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Technical Resources

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American National Standard

Tolerance Specification for Gear Hobs

ANSI/AGMA 1102-A03



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American National Standard

Tolerance Specification for Gear Hobs

ANSI/AGMA 1102-A03

[Revision of AGMA 120.01 (1975)]

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Approved December 11, 2003

ABSTRACT

The purpose of this standard is to provide specifications for nomenclature, dimensions, tolerances, and inspection of gear hobs, and thereby establish a basis for mutual understanding in this respect in the use and manufacture of these tools.

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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 ANSI/AGMA Standard 1102-A03, *Tolerance Specification for Gear Hobs*.]

ANSI/AGMA 1102-A03 is a replacement of AGMA 120.01. The first draft of AGMA 120.01 was prepared by the Cutting Tools Committee in May, 1972. Its purpose was to consolidate all AGMA standards relating to hobs; i.e., AGMA 121.02, 122.02, 123.01 and 124.01. The purpose of consolidating these standards was to provide the information as a handy updated reference on gear-cutting tools for efficient use by manufacturers and users of these tools.

The committee decided at the 1972 Semi-Annual Meeting to include Standard 124.01, *Wormgear Hobs*, as an Information Sheet. AGMA 120.01 was approved by the Cutting Tools Committee on November 6, 1973. It was approved by the AGMA Membership as of February 28, 1975.

ANSI/AGMA 1102-A03 is the result of a rewrite of AGMA 120.01, incorporation of the metric system, addition of inspection procedures, and development of equation based tolerances. Other additions include increased tolerance grade levels, expansion of tolerances for multi-thread hobs, line of action testing, and expansion of the hob range of sizes.

The first draft of AGMA 1102-A03 was made in February, 1999. It was approved by the AGMA membership in October, 2003. It was approved as an American National Standard on December 11, 2003.

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 – Tolerance Specification for Gear Hobs

1 Scope

This standard provides specifications for nomenclature, dimensions, tolerances, and inspection for gear hobs for modules 0.63 to 40 mm. It establishes a basis for understanding the use and manufacture of these tools.

1.1 Application

This standard applies to single and multiple-thread hobs for spur and helical gears.

1.2 Exceptions

This standard is not intended to completely define the hob tooth profile as it relates to the exact gear profile. It is advisable to check gear tooth profile specifications with the hob manufacturer involved. Examples include cutting depth and hob tooth profile modification as they affect gear tooth tip relief for fine-pitch and coarse-pitch hobs.

Where conditions require use of hobs of special design or specifications, such hobs shall be considered beyond the scope of 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.

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

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

MIL-STD-105D, *Sampling Procedures and Tables for Inspection by Attributes*

3 Terminology and definitions

The terms and definitions used in this standard are, wherever possible, consistent with ANSI/AGMA 1012-F90 and other approved AGMA documents. However, some symbols and definitions used in this standard may differ from other AGMA Standards. Users should assure themselves that they fully understand the terms, definitions, and symbols as contained in this standard.

Nomenclature used in this standard and the hob elements referred to are illustrated in figure 1. Nomenclature of hob elements and other terms relating to hobbing are presented as follows:

active hob length: axial length of the toothed portion of the hob.

allowed deviation: maximum deviation a hob can have without exceeding the tolerance.

auxiliary leads: feature employed in some hobs, especially worm gear hobs, wherein both sides of the hob thread have leads different from the nominal hob lead; one side longer, the other side shorter. This results in the tooth thickness being successively less toward the roughing end of the hob.

axial plane: plane containing the axis of rotation.

axial pressure angle: see definition under **pressure angle**.

back-off: see preferred term **cam relief**, under **relief**.

bore diameter: diameter of the mounting hole for arbor type hobs.

