capacity and the surge point capacity at the rated head when the unit is operating at rated suction temperature and gas composition

3.1.60

ultimate load rating

<hydrodynamic thrust bearing> load that shall produce the minimum acceptable oil film thickness without inducing failure during continuous service, or the load that shall not exceed the creep initiation or yield strength of the babbitt or bearing material at the location of maximum temperature on the pad, whichever load is less

3.1.61

unit responsibility

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

3.1.62

witnessed (tests and inspections)

<tests and inspections> inspection or test where 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 the purchaser's representative is in attendance

3.2 Abbreviated terms

A_{c1}	amplitude at N_{c1} , μm (mil)
A_{max}	maximum probe response amplitude (p-p) considering all vibration probes, over the range of N_{ma} to N_{mc} , for the unbalance amount/case being considered, μm (mil)
AF	amplification factor (refer to API RP 684 and Figure 2)
AF_1	amplification factor of the first critical speed, defined as: $AF_1 = N_{c1}/(N_2 - N_1)$
AMB	active magnetic bearing
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASME code	ASME boiler and pressure vessel code
ASTM	American Society for Testing and Materials
A_{vl}	the mechanical test vibration limit defined in 4.8.2.10 , μm (mil)
AWS	American Welding Society
CCW	counter clockwise (rotation)
CSR	critical speed ratio, defined as: $CSR = N_{\text{mc}}/\text{FCSR}$
CW	clockwise (rotation)
cf	(Latin conferre) confer or compare — cross reference
DN	nominal diameter
δ	logarithmic decrement
δ_A	minimum log decrement at the anticipated cross coupling for either minimum or maximum component clearance
δ_b	basic log decrement of the rotor and support system only

δ_f	log decrement of the complete rotor support system from the Level II analysis
FCSR	first undamped critical speed on rigid supports, r/min
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MAWP	maximum allowable working pressure
MCS	maximum continuous speed
N	operating speed, r/min
N_{cn}	rotor n^{th} critical speed, r/min
N_{c1}	rotor first critical speed, r/min
N_{ma}	minimum allowable speed, r/min
N_{mc}	maximum continuous speed, r/min
N_1	initial (lesser) speed at $0,707 \times$ peak amplitude, r/min
N_2	final (greater) speed at $0,707 \times$ peak amplitude, r/min
NACE International	National Association of Corrosion Engineers
NFPA	National Fire Protection Association
PPM	proactive preventive maintenance
OEM	Original Equipment Manufacturer
Q_A	anticipated cross coupling for the rotor, kN/mm (klbf/in), defined as: $Q_A = \sum_{i=1}^S q_{Ai}$
Q_0	minimum cross coupling needed to achieve a log decrement equal to zero for either minimum or maximum component clearance, kN/mm (klbf/in)
q_a	cross coupling defined in Formula (7) or (8) for each stage or impeller, kN/mm (klbf/in)
R_{out}	combined mechanical and electrical runout, μm (mil)
ρ_{ave}	average gas density across the rotor, kg/m^3 (lb/ft ³)
S	number of stages or impellers
S_{an}	actual separation for n^{th} critical speed, r/min
S_{a1}	actual separation for 1st critical speed, r/min
SM	separation margin (see Figure 2)
SM_a	forced response analysis actual separation margin, %
SM_{an}	separation margin for n^{th} critical speed, %

SM_r	forced response analysis required separation margin, %
SM_1	separation margin for the 1st critical speed, %, $= 100 \times S_{a1}/N_{ma}$
STD	standard
U_a	input unbalance for the rotordynamic response analysis, g-mm (oz-in), $= 2 \times U_r$
U_r	maximum allowable residual unbalance, g-mm (oz-in)
VDDR	vendor (supplier) drawing and data requirements
VFD	variable frequency drive (variable speed motor drive)

4 General

4.1 Dimensions and units

Drawings and maintenance dimensions shall be in SI units or United States customary (USC) units. Use of an SI datasheet indicates that SI units shall be used. Use of an USC datasheet indicates that USC units shall be used.

NOTE Datasheets for SI and USC units are provided in ISO 10439-2:2015, Annex A, ISO 10439-3:2015, Annex A, and ISO 10439-4:2015, Annex A.

