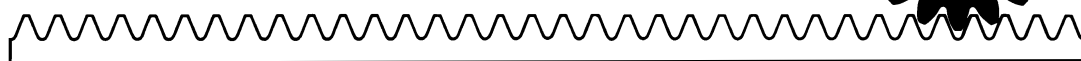


AMERICAN NATIONAL STANDARD

*Accuracy Classification System - Radial
Measurements for Cylindrical Gears*



AGMA STANDARD

American National Standard

Accuracy Classification System - Radial Measurements for Cylindrical Gears

ANSI/AGMA 2015-2-A06

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Approved June 22, 2006

ABSTRACT

This standard establishes a classification system relevant to radial (double flank) composite deviations of individual cylindrical involute gears. It serves as a concise means of specifying gear accuracy without the immediate need of supplying individual tolerances. It simplifies discussions of gear accuracy between gear manufacturer and purchaser. It specifies the appropriate definitions of gear tooth accuracy terms, the structure of the gear accuracy system and the tolerances (allowable values of the deviations). Annex A provides information on the accuracy of master gears. Annex B provides information on runout tolerance values.

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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 Standard 2015-2-A06, *Accuracy Classification System - Radial Measurements for Cylindrical Gears*.]

This standard provides tolerances for different gear accuracy grades from C4 to C12 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. 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 the AGMA membership in January 1988, and as a American National Standard Institute (ANSI) standard on March 31, 1988.

ANSI/AGMA 2015-2-A06 combines the grading system of ISO 1328-2:1997 with the methods of ANSI/AGMA 2000-A88 and ISO/TR 10064-2:1996. The descriptions and measuring methods that were in ISO 1328:1975 were put in ISO/TR 10064-2 and are included in AGMA 915-2-A05. ANSI/AGMA 2015-2-A06 and AGMA 915-2-A05 are made to work together as a system.

The user of this American National Standard is alerted that numerous differences exist between it and ANSI/AGMA 2000-A88. A major difference is the accuracy grade numbering system has been reversed, such that the smallest number represents the smallest tolerance. The tooth-to-tooth data should be filtered before comparing to the tolerance; previously unfiltered data was used. The user of ANSI/AGMA 2015-2-A06 must be very careful when comparing tolerance values formerly specified using ANSI/AGMA 2000-A88.

The first draft of AGMA 2015-2-A06 was made in April, 1998. It was approved by the AGMA membership in July, 2006. It was approved as an American National Standard on June 22, 2006.

Suggestions for improvement of this standard will be welcome. They should be sent to the American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314.

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

1 Scope

This part of ANSI/AGMA 2015 establishes a system of accuracy relevant to radial composite deviations of individual cylindrical involute gears. It specifies the appropriate definitions of gear tooth accuracy terms, the structure of the gear accuracy system and the allowable values of the above mentioned deviations.

The radial measurement accuracy system has different grade ranges than the elemental ranges in ANSI/AGMA 2015-1-A01. The diameter and module ranges for radial composite deviations and runout are also different.

The radial composite accuracy system comprises 9 accuracy grades for total or tooth-to-tooth radial composite deviations of which grade C4 is the most accurate and grade C12 is the least accurate. This standard is for the ranges:

$$0.2 \leq m_n \leq 5$$

$$2 \text{ mm} \leq d \leq 1000 \text{ mm}$$

$$3 \leq z \leq 1000$$

$$\beta \leq 45^\circ$$

where

m_n is normal module;

d is reference pitch diameter;

z is number of teeth;

β is helix angle.

See clause 7 for tolerances.

Annex A provides information on master gear design and tolerances. Annex B provides information on runout, including an equation for determining the tolerance, for use if agreed upon between manufacturer and purchaser.

There is no correlation between accuracy grades of elemental measurements specified by ANSI/AGMA 2015-1-A01 and radial composite measurements.

2 Normative references

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions were valid. All publications are subject to revision, and the users of this standard are encouraged to investigate the possibility of applying the most recent editions of the publications listed.

AGMA 915-2-A05, *Inspection Practices – Part 2: Cylindrical Gears – Radial Measurements*

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

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

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

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

3 Symbols, terminology and definitions

The 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-G05.

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 Symbols

Symbols are based on those given in ISO 701, see table 1.

3.2 Definitions

master gear. A master gear is a gear of known accuracy, designed to mesh with the gear to be inspected for radial composite deviation.

product gear. The “product gear” is the gear which is being measured or evaluated.

tooth-to-tooth radial composite deviation, f_{id} . Tooth-to-tooth radial composite deviation is the value of the greatest radial composite deviation within any one pitch, $360^\circ/z$, when the product gear with its right and left flank simultaneously in contact with those of the master gear, is turned through one complete revolution, see figure 1.

The long term component sinusoidal effect of eccentricity should be removed from the wave form before determining the tooth-to-tooth deviation value, see figure 2 and clause 4.5.2.

total radial composite deviation, F_{id} . Total radial composite deviation is the difference between the maximum and minimum values of center distance which occur during a radial (double-flank) composite test. Figure 1 shows an example of a relevant diagram.

