

AMERICAN NATIONAL STANDARD

*Accuracy Classification System -
Tangential Measurements for Cylindrical
Gears*

ANSI/AGMA 2015-1-A01



AGMA STANDARD

American National Standard

Accuracy Classification System - Tangential Measurements for Cylindrical Gears

ANSI/AGMA 2015-1-A01

[Revision of ANSI/AGMA 2000-A88]

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 quoted or extracted. Credit lines should read: Extracted from ANSI/AGMA 2015-1-A01, *Accuracy Classification System - Tangential Measurements for Cylindrical Gears*, with the permission of the publisher, the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314.]

Approved August 1, 2002

ABSTRACT

This standard, for spur and helical gearing, correlates gear accuracy grades with gear tooth tolerances. It provides information on minimum requirements for accuracy groups as well as gear measuring practices. Annex material provides guidance on filtering and information on comparison of gear inspection methods.

Published by

**American Gear Manufacturers Association
1500 King Street, Suite 201, Alexandria, Virginia 22314**

Copyright © 2002 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: 1-55589-797-5

Contents

	Page
Foreword	iv
1 Scope	1
2 Normative references	1
3 Symbols, terminology and definitions	2
4 Manufacturing and purchasing considerations	8
5 Application of the AGMA classification system	14
6 Measuring methods and practices	14
7 Tolerance values	14
8 Master gears	16

Annexes

A Tolerance tables	17
B Tolerance system development and comparison	21
C Example of statistical process control (SPC) application	31
D Involute and helix data filtering	33
E Sector pitch deviation	35

Bibliography	37
--------------------	----

Figures

1 Helix deviations	4
2 Profile deviations	5
3 Functional profile	6
4 Pitch deviations	7
5 Illustration of AGMA classification number	14

Tables

1 Alphabetical table of terms with symbols, by terms	2
2 Alphabetical table of symbols with terms, by symbols	3
3 Reference for methods and tolerances	9
4 Gear types and measurement methods	10
5 Minimum number of measurements	10

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 ANSI/AGMA Standard 2015-1-A01, *Accuracy Classification System – Tangential Measurements for Cylindrical Gears*.]

This standard provides tolerances for different gear accuracy grades from A2 to A11 for unassembled spur and helical gears. Applicable definitions are provided.

The purpose is to provide a common basis for specifying accuracy, and for the procurement of unassembled gears. It is not a design manual for determining the specific quality levels for a given application.

AGMA 390.03 of 1973 was a consolidation of several AGMA publications, including:

AGMA 235.02 (Feb. 1966), *Information Sheet for Master Gears*

AGMA 239.01 (Oct. 1965), *Measuring Methods and Practices Manual for Control of Spur, Helical and Herringbone Gears*

AGMA 239.01A (Sept. 1966), *Measuring Methods and Practices Manual for Control of Bevel and Hypoid Gears*, and parts of

AGMA 236.05 (ASA B6.11, June 1956), *Inspection of Fine-Pitch Gears*

AGMA 390.02 (Sept. 1964), *Gear Classification Manual* originally published as AGMA 390.01 (1961)

Data was added for Gear Rack and Fine-Pitch Worms and Wormgears. The former AGMA 390.02 for Coarse-Pitch and Fine-Pitch Spur, Helical and Herringbone Gearing was enhanced to offer a single, compatible classification system. The tolerance identifier “Q” was added to indicate that the tolerances in 390.03 apply. If Q is not used as a prefix in the quality number, tolerances in AGMA 390.01 and 390.02 applied.

ANSI/AGMA 2000-A88 was an update of those sections from AGMA 390.03 for parallel axis gears only. Additionally, the formulas stated the tolerances in metric terms. The content was revised, but basic tolerance levels were unchanged from AGMA 390.03. The other material in AGMA 390.03 on Bevels and Worms was replaced by ANSI/AGMA 2009-A99 and ANSI/AGMA 2011-A98, respectively. ANSI/AGMA 2000 was approved by AGMA membership in January 1988, and as a American National Standard Institute (ANSI) standard on March 31, 1988.

The user of this American National Standard is alerted that differences exist between it and ANSI/AGMA 2000-A88. Differences include, but are not limited to:

- Accuracy grade numbering system is reversed, such that the smallest number represents the smallest tolerance;
- Relative magnitudes of elemental tolerances for a single grade are in a different proportion;
- The “helix evaluation range”, where the tolerances are applied, are defined for less flank area than in ANSI/AGMA 2000-A88;
- The “K Chart” is not used for the permissible tolerance values;
- Runout is not included as one of the elements with a tolerance;
- Concepts of “mean measurement trace”, “design profile”, “slope deviation” and “form deviation” are added, similar to ISO 1328-1.

Therefore, the user of ANSI/AGMA 2015-1-A01 must be very careful when comparing tolerance values formerly specified using ANSI/AGMA 2000-A88.