4.2 Statutory requirements

The purchaser and the supplier shall determine the measures to be taken to comply with any governmental codes, regulations, ordinances, directives, or rules that are applicable to the equipment, its packaging, and any preservatives used.

4.3 Unit responsibility

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

4.4 Basic design

4.4.1 General

4.4.1.1 General requirements relating to performance are given in 4.4.1.1.1 to 4.4.1.1.5.

4.4.1.1.1 The equipment shall be capable of operating within the entire performance map, at all specified operating conditions, as well as accommodating other conditions such as momentary surge, settling-out, trip, and start-up.

4.4.1.1.2 * The purchaser shall specify all operating conditions for the equipment. Normal operating point shall be indicated.

NOTE Special operating conditions such as air dry out, field commissioning test run, catalyst regeneration, etc. can all be specified in order to ensure that operation can satisfactorily be met.

4.4.1.1.3 The compressor shall be designed to deliver normal head at the normal inlet volumetric flow. Performance tolerances given in the testing sections shall apply.

NOTE 1 The purchaser can furnish mass flow which is then converted to volumetric flow by the supplier.

NOTE 2 If a factory test is not performed, additional measuring tolerances can be considered for field measurements.

NOTE 3 See 6.3 of the applicable part for performance tolerances.

4.4.1.1.4 The overload condition shall be indicated on performance curves. Unless otherwise agreed, the sectional overload condition shall be at least 115 % of the rated condition.

NOTE See 3.1.33 for the definition of overload.

4.4.1.1.5 The purchaser shall supply a gas analysis. Gas properties used shall be agreed.

4.4.1.2 Any planned maintenance or inspection that may be required during the 5-year uninterrupted operation period shall be able to be performed without shutting down the equipment.

NOTE 1 It is recognized that this is a design criterion.

NOTE 2 It is realized that there are some services where this objective is easily attainable and others where it is difficult.

NOTE 3 Auxiliary system design and the design of the process in which this system is installed are very important in meeting this objective.

4.4.1.3 Unless otherwise specified, cooling water systems including those on process coolers shall be in accordance with ISO 10438.

NOTE API 614 5th edition is identical to ISO 10438 (all parts):2007.

4.4.1.4 * The purchaser shall advise the supplier in the inquiry of any specific requirements for liquid injection.

4.4.1.5 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the supplier at or before the coordination meeting. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

4.4.1.6 * The applicable electrical codes and area classification shall be specified.

NOTE Electrical codes vary widely depending upon the installed location. In the US, one of the governing codes is the National Electrical Code document number NFPA 70:2008, Articles 500, 501, 502, 504, and 505. In the European Union, the ATEX (from the French Atmosphere Explosible) directives, which are statutory law, govern. Other countries generally accept approval by an independent third party which states the equipment conforms to the governing standards. One of the third parties in the US is Underwriter Lab (UL) and in Canada it is the Canadian Standards Association (CSA).

4.4.1.7 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.

NOTE This can be accomplished by the use of shouldering, cylindrical dowels or keys.

4.4.1.8 All components, which are specific as to rotational direction, top or bottom casing half location, or axial location in the machine shall be designed to prevent incorrect installation.

4.4.1.9 * The equipment including all auxiliaries shall be suitable for operation under the environmental conditions specified by the purchaser. These conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, humidity, dusty or corrosive conditions, wind loads, and seismic zone.

4.4.1.10 * Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the supplier having unit responsibility. The equipment furnished by the supplier shall conform to the maximum allowable sound pressure level specified. The supplier shall provide expected values for maximum sound pressure level per octave band for the equipment.

NOTE The installed SPL depends on the installation

4.4.1.11 * If specified, sound power levels based on calculation methods shall be supplied in addition to sound pressure level based on a free field analysis.

NOTE ISO 3740, ISO 3744, and ISO 3746 or ASME PTC 36 can be consulted for guidance. ISO 10494 can be consulted for gas turbine drive packages.

4.4.1.12 Unless otherwise specified, the design lubricant shall be hydrocarbon oil of viscosity Grade 32 in accordance with ISO 8068 Type AR.

