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Ersatz für
DIN EN ISO 10441:2001-03**Erdöl- und Erdgasindustrie –
Nachgiebige Kupplungen zur mechanischen Kraftübertragung –
Besondere Anwendungsfälle (ISO 10441:2007);
Englische Fassung EN ISO 10441:2007**

Petroleum, petrochemical and natural gas industries –
Flexible couplings for mechanical power transmission –
Special-purpose applications (ISO 10441:2007);
English version EN ISO 10441:2007

Industries du pétrole, de la pétrochimie et du gaz naturel –
Accouplements flexibles pour transmission de puissance mécanique –
Applications spéciales (ISO 10441:2007);
Version anglaise EN ISO 10441:2007

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Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

Nationales Vorwort

Diese Europäische Norm wurde vom Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: Frankreich) erstellt. Es handelt sich dabei um die unveränderte Übernahme von ISO 10441:2007, erarbeitet von ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“.

Für Deutschland hat hieran der NA 109-00-06 AA „Verfahrenstechnische Anlagen und Ausrüstungen“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 13/1983 nur die englische Originalfassung der ISO-Norm.

Diese Norm enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“, „ft“, „inch“, „lb“, „psi“, die im Deutschen Normenwerk nicht zugelassen sind. Es wird jedoch ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

$$^{\circ}\text{C} = (5/9) (^{\circ}\text{F} - 32)$$

$$1 \text{ ft} = 0,304 8 \text{ m}$$

$$1 \text{ inch} = 25,4 \text{ mm}$$

$$1 \text{ lb} = 0,453 592 37 \text{ kg}$$

$$1 \text{ psi} = 6 894,757 \text{ Pa}$$

Änderungen

Gegenüber DIN EN ISO 10441:2001-03 wurden folgende Änderungen vorgenommen:

- a) die allgemeinen Anforderungen an alle Kupplungsarten wurden im Abschnitt 8 neu zusammengefasst;
- b) die bisherigen informativen Anhänge A, B und C wurden gestrichen;
- c) neue Anhänge A bis C mit normativen Angaben für verschiedene Kupplungsarten wurden aufgenommen;
- d) weitere Angaben zur Auslegung von Kupplungen werden als informative Angaben in den Anhängen D bis G sowie I und J neu gefasst, Anhang H enthält normative Angaben für Kupplungskäfige;
- e) die Norm wurde redaktionell überarbeitet.

Frühere Ausgaben

DIN EN ISO 10441: 2001-03

English Version

Petroleum, petrochemical and natural gas industries - Flexible couplings for mechanical power transmission - Special-purpose applications (ISO 10441:2007)

Industries du pétrole, de la pétrochimie et du gaz naturel -
Accouplements flexibles pour transmission de puissance
mécanique - Applications spéciales (ISO 10441:2007)

Erdöl- und Erdgasindustrie - Nachgiebige Kupplungen zur
mechanischen Kraftübertragung - Besondere
Anwendungsfälle (ISO 10441:2007)

This European Standard was approved by CEN on 28 February 2007.

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 Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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Foreword

This document (EN ISO 10441:2007) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" 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 September 2007, and conflicting national standards shall be withdrawn at the latest by September 2007.

This document supersedes EN ISO 10441:1999.

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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 10441:2007 has been approved by CEN as EN ISO 10441:2007 without any modifications.

Introduction

This International Standard was developed from the API Std 671, 3rd edition, 1998. It is intended that the 4th edition of API Std 671 will be identical to this International Standard.

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 vendor 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 vendor should identify any variations from this International Standard and provide details.

This International Standard requires the purchaser to specify certain details and features.

A bullet (●) at the beginning of a subclause or paragraph indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the datasheet(s), typical examples of which are included as Annex J; otherwise it should be stated in the quotation request or in the order.

1 Scope

This International Standard specifies the requirements for couplings for the transmission of power between the rotating shafts of two machines in special-purpose applications in the petroleum, petrochemical and natural gas industries. Such applications are typically in large and/or high speed machines, in services that can be required to operate continuously for extended periods, are often unspared and are critical to the continued operation of the installation. By agreement, it can be used for other applications or services.