ANSI/AGMA 2015-1-A01 is a replacement for ANSI/AGMA 2000-A88 and ANSI/AGMA ISO 1328-1. It is a complete revision, including accuracy grades, in order to be more compatible with ISO. It combines the grading system of ISO 1328-1 with the methods of ANSI/AGMA 2000-A88, and adds concepts of accuracy grade grouping for minimum measurement requirements, filtering, data density, and roughness limits to form deviations.

This revision was started by the AGMA Inspection and Handbook Committee in 1997. It was approved by the AGMA membership in June, 2001. It was approved as an American National Standard on August 1, 2002.

Suggestions for improvement of this standard will be welcome. They should be sent to the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314.

PERSONNEL of the AGMA Inspection and Handbook Committee

Chairman: Edward Lawson M&M Precision Systems Corp.

ACTIVE MEMBERS

D.R. Choiniere . . Profile Engineering, Inc.
 J. Clatworthy Gear Metrology, Inc.
 B.L. Cox BWXT Y-12, LLC
 T.C. Glasener . . . Xtek, Incorporated
 G.G. Grana The Gleason Works
 B. Hofrichter Arrow Gear Company
 I. Laskin Consultant

S. Lindley The Falk Corporation
 M. May The Gleason Works
 D.A. McCarroll . . . ZF Industries
 D.R. McVittie Gear Engineers, Inc.
 S. Moore Martin Sprocket & Gear, Inc.
 L.J. Smith Consultant
 R.E. Smith R.E. Smith & Company, Inc.

ASSOCIATE MEMBERS

M. Antosiewicz . . The Falk Corporation
 M.J. Barron Gear Motions, Inc.
 D. Behling Hamilton Sundstrand Aero.
 M.K. Considine . . Considine Associates
 R. Considine Considine Associates
 J.S. Cowan Eaton Corporation
 M.E. Cowan Process Equipment Co.
 B. Cowley Mahr Corporation
 C. Dick The Horsburgh & Scott Co.
 H.D. Dodd Caterpillar, Inc.
 R. Green R-7 Group, Gear Consultants
 D. Gregory Gear Products, Inc.
 B. Gudates Fairfield Manufacturing Co., Inc.
 J.S. Hamilton Regal-Beloit Corporation
 H. Harary NIST
 D. Heinrich Xtek, Incorporated
 G. Henriot Consultant
 J. Horwell Brown & Sharpe
 S. Johnson The Gear Works - Seattle, Inc.
 T. Klemm Liebherr
 D.E. Kosal National Broach & Machine Co.
 J. Koshiol Columbia Gear Corporation

W.E. Lake Mitsubishi Gear Tech.Center (AG)
 A.J. Lemanski Penn State University
 G.A. Luetkemeier . . Rockwell Automation/Dodge
 D. Matzo Northwest Gears, Inc.
 P.A. McNamara . . . Caterpillar, Inc.
 W.J. Michaels Sundstrand Corporation
 M. Milam Amarillo Gear Company
 T. Miller The Cincinnati Gear Company
 M. Nanlawala IIT Research Institute/INFAC
 M. Octrue Centre Technique Des Ind. Mec.
 T. Okamoto Nippon Gear Company, Ltd.
 J.A. Pennell Univ. of Newcastle-Upon-Tyne
 K.R. Price Eastman Kodak Company
 R.S. Ramberg The Gear Works - Seattle, Inc.
 V.Z. Rychlinski . . . Brad Foote Gear Works, Inc.
 D.H. Senkfor Precision Gear Company
 S. Shariff PMI Food Equipment Group
 E. Storm Consultant
 T. Waldie Philadelphia Gear Corporation
 R.F. Wasilewski . . . Arrow Gear Company
 F.M. Young Forest City Gear Company
 P. Zwart Caterpillar, Inc.

American National Standard – Accuracy Classification System – Tangential Measurements for Cylindrical Gears

1 Scope

This part of ANSI/AGMA 2015 establishes an accuracy grade system relevant to tangential measurements on flanks of individual cylindrical involute gears.

It specifies definitions for gear tooth accuracy terms, the structure of the gear accuracy grade system, and allowable values.

It is strongly recommended that any user of this part of ANSI/AGMA 2015 be very familiar with the methods and procedures outlined in AGMA 915-1-A02. Use of techniques other than those of AGMA 915-1-A02 combined with the limits described in this part of ANSI/AGMA 2015 may not be suitable.

This standard provides the gear manufacturer and the gear buyer with a mutually advantageous reference for uniform tolerances. Ten accuracy grades are defined in this standard, numbered A2 through A11, in order of decreasing precision.