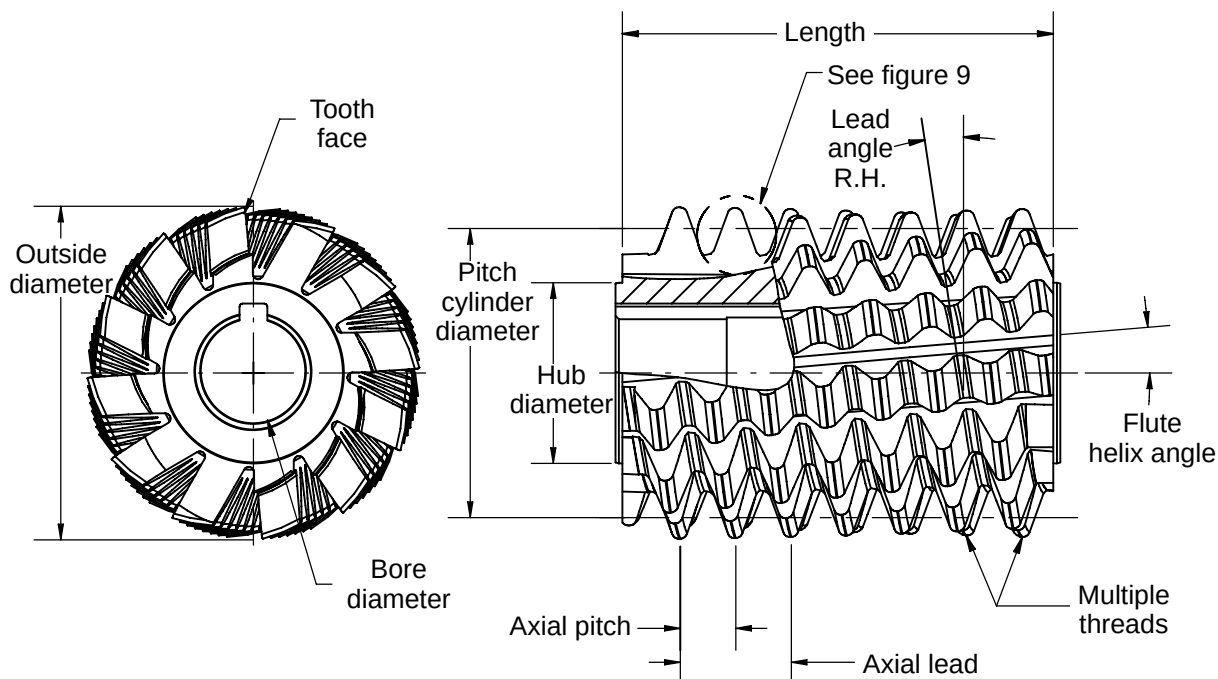


Figure 1 - Hob nomenclature

bore diameter: diameter of the mounting hole for arbor type hobs.

cam: radial drop of the form in the angular distance between adjacent tooth faces. See figure 2.

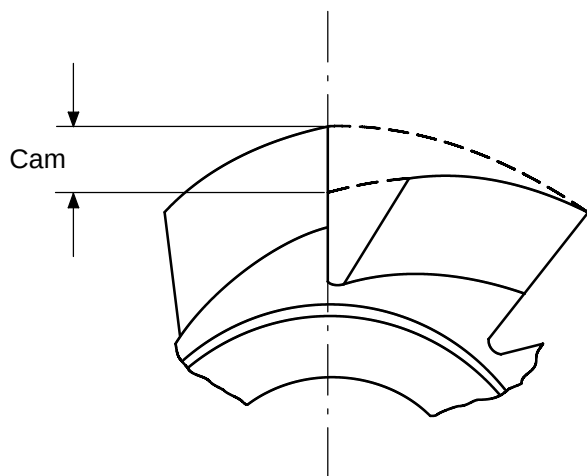


Figure 2 - Cam

cam relief: see definition under **relief**.

chamfer: beveled surface to eliminate an otherwise sharp corner.

clutch keyway: see **face keyway**.

depth of cut: radial depth to which the hob is sunk into the workpiece. See related term **whole depth**.

deviation: differences observed during testing that are compared against the specified value or tolerance.

engagement zone: axial distance within which the hob interacts with the involute portion of a gear tooth profile being generated. It is equal to the axial component of the hob line of action within the confines of the functional profile. See figure 3.