Couplings covered by this International Standard are designed to accommodate parallel (or lateral) offset, angular misalignment and axial displacement of the shafts without imposing unacceptable mechanical loading on the coupled machines. It is applicable to gear, metallic flexible element, quill shaft and torsionally resilient type couplings. Torsional damping and resilient type couplings are detailed in Annex A; gear-type couplings are detailed in Annex B and quill shaft style couplings are detailed in Annex C.

This International Standard covers the design, materials of construction, manufacturing quality, inspection and testing of special-purpose couplings.

This International Standard does not define criteria for the selection of coupling types for specific applications.

This International Standard is not applicable to other types of couplings, such as clutch, hydraulic, eddy-current, rigid, radial spline, chain and bellows types.

2 Normative references

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

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

ISO 286-2, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*

ISO 2491, *Thin parallel keys and their corresponding keyways (Dimensions in millimetres)*

ANSI Y14.2M¹⁾, *Line Conventions and Lettering*

ANSI/AGMA 9000²⁾, *Flexible Couplings — Potential Unbalance Classification*

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

ANSI/AGMA 9003, *Flexible Couplings — Keyless Fits*

ANSI/AGMA 9004, *Flexible Couplings — Mass Elastic Properties and other Characteristics (Inch Series)*

ANSI/AGMA 9104, *Flexible Couplings — Mass Elastic Properties and other Characteristics (Metric Series)*

ANSI/AGMA 9112, *Bores and Keyways for Flexible Couplings (Metric Series)*

1) American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA.

2) American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, VA 22314-1560, USA.

ANSI/ASME B1.1³⁾, *Unified inch screw threads, UN and UNR thread form*

DIN 7190⁴⁾, *Interference fits — Calculation and design rules*

3 Terms and definitions

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

3.1

angular misalignment

⟨double-engagement couplings⟩ two minor angles between the extension of each machine centreline and the centreline of the structure joining the two flexible elements

3.2

angular misalignment

⟨single-engagement couplings⟩ minor angle between the extensions of two machine-shaft centrelines

NOTE If the shaft centrelines do not intersect, a single-engagement coupling is not appropriate.

3.3

assembly balance

procedure in which a completely assembled coupling is balanced as a unit

3.4

assembly balance check

procedure in which an assembled coupling is placed on a balancing machine and the residual unbalance is measured

NOTE An assembly balance check can be carried out on a component balanced coupling, or on an assembly-balanced coupling.

3.5

axial displacement

change in the relative axial position of the adjacent shaft ends of two coupled machines, usually caused by thermal expansion

3.6

component balance

procedure for achieving coupling balance in which the components or factory assembled sub-assemblies are balanced separately before assembly of the coupling

3.7

continuous torque rating

coupling manufacturer's declared maximum torque that the coupling is capable of transmitting continuously for unlimited periods

3.8

crown diameter

major diameter of the external teeth of a gear-type coupling

3) ASME International, Three Park Avenue, New York, NY 10016-5990, USA.

4) Deutsches Institut für Normung, Burggrafenstrasse 6, Sresemannallee 15, Berlin, Germany D-10787.

3.9

distance between shaft ends

DBSE

distance from the extreme end of one shaft (including any threaded end) to the extreme end of the next shaft or, in the case of integral flanges, the distance from the mating faces

3.10

double engagement coupling

coupling with two planes of flexure

NOTE This arrangement enables couplings of certain types, notably gear and metallic flexible element types, that cannot normally accommodate parallel (or lateral) offset, to do so.

3.11

factor of safety

factor that is used to cover uncertainties in a coupling design

EXAMPLES Analytical assumptions in stress analysis, material properties, manufacturing tolerances, etc.

NOTE Under given design conditions, the factor of safety is the material yield strength divided by the calculated stress, where the stress is a function of torque, speed, misalignment and axial displacement.

3.12

fatigue factor of safety

factor of safety at the published continuous rated conditions of torque, speed, misalignment and axial displacement, used by the manufacturer to establish the coupling rating

See 7.1.

NOTE The fatigue factor of safety is further explained and defined in Annex D.

