



American
Gear Manufacturers
Association

ANSI/AGMA 9103-C17
(Revision of ANSI/AGMA 9103-B08)

American National Standard

**Flexible Couplings –
Keyless Fits (Metric Edition)**

ANSI/AGMA 9103-C17

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National
Standard*****Flexible Couplings – Keyless Fits (Metric Edition)***

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ABSTRACT

This standard presents information on design, dimensions, tolerances, inspection, mounting, removal, and equipment that is in common use with keyless tapered and keyless straight (cylindrical) bore hubs for flexible couplings.

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Foreword

[The foreword, footnotes and annexes, if any, in this document are provided for informational purposes only and are not to be construed as a part of AGMA 9103-C17, *Flexible Couplings – Keyless Fits (Metric Edition)*.]

This standard was developed after intensive study of existing practices, standards and literature. The intent of this document is to offer to rotating equipment designers and users a standard for design practice and dimensions regarding keyless fits for flexible couplings. In general, the information in this standard is a consolidation of the most common practices and standards currently in existence.

This AGMA standard and related publications are based on typical or average data, conditions, or applications.

Work was begun on ANSI/AGMA 9003-A91 in 1985 and was approved by the AGMA membership in February 1991. It was approved as an American National Standard on May 20, 1991.

ANSI/AGMA 9103-B08 split the original standard into inch (ANSI/AGMA 9003-B08) and metric versions, updated Annex B and added an example calculation as Annex D.

The first draft of ANSI/AGMA 9103-B08 was made in October 2004. It was approved by the AGMA membership in October 2007. It was approved as an American National Standard on May 20, 2008.

ANSI/AGMA 9103-C17 provides a revised description of the effective hub to shaft engagement length, and Figure 5c has been deleted as a result.

The first draft of ANSI/AGMA 9103-C17 was made in August 2016. It was approved by the membership in November 2017 and as an American National Standard on December 6, 2017.

Suggestions for improvement of this standard will be welcome. They may be submitted to tech@agma.org.

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American National Standard –

Flexible Couplings – Keyless Fits (Metric Edition)

1 Scope

This standard presents information on design, dimensions, tolerances, inspection, mounting, removal, and equipment that is in common use with keyless tapered and keyless straight (cylindrical) bore hubs for flexible couplings. Calculated hub stress values and hub to shaft torque capacities are nominal values. This standard does not present a rigorous analysis of the components.

1.1 Applicability

This Standard applies only to hubs and solid shafts made of steel, which generally have material properties of modulus of elasticity equal to 2.07×10^5 MPa, density equal to 7830 kg/m³, and thermal expansion coefficient equal to 11.4×10^{-6} mm/mm/°C.

1.2 Exclusions

This standard does not apply to couplings attached to shafts with keyways, splines, split hubs or polygon bores.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI/AGMA 9112-A04, *Bores and Keyways for Flexible Couplings (Metric Series)*

ANSI/AGMA 9009-D02, *Flexible Couplings – Nomenclature for Flexible Couplings*

3 Terms and symbols

3.1 Terms

The terms used, wherever applicable, conform to the following Standards:

ANSI Y10.3-1968, *Letter Symbols for Quantities Used in Mechanics of Solids*

ANSI/AGMA 1012-G05, *Gear Nomenclature, Definition of Terms with Symbols*

3.2 Symbols

The symbols used in the formulas are shown in Table 1.

NOTE: The symbols and definitions used in this standard may differ from other AGMA standards. The user should not assume that familiar symbols can be used without a careful study of these definitions.

Table 1 – Symbols and definitions^{1), 2)}

Symbol	Definition	Units	First used
C_e	Ratio of average bore diameter of section to outside diameter of section under consideration, $C_e = D_b/D_o$	- -	Eq 2
D	Shaft diameter at largest end of bore	mm	Eq 13
D_b	Average bore diameter of section	mm	Eq 1
D_o	Outside diameter of section	mm	Eq 2
E	Modulus of elasticity	MPa	Eq 2
I	Diametral interference	mm	Eq 13
I_c	Loss of interference when rotating	mm	5.1.4
I_{max}	Maximum diametral interference when not rotating	mm	Eq 4
I_{min}	Minimum diametral interference fit required to transmit the design torque at specified speed	mm	5.1.4
i	Interference rate	mm/mm	7.2
L	Effective length of hub to shaft engagement	mm	Eq 1
N	Specified rotational speed	1/min	Eq 3
p_1	Calculated pressure at hub bore to mount or dismount hub due to maximum interference fit	MPa	5.2.1
p_2	Maximum recommended pressure at hub bore when mounting or dismounting the hub	MPa	5.2.2
p_{min}	Minimum pressure at hub bore for design torque calculation	MPa	5.1.3
Ra	Arithmetic average of surface finish	mm	5.1.1
S	Advance	mm	7.3
S_d	Advance per millimeter of shaft diameter	mm/mm	7.3
S_y	Tensile yield strength of the selected hub material	MPa	5.3.1
T	Design torque capacity of hub-to-shaft connection	Nm	5.1.2
t	Taper, rate of change of diameter per unit length	mm/mm	Eq 14
α	Thermal expansion coefficient	mm/mm/°C	Eq 17
ΔT	Required temperature difference between hub and shaft for mounting hub	°C	Eq 17
σ_H	Maximum hoop stress in mounted hub when rotating	MPa	Eq 7
σ_{max}	Maximum hub stress at hub bore due to hydraulic pressure when mounting or dismounting	MPa	5.3.1
σ_R	Radial stress at hub bore due to interference fit of mounted hub while rotating	MPa	Eq 7
σ_{Rv}	Radial stress in hub due to rotational speed	MPa	Eq 7
σ_{rot}	Combined stress in hub when rotating	MPa	Eq 7
σ_v	Hoop stress in hub due to rotational speed	MPa	Eq 7
μ	Apparent coefficient of friction	- -	5.1.1
NOTE: ¹⁾ Equations in this standard require the use of consistent units. ²⁾ For this standard, pressure is noted in megapascals (MPa) to be consistent with hydraulic gages. 1 MPa = 1 N/mm ² .			

