



American  
Gear Manufacturers  
Association

**ANSI/AGMA 6001-F19**  
Revision of ANSI/AGMA 6001-E08

## **American National Standard**

# Design and Selection of Components for Enclosed Gear Drives

ANSI/AGMA 6001-F19

This is a preview. [Click here to purchase the full publication.](#)

**American  
National  
Standard*****Design and Selection of Components for Enclosed Gear Drives***

ANSI/AGMA 6001-F19

(Revision of ANSI/AGMA 6001-E08)

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretation of this standard should be addressed to the American Gear Manufacturers Association.

**CAUTION NOTICE:** AGMA technical publications are subject to constant improvement, revision, or withdrawal as dictated by experience. Any person who refers to any AGMA technical publication should be sure that the publication is the latest available from the Association on the subject matter.

[Tables or other self-supporting sections may be referenced. Citations should read: See ANSI/AGMA 6001-F19, *Design and Selection of Components for Enclosed Gear Drives*, published by the American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, Virginia 22314, <http://www.agma.org>.]

Approved January 18, 2019

**ABSTRACT**

This standard outlines the basic practices for the design and selection of components, other than gearing, for use in commercial and industrial enclosed gear drives.

Published by

**American Gear Manufacturers Association  
1001 N. Fairfax Street, Suite 500, Alexandria, Virginia 22314**

Copyright © 2019 by American Gear Manufacturers Association  
All rights reserved.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without prior written permission of the publisher.

Printed in the United States of America

ISBN: 978-1-64353-035-2

**Contents**

Foreword .....	v
1 Scope.....	1
1.1 Exceptions.....	1
1.2 Intended use.....	1
2 Normative references .....	1
3 Symbols and definitions.....	2
3.1 Definitions.....	2
3.2 Symbols.....	2
4 Design conditions .....	5
4.1 Load spectrum analysis .....	5
4.2 Momentary peak loads .....	6
4.3 System analysis .....	6
5 Shafts.....	6
5.1 Design criteria .....	6
5.2 Fatigue safety factor.....	7
5.3 Peak load safety factor.....	7
5.3.1 Allowable stress to yield strength factor, $F_{ya}$ .....	8
5.3.2 Peak load factor, $F_p$ .....	8
5.4 Calculated stresses .....	8
5.4.1 The general case.....	10
5.4.2 The simplified case.....	12
5.5 Material requirements .....	14
5.5.1 Estimated properties of steel .....	14
5.6 Modified fatigue strength.....	15
5.6.1 Surface finish factor, $k_a$ .....	16
5.6.2 Size factor, $k_b$ .....	16
5.6.3 Reliability factor, $k_c$ .....	17
5.6.4 Temperature factor, $k_d$ .....	17
5.6.5 Life factor, $k_e$ .....	18
5.6.6 Modifying factor for stress concentration, $k_f$ .....	18
5.6.7 Miscellaneous effects factor, $k_g$ .....	22
5.6.8 Permissible number of peak load cycles .....	23
5.7 Deflection .....	23
5.7.1 Permissible deflection.....	24
6 Keys and interference fits .....	25
6.1 Size and tolerances.....	25
6.2 Limitations .....	25
6.3 Keyed interference fit .....	26
6.4 Allowable compressive stress .....	26
6.5 Allowable shear stress .....	27
6.6 Allowable torque based on compressive stress calculation.....	27
6.7 Allowable torque based on shear stress calculation .....	27
6.8 Allowable torque.....	27
6.9 Keyless interference fit.....	27

6.10	Reversing loads .....	28
7	Bearings.....	29
7.1	Roller and ball bearing selection criteria .....	29
7.1.1	Reliability .....	29
7.1.2	Life adjustment factors .....	29
7.2	Sleeve bearing selection criteria .....	29
7.2.1	Boundary and mixed film regimes .....	30
7.2.2	Hydrodynamic regime.....	30
8	Housings.....	31
8.1	Housing construction and styles .....	31
8.2	Housing materials .....	32
8.3	Housing rigidity and strength.....	32
8.4	Housing accessory provisions.....	33
8.4.1	Inspection covers.....	33
8.4.2	Fill, vent, and drain provisions .....	33
8.4.3	Lifting provisions.....	33
9	Threaded fasteners .....	33
9.1	Fastener preload tensile stress, $\sigma_M$ .....	34
9.2	Fastener torque, $T_f$ .....	35
9.3	Allowable fastener tensile stress, $\sigma_{fa}$ .....	35
9.3.1	Allowable tensile load, $F_A$ .....	36
9.4	Engagement length .....	36
9.5	Locking devices for fasteners.....	36
10	Miscellaneous components .....	36
10.1	Shims .....	36
10.2	Gaskets .....	37
10.3	Oil seals.....	37
10.4	Breathers.....	37
10.5	Expansion chambers.....	38
10.6	Oil level indicators .....	38
10.7	Bearing retainers .....	38
10.8	Grease retainers .....	38
10.9	Dowels and pins.....	38
10.9.1	Dowels and pins used for positive location .....	38
10.9.2	Dowels and pins used to prevent movement .....	38
10.10	Spacers .....	39
10.11	Seal retainers .....	39
10.12	Special tools .....	39
10.13	Monitoring.....	39
10.13.1	Temperatures; sump, inlet, bearing race(s) .....	39
10.13.2	Pressures; inlet.....	39
10.13.3	Oil level.....	39
10.13.4	Chip or ferrous debris monitor .....	39
10.13.5	Flow .....	40
10.13.6	Vibration.....	40