3.13

flex-hub coupling

gear-type coupling with the external teeth on the hubs and the internal teeth in the sleeves

3.14

gear coupling

coupling of the mechanical contact type that transmits torque and accommodates angular misalignment, parallel offset and axial displacement by relative rocking and sliding motion between mating, profiled gear teeth

3.15

half coupling

composite of all of the components of the coupling attached to, and supported from, one shaft including an appropriate portion of the spacer assembly in the case of a double-engagement coupling or of the flexing elements of a single-engagement coupling

3.16

idling adapter

solo plate

device designed to rigidly hold in alignment the floating parts of certain types of couplings to allow uncoupled operation of the driving or driven machine without dismounting the coupling hub

3.17

lateral offset

lateral distance between the centrelines of two shafts, which are not parallel, measured perpendicularly to the centreline and in the plane of the shaft end of the driving machine

See Annex F.

3.18**manufacturer**

agency responsible for the design and fabrication of the coupling

NOTE The manufacturer is not necessarily the vendor.

3.19**maximum allowable temperature**

maximum continuous temperature for which the manufacturer has designed the coupling

3.20**maximum continuous angular misalignment**

maximum angular misalignment at each plane of flexure that the coupling is able to tolerate for unlimited periods

NOTE Maximum continuous angular misalignment can be expressed as either

- a) a single value when transmitting the coupling continuous torque rating at the coupling rated speed, and simultaneously subjected to the coupling maximum continuous axial displacement, or
- b) a range of values expressed as an inter-related function of speed, torque, and axial displacement.

3.21**maximum continuous axial displacement**

maximum axial displacement the coupling is able to tolerate for unlimited periods

NOTE Maximum continuous axial displacement can be expressed as either

- a) a single value when transmitting the coupling continuous torque rating at the coupling rated speed and simultaneously subjected to the coupling maximum continuous angular misalignment, or
- b) a range of values expressed as an inter-related function of speed, torque, and angular misalignment.

3.22**maximum continuous speed**

highest rotational speed at which the coupling, as made and tested, is capable of continuous operation

3.23**metallic flexible-element coupling**

coupling type that obtains its flexibility from the flexing of thin metallic discs, diaphragms or links

3.24**moment simulator**

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

NOTE A moment simulator can also be designed to serve as an idling adapter (solo plate).

3.25**momentary torque limit**

torque that corresponds to a factor of safety of 1,0 with respect to the most highly stressed component's material yield strength, allowing for a combination of speed, angular misalignment and axial displacement

3.26**normal operating point**

point at which usual operation is expected

NOTE This point is usually the point at which the machine manufacturer(s) certify(ies) that performance is within the tolerances stated to the owner.

3.27

owner

final recipient of the equipment, who may delegate another agent as the purchaser of the equipment

3.28

parallel offset

distance between the centrelines of two coupled shafts that are parallel but not in the same straight line

See Annex F.

3.29

peak torque rating

maximum torque the coupling can tolerate for short periods

3.30

pilot

rabbet

register

surface that positions a coupling component, sub-assembly, or assembly radially with respect to another coupling component

3.31

potential unbalance

probable net unbalance of a complete coupling

NOTE 1 Potential unbalance results from a combination of the residual unbalance of individual components and sub-assemblies and possible eccentricity of the components and sub-assemblies due to run-out and tolerances of the various surfaces and registers. Since it can be assumed that the actual values of the various contributory unbalances are random in both magnitude and direction, the numerical value of the potential unbalance is the square root of the sum of the squares of all the contributory unbalances. Typical contributory unbalances are

- a) the residual unbalance of each component or sub-assembly,
- b) errors in the balance of each component or sub-assembly resulting from eccentricity in the fixture used to mount the component or sub-assembly in the balance machine,
- c) the unbalance of each component or sub-assembly due to eccentricity resulting from clearance or run-out of the relevant registers or fits.

NOTE 2 The concept of potential unbalance is explained more fully and a worked example is provided in Annex E.

3.32

purchaser

agency that issues the order and the specification to the vendor

NOTE The purchaser can be the owner of the plant in which the equipment is to be installed, the owner's appointed agent or, frequently, the manufacturer of the driven machine.

3.33

quill-shaft coupling

coupling that is both laterally and torsionally flexible, with angular misalignment, parallel offset and torsional fluctuations being accommodated by elastic deformation of a relatively long, slender shaft

NOTE Quill-shaft couplings, unless combined with another type, cannot accommodate axial displacement.