Table 1 - Symbols and terms

Symbol	Term	Units
C	Accuracy grade number	-
d	Reference pitch diameter	mm
F_{id}	Radial composite deviation, total	μm
F_{idT}	Radial composite tolerance, total	μm
f_{id}	Tooth-to-tooth radial composite deviation	μm
f_{idT}	Tooth-to-tooth radial composite tolerance	μm
$L_{\alpha c}$	Functional profile length	mm
m_n	Normal module	mm
z	Number of teeth	-
α	Pressure angle	degrees
β	Helix angle	degrees
ε_β	Overlap ratio	-

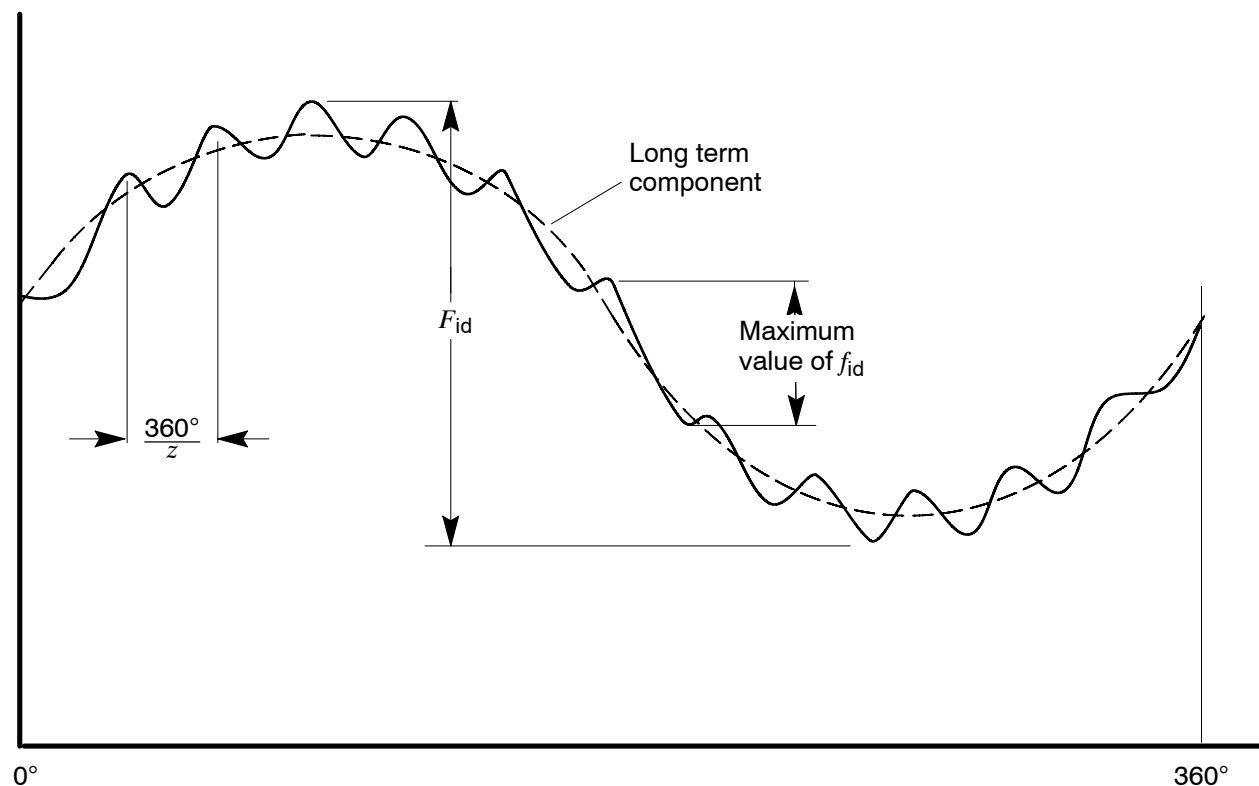


Figure 1 - Radial composite deviation diagram

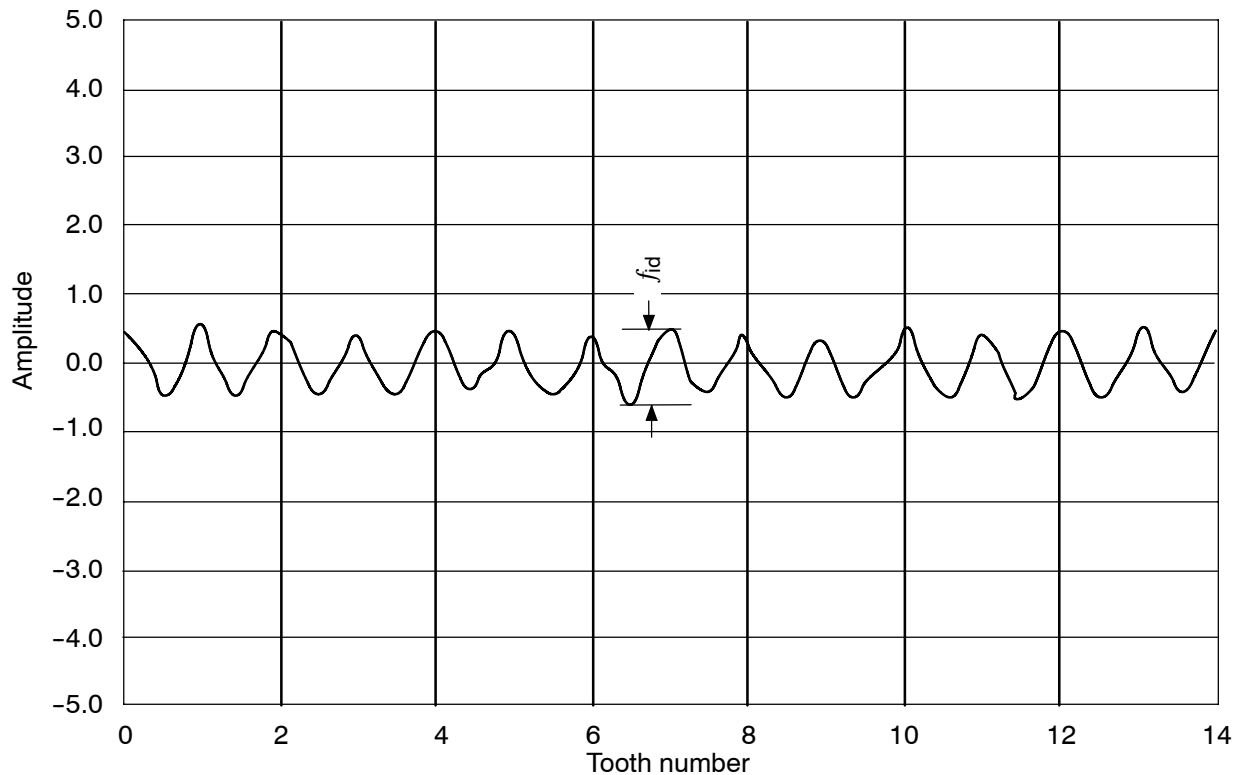


Figure 2 - Tooth-to-tooth radial composite deviation diagram, long term component removed

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 included with standard manufacturing processes. Specific requirements are to be stated in the contractual documents.

4.1 Manufacturing certification

Certification of conformance with a 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 normally considered items which are to be mutually agreed upon between manufacturer and purchaser.

NOTE: Specifying an AGMA accuracy grade or measurement criteria that requires closer tolerances than required by the application may increase the cost unnecessarily.

4.2 Process control

Process control is defined as the method by which gear accuracy is maintained through control of each individual step of the manufacturing process. Upon completion of all manufacturing operations, a specific gear has been given an inherent level of accuracy; this level of accuracy was established during the manufacturing process, and it is independent of any final inspection.

Process control includes elements such as manufacturing planning, maintenance of machine tools, cutting tool selection and maintenance, heat treatment control, and accuracy assurance programs, as needed, to achieve and maintain the

necessary gear accuracy. When properly applied, gears manufactured by specific control techniques will be found to be of uniform accuracy. Therefore, little or no final inspection may be necessary for a gear, particularly in some classification levels, assurance of the necessary accuracy having been built-in through careful manufacturing control at each step.