1.1 Equations for tolerances

Equations for tolerances and their ranges of validity are provided in 7.2 for the defined accuracy of gearing. In general, these tolerances cover the following ranges:

$$\begin{aligned} 5 &\leq z \leq 1000 \text{ or } 10\,000/m_n \text{ whichever is less} \\ 5 \text{ mm} &\leq D \leq 10\,000 \text{ mm} \\ 0.5 &\leq m_n \leq 50 \\ 4 \text{ mm} &\leq b \leq 1000 \text{ mm} \\ \beta &\leq 45^\circ \end{aligned}$$

where

- D is pitch diameter;
- m_n is normal module;
- b is facewidth (axial);
- z is number of teeth;
- β is helix angle.

See clause 4 for required and optional measuring methods.

1.2 Exceptions

This standard does not apply to enclosed gear unit assemblies, including speed reducers or increasers, gear motors, shaft mounted reducers, high speed units, or other enclosed gear units which are manufactured for a given power, speed, ratio or application.

Gear design is beyond the scope of this standard. The use of the accuracy grades for the determination of gear performance requires extensive experience with specific applications. Therefore, the users of this standard are cautioned against the direct application of tolerance values to a projected performance of unassembled (loose) gears when they are assembled. Refer to the latest AGMA Publications Index for applicable standards.

NOTE: Tolerance values for gears outside the limits stated in this standard should be established by determining the specific application requirements. This may require setting a tolerance smaller than calculated by the formulas in this standard.

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.

AGMA 915-1-A02, *Inspection Practices – Part 1: Cylindrical Gears – Tangential Measurements*

AGMA 915-3-A99, *Inspection Practices – Gear Blanks, Shaft Center Distance and Parallelism*

ANSI/AGMA 1012-F90, *Gear Nomenclature, Definitions of Terms with Symbols*

ANSI/AGMA 2110-A94, *Measuring Instrument Calibration – Part I, Involute Measurement (Metric)*

ANSI/AGMA 2113-A97, *Measuring Instrument Calibration, Gear Tooth Alignment Measurement*

ANSI/AGMA 2114-A98, *Measuring Instrument Calibration, Gear Pitch and Runout Measurements*

ISO 701:1998, *International gear notation – Symbols for geometrical data*

3 Symbols, terminology and definitions

The symbols, terminology and definitions pertaining to the tolerances and inspection of spur and helical gear teeth are listed here for use in this standard. For other definitions of geometric terms related to gearing, see ANSI/AGMA 1012-F90.

NOTE: Some of the symbols and terminology contained in this document may differ from those used in other documents and AGMA standards. Users of this standard should assure themselves that they are using the symbols, terminology and definitions in the manner indicated herein.

3.1 Fundamental terms and symbols

The terminology and symbols used in this standard are listed alphabetically by term in table 1, and alphabetically by symbol in table 2.

3.2 Definitions

cumulative pitch deviation, total, F_p The largest algebraic difference between the index deviation values for a specified flank.

Distinction is not made as to the direction or algebraic sign of this reading. Such a distinction would require a purely arbitrary specification of a direction (clockwise or counterclockwise) traveled between the two teeth comprising the total cumulative pitch deviation.

Table 1 – Alphabetical table of terms with symbols, by terms

Terms	Symbol	Units	Where used
Accuracy grade	A	– –	7.1.2
Accuracy grade identifier prefix	A	– –	1
Contact pattern measurement	c_p	– –	Table 3
Cumulative pitch deviation, total	F_p	μm	3.2
Cumulative pitch deviation tolerance, total	F_{pT}	μm	7.2.2
Design outside diameter	D_o	mm	Eq 2
Diameter, pitch	D	mm	1.1
Facewidth (axial)	b	mm	1.1
Functional profile length	$L_{\alpha c}$	mm	3.2
Gear form filter cutoff	λ_g	mm	Eq 1
Helix angle	β	deg	1.1
Helix deviation, total	F_β	μm	3.2
Helix evaluation range	L_β	mm	3.2
Helix form deviation	$f_{f\beta}$	μm	3.2
Helix form tolerance	$f_{f\beta T}$	μm	7.2.6.3
Helix slope deviation	$f_{H\beta}$	μm	3.2
Helix slope tolerance	$f_{H\beta T}$	μm	7.2.6.2
Helix tolerance, total	$F_{\beta T}$	μm	7.2.6.1
Normal module	m_n	mm	1.1
Number of teeth	z	– –	1.1
Number of pitches in a sector	k	– –	Figure 4
Pitch, transverse circular	p_t	mm	Figure 4
Profile deviation, total	F_α	μm	3.2
Profile form deviation	$f_{f\alpha}$	μm	3.2
Profile form tolerance	$f_{f\alpha T}$	μm	7.2.5.3
Profile slope deviation	$f_{H\alpha}$	μm	3.2
Profile slope tolerance	$f_{H\alpha T}$	μm	7.2.5.2

(continued)

Table 1 (concluded)