3.34

rated speed

highest rotational speed at which the coupling is required to be capable of transmitting the continuous torque rating while simultaneously subjected to the rated angular misalignment and the coupling rated axial displacement

3.35**residual unbalance**

level of unbalance remaining in a component or assembly after it has been balanced, either to the limit of the capability of the balancing machine or in accordance with the relevant standard

3.36**service factor**

factor applied to the steady-state torque in order to allow for off-design conditions, cyclic and other variations as well as equipment variations resulting in higher torque than that at the equipment normal operating point

NOTE Service factor is not the same as the factor of safety, 3.11 or the fatigue factor of safety, 3.12.

3.37**single-engagement coupling**

coupling with only one plane of flexure

NOTE This type of coupling can accommodate angular misalignment and axial displacement. Single-engagement couplings of some types, notably gear and metallic flexible element types, do not normally accommodate parallel (or lateral) offset. Certain types of single-engagement couplings (not covered by this International Standard) can accommodate offset misalignment to a limited extent.

3.38**spacer**

part of a coupling that is removable to give access for maintenance and/or removal of the coupling hubs

NOTE The spacer can be a single component or an assembly.

3.39**spacer gap length**

distance between coupling hubs or sleeves in which the coupling spacer is installed

NOTE Spacer gap length is not necessarily equal to the distance between the shaft ends.

3.40**torsional damping**

absorption or dissipation of oscillatory rotary energy

NOTE Torsional damping is necessary in some cases to limit the build-up of steady-state torsional resonant oscillations in a system.

3.41**torsional natural frequency**

frequency of the undamped, free-rotational vibration of a system composed of revolving mass inertias acting in combination with the restraining torsional rigidities of the connected shafts and couplings

3.42**torsionally resilient coupling**

coupling with increased flexibility in a rotational direction, increased capability to recover from flexing and with hysteresis capability

NOTE Resilience is the ability to recover from deformation under repeated flexing, taking account of energy storage and hysteresis effects. Some types of torsionally resilient couplings can also be designed to accommodate misalignment and/or axial displacement.

3.43**torsional stiffness**

ratio of the applied torque to the resulting torsional displacement of either a complete coupling or part of the coupling, such as a spacer

NOTE With some types of couplings, the torsional stiffness is not constant but is a function of the magnitude of the torque and, with oscillating torques, also the frequency.

3.44
total indicator reading

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

NOTE 1 For a perfectly cylindrical surface, the total indicator reading implies an eccentricity equal to half the reading. For a perfectly flat face, the total indicator reading implies an out-of-squareness equal to the reading. If the surface in question is not perfectly cylindrical or flat, the interpretation of the meaning of total indicator reading is more complex and can represent ovality or lobing.

NOTE 2 Total indicator reading is also known as “full indicator movement”.

3.45
unit responsibility

responsibility for co-ordinating the delivery and technical aspects of the equipment and all auxiliary systems included in the scope of the order

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

3.46
vendor supplier
agency that supplies the equipment

NOTE The vendor is the manufacturer of the equipment or the manufacturer's agent and normally is responsible for service support.

4 Statutory requirements

The purchaser and the vendor shall mutually determine the measures to be taken to comply with any federal, state or local codes, regulations, ordinances or rules that are applicable to the equipment.

5 Coupling selection

- **5.1** The purchaser shall specify the type of coupling required. Unless otherwise specified, the coupling shall be a metallic flexible-element coupling. For torsional damping and resilient couplings, refer to Annex A; for gear couplings, refer to Annex B; and for quill-shaft couplings, refer to Annex C.

5.2 The coupling shall be selected based on the equipment loading and shall be capable of transmitting the maximum steady-state torques, cyclic torques, and the maximum transient torques under all conditions of angular misalignment, axial displacement, speed and temperature, simultaneously, to which it will be subjected in service.

In general, a special-purpose coupling shall be designed and constructed for a minimum service life of five years for flexible element couplings and three years for gear and torsional damping and resilient couplings.

Figure 1 provides guidance for the typical selection process for a coupling.

- **5.3** If specified, the coupling, coupling-to-shaft juncture and shafting may be sized for a future condition.