4.4.2 Speed requirements

4.4.2.1 The equipment's maximum continuous speed shall not be less than 105 % of the rated speed for variable speed machines (including VFD-controlled electric motors) and shall be equal to the synchronous speed for constant speed motor drives.

4.4.2.2 The equipment's trip speed shall not be less than the limiting speed of the emergency overspeed device furnished with the driver. Table 1 provides typical values for various drivers. Purchaser and supplier shall agree whether turbine trip speed based on loss of inertial load applies to the compressor.

Table 1 — Driver trip speeds

Driver type	Trip speed (% of maximum continuous speed)
Steam Turbine	
NEMA Class Aa	115 %
NEMA Class B, C, Da	110 %
Gas turbine	105 %
Variable speed motor	100 %
Variable speed gear	102 %
Constant speed motor	100 %
Reciprocating engine	110 %

4.4.2.3 Equipment shall be designed to operate simultaneously at the MAWP and trip speed without damage, regardless of driver power.

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

4.4.3 The equipment (machine, driver, and ancillary equipment) shall perform on the test stand and on their permanent foundation within the specified acceptance criteria. After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the supplier who has unit responsibility.

4.4.4 * Many factors (such as piping loads, alignment at operating conditions, supporting structure, handling during shipment, and handling and assembly at the site) can adversely affect site performance.

To minimize the influence of these factors, the supplier shall, when requested, review and comment on the purchaser's piping and foundation drawings. If specified, the supplier's representative shall witness

- a) a check of the piping alignment performed by unfastening the main process connections of the equipment,
- b) the initial shaft alignment check at ambient conditions (cold alignment), and
- c) the check shaft alignment at the operating temperature (hot alignment).

NOTE Refer to API RP 686 for basic guidelines for conducting piping alignments and shaft hot and cold alignments.

4.4.5 * Motors, generators, instrumentation, 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 IEC 60079-10-1 or NFPA 70:2008, Articles 500 to 505 as applicable, as well as local codes specified and furnished by the purchaser.

NOTE See 4.4.1.6.

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

4.4.7 * If specified, the machine or machines shall be suitable for field run on air. Performance parameters, including any required precautions, shall be agreed.

4.5 Materials

4.5.1 General

4.5.1.1 Materials of construction shall be the manufacturer's standard for the specified operating and site environmental conditions, except as required or prohibited by the data sheets or by this standard. ISO 10439-2:2015, Annex D, ISO 10439-3:2015, Annex D, and ISO 10439-4:2015, Annex D list material specifications that, when used with appropriate heat treatment or impact testing requirements or both, are generally considered acceptable for major component parts. The metallurgy of all major components shall be clearly stated in the supplier's proposal. See 5.6 for requirements for auxiliary piping materials.

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

NOTE Where international standards are not available, internationally recognized national or other standards can be used.

4.5.1.3 * The purchaser shall specify any corrosive agents (including trace quantities) present in the motive and process fluids in the site environment, including constituents that may cause corrosion.

NOTE 1 Typical agents of concern are hydrogen sulfide, amines, chlorides, cyanide, fluoride, naphthenic acid, and polythionic acid.

NOTE 2 Selection of materials is a joint effort between manufacturer and supplier. Conditions including non-running conditions need to be considered.

4.5.1.4 The supplier shall specify the optional tests and inspection procedures that may be necessary to ensure that materials are satisfactory for the service. Such tests and inspections shall be listed in the proposal.

NOTE The purchaser can specify additional optional tests and inspections, especially for materials used for critical components or in critical services.

4.5.1.5 Low-carbon steels can be notch sensitive and susceptible to brittle fracture at ambient or lower temperatures. Therefore, only fully killed, normalized steels made to fine-grain practice are acceptable for pressure-containing machine components. The use of steel made to a coarse austenitic grain size practice (e.g. ASTM A515) shall not be used.

4.5.1.6 Unless otherwise specified, if hydrogen sulfide has been identified in the gas composition, materials exposed to that gas shall be selected in accordance with the requirements of NACE MR0103 and where applicable the referenced NACE SP0472.

NOTE 1 NACE MR0103 requires restrictive hardness limits, more restrictive weld qualification procedures, and limits to the carbon equivalent levels of materials versus NACE MR0175 (See 4.5.1.7).