NOTE: Documentation may be deemed unnecessary for products manufactured under process control when inspection records are not specified in the purchase contract.

Gears made in quantity may be inspected at various steps in their manufacturing process on a statistical basis. It is possible that a specific gear can pass through the entire production process without ever having been measured. Based on appropriate confidence in the applied process control, the manufacturer of that gear must be able to certify that its quality is equal to those gears that were measured.

For information on the use of statistical process control, see ANSI/AGMA 2015-1-A01, annex C.

4.3 Measurement methods

In this standard, gear accuracy is qualified by observation of total radial composite deviation, F_{id} , and tooth-to-tooth radial composite deviation, f_{id} .

The manufacturer or the purchaser may wish to observe one or more of the functional characteristics provided in this standard. However, a gear that is specified to an AGMA accuracy grade must meet all applicable individual tolerance requirements.

When measurement according to this standard is specified, unless otherwise agreed upon, the manufacturer may select:

- the measurement method to be used from among the applicable methods described in AGMA 915-2-A05;
- the piece of measurement equipment to be used by the selected measurement method, provided it is in proper calibration;
- the master gear to be used, as long as it meets the requirements provided in annex A.

NOTE 1: This standard provides tolerances for unassembled gears. The measurement of gearing mated in an assembly for a specific application is beyond the scope of this document.

NOTE 2: When applications require measurements beyond those recommended in this standard, special measurement methods should be negotiated prior to manufacturing the gear.