4 Responsibility

The purchaser has the sole responsibility for specifying the peak torque and all other pertinent loading and operating information affecting the hub-to-shaft juncture. The machine designer is totally responsible for the design of the hub-to-shaft juncture. The sole responsibility of the coupling manufacturer is to provide hubs designed and manufactured according to the purchaser's specifications.

Compliance with this standard does not constitute a warranty of the rating of the hub to shaft juncture under installed conditions. This standard only applies to the hub design. There can be personal injury or catastrophic failure of the shaft or hub-to-shaft juncture as a result of incorrect design, installation, or removal error, or other factors unrelated to the hub design.

WARNING: When working with hydraulic mounting and removal equipment **EXTREME** care and caution must be used to prevent personal injury and damage to equipment due to explosive axial movement at the time of hub release.

5 Design considerations

The design of keyless fits in power transmission couplings is based on the calculations required for the safe transmission of the specified torque through the coupling hub-to-shaft juncture. These calculations consist of the following:

- The interference fit required to transmit the specified torque;
- The pressures involved in mounting and dismounting the hub;
- The stresses in the hub during mounting or dismounting and during operation.

The equations in the following sections for hub pressures and stresses account for hubs of substantially uniform cross sections. The equation for torque capacity of the hub-to-shaft juncture assumes the hub outside diameter is uniform and equal to the outside diameter of the minimum hub section. The torque as calculated is conservatively low.

When a hub has multiple outside diameters such as shown in Figure 1, the hub can be split into sections and the torque capacity of each section calculated separately. The total capacity is the sum of the separate section capacities. Hub configuration must be considered when performing stress and mounting pressure calculations (see Figures 1, 2, 3, and 4).

Shrink or interference fit analysis is generally based on Lamé's equations for a thick walled cylinder under internal pressure.

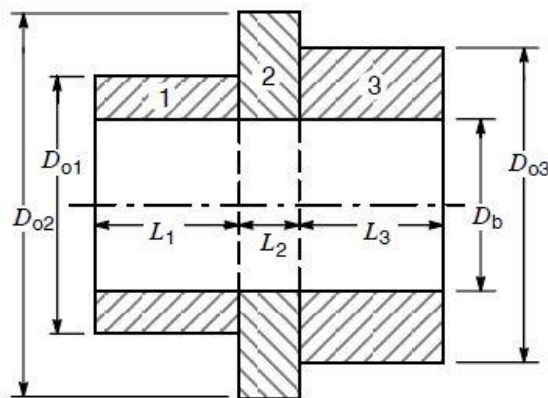


Figure 1 – Hub with multiple sections

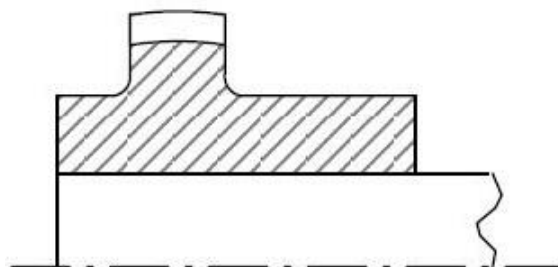


Figure 2 – Flexible hub, gear tooth section influencing torque capacity and pressure