NOTE 2 It is the responsibility of the purchaser to determine the amount of H₂S that may be present, considering normal operation, start-up, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.

4.5.1.7 * If specified, ISO 15156-3 shall be used in place of NACE MR0103.

NOTE 1 ISO 15156-3 applies to material potentially subject to sulfide and chloride stress-corrosion cracking in oil and gas production facilities. These are upstream facilities; however, ISO 15156-3 (NACE MR0175 earlier editions) have been applied to compressors in downstream facilities since the fifth edition of API 617 (1988) prior to the introduction of NACE MR0103-2007.

NOTE 2 A survey conducted on units built in accordance with NACE MR0175 in previous API 617 editions has indicated no failures. The more restrictive requirements of NACE MR0103 may therefore not be required to provide sufficient protection against corrosion.

NOTE 3 NACE MR0175-2008 is identical to ISO 15156-3.

4.5.1.8 Ferrous materials not covered by NACE MR0103 or ISO 15156-3 shall have a maximum yield strength of 620 N/mm² (90 000 psi) and a maximum Rockwell hardness of HRC 22. Components fabricated by welding shall be postweld heat treated, if required, so that both the weld and the heat-affected zones meet the yield strength and hardness requirements.

NOTE NACE MR0175-2008 is identical to ISO 15156-3.

4.5.1.9 If austenitic stainless steel parts exposed to conditions that can promote intergranular corrosion are fabricated, hard faced, overlaid, or repaired by welding, they shall be made of low-carbon or stabilized grades.

NOTE Overlays or hard surfaces that contain more than 0,10 % carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel, unless a buffer layer that is not sensitive to intergranular corrosion is applied.

4.5.1.10 Austenitic steels shall not be used in services where stress-corrosion cracking is a possibility.

4.5.1.11 Materials that have a yield strength in excess of 827 MPa (120 000 psi) or hardness in excess of Rockwell C 34 are prohibited for use in hydrogen gas service where the partial pressure of hydrogen exceeds 689 kPa (100 psi gauge) or the hydrogen concentration exceeds 90 molar per cent at any pressure.

4.5.1.12 External parts that are subject to rotary or sliding motions (such as control linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment.

4.5.1.13 Minor parts such as nuts, springs, washers, gaskets, and keys shall have corrosion resistance at least equal to that of specified parts in the same environment.

4.5.1.14 Where mating parts such as studs and nuts of austenitic stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an anti-seizure compound of the proper temperature specification and compatible with the specified process fluid(s).

NOTE Anti-seizure compounds can alter friction factors and are considered in specified torque loading in order to achieve the necessary preload.

4.5.1.15 O-ring materials shall be compatible with all specified services. Special consideration shall be given to the selection of O-rings for high-pressure services to ensure that they are not damaged upon rapid depressurization (explosive decompression). For vertically split case designs, the supplier shall state the maximum allowable depressurizing rate of the compressor casing required to prevent explosive decompression of the O-ring material supplied.

NOTE Susceptibility to explosive decompression depends on the gas to which the O-ring is exposed, the compounding of the elastomer, temperature of exposure, the rate of decompression, and the number of cycles.

4.5.1.16 * If specified, copper or copper alloys shall not be used for parts of machines or auxiliaries in contact with process fluids. Nickel-copper alloy (UNS N04400), bearing babbitt, and precipitation hardened stainless steels are excluded from this requirement.

NOTE Certain corrosive fluids in contact with copper alloys have been known to form explosive compounds.

4.5.1.17 * Coatings

If specified, mutually acceptable coatings shall be applied to the rotating and/or stationary components in the gas path. When coatings are applied to rotating components, the acceptance balance shall be made after coatings have been applied. The sequence of procedures for balancing and coating of rotating components shall be agreed.

NOTE 1 It is advisable to pre-balance in order to minimize balance corrections and subsequent repair to coating areas for the final acceptance balance. By minimizing the area repaired, a final check balance after repair may not be required.

NOTE 2 API RP 687:2009, Chapter 1 Appendix L is an informative tutorial on coatings.

4.5.1.18 Positive material identification (PMI)

4.5.1.18.1 * The extent of PMI testing shall be specified for materials, welds, fabrications, and piping. This shall be fully defined, including any sampling requirements.