4.3.1 Equipment verification

Equipment used for the composite measurement of product gears shall be verified periodically according to standard calibration procedures, such as those in ANSI/AGMA 2116-A05. This should also include a determination of the uncertainty of the measuring process.

4.3.2 Datum axis

Specification of gear geometry requires definition of an appropriate reference axis of rotation, called the datum axis. It is defined by specification of datum surfaces, see AGMA 915-3-A99. The datum axis is the reference for measurements and associated tolerances.

4.4 Additional considerations

When specifying the accuracy of a gear, there are additional or special considerations that must be reviewed. These considerations may include items such as:

- backlash allowance in tooth thickness;
- materials furnished by the purchaser;
- matching gears as sets;
- master gears for composite measurement;
- replacement gearing;
- modified AGMA accuracy grade;
- center distance and backlash markings on gear and pinion;
- record of tooth contact patterns by photographs, transfer tapes, etc.

The listed items and other special considerations should be reviewed and agreed upon by the manufacturer and purchaser.

4.4.1 Backlash

An individual gear does not have backlash. Backlash is only present when one gear mates with another. The backlash of a gear set is dependent upon tooth thickness, runout, tooth geometry of each member in mesh, and their operating center distance.

The methods of determining the backlash and backlash tolerances required for individual applications are beyond the scope of this standard (for additional information see ANSI/AGMA 2002-B88).

4.4.2 Material furnished by the purchaser

When heat treating, plating or other finishing operations are required, the gear manufacturer shall assume responsibility for the final accuracy only when the material furnished by the purchaser is in accordance with the agreed upon specifications, or so specified in the purchasing contract.

4.4.3 Matching gears as sets

Matched sets can be provided and are required in many applications. In such a case, the manufacturer and purchaser shall agree on the details of the additional specifications concerning how the matching is to be performed and verified. Applications requiring high accuracy gearing may necessitate the matching, or modifying, of pinion and gear profiles and helix such that the matched set is satisfactory for the application. When gears are sold as matching pairs, the matching process assumes greater importance than the individual gear measurements.

NOTE: This standard provides tolerances for unassembled gears only. The inspection of gearing mated in an assembly for a specific application is beyond the scope of this standard.

4.4.4 Master gears for composite action tests

A master gear shall be used for radial composite tests. The design, accuracy, and cost of a master gear shall be negotiated between the manufacturer and purchaser of the product gear. Providing or manufacturing a special master gear should be scheduled to be available when the manufactured gear is to be inspected by composite measurements.

The master gear for a radial composite test should engage the product gear over the functional profile length, L_{ac} , as defined in ANSI/AGMA 2015-1-A01. It should also explore the full active facewidth of the mating gear.

Master gears are subject to wear and should be periodically verified.

See annex A for additional master gear information.

4.4.5 Modified AGMA accuracy grade

Conditions may require that one of the individual elements of composite tolerances be of a lower or higher accuracy grade. In such cases, it is possible to modify the accuracy grade to include an accuracy grade for each composite tolerance.

4.5 Acceptance criteria

The tolerances, methods and definitions contained in this standard prevail unless contractual agreements between manufacturer and purchaser contain specific exceptions.

The tolerances for radial composite deviation apply to the inspection of a gear running with a master gear. They should only be applied to the measurement of two product gears running together with prior agreement between manufacturer and purchaser.

4.5.1 Evaluation of accuracy grade

The overall accuracy grade of a gear is determined by the largest accuracy grade number measured for any tolerated parameter specified for the gear by this standard.

Measurement uncertainty should be considered when determining conformance.

4.5.2 Evaluation of tooth-to-tooth composite deviation

Tooth-to-tooth composite deviation can be greatly influenced by pitchline runout, especially on gears with low numbers of teeth. The true tooth-to-tooth deviation value should be analyzed by use of a filter to remove the influence of eccentricity, see AGMA 915-2-A05, clause 4.8. The tolerance values in 7.2 apply with or without the use of an eccentricity filter.

5 Application of the AGMA classification system

5.1 Correlation of composite and element deviations

The accuracy grade determined for a gear measured with the composite methods of this standard may be different from the accuracy grade determined for that gear by the elemental methods of ANSI/AGMA 2015-1-A01. Users are cautioned that specification to AGMA 2015-2-A06 alone provides no control over deviations of index or total cumulative pitch that may occur without radial deviations. See AGMA 915-1-A02 and AGMA 915-2-A05, clause 7.6 for more information on index deviation.

There is a general tendency for increased elemental deviations to result in increased composite deviations. However, it is possible for large elemental deviations to be compensatory in nature, resulting in very small composite deviations. In such cases,

gears may provide excellent functional performance in application despite large elemental deviations.

The relationship between elemental deviations and resulting composite deviations and functional performance is also affected by the contact ratio of the gear set.