Terms	Symbol	Units	Where used
Profile tolerance, total	$F_{\alpha T}$	μm	7.2.5.1
Single flank composite deviation, tooth-to-tooth (filtered)	f_{is}	μm	3.2
Single flank composite deviation, total	F_{is}	μm	3.2
Single flank composite tolerance, tooth-to-tooth	f_{isT}	μm	7.2.3
Single flank composite tolerance, total	F_{isT}	μm	7.2.4
Single pitch deviation	f_{pt}	μm	3.2
Single pitch deviation tolerance	f_{ptT}	μm	7.2.1
Tolerance diameter	d_T	mm	3.2
Tooth thickness measurement	s	--	Table 3

Table 2 - Alphabetical table of symbols with terms, by symbols

Symbol	Terms	Units	Where used
A	Accuracy grade identifier prefix	--	1
A	Accuracy grade	--	7.1.2
b	Facewidth (axial)	mm	1.1
c_p	Contact pattern measurement	--	Table 3
D	Diameter, pitch	mm	1.1
D_o	Design outside diameter	mm	Eq 2
d_T	Tolerance diameter	mm	3.2
F_{is}	Single flank composite deviation, total	μm	3.2
F_{isT}	Single flank composite tolerance, total	μm	7.2.4
F_p	Cumulative pitch deviation, total	μm	3.2
F_{pT}	Cumulative pitch deviation tolerance, total	μm	7.2.2
F_{α}	Profile deviation, total	μm	3.2
$F_{\alpha T}$	Profile tolerance, total	μm	7.2.5.1
F_{β}	Helix deviation, total	μm	3.2
$F_{\beta T}$	Helix tolerance, total	μm	7.2.6.1
f_{α}	Profile form deviation	μm	3.2
$f_{\alpha T}$	Profile form tolerance	μm	7.2.5.3
f_{β}	Helix form deviation	μm	3.2
$f_{\beta T}$	Helix form tolerance	μm	7.2.6.3
$f_{H\alpha}$	Profile slope deviation	μm	3.2
$f_{H\alpha T}$	Profile slope tolerance	μm	7.2.5.2
$f_{H\beta}$	Helix slope deviation	μm	3.2
$f_{H\beta T}$	Helix slope tolerance	μm	7.2.6.2
f_{is}	Single flank composite deviation, tooth-to-tooth (filtered)	μm	3.2
f_{isT}	Single flank composite tolerance, tooth-to-tooth	μm	7.2.3
f_{pt}	Single pitch deviation	μm	3.2
f_{ptT}	Single pitch deviation tolerance	μm	7.2.1
k	Number of pitches in a sector	--	Figure 4
$L_{\alpha c}$	Functional profile length	mm	3.2
L_{β}	Helix evaluation range	mm	3.2
m_n	Normal module	mm	1.1
p_t	Pitch, transverse circular	mm	Figure 4
s	Tooth thickness measurement	--	Table 3
z	Number of teeth	--	1.1
β	Helix angle	deg	1.1
λ_g	Gear form filter cutoff	mm	Eq 1

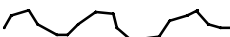
This standard specifies direction of tolerancing for total cumulative pitch deviation to be along the arc of the tolerance diameter, d_T , circle within the transverse plane. Tolerances for total cumulative pitch deviation are provided by the formula in 7.2.2 of this standard.

datum axis The datum axis of the gear is defined by

the datum surfaces. It is the axis to which the gear details, and in particular the pitch, profile, and helix tolerances are defined. See AGMA 915-3-A99.

design helix The helix specified by the designer as shown on the design specification. When not specified, it is an unmodified helix. See figure 1.

Key

— — — — — : Design helix  : Measured helix - - - - - : Mean helix line

- i) Design helix: unmodified helix
Measured helix: with minus material outside the evaluation range
- ii) Design helix: modified helix (example)
Measured helix: with minus material outside the evaluation range
- iii) Design helix: modified helix (example)
Measured helix: with excess of material outside the evaluation range