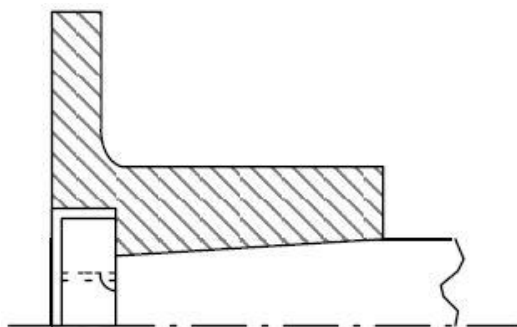


Figure 3 – Rigid hub, flange not influencing torque capacity and pressure

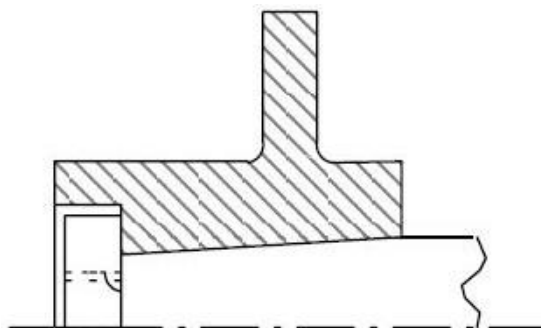


Figure 4 – Rigid hub, flange influencing torque capacity and pressure

The bore used in the determination of the pressure for tapered and cylindrical bore configurations is as shown in Figures 5a and 5b. The following equations are based on the assumption that the shaft and hub have substantially equal surface finish, hardness, and modulus of elasticity.

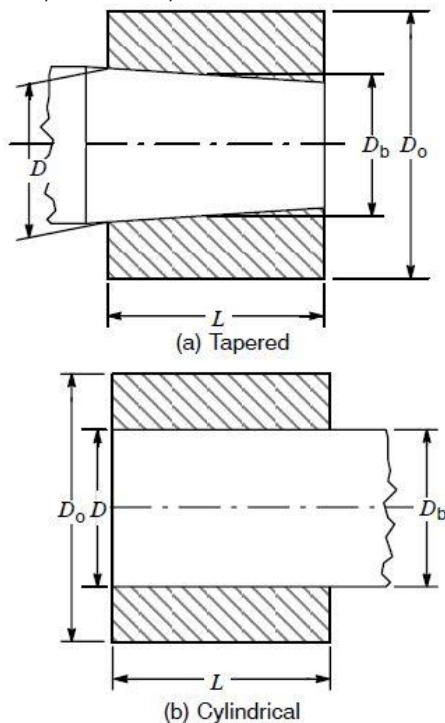


Figure 5 – Bore configurations

5.1 Determination of interference fit required to transmit the specified torque

The interference fit required is dependent upon the design torque to be transmitted, the coefficient of friction selected, the physical dimensions of the hub and the specified speed of operation. The interference fit range is determined by either the minimum/maximum shaft and bore diameters for cylindrical bores, or by the minimum/maximum hub advance for tapered bores.

5.1.1 Apparent coefficient of friction, μ

The apparent coefficient of friction, μ , between the hub and shaft can vary widely depending on such factors as cleanliness, oil type, contact pattern, surface finish and rate of load application. Values which are widely used are:

$\mu = 0.12$ to 0.15 if hydraulically mounted with each surface having a finish of 0.8 micrometers Ra maximum, and adequate draining time after mounting.

$\mu = 0.15$ to 0.20 if heat-shrink mounted with clean and dry surfaces, each having a surface finish of 0.8 micrometers Ra maximum.

5.1.2 Design torque capacity of hub-to-shaft fit, T

The design torque capacity, T , of the hub-to-shaft fit is a function of the hub dimensions, the interference fit, the hub and shaft material, centrifugal expansion and coefficient of friction. The design capacity should exceed the peak torque of the application. When the peak torque is well defined, the hub to shaft torque capacity should exceed the peak torque by a minimum factor of 1.15 . When the peak torque is not well defined, this factor should be increased or based on experience with similar applications.

NOTE: The peak torque is the highest value of torque applied at the hub-to-shaft fit.

5.1.3 Minimum pressure at the hub bore for design torque calculations, $p_{\min}$

The minimum pressure, $p_{\min}$, at the hub bore, is based on the design torque capacity, apparent coefficient of friction and the physical dimensions of the hub. The minimum pressure is normally calculated for the smallest hub section which results in a conservative torque capacity of the hub-to-shaft fit. It is calculated as follows:

$$p_{\min} = \frac{2(T)(1000)}{\pi D_b^2 L \mu} \quad (1)$$

where

- T is design torque capacity of hub-to-shaft connection, Nm;
- D_b is average bore diameter of section, mm;
- L is the effective length of hub to shaft engagement, mm;
- μ is apparent coefficient of friction.

The effective length of hub to shaft engagement shall not include hub overhang, or oil distribution grooves and O-ring grooves in either the hub bore or the shaft.

5.1.4 Minimum diametral interference fit required to transmit the design torque at specified speed, $I_{\min}$

The minimum diametral interference fit, $I_{\min}$, required to transmit the design torque capacity at the specified speed, is based on the minimum pressure as calculated using 5.1.3 plus the loss of interference fit due to differential expansion of the hub and shaft due to rotation, I_c . It is calculated for the smallest hub section which results in a conservative torque capacity of the hub-to-shaft fit. It is calculated as follows:

$$I_{\min} = \frac{2 p_{\min} D_b}{E(1 - C_e^2)} + I_c \quad (2)$$