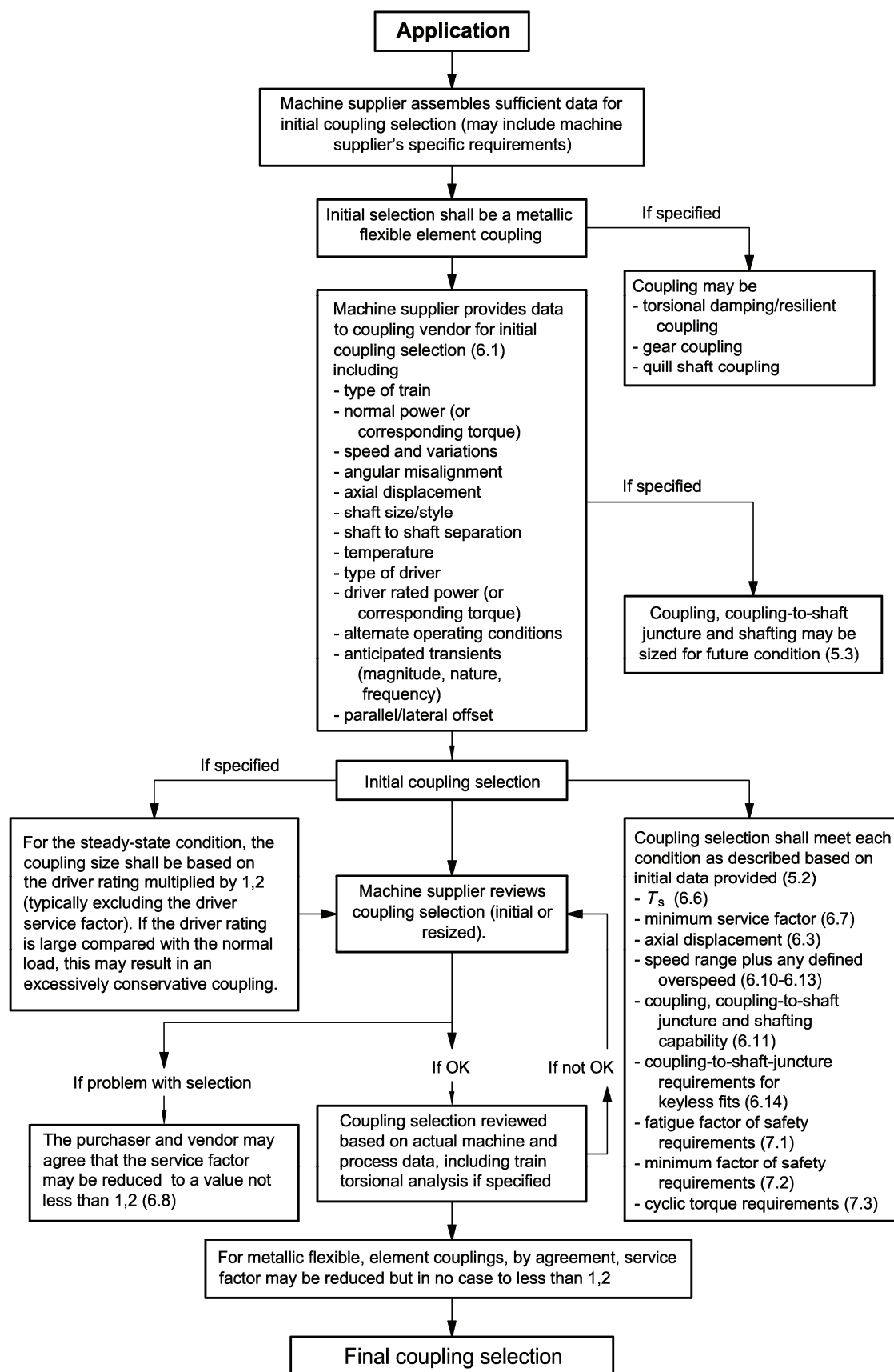


Figure 1 — Typical coupling selection process

6 Coupling design

- **6.1** The purchaser shall specify the following requirements, where applicable:
 - a) type of train;
 - b) normal power;
 - c) normal speed and variations;
 - d) maximum continuous speed;
 - e) any defined overspeed;
 - f) angular misalignment;
 - g) axial displacements;
 - h) shaft sizes and styles;
 - i) distance between shaft-ends;
 - j) temperature;
 - k) type of driver;
 - l) driver power rating (list and driver service factor);
 - m) expected transient (peak) and cyclic torque conditions, including magnitude, nature and number of occurrences of transients to which the coupling will be subjected in service.
- **6.2** The purchaser shall specify the maximum angular misalignments the coupling is expected to experience during start-up, normal operation and shut-down of the coupled machines, normally expressed as parallel (or lateral) offset and/or angular misalignment between the coupled shafts. These values shall allow for all the known effects on the machines from thermal, pressure and dynamic forces. Unless otherwise specified, the steady-state angular misalignment capability across each flexible element shall be not less than 0,2°.
- **6.3** The purchaser shall specify the maximum axial displacements the coupling is expected to experience, expressed as the amount and direction of the relative movement of the shaft ends toward or away from each other as the coupled machines go through their start-up, normal operation and shut-down cycle. These dimensions shall be given from the machine at ambient conditions, non-operating position. Unless otherwise specified, the minimum steady-state axial deflection (plus/minus) capability shall be determined by the largest shaft diameter divided by 125.
- **6.4** The purchaser shall specify the speed range for the fully assembled coupling, moment simulator and solo plate for both continuous speed and any defined overspeed.

6.5 The steady-state torque, T_n , expressed in newton-metres (inch-pounds force), shall be determined as given in Equation (1):

$$T_n = \frac{K_1 \times P_{\text{normal}}}{N_{\text{normal}}} \quad (1)$$

where

K_1 is a constant, equal to 9 550 (63 000);

P_{normal} is the input power required by the driven machine at the specified normal operating point, expressed in kilowatts (horsepower);

N_{normal} is the speed corresponding to the normal power, expressed in revolutions per minute.

- If specified by the purchaser, the steady-state torque shall be based on the power required by the driven machine at the rated operating point and the corresponding speed rather than that at the normal operating point. This can be appropriate if the power required by the driven machine at the rated point is significantly higher than that at the normal point.

NOTE 1 This situation can occur, for example, in the case of a centrifugal compressor with a number of different specified operating duties.