4.5.1.18.2 When PMI is specified, techniques providing quantitative results shall be used.

4.5.1.18.3 Mill test reports, material composite certificates, visual stamps, or markings shall not be considered as substitutes for PMI testing.

4.5.1.18.4 PMI results shall be within governing standard limits with allowance for the accuracy of the PMI device as specified by the device manufacturer.

4.5.1.19 Low-temperature service

NOTE See [3.1.18](#).

4.5.1.19.1 Pressure casings and rotating elements shall be designed with materials that comply with the paragraphs included in this section.

4.5.1.19.2 * If specified, other components of the machinery train shall also be evaluated for the prevention of brittle fracture due to materials exhibiting change from ductile to brittle fracture as temperatures are reduced.

4.5.1.19.3 * The purchaser shall specify the minimum design metal temperature and concurrent pressure used to establish impact test and other material requirements.

NOTE Normally, this is the lower of the minimum surrounding ambient temperature or minimum fluid pumping temperature; however, the purchaser can specify a minimum design metal temperature based on properties of the pumped fluid, such as autorefrigeration at reduced pressures.

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

NOTE A good design practice includes the selection of fabrication methods, welding procedures, and materials for supplier-furnished steel pressure retaining parts that may be subject to temperatures below the ductile-brittle transition temperature. The published design-allowable stresses for materials in internationally recognized standards such as the ASME Code and ANSI standards are based on minimum tensile properties.

4.5.1.19.5 All carbon and low-alloy steel pressure-containing components for low-temperature service including nozzles, flanges, and weldments shall be impact tested in accordance with the requirements of Section VIII, Division 1, Sections UCS-65 to 68, of the ASME Code or equivalent standard. High-alloy steels shall be tested in accordance with Section VIII, Division 1, Section UHA-51, of the ASME Code or equivalent standard.

NOTE 1 In some situations, impact testing of a material is not necessary depending on the minimum design metal temperature, thermal, mechanical, and cyclic loading, and the governing thickness. Refer to requirements of Section VIII, Division 1, Section UG-20F of the ASME Code, for example.

NOTE 2 Design codes other than ASME can require additional certification and material testing.

4.5.1.19.6 Governing thickness used to determine impact testing requirements shall be the greater of the following:

- a) the nominal thickness of the largest butt-welded joint;
- b) the largest nominal section for pressure containment, excluding
 - 1) structural support sections such as feet or lugs,
 - 2) sections with increased thickness required for rigidity to mitigate shaft deflection, and
 - 3) structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers;
- c) one-fourth of the nominal flange thickness, including parting flange thickness for axially split casings (in recognition that the predominant flange stress is not a membrane stress).

The results of the impact testing shall meet the minimum impact energy requirements of Section VIII, Division 1, Section UG-84, of the ASME Code or equivalent standard.

4.5.1.19.7 For materials and thicknesses not covered by Section VIII, Division 1 of the ASME Code or equivalent standards, the purchaser shall specify the requirements.

4.5.2 Castings

4.5.2.1 Castings shall comply with material specification requirements regarding porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects. Surfaces of castings shall be cleaned by sandblasting, shotblasting, chemical cleaning, or other standard methods. Mould-parting fins and the remains of gates and risers shall be chipped, filed, or ground flush.

4.5.2.2 The use of chaplets in pressure castings shall be held to a minimum. Where chaplets are necessary, they shall be clean and corrosion free (plating is permitted) and of a composition compatible with the casting.

4.5.2.3 Pressure-containing ferrous castings shall only be repaired as specified in [4.5.2.3.1](#) to [4.5.2.3.3](#).

4.5.2.3.1 Weldable grades of steel castings shall be repaired, using a qualified welding procedure based on the requirements of the appropriate pressure vessel code such as Section VIII, Division 1 and Section IX of the ASME Code. After major weld repairs and before hydrotest, the complete repaired casting shall be given a postweld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metal and dimensional stability during subsequent machining operations.

4.5.2.3.2 Cast grey iron may be repaired by plugging within the limits specified in ASTM A278, ASTM A395, or ASTM A536. The holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed.