5.2 Basis of classification system

The AGMA classification system is an alphanumeric code which contains two items, accuracy grade and prefix. The AGMA classification number specifying tolerances according to this document shall consist of a prefix letter “C” identifying the tolerance source as AGMA 2015-2-A06, and an accuracy grade identifying the specific tolerances. An example of an AGMA classification number for a given set of conditions is given in figure 3.

When gear geometry is not within the specified ranges of application listed in clauses 1 and 7, use of the tolerance formulas shall be agreed upon between manufacturer and purchaser.

5.3 Additional characteristics

In certain applications there may be additional characteristics that may require tolerances in order to assure satisfactory performance. For example, if dimensions for tooth thickness or surface finish tolerances are desirable in order to assure satisfactory performance in special applications, such

dimensions and tolerances should appear on drawings or purchase specifications. Methods of measuring some of these characteristics are discussed in AGMA 915-1-A02, ANSI/AGMA 2002-B88, ISO 10064-4, and in the annexes.

5.4 Accuracy tolerances

The tolerance for each item that governs the accuracy of gears shall be calculated by the equations given in clause 7.

6 Measuring methods and practices

The measuring methods and practices for spur and helical gears can be found in AGMA 915-2-A05.

7 Tolerance values

The tolerance values for each item that governs accuracy grade are calculated by the equations given in 7.2 and 7.3.

Values outside the limits of the equations are beyond the scope of this standard and are not to be extrapolated. The specific tolerances for such gears are to be agreed upon by the manufacturer and purchaser.

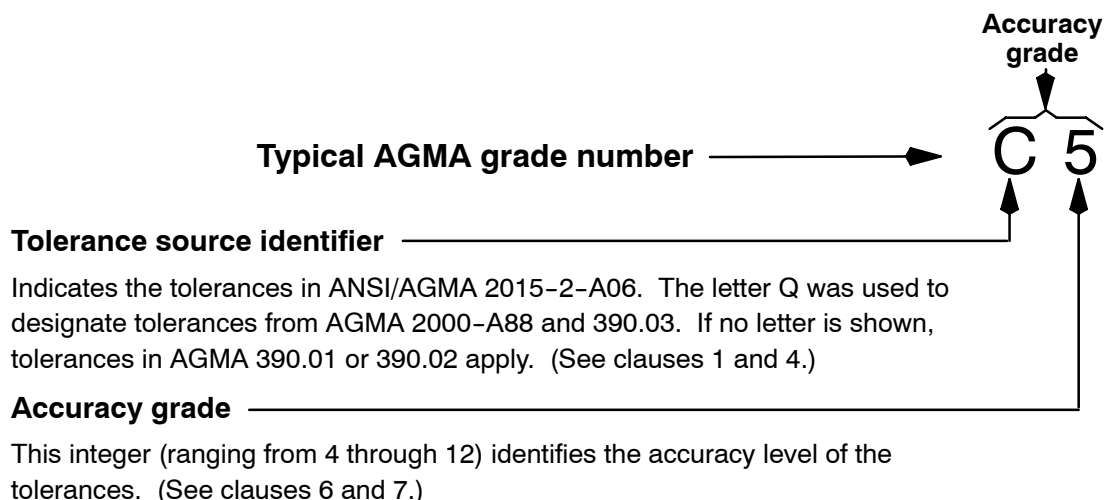


Figure 3 - Illustration of AGMA classification number

7.1 Use of equations

7.1.1 Range of application

The range of application is per clause 1:

Accuracy grades C4 through C12 only

$$0.2 \leq m_n \leq 5$$

$$2 \text{ mm} \leq d \leq 1000 \text{ mm}$$

$$3 \leq z \leq 1000$$

$$\beta \leq 45^\circ$$

7.1.2 Step factor

The step factor between two consecutive grades is $\sqrt{2}$. Values of the next higher (or lower) grade are determined by multiplying (or dividing) by $\sqrt{2}$. The required value for any accuracy grade may be determined by multiplying the unrounded calculated value for grade 5 by $\sqrt{2}^{(C-5)}$ where C is the number of the required accuracy grade.

7.1.3 Rounding rules

Values calculated from the equations in 7.2 and 7.3 are to be rounded as follows:

- If greater than 10 micrometers, round to the nearest integer;
- If 10 micrometers or less but greater than 5 micrometers, round to the nearest 0.5 micrometer.
- If 5 micrometers or less, round to the nearest 0.1 micrometer.

NOTE: If the measuring instrument reads in inches, values calculated from equations 1 and 2 are to be converted to ten thousandths of an inch and then rounded according to the rules for micrometers (i.e., substitute the word tenths for micrometers in the rules above).