NOTE 2 Basing the coupling torque rating on the driven-machine-rated operating point rather than the normal point can result in a coupling that is undesirably large or heavy. This can be significant if one or both of the connected machines is sensitive to overhung mass.

The purchaser should also consider possible future up-rating of the connected machines, for example augmentation of the power output of a gas turbine by water injection.

6.6 Unless otherwise specified, the steady-state selection torque, T_s , expressed in newton-metres (inch-pounds), used to select the coupling shall be as given in Equation (2):

$$T_s = T_n \times F_S \quad (2)$$

where F_S is the service factor (as specified for the specific coupling type).

NOTE The service factor allows for various modes of off-design operation that can result from such factors as a change in density of the fluid (molar mass, temperature or pressure variation), unequal load sharing, fouling or driver output at maximum conditions.

6.7 Unless otherwise specified, the coupling shall have, as a minimum, a service factor of 1,5 for a metallic flexible-element coupling.

6.8 The service factor may be reduced by agreement between the purchaser and the vendor if

- a) the characteristics of the driver and driven machines and the operating process are well understood, or
- b) all reasonable attempts to achieve the specified steady-state torque service factor fail to result in a coupling mass and subsequent overhung moment commensurate with the requirement for rotor dynamics of the connected machines.

In no case shall the service factor be reduced to a value lower than 1,2 based on the normal power.

- **6.9** If specified, for the steady-state conditions, the coupling shall be sized based on the driver rating multiplied by 1,2 (typically, excluding the driver service factor).

NOTE If the driver rating is large compared with the normal load, this requirement can result in an excessively conservative coupling selection.

6.10 If the machine train is driven by an induction motor, the coupling, coupling-to-shaft juncture and the machinery shafting shall be capable of transmitting 115 % of the expected transient (peak) torque encountered during a start-up without damage.

6.11 If the machine train is driven by a synchronous motor, the coupling shall be capable of withstanding the cyclic torque associated with start-up for the expected number of starts specified by the purchaser. A limited life fatigue stress analysis shall be carried out to verify this.

NOTE For initial coupling selection, a large cyclic torque requirement is typically assumed until all conditions are known so that the torsional response analysis can be completed.

- **6.12** If specified, the coupling shall be capable of transmitting a specified transient torque associated with a generator short circuit and/or a motor breaker re-closure without damage.

NOTE During these situations large torques can occur, which require that the total system be subsequently examined for possible damage.