4.5.2.3.3 All repairs that are not covered by ASTM specifications shall be subject to the purchaser's approval.

4.5.2.4 Cored voids, which become fully enclosed by methods such as plugging, welding, or assembly, are prohibited.

4.5.2.5 All ductile (Nodular) iron castings shall be produced in accordance with ASTM A395 or other equivalent internationally recognized standard as approved. The production of the castings shall conform to the conditions specified in [4.5.2.5.1](#) to [4.5.2.5.4](#).

4.5.2.5.1 The keel or Y block cast at the end of the pour shall have a thickness not less than the thickness of critical sections of the main casting. This test block shall be tested for tensile strength and hardness and shall be microscopically examined. Classification of graphite nodules under microscopic examination shall be in accordance with ASTM A247. There shall be no intercellular flake graphite.

NOTE Critical sections are typically heavy section changes, high-stress points such as flanges. Normally, bosses and similar sections are not considered critical sections of a casting. If critical sections of a casting have different thicknesses, average-sized keel or Y blocks may be selected in accordance with ASTM A395.

4.5.2.5.2 A minimum of one set (three samples) of Charpy V-notch impact specimens at one-third the thickness of the test block shall be made from the material adjacent to the tensile specimen on each keel or Y block. All three specimens shall have an impact value not less than 12 J (9 ft-lbf) and the mean of the three specimens shall not be less than 14 J (10 ft-lbf) at room temperature.

4.5.2.5.3 If approved, non-pressurized ductile (Nodular) iron castings may be produced in accordance with ASTM A536 or other equivalent internationally recognized standard.

4.5.2.5.4 An "as-cast" sample from each ladle shall be chemically analysed.

4.5.2.5.5 Brinell hardness tests shall be made on the actual casting at feasible critical sections such as section changes, flanges, and other accessible locations. Sufficient surface material shall be removed before hardness tests are made to eliminate any skin effect. Tests shall also be made at the extremities of the casting at locations that represent the sections poured first and last. These shall be made in addition to hardness test on keel or Y blocks in accordance with [4.5.2.5.1](#).

4.5.3 Forgings

4.5.3.1 The forging material should be selected from those listed in ISO 10439-2:2015, Annex D, ISO 10439-3:2015, Annex D, and ISO 10439-4:2015, Annex D as applicable.

4.5.3.2 Pressure-containing ferrous forgings shall not be repaired except as specified in [4.5.3.2.1](#) and [4.5.3.2.2](#).

4.5.3.2.1 Weldable grades of steel forgings shall be repaired by welding. Using a qualified welding procedure based on the requirements of the appropriate pressure vessel code such as Section VIII, Division I and Section IX of the ASME Code or the equivalent specified standard. After major weld repairs and before hydrotest, the complete forging shall be given a postweld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metal.

4.5.3.2.2 All repairs that are not covered by ASTM specifications shall be subject to the purchaser's approval.

4.5.4 Welding

4.5.4.1 Unless otherwise specified, non-pressurized component welding, such as welding on baseplates, non-pressure ducting, lagging, and control panels, shall be performed and inspected by operators and procedures qualified in accordance with AWS D 1.1 or ASME Section IX or other purchaser-approved standard.

4.5.4.2 Welding of piping, pressure-containing parts, rotating parts, and other highly stressed parts, weld repairs, and any dissimilar-metal welds shall be performed and inspected by operators and procedures qualified in accordance with Section VIII, Division I and Section IX of the ASME Code or purchaser approved standard such as EN 287 and EN 288 for weld qualifications or procedures or other purchaser-approved standards.

4.6 Casings

4.6.1 Pressure-containing casings

4.6.1.1 The pressure casing shall be designed in accordance with [4.6.1.1.1](#) or [4.6.1.1.2](#). The casing joint bolting shall be in accordance with [4.6.1.1.4](#).

4.6.1.1.1 The allowable tensile stress used in the design of the pressure casing (excluding bolting) for any material shall not exceed 0,25 times the minimum ultimate tensile strength for that material at the maximum specified operating temperature. For cast materials, the allowable tensile stress shall be multiplied by the appropriate casting factor as shown in [Table 2](#).