7.2 Radial composite tolerance, tooth-to-tooth, f_{idT}

Radial composite tolerance, tooth-to-tooth, f_{idT} , is to be calculated according to equation 1.

$$f_{idT} = 0.2 [0.025 d + 0.3 m_n + 19] \left(\sqrt{2} \right)^{C-5} \quad (1)$$

7.3 Radial composite tolerance, total, F_{idT}

Radial composite tolerance, total, F_{idT} , is to be calculated according to equation 2.

$$F_{idT} = 1.08 [0.025 d + 0.3 m_n + 19] \left(\sqrt{2} \right)^{C-5} \quad (2)$$

Annex A

(informative)

Classification and accuracy tolerances for spur and helical master gears

[This annex is provided for informational purposes only and should not be construed as a part of ANSI/AGMA 2015-2-A06, *Accuracy Classification System - Radial Measurements for Cylindrical Gears*.]

A.1 Purpose

The purpose of this annex is to give tabulations of tooth element tolerances, composite action tolerances, and other dimensional tolerances for spur and helical master gears.

Master gears are used mainly for composite error testing. In addition, master gears can also be used for verifying gear testers. The determination of individual deviations in cylindrical gears calls for special equipment.

The calibration certificates of master gears shall contain detailed results of all the required measured values and the measurement conditions. Master gears shall conform to accuracy grade M1 or M2.

A.2 Master gear blank

Master gear design should be determined by the manufacturer and the purchaser of the master gear with consideration given to the composite gear tester design, and should be in accordance with clause 4.4.4. See table A.1 for recommended master gear blank tolerances.

Master gears can be mounted from a datum bore or a shaft with location between centers or journal diameters, see figure A.1.

Master gears are to be made from a suitable steel that has been stabilized, hardened, ground, and has a finished surface hardness of 60 Rc minimum.

A.3 Marking of master gears

The suggested marking of spur or helical master gears is shown in table A.2.

**Table A.1 - Master gear blank tolerance values, Module range 0.2 - 5 m_n ,
Pitch diameter range 12 - 150 mm**

Characteristic	Master gear class tolerance (micrometers, μm)	
	M1	M2
Axial runout ^{1), 2)} diameters < 75mm diameters $\geq$ 75mm	2.0	2.0
	4.0	4.0
Radial runout of reference band(s) diameters < 75mm diameters $\geq$ 75mm	2.0 ⁶⁾	2.0 ⁵⁾
	3.0 ⁶⁾	4.0 ⁵⁾
Outside diameter runout ²⁾	8.0	8.0
Bore diameter ^{3), 4)} diameters < 30mm diameters $\geq$ 30mm	2.5	2.5
	5.0	5.0

NOTES:

1) Full indicator movement (FIM)

2) The largest continuous checking diameter should be used.

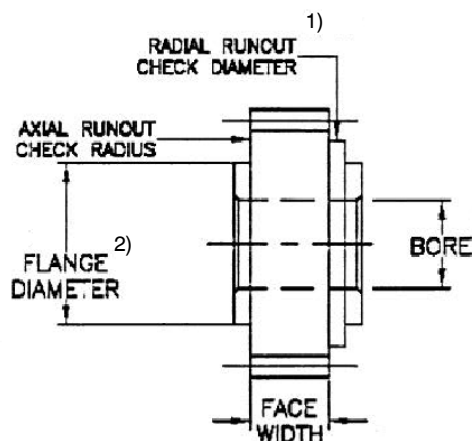
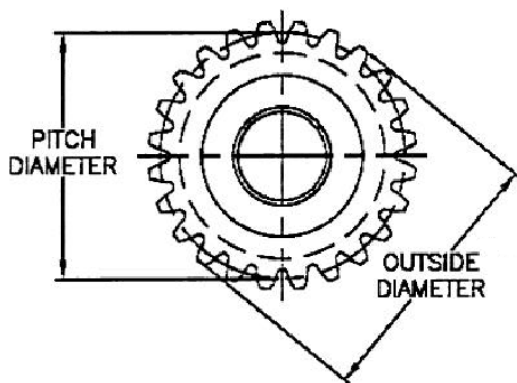
3) Tolerance to be applied plus (+).

4) Bore tolerance applies to the center 90% of the bore length. Bell mouth will be allowed on 10% of the total bore length with a length of bell mouth not to exceed 6 mm total.

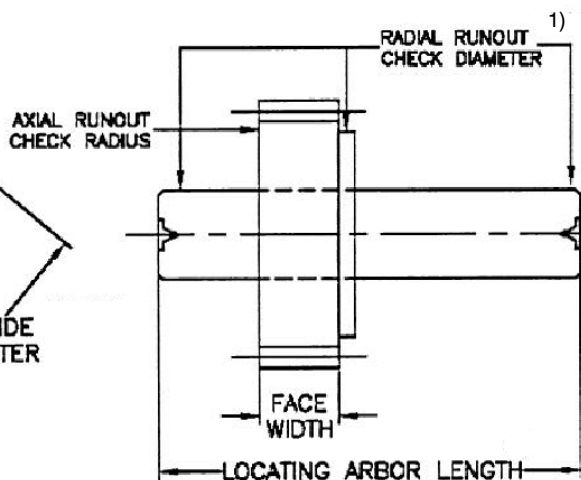
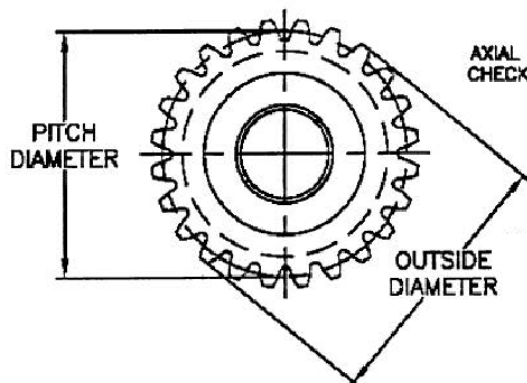
5) Radial runout datum diameter is optional. May be provided by agreement between the manufacturer and the customer.