6.13 Unless otherwise specified, the coupling-to-shaft juncture and the machinery shafting shall be capable of operating at a steady-state torque determined in accordance with 6.6, substituting a service factor of 1,75.

6.14 Unless otherwise agreed, the torque capacity of a coupling-to-shaft juncture that is hydraulically fitted and keyless shall be determined by using the methods and equations in ANSI/AGMA 9003 or DIN 7190. Other methods of calculation may be used with the approval of the purchaser.

The coefficient of friction used shall be 0,15.

The assumed length of hub engagement shall not include "O"-ring and oil-distribution grooves in the hub or the shaft.

6.15 Couplings may be designed to transmit torque through flange face friction. Unless otherwise agreed, a value of 0,15 shall be assumed for the coefficient of friction. However, the fasteners for coupling flanges, including integral flanges, shall be not less than that required to transmit the specified torques, as identified in 6.9 through 6.12, in shear.

7 Coupling ratings

7.1 The vendor shall state the continuous torque rating at the rated speed, when simultaneously subjected to the maximum continuous angular misalignment and the maximum continuous axial displacement. The fatigue factor of safety at the continuous torque rating and any published combination of speed, angular misalignment and axial displacement shall be determined using the proportional increase method with either the modified Goodman diagram or constant-life curves (see Annex D), together with the mean and cyclic stresses induced in the flexible element under the evaluated conditions. If the modified Goodman diagram is used, the fatigue factor of safety shall be not less than 1,25. If the constant-life curve is used, the fatigue factor of safety shall be not less than 1,35. Regardless of the method used, data for material strength shall be drawn from published industry standards or test data.

NOTE This subclause defines (for the coupling manufacturer) the minimum fatigue factors of safety and the methods for applying them to recognized material properties. This definition standardizes the basis for continuous coupling ratings. Details of the design, such as equations and analysis used to derive the stresses, are often considered proprietary and are not a point of documentation.

7.2 The vendor shall state the peak torque rating of the coupling. With the coupling subjected simultaneously to its peak torque rating and rated conditions of speed, axial displacement and angular misalignment, all torque-transmitting coupling components shall have a factor of safety not less than 1,15 with respect to the component's material yield strength. The manufacturer shall also state the momentary torque limit that corresponds to a factor of safety of 1,0 with respect to the yield strength of the most highly stressed component.

The vendor shall advise which components, if any, should be inspected and/or replaced following the occurrence of torque greater than the peak torque rating.

NOTE This defines (for the coupling manufacturer) the minimum factor of safety for transient and momentary coupling loads.

7.3 For applications where cyclic torques can occur (such as from synchronous motor, generator or reciprocating compressor), the coupling design shall be determined by completing a fatigue analysis. The analysis shall take into account the normal operating conditions in conjunction with the transient conditions

(see 6.1). Depending on whether the cyclic loads are considered for a limited number of occurrences or considered to be infinite, either a low-cycle fatigue analysis or high-cycle fatigue analysis shall be performed for the various torque-transmitting components in the coupling. For low-cyclic fatigue analysis, the resultant mean and cyclic stresses plotted on a fatigue diagram shall fall under the applicable life curve (i.e. 10^4 , 10^5 , 10^6 or 10^7 cycles).

- The life curve used shall be based on the purchaser specifying the number of occurrences of transients to which the coupling will be subjected in service. For high-cycle fatigue analysis, the analysis and safety factors shall be as specified in 7.1. Transient applications do not require the application of a service factor.

In applications where potentially damaging, infrequent, maximum momentary or fault torques occur, the provision of an overload device may be considered to protect the coupling and equipment. Care should be taken that the overload device does not trip prematurely due to low- or high-cycle fatigue of any sacrificial elements. Precautions should also be taken to ensure that the device remains relatively intact after a trip until the connected equipment is brought to a stop.

8 Coupling requirements

8.1 Metallic flexible-element couplings

8.1.1 The requirements of 8.1 apply only to metallic flexible-element couplings. For torsionally resilient couplings, gear couplings and quill-shaft couplings, the requirements of Annexes A, B or C, respectively, shall apply.

8.1.2 Unless otherwise specified, flexible elements shall be metallic.

8.1.3 If the flexible elements of a coupling are combined in a factory-assembled pack, the coupling spacer shall be removable without disturbance to the factory assembly of the elements.