**Annexes**

Annex A (informative) Allowable stresses for typical key materials .....	41
Annex B (informative) Material properties for typical threaded fasteners .....	43
Annex C (informative) Previous method – shaft design .....	45
Annex D (informative) Sample problems – transmission shaft design .....	48
Annex E (informative) Shaft deflection .....	55
Annex F (informative) Sample problems – keys .....	60
Annex G Bibliography .....	66

**Figures**

Figure 1 – Design criteria .....	7
Figure 2 – Cyclic loading .....	10
Figure 3 – Stress convention showing orbiting element .....	11
Figure 4 – Surface finish factor, $k_a$ [2] .....	16
Figure 5 – Size factor, $k_b$ [2] .....	16
Figure 6 – Reliability factor, $k_c$ [1] [2] .....	17
Figure 7 – Notch sensitivity – through hardened steel, $q$ [2] .....	19
Figure 8 – Theoretical stress concentration factor in bending for a circular shaft with a square shoulder, $K_t$ (nominal stress is calculated at diameter $d_{she}$ ) [7] .....	20
Figure 9 – Theoretical stress concentration factor in bending for a circular shaft with a u-notch, $K_t$ (nominal stress is calculated at diameter $d_{she}$ ) [7] .....	21
Figure 10 – Theoretical stress concentration factor in bending for a circular shaft with a radial hole, $K_t$ (based on full section without considering hole) [7] .....	22
Figure 11 – Key nomenclature .....	26
Figure 12 – Variation of coefficient of friction versus the bearing parameter .....	30
Figure 13 – Cast housings .....	31
Figure 14 – Fabricated housings .....	32
Figure 15 – Fastener grip requirement .....	34

**Tables**

Table 1 – Symbols used in equations .....	2
Table 2 – Modifying factor for stress concentration, $k_t$ – typical values for keyways in solid round steel shafts <sup>1)</sup> [8] .....	22
Table 3 – Typical allowable misalignment per bearing type .....	24
Table 4 – Joint stiffness factor, $K_J$ .....	36

## 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 Standard 6001-F19, *Design and Selection of Components for Enclosed Gear Drives*.]

AGMA 260.02 was approved by the AGMA membership on February 1, 1973 and issued in January of 1974. It consolidated with minor revision, information contained in the following superseded AGMA Standards:

AGMA 255.02 (November 1964), *Bolting (Allowable Tensile Stress) for Gear Drives*;

AGMA 260.01 (March 1953), *Shafting – Allowable Torsional and Bending Stresses*;

AGMA 260.02, also incorporated allowable stresses for keys;

AGMA 265.01, *Bearings – Allowable Loads and Speeds*.

The purpose of ANSI/AGMA 6001-C88, as a replacement for AGMA 260.02, was to establish a common base for the design and selection of components for the different types of commercial and industrial gear drives.

ANSI/AGMA 6001-C88 was expanded to include a generalized shaft stress equation which included hollow shafting, miscellaneous components, housings, and keyway stress calculations. All design considerations were revised to allow for 200 percent peak load for helical, spiral bevel, spur and herringbone gearing, and 300 percent peak load for wormgearing. The bearing section was updated to include consideration of life adjustment factors, bearing lives other than 5000 hours and reliability levels other than  $L_{10}$ .

During the preparation of ANSI/AGMA 6001-C88, a considerable amount of time was spent on the shaft design section in an effort to include the most recent theories on shaft stresses and material characteristics. The standard included the existing practice for shaft design, and for reference purposes, appendix C included a description of, and excerpts from, ANSI/ASME B106.1M, *Design of Transmission Shafting*, published in 1985 [1].

ANSI/AGMA 6001-C88 was approved by the membership in May 1988 and approved as an American National Standard on June 24, 1988.

ANSI/AGMA 6001-D97 was expanded to include more recent theories on shaft design and analysis. Also, equations for shaft deformation were added. ANSI/AGMA 6001-D97 was approved by the membership in October 1996 and approved as an American National Standard on August 7, 1997.

ANSI/AGMA 6001-E08 was updated as required by ANSI practices. In the process, several improvements and simplifications were included. Minimum material requirements were added for shaft material and the shaft deflection clause was moved to an annex. Also, the clauses on keys and fasteners were revised to reflect current practices with higher allowable stresses in some cases.

The first draft of ANSI/AGMA 6001-E08 was made in August 2002. It was approved by the AGMA membership in September 2008. It was approved as an American National Standard on December 19, 2008.

ANSI/AGMA 6001-F19 was reviewed and updated in accordance with ANSI practices, with general updates and corrections that accumulated since publication of E08. In particular, Clause 8, Housings, was expanded to include graphics and discussion of stress analysis. Also, Clause 10, Miscellaneous components, was significantly upgraded in content.