6) Radial runout datum diameter is required.

BORE MOUNTED MASTER GEAR



ARBOR MOUNTED MASTER GEAR



NOTES:

1) For grade M2 radial runout datum diameter is optional and may be provided by agreement between the manufacturer and the purchaser. Radial runout datum diameter is required for grade M1 master gears made to this design.

2) Flange diameters are optional.

Figure A.1 - Master gear blank

A.4 Designation of master gear grade number

The grade of accuracy for spur and helical master gears is designated by its grade number, prefixed by *Master M* denoting *Master Gear Grade Number*, and suffixed by a code letter, T or R, designating the method of establishing the master's grade. The letter T is for elemental tolerances and the letter R for radial composite tolerances. Example: Master M2R. When the master gear grade has been

established by both elemental and radial composite tolerances, as is required for grade 1, the suffix may be RT. Example: M1RT.

A.5 Master gear tooth tolerances

Two gear tooth tolerance grades are provided for spur and helical master gears. Elemental tolerances are provided in table A.3. Composite tolerances are provided in table A.4.

Table A.2 - Suggested marking of master gears

Spur	Marking	
Module or diametral pitch	M or DP	Required
Pressure angle	PA	Required
Base diameter	BD	Optional
Number of teeth	T	Required
Circular tooth thickness ²⁾	CTT	Required
Test radius ³⁾	TR	Optional
AGMA master gear class	M1T, M2T, M1R, M2R	Required ¹⁾
Manufacturer	XYZ	Optional
Helical	Marking	
Normal module or normal diametral pitch	NM or NDP	Required
Normal pressure angle	NPA	Required
Base diameter	BD	Optional
Number of teeth	T	Required
Helix angle and hand	RHA or LHA	Required
Lead	L	Optional
Normal circular tooth thickness ²⁾	NCTT	Required
Test radius ³⁾	TR	Optional
AGMA master gear class	M1T, M2T, M1R, M2R	Required ¹⁾
Manufacturer	XYZ	Optional
NOTES:		
1) Should only be labeled if compliant with this Standard.		
2) Normal circular tooth thickness is taken at the diameter obtained by multiplying the number of teeth by the transverse module, and is calculated from the final measurement over one pin.		
3) See AGMA 915-2-A05, clause 5.2.		

**Table A.3 - Tooth tolerances for spur and helical master gears -
Classification by elemental tolerance , module 0.5- 5 m_n ¹⁾**

Elemental	M1T (micrometers)	M2T (micrometers)
Runout, F_r ²⁾ $0.5 \leq m_n \leq 1.25$ and $d \leq 50\text{mm}$ $1.25 < m_n \leq 5.0$ or $d > 50\text{mm}$	3.0	5.0
	5.0	7.0
Profile, F_{α} ³⁾ $0.5 \leq m_n \leq 1.25$ and $d \leq 50\text{mm}$ $1.25 < m_n \leq 5.0$ or $d > 50\text{mm}$	2.0	3.0
	3.5	3.5
Single pitch tolerance, f_{pt}	2.5	3.5
Helix tolerance, F_{β} ⁴⁾ $b < 13$	2.0	3.0
Helix tolerance, F_{β} ⁴⁾ $13 \leq b < 25$	2.5	3.5
Helix tolerance, F_{β} ⁴⁾ $25 \leq b < 50$	3.0	4.0
Helix tolerance, F_{β} ⁴⁾ $50 \leq b < 75$	3.5	4.5
Helix tolerance, F_{β} ⁴⁾ $75 \leq b < 100$	4.0	5.0
Helix tolerance, F_{β} ⁴⁾ $100 \leq b \leq 125$	5.0	6.0
NOTES:		
1) When considering master gears with fewer than 20 teeth, check with the manufacturer regarding calibration and use.		
2) FIM is Full Indicator Movement.		
3) Not applicable to finer than 0.5 module. The profile tolerances shown are total band width tolerance.		
4) Predicated on the allowance of an additional 3 μm for end relief at either end of the face; however, 80 percent central face shall be within the tolerance shown. Face width expressed by "b".		