Table 2 — 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

4.6.1.1.2 Pressure-containing components may be designed with the aid of finite element analysis provided that the design limits comply with Section VIII, Division 2 of the ASME Code stress intensity as modified by Formula (1).

$$\text{MASI} = \text{CSI} \times (\text{P}_{\text{ch}}/150) \quad (1)$$

where

MASI is the maximum allowable stress intensity expressed in kPa (psi);

CSI is the code stress intensity expressed in kPa (psi);

P_{ch} is the code hydrotest pressure, expressed in per cent of MAWP.

The manufacturer shall state the source of the material properties, such as ASTM, as well as the casting factors applied in his proposal.

NOTE Refer to ASME Code Section VIII, Div 2 Part AD-140(a) for definition of stress intensity.

4.6.1.1.3 A corrosion allowance of at least 3 mm (0.12 in) shall be added to the casing thickness used in 4.6.1.1.1 or 4.6.1.1.2.

NOTE In general, deflection is the determining consideration in the design of casings. Ultimate tensile or yield strength is seldom the limiting factor.

4.6.1.1.4 For casing joint bolting, the allowable tensile stress (as determined in 4.6.1.1.1) shall be used to determine the total bolting area based on hydrostatic load and gasket preload as applicable. The preload stress shall not exceed 75 % of the bolting material minimum yield. During hydrotest, the bolting preload stress shall not exceed 90 % of the bolting material minimum yield and a positive method for measuring bolting elongation shall be used. Preload during the assembled gas leakage test shall not exceed 75 % of the bolting material minimum yield strength.

Thread stress in the nut or case can be the limiting factor and should be evaluated.

NOTE Torque wrenches are not an acceptable way to determine bolt elongation due to variations in friction factor.

4.6.1.2 For flammable or toxic gases, compressor casings shall be steel or purchaser-approved alloy. Expander casings shall be made of material in ISO 10439-4:2015, Annex D or approved alloy.

4.6.1.3 For air or non-flammable gases, casings may be steel, ductile iron, or cast iron materials depending on the following ratings:

4.6.1.3.1 Ductile iron casings can be used up to the flange rating in accordance with ASME B16.42 Class 300.

4.6.1.3.2 Cast iron casings can be used up to the flange rating in accordance with ASME B16.1 Class 250.

4.6.1.4 Jackscrews, guide rods, cylindrical casing-alignment dowels, and/or special tools shall be provided to facilitate disassembly and reassembly. Guide rods shall be of sufficient length to prevent damage to the internals or casing studs by the casing during disassembly and reassembly. Lifting lugs or eyebolts shall be provided for lifting only the top half of the casing of axially split casings. When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counterbored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face.

NOTE "Special tools" could be extraction rigs for radially split equipment or rollers on the bundles of these machines.

4.6.1.5 The use of threaded holes in pressure parts of cast iron casings shall be minimized. To prevent leakage in pressure sections of casings, metal equal in thickness to at least 12 mm (1/2 in), in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and threaded holes. The depth of the threaded holes shall be at least 1,5 times the diameter of the threaded insert (stud, plug, etc.).

4.6.1.6 The sealing of stud clearance holes to prevent leakage is not permitted.

4.6.1.7 Bolting shall be furnished as specified in [4.6.1.7.1](#) to [4.6.1.7.6](#).

4.6.1.7.1 The details of threading shall conform to ISO 261 or ASME B1.1.

NOTE 1 ISO 261 covers general metric screw threads and ASME B 1.1 covers general inch series screw threads.

NOTE 2 For the purposes of this provision, ASME B 1.13M is equivalent to ISO 261.

NOTE 3 Glossary of terms for screw threads can be found in ASME B 18.12.

4.6.1.7.2 Studs shall be supplied on the main joint of axially split casings and bolted end covers of radially split casings. Studs shall be used instead of cap screws, on all other external joints, except where hexagonal head cap screws are essential for assembly purposes and have been approved by the purchaser.

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

4.6.1.7.4 Supplier shall advise whether bolting that needs to be disassembled for maintenance is metric or imperial thread series.

4.6.1.7.5 * If specified, the main casing joint studs and nuts shall be designed for the use of hydraulic bolt tensioning. Procedures and extent of special tooling provided by the supplier shall be agreed.