The first draft of ANSI/AGMA 6001-F19 was made in April 2018. It was approved by the AGMA membership in December 2018. It was approved as an American National Standard on January 18, 2019.

Suggestions for improvement of this standard will be welcome. They should be sent to [tech@agma.org](mailto:tech@agma.org).

**PERSONNEL of the AGMA Enclosed Drives for Industrial Applications Committee**

Chairman: Todd Praneis ..... Cotta Transmission Company

**ACTIVE MEMBERS**

M. Allen ..... Amarillo Gear Company  
H. Almoghrabi ..... Nord Gear Corporation  
J. Bond ..... Integrated Machinery Solutions  
M. Groff ..... Xtek  
R. Holly ..... Rexnord Gear Group  
H. Johnson ..... BHGE, Lufkin Industries  
A. Miles ..... SEW-Eurodrive  
W. Weber ..... Flender

## American National Standard –

# Design and Selection of Components for Enclosed Gear Drives

## 1 Scope

This standard provides an acceptable practice for the design and selection of components for enclosed gear drives. Fundamental equations provide for the proper sizing of shafts, keys, and fasteners based on stated allowable stresses. Other components are discussed in a manner to provide an awareness of their function or specific requirements. This standard applies to the following types of commercial and industrial enclosed gear drives, individually or in combination: spur, helical, herringbone, double helical, or bevel gearing in single or multiple stages. Bevel gear drives may include shaft angles other than 90 degrees.

### 1.1 Exceptions

The equations in this standard are not applicable when gear drives are subjected to conditions that introduce vibrations of a sufficient level to affect the performance of the gear drive and may result in unpredictable fatigue failure.

The procedure for design or selection of the specific gear components is varied and complex and is beyond the scope of this standard. Designers must refer to the specific rating or enclosed drive standards for this aspect of drive design.

### 1.2 Intended use

The equations and values presented provide a general approach to design. Deviations from the methods and values stated in this standard may be made when justified by experience, testing, or more specific analysis. This standard is intended for use by experienced gear designers capable of selecting reasonable values based on their knowledge of the performance of similar designs and the effect of such items as lubrication, deflection, manufacturing tolerances, metallurgy, residual stresses, and system dynamics. It is not intended for use by the engineering public at large.

## 2 Normative references

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

ANSI B17.1, *Keys and Keyseats*

ANSI B17.2, *Woodruff Keys and Keyseats*

AGMA 927-A01, *Load Distribution Factors – Analytical Methods for Cylindrical Gears*

AGMA 938-A05, *Shot Peening of Gears*

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

ANSI/AGMA 2001-D04, *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth*

ANSI/AGMA 9003-C17, *Flexible Couplings – Keyless Fits*

ANSI/AGMA 9005-F16, *Industrial Gear Lubrication*



ANSI/AGMA ISO 6336-6-A08, *Calculation of Load Capacity of Spur and Helical Gears – Part 6: Calculation of Service Life Under Variable Load*

ANSI/AGMA 9002-C14, *Bores and Keyways for Flexible Couplings (Inch Series)*

DIN 6885-1:1968, *Drive Type Fastenings without Taper Action; Parallel Keys, Keyways, Deep Pattern*

### 3 Symbols and definitions

The symbols and definitions used in this standard may differ from those in other AGMA standards. The user should not assume that familiar symbols can be used without a careful study of the applicable section(s) and equation(s).

#### 3.1 Definitions

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

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

#### 3.2 Symbols

The symbols used in this standard are shown in Table 1.

**NOTE:** The symbols and terms contained in this document may vary from those used in other AGMA standards. Users of this standard should assure themselves that they are using these symbols and terms in the manner indicated herein.

**Table 1 – Symbols used in equations**

Symbol	Term	Units	First referenced
$A$	Coefficient	--	Fig 4
$A_c$	Minimum compressive area of key in shaft or hub	in <sup>2</sup>	Eq 49
$A_R$	Fit holding capacity	lb	Eq 52
$A_s$	Shear area	in <sup>2</sup>	Eq 50
$A_{ts}$	Tensile strength area of fastener	in <sup>2</sup>	Eq 60
$B$	Coefficient	--	Fig 4
$b_k$	Width of the key	in	Eq 41
$c$	Coefficient	--	Eq 37
$D_f$	Fastener nominal diameter	in	Eq 57
$D_{fm}$	Fastener nominal diameter	mm	Eq 58
$d_{he}$	Outside diameter of hub	in	Eq 55
$d_{hi}$	Inside diameter of hub	in	Eq 55
$d_{she}$	Outside diameter of the shaft section being analyzed	in	Eq 6
$d_{shi}$	Shaft inside diameter	in	Eq 6
$d_{sho}$	Outside diameter adjacent to the shaft section being analyzed	in	Fig 8
$E_H$	Modulus of elasticity for hub material	lb/in <sup>2</sup>	Eq 53
$E_S$	Modulus of elasticity for shaft material	lb/in <sup>2</sup>	Eq 53
$F_A$	Allowable tensile load	lb	Eq 60
$F_M$	Fastener tensile preload	lb	Eq 57

(continued)