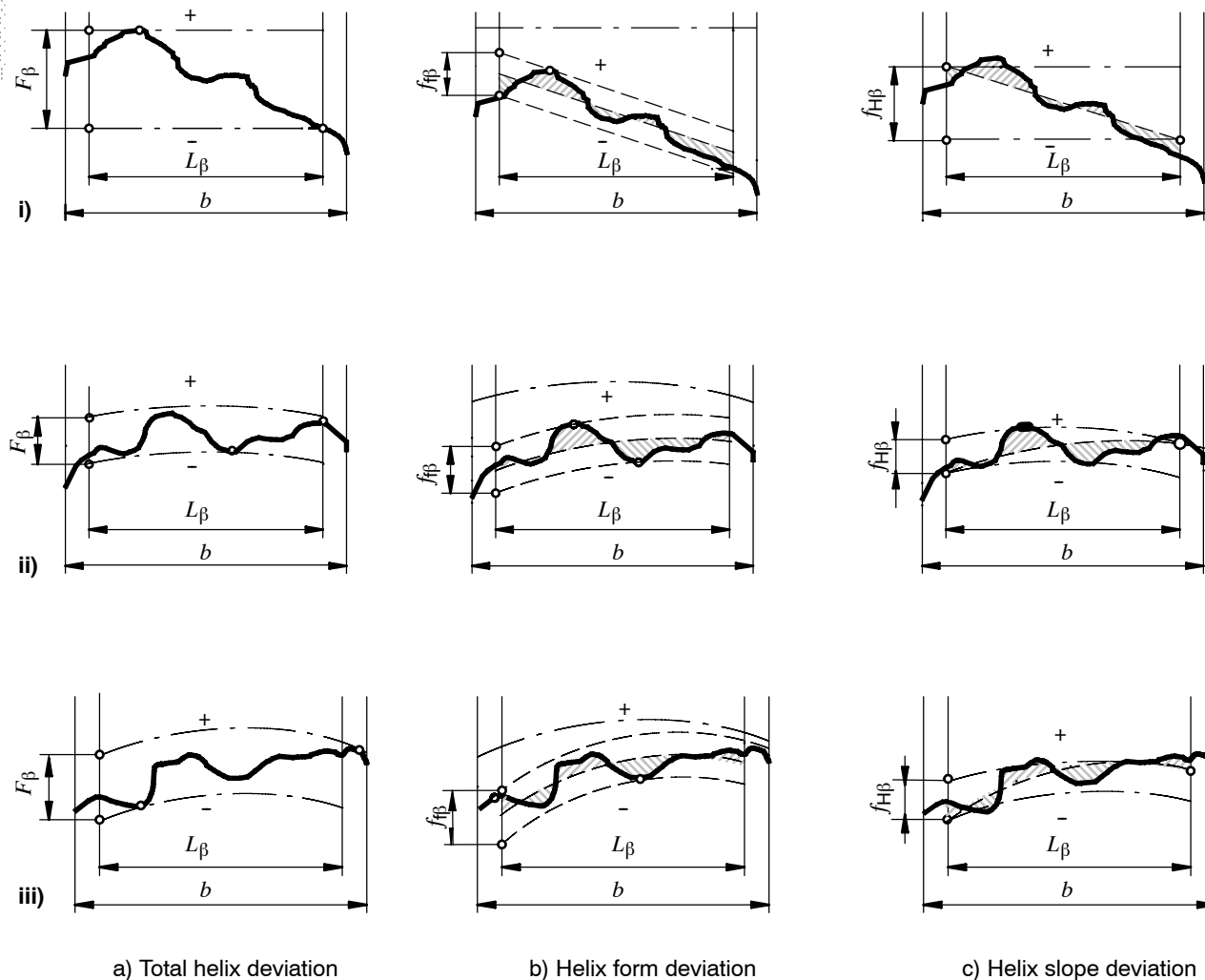
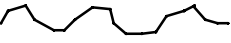


Figure 1 - Helix deviations

design profile The profile specified by the designer as shown on the design specification. When not specified, it is an unmodified involute. See figure 2.

functional profile That portion of the tooth flank between the profile control diameter and the start of tip break.

Key

— : Design profile  : Measured profile - - - - : Mean profile line

TB Start of tip break
CD Profile control diameter

- i) Design profile: unmodified involute
Measured profile: with minus material outside the evaluation range
- ii) Design profile: modified involute (example with tip relief only)
Measured profile: with minus material outside the evaluation range
- iii) Design profile: modified involute (example with full contour)
Measured profile: with excess of material near the tip