4.6.1.7.6 The minimum quality bolting material for pressure joints shall be carbon steel (such as ASTM A307, Grade B) for cast iron casings and high-temperature alloy steel (such as ASTM A193, Grade B7) for steel casings. Carbon steel nuts (such as ASTM A194, Grade 2H) shall be used. Where space is limited, case-hardened carbon steel nuts (such as ASTM A563, Grade A) shall be used.

NOTE For low temperature requirements, see [4.5.1.19](#).

4.6.1.8 Materials, casting factors, and the quality of any welding shall be equal to those required by Section VIII, Division 1 of the ASME Code or other purchaser-approved standard. The manufacturer's data report forms, as specified in the code, are not required unless required by regulation.

NOTE For low temperature requirements, see [4.5.1.19](#).

4.6.1.9 Welding of piping, pressure-containing parts, weld repairs and any dissimilar-metal welds shall be performed and inspected by operators and procedures qualified in accordance with Section VIII Division I and Section IX of the ASME Code or other purchaser approved standard.

4.6.2 Casing repairs and inspections

4.6.2.1 The supplier shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and non-destructively examined for soundness and compliance with the applicable qualified procedures (see [4.6.1.9](#)). Repairs shall be non-destructively tested by the same method used to detect the original flaw; however, the minimum level of inspection after the repair shall be by the magnetic particle method in accordance with [6.2.2.4](#) for magnetic material and by the liquid penetrant method in accordance with [6.2.2.5](#) for non-magnetic material.

Unless otherwise specified, procedures for major repairs shall be subject to review by the purchaser prior to any repair.

4.6.2.2 The purchaser shall be notified before making a major repair to a pressure-containing part. Major repair, for the purpose of purchaser notification only, is any defect that equals or exceeds any of the three criteria defined below:

- a) the depth of the cavity prepared for repair welding exceeds 50 % of the component wall thickness;
- b) the length of the cavity prepared for repair welding is longer than 150 mm (6 in) in any direction;
- c) the total area of all repairs to the part under repair exceeds 10 % of the surface area of the part.

4.6.2.3 Actual repairs shall be made as required by the following documents:

- a) the repair of plates, prior to fabrication, shall be performed in accordance with the ASTM standard to which the plate was purchased;
- b) the repair of castings or forgings shall be performed prior to final machining in accordance with the ASTM standard to which the casting or forging was purchased;
- c) the repair of a fabricated casing or the defect in either a weld or the base metal of a cast or fabricated casing, uncovered during preliminary or final machining, shall be performed in accordance with Section VIII of the ASME Code or other purchaser-approved standard.

4.6.2.4 Pressure-containing casings made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 4.6.2.4.1 to 4.6.2.4.6.

4.6.2.4.1 Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by Section VIII, Division 1, UG-93 (d) (3) of the ASME Code. Alternative standards may be applied when approved by the purchaser.

4.6.2.4.2 Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after postweld heat treatment

4.6.2.4.3 * If specified, the quality control of welds that will be inaccessible on completion of the fabrication shall be agreed on by the purchaser and supplier prior to fabrication.

4.6.2.4.4 Pressure-containing welds, including welds of the case to horizontal or vertical joint flanges, shall be full penetration (complete joint) welds unless otherwise approved by the purchaser prior to any fabrication.

NOTE This does not apply to auxiliary connections as described in 4.6.4.3.

4.6.2.4.5 Casings and fabrications that require machining to precise dimensions and tolerances to ensure assembly shall be heat treated regardless of thickness.

NOTE The ASME code does not require all fabrications to be postweld heat treated.

4.6.2.4.6 All pressure-containing welds shall be examined as required by Section VIII, Division 1 of the ASME Code. Requirements for additional examination shall be agreed.

NOTE See 4.6.3 for required procedures and acceptance criteria.

4.6.3 Material inspection of pressure-containing parts

NOTE Refer to 6.2.2 for inspection of non-pressure-containing parts

4.6.3.1 Regardless of the generalized limits presented in this section, it shall be the supplier's responsibility to review the design limits of all materials and welds in the event that more stringent requirements are specified. Defects that exceed the limits imposed in 4.6.3 shall be removed to meet the