**Table A.4 - Composite tolerances for spur and helical master gears -
Classification by radial composite tolerance, module 0.2- 2.5 m_n ^{1), 2)}**

Radial composite test	M1R (micrometers)	M2R (micrometers)
Tooth-to-tooth, f_{id} , $0.2 \leq m_n \leq 1.25$ and $d \leq 60\text{mm}$ $1.25 < m_n \leq 2.5$ or $d > 60\text{ mm}$	1.5	2.5
	4.0	5.0
Total, F_{id} $0.2 \leq m_n \leq 1.25$ and $d \leq 60\text{mm}$ $1.25 < m_n \leq 2.5$ or $d > 60\text{mm}$	2.5	5.0
	8.5	12.0
NOTES: 1) When considering master gears with fewer than 20 teeth, check with the manufacturer regarding calibration and use. 2) When a radial composite check is specified, it is necessary to check this master with another master of like or higher accuracy class. Grade M1, for module 0.5 and larger, can only be accepted on the basis of radial composite check as described above.		

Annex B

(informative)

Allowable values of runout

[This annex is provided for informational purposes only and should not be construed as a part of ANSI/AGMA 2015-2-A06, *Accuracy Classification System - Radial Measurements for Cylindrical Gears*.]

B.1 Purpose

This annex gives informative values and a method for applying the runout formula to develop values of recommended limits. Runout may be used for gears covered in this standard.

B.2 Runout, F_r

The value of the runout, F_r , of the gear is the difference between the maximum and the minimum radial distance from the gear axis, of a probe (ball, cylinder, anvil) which is placed successively in each tooth space. During each check, the probe contacts both the right and left flanks at approximately mid tooth-depth. Figure B.1 shows an example of a runout diagram, in which the eccentricity is a portion of the runout, see AGMA 915-2-A05.

B.3 Recommended formula for runout tolerances, F_{rT}

Runout tolerance, F_{rT} , is to be calculated according to equation B.1.

$$F_{rT} = 0.8[0.025 d + 0.3 m_n + 19] \left(\sqrt{2} \right)^{C-5} \quad (\text{B.1})$$

where the range of application is restricted as follows:

Accuracy grades C4 through C12 only

$$0.5 \leq m_n \leq 50$$

$$5 \text{ mm} \leq d \leq 12000 \text{ mm}$$

B.4 Rounding rules

The tolerance values are rounded versions of values calculated using the formula. If values are greater than $10 \mu\text{m}$, they are rounded to the nearest integer. If $10 \mu\text{m}$ or less, they are rounded to the nearest $0.5 \mu\text{m}$ value or integer.

B.5 Validity

When procurement documents state the required gear accuracy grade in ANSI/AGMA 2015-2-A06, but without other stipulant, that accuracy grade applies only to deviations of all elements according to clause 5 of this standard. By agreement, runout tolerance limits may be specified between manufacturer and purchaser.

When tolerance values are small, particularly when less than $5 \mu\text{m}$, the measuring apparatus must be of sufficiently high precision to ensure that values can be measured and repeated with the requisite accuracy.

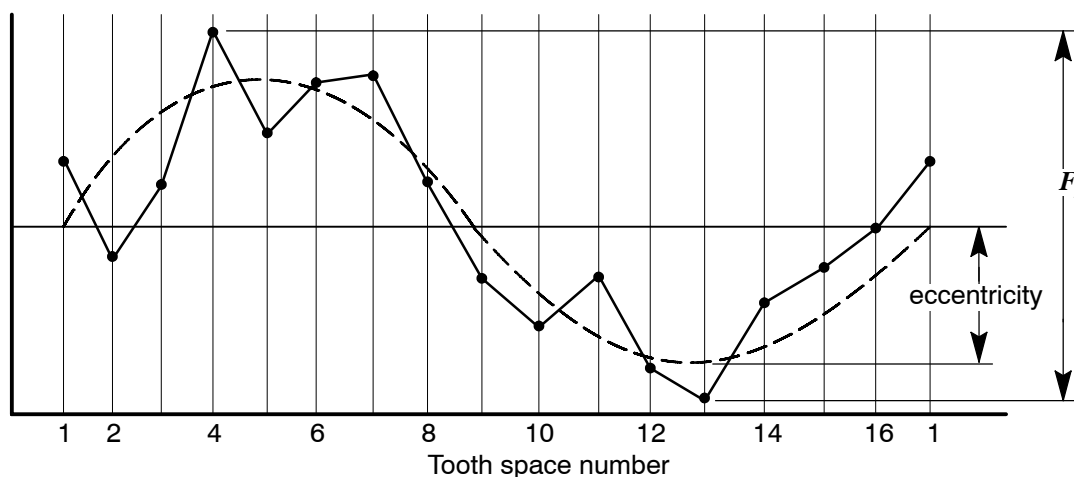


Figure B.1 - Runout diagram of a gear with 16 teeth

Bibliography

The following documents are either referenced in the text of AGMA 2015-2-A06, *Accuracy Classification System – Radial Measurement for Cylindrical Gearss*, or indicated for additional information.

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