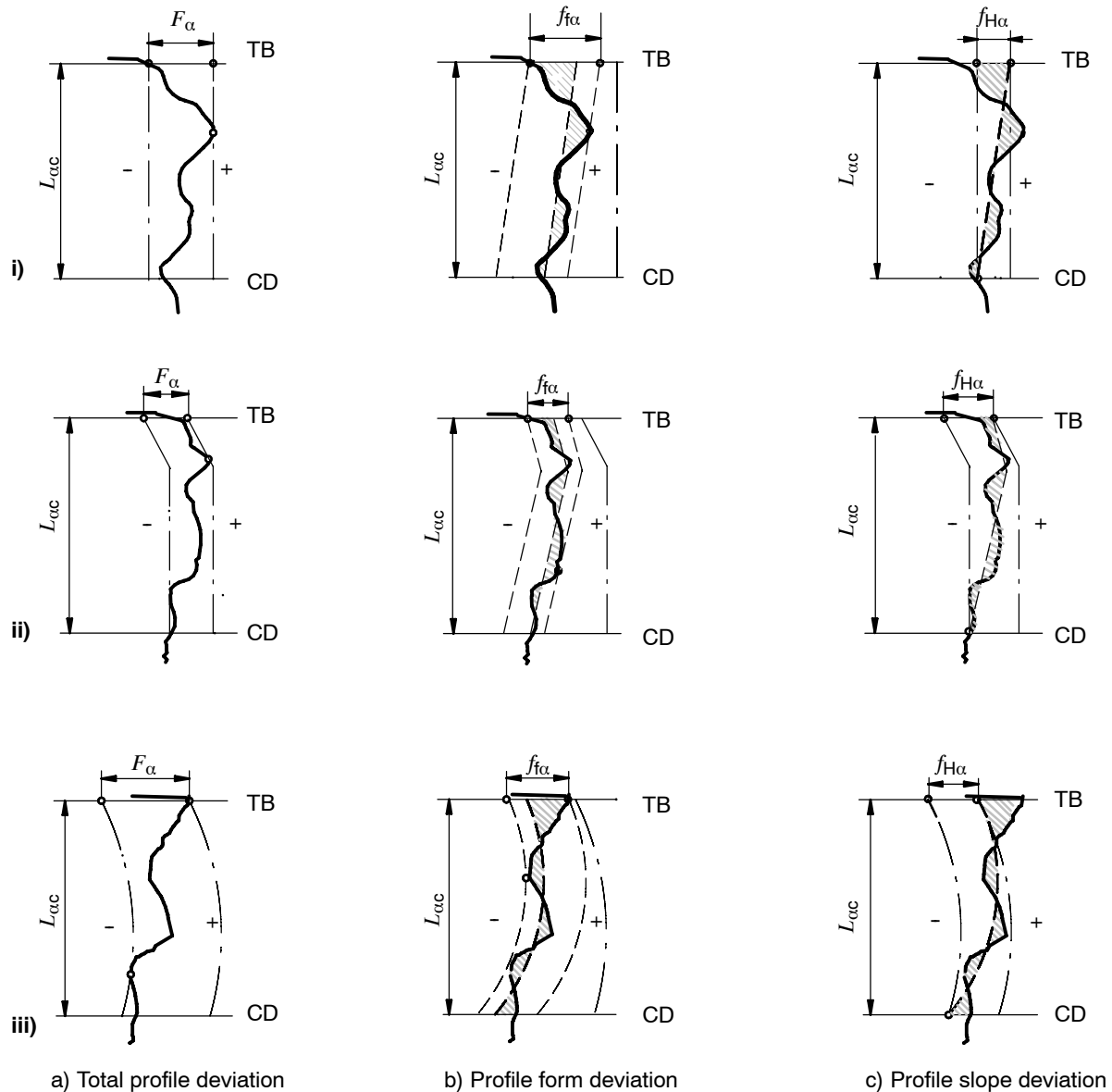


Figure 2 - Profile deviations

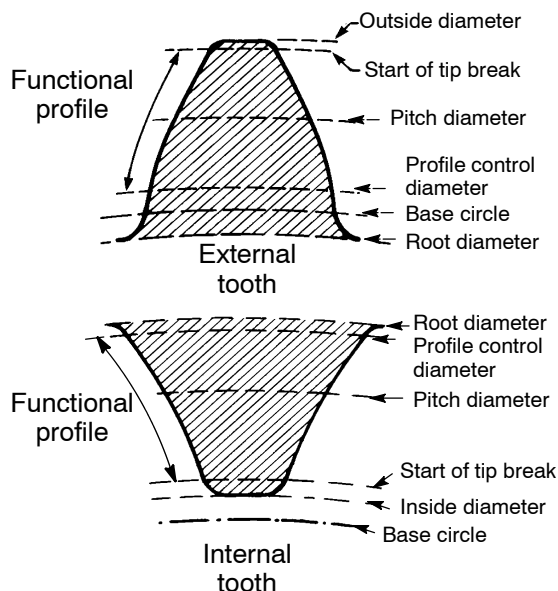


Figure 3 - Functional profile

functional profile length, L_{ac} The difference between the roll path lengths at the points that define the limits of the functional profile.

gear form filter cutoff, λ_g The wavelength at which either involute profile or helix measurement data are segregated by the low-pass filter, thereby including only longer wavelength deviations.

This filter cutoff should be stated in terms of roll path length. It shall be calculated as follows:

$$\lambda_g = \frac{L_{ac}}{30} \text{ but not less than } 0.25 \text{ mm} \quad (1)$$

where

λ_g is the gear form filter cutoff, mm.

helix deviation Amount by which a measured helix deviates from the design helix. Deviations caused by plus material outside the helix evaluation range must be included in the calculation of helix form deviation, $f_{H\beta}$, and total helix deviation, $F_{H\beta}$. Minus material outside the helix evaluation range may be ignored. This standard specifies the direction of tolerancing for helix deviation to be in a transverse plane, on a line tangent to the base circle.

helix deviation, total, $F_{H\beta}$ Distance between two design helix lines which enclose the actual helix trace over the evaluation range, L_{β} , see figure 1a.

helix evaluation range, L_{β} Unless otherwise specified, the helix length of trace shortened at each end by the smaller of the following two values: 5% of the helix length of trace, or the length equal to one module.