- **8.1.4** If the coupling is required to operate within a close-fitting, enclosed coupling guard, the purchaser shall provide details of the guard for the vendor to inspect. The vendor shall determine and so advise if cooling is required and, if necessary, shall recommend a cooling system for the coupling. See Annex H for coupling guard requirements.

8.1.5 If a tapered bore or integral flange is specified for one or both ends of the coupling, the vendor shall supply spacer shims to adjust the spacer gap. The shims shall provide a range of adjustment of $\pm 1,6$ mm ($1/16$ in), i.e. 3,2 mm ($1/8$ in) total, for shafts with a nominal diameter less than 102 mm (4 in). For shafts with a nominal diameter 102 mm (4 in) or greater, the shims shall provide a range of $\pm 3,2$ mm ($1/8$ in), i.e. 6,4 mm ($1/4$ in) total.

8.1.6 Unless otherwise agreed, the design of metallic flexible-element couplings shall be such that in the event of complete failure of the flexible element or elements in one plane of flexure, the spacer assembly is retained in approximately its normal position.

- **8.1.7** When specified, couplings shall incorporate a feature that allows transmission of load for a limited period, in the event of a complete flexible element failure. This feature may be considered for turbine main-drive couplings to provide an additional safety factor to prevent turbine overspeed in the event of coupling failure and complete loss of load.

8.2 Machining

All coupling parts, other than fasteners and flexible discs, shall be machined all over to minimize inherent unbalance. All exposed surfaces shall be finished to an arithmetic average roughness of $3,2 \mu\text{m}$ (125 microinches) or better.

8.3 Spacer

All couplings shall be of the spacer type. The spacer shall be of sufficient length to allow removal of coupling hubs and to allow for maintenance of adjacent bearings and seals without removal of the shaft or disturbance of the equipment alignment. Unless otherwise specified by the purchaser, the spacer length shall correspond to a distance between shaft-ends of 460 mm (18 in).

NOTE The spacer gap length is not necessarily the same as the spacer length.

8.4 Hub type

- The purchaser shall specify whether the coupling shall be designed to fit to integral flange(s) or be provided with removable hub(s).

NOTE The two ends of the couplings are not necessarily the same.

8.5 Integral flanges

8.5.1 If the coupling is to fit to integrally flanged shaft end(s), the coupling vendor and the manufacturer with unit responsibility shall agree on the flange geometry. The holes shall be machined with computer numerical-controlled (CNC) equipment. A drill fixture (or template) shall be used only if CNC equipment is not available. In either case, inspection shall be performed to assure proper location of the mating coupling flanges. The coupling vendor shall supply the drill fixture (or template), if required.

8.5.2 Unless otherwise specified, the coupling shall mate directly to the integral flange without an adapter.

NOTE 1 Addition of an adapter between the coupling and the integral flange increases the overhung moment and adds another fit whose runout and clearance it is necessary to control in order to maintain balance. Further, the issue of who is responsible for supplying the adapter (machine manufacturer or coupling manufacturer) requires an agreement for each order.

NOTE 2 For certain machines, particularly gas turbines, space limitations can make it impractical to comply with the requirement in 8.5.2.

8.6 Hubs

8.6.1 Removable hubs

- **8.6.1.1** Removable coupling hubs shall be fitted to the shaft using an interference fit to positively locate and centre the hub, and therefore the rest of the coupling, on the shaft. These hubs may have a parallel or taper bore, with or without keyways, or may be splined with a major diameter fit, or splined with a side fit and fore and aft locating pilots, as specified by the purchaser.
- The degree of interference shall be specified by the purchaser and is subject to approval by the vendor.

The following guidelines are recommended for hub to shaft fits.

- a) The interference fit for straight-bore, keyed hubs should be from 0,000 50 mm/mm (in/in) to 0,000 75 mm/mm (in/in) of bore diameter.
- b) The interference fit for tapered-bore, keyed hubs should be at least 0,001 mm/mm (in/in) of bore diameter.
- c) The interference rate for taper-bore, hydraulically fitted hubs should be based upon the torque that is required to be transmitted. As a maximum, the interference rate should not exceed 0.003 mm/mm (in/in) of bore diameter to avoid potential bonding problems.
- d) Some international machinery manufacturers may use preferred fits for shafts and bores.