NOTE: It is the responsibility of the gear designer to assure that the helix evaluation range is adequate for the application.

helix form deviation, $f_{H\beta}$ Distance between two facsimiles of the mean helix line, which are each placed with constant separation from the mean helix line, so as to enclose the actual helix trace over the evaluation range, L_{β} , see figure 1b.

helix length of trace Unless otherwise specified, full facewidth is limited toward the ends of the teeth by the end faces or, if present, the start of end chamfers, rounds, or other modification intended to exclude that portion of the tooth from engagement. The helix length of trace should be stated as the axial component of the helix.

helix slope deviation, $f_{H\beta}$ Distance between two design helix lines which intersect the mean helix line at the end points of the evaluation range, L_{β} , see figure 1c.

Deviations are deemed to be positive when helix angles are larger and negative when helix angles are smaller, than the designed helix angle. The helix deviations of spur gears if other than zero are indicated by the subscripts "R" and "L", instead of an algebraic sign, implying deviations in the sense of right or left helices respectively.

index deviation The displacement of any tooth flank from its theoretical position, relative to a datum tooth flank, see figure 4.

Distinction is made as to the direction and algebraic sign of this reading. A condition wherein the actual tooth flank position was nearer to the datum tooth flank, in the specified measuring path direction (clockwise or counterclockwise), than the theoretical position would be considered a minus (-) deviation. A condition wherein the actual tooth flank position was farther from the datum tooth flank, in the specified measuring path direction, than the theoretical position would be considered a plus (+) deviation.

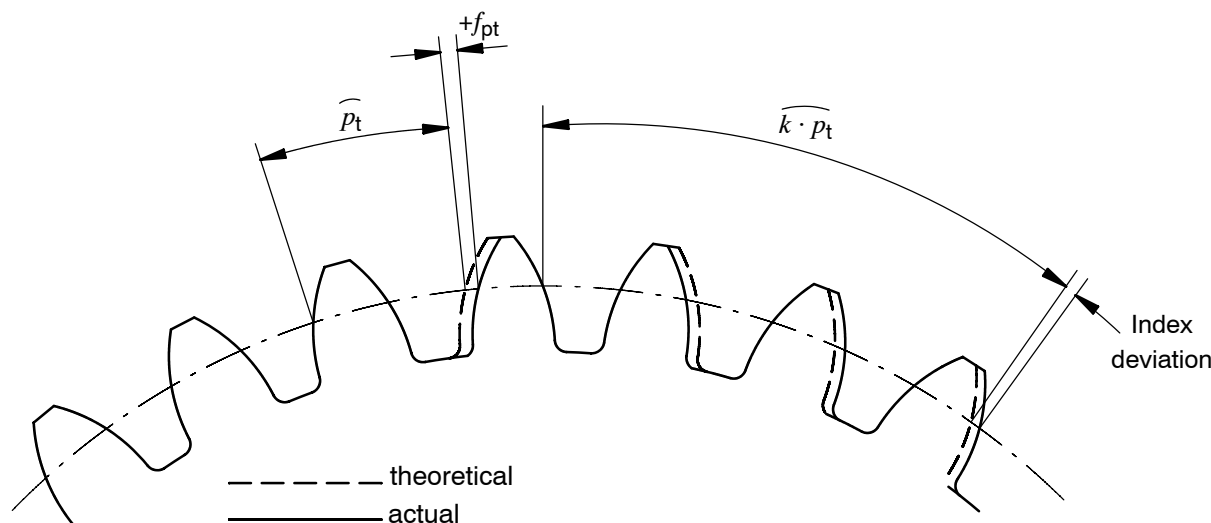


Figure 4 - Pitch deviations

This standard specifies direction of tolerancing for index deviation to be along the arc of the tolerance diameter, d_T , circle within the transverse plane.

mean helix line A line (or curve) that has the same shape as the design helix, but aligned with the measured trace. It is developed by subtracting the ordinates of a straight-line gradient from the ordinates of the design helix. Within the evaluation range, L_β , the straight-line gradient is found by applying the least squares method to the deviation of the measured helix trace from the specified design helix.

NOTE: This helix is an aid in the determination of the deviations $f_{t\beta}$ (figure 1b) and $f_{H\beta}$ (figure 1c).

mean profile line A line (or curve) that has the same shape as the design profile, but aligned with the measured trace. It is developed by subtracting the ordinates of a straight-line gradient from the ordinates of the design profile. Within the functional profile length, $L_{\alpha c}$, the straight-line gradient is found by applying the least squares method to the deviation of the measured profile trace from the specified design profile.

NOTE: This profile is an aid in the determination of $f_{t\alpha}$ (figure 2b) and $f_{H\alpha}$ (figure 2c).

profile control diameter A specified diameter of the circle beyond which the tooth profile must conform to the specified involute curve. See functional profile.

profile deviation Amount by which a measured profile deviates from the design profile. Deviations caused by plus material beyond the tip break must

be included in the calculation of the profile form deviation, $f_{t\alpha}$, and total profile deviation, F_α . Minus material beyond the tip break may be ignored. This standard specifies the direction of tolerancing for profile deviation to be in a transverse plane, on a line tangent to the base circle.

profile deviation, total, F_α Distance between two design profile lines which enclose the actual profile trace over the functional profile length, $L_{\alpha c}$, see figure 2a.

profile evaluation range The profile is evaluated over the specified functional profile length.

profile form deviation, $f_{t\alpha}$ Distance between two facsimiles of the mean profile line, which are each placed with constant separation from the mean profile line, so as to enclose the actual profile trace over the functional profile length, $L_{\alpha c}$, see figure 2b.

profile slope deviation, $f_{H\alpha}$ Distance between two design profile lines which intersect the mean profile line at the endpoints of the functional profile length, $L_{\alpha c}$, see figure 2c.

The profile slope deviation is deemed to be positive and the corresponding pressure angle deviation is deemed to be negative when the mean profile line shows an increase in material toward the tooth tip, relative to the design profile.

roll path length The linear distance along a base tangent line from its intersection with the base circle to the given point on the involute curve in the transverse plane.

NOTE: Roll path length is an alternative to roll angle for specification of selected diameter positions on an involute profile.

single flank composite test A test of transmission error, performed where mating gears are rolled together, at their proper center distance, with backlash, and with only the driving and driven flanks in contact. Deviations are measured in terms of angular displacement and converted to linear displacement at the pitch radius.

single flank composite deviation, tooth-to-tooth (filtered), f_{is} The value of the greatest single flank composite deviation over any one pitch ($360/z$), after removal of the long term component (sinusoidal effect of eccentricity), during a single flank composite test, when the gear is moved through one revolution.

single flank composite deviation, total, F_{is} The maximum measured transmission error range, during a single flank composite test, when the gear is moved through one revolution.

single pitch deviation, f_{pt} The displacement of any tooth flank from its theoretical position relative to the corresponding flank of an adjacent tooth, see figure 4.

Distinction is made as to the algebraic sign of this reading. Thus, a condition wherein the actual tooth flank position was nearer to the adjacent tooth flank than the theoretical position would be considered a minus (–) deviation. A condition wherein the actual tooth flank position was farther from the adjacent tooth flank than the theoretical position would be considered a plus (+) deviation.

This standard specifies tolerancing direction of measurement for single pitch deviation to be along the arc of the tolerance diameter, d_T , circle within the transverse plane. Tolerances for single pitch deviation are provided by the formula in 7.2.1 of this standard.

start of tip break Minimum specified diameter at which the tip break can occur. See ANSI/AGMA 1012-F90.

tolerance diameter, d_T The diameter located one normal module below the design outside diameter, thereby being approximately at mid-height.

$$d_T = D_o - 2m_n \quad (2)$$

where:

d_T is tolerance diameter, mm;

D_o is design outside diameter, mm;

m_n is normal module, mm.

The location of pitch and helix measurements shall be at the tolerance diameter. See 4.3.3.

transmission error The deviation of the position of the driven gear, for a given angular position of the driving gear, from the position that the driven gear would occupy if the gears were geometrically perfect.

4 Manufacturing and purchasing considerations

This standard provides classification tolerances and measuring methods for unassembled gears. This clause presents considerations for control of the various phases of manufacturing, including the recommended methods of measurement control.

These methods provide the manufacturer and purchaser with recommendations for verifying the accuracy of a manufactured product, as well as information relative to the interpretation of measurement data.

Some design and application considerations may warrant measuring or documentation not normally available in standard manufacturing processes. Specific requirements are to be stated in the contractual documents.

In the previous (AGMA 2000-A88) classification system, higher AGMA accuracy numbers designated higher precision. In this standard, lower AGMA accuracy grades designate higher precision in order to be consistent with international standards. To avoid confusion, the designator “A” shall be used when specifying accuracy grades from this standard.

4.1 Manufacturing certification

Certification of variations in accordance with the gear's specific AGMA accuracy grade and inspection charts or data can be requested as part of the purchase contract.

The manufacturing of gearing to a specified accuracy may or may not include specific measurements. When applications warrant, detailed specific measurements, data analysis, and additional considerations may be necessary to establish acceptance criteria for a gear. The specific methods of measurement, documentation of accuracy grade, and other geometric tolerances of a gear are