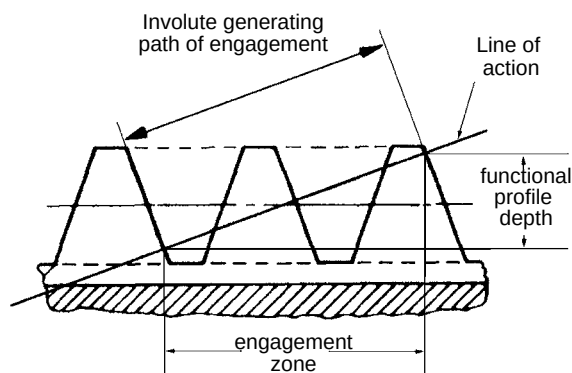


Figure 3 - Engagement zone

evaluation zone: full toothed portion of the hob.

face keyway: transverse slot across the hub face.

fillet: 1) curved line joining two lines to eliminate a sharp internal corner; 2) curved surface joining two surfaces to eliminate a sharp internal corner.

flute: longitudinal groove, either straight or helical, that forms the tooth face of one row of hob teeth and the backs of the preceding row.

flute helix angle: angle which a helical tooth face makes with an axial plane, measured on the hob pitch cylinder.

flute index: see **tooth face index**.

flute lead: axial advance of a flute face in one turn around the axis of a hob.

flute lead deviation: deviation of a hob tooth face from the desired helical surface.

full tip radius: continuous radius tangent to top and side cutting edges.

functional profile: portion of hob tooth that generates the involute profile of a gear tooth. It is limited toward the tip by the start of tip radius or, when present, start of protuberance modification. It is limited toward the root by the hob tooth dedendum or, when present, start of tip relief or chamfer modification. See figure 3.

functional profile depth: depth of the functional profile.

gash: see preferred term **flute**.

generated fillet: at the bottom of the hobbled form, fillet joining the root diameter with the desired generated form. This fillet is not a true radius (trochoid form).

generated fillet height: on the hobbled workpiece, radial distance from the root diameter to the point where the generated fillet joins the desired generated form.

helicoid, Archimedes: plane surface of compound curvature, defined by its intersections with the following planes:

- intersection with a transverse plane is an Archimedes spiral;
- intersection with a concentric cylinder is a helix;
- intersection with an axial plane is a straight line.

helicoid, involute: plane surface of compound curvature, defined by its intersections with the following planes:

- intersection with a transverse plane is an involute curve;

- intersection with a concentric cylinder is a helix;
- intersection with a plane of action is a straight line.

hob addendum: radial distance between the top of the hob tooth and the pitch cylinder (gear dedendum).

hob dedendum: in **topping hobs**, radial distance between the bottom of hob tooth profile and **pitch cylinder** (gear addendum).

hob full-topping: hob that cuts the gear outside diameter and chamfers the gear tooth tip.

hob, non-topping: hob that does not cut the outside diameter of the gear.

hob, topping: hob that cuts the gear outside diameter.

hob runout: runout of the hob when mounted in a hobbing machine, measured radially on hub diameter, and axially on hub face.

hob, semi-topping: hob that produces a chamfer or tip relief on the gear.

hob teeth in engagement zone: within a given thread, the approximate number of hob teeth included in the engagement zone. This is also the number of teeth involved in generating the involute portion of the gear tooth profile. See figure 3.

hob tip modification: modification on the sides of the hob tooth near the top.

hob tooth depth: minimum active depth of hob tooth form.

hook: see preferred term **rake**.

hub: qualifying surface at each end of an arbor type hob which is provided for checking diameter and face runout. On a shank style hob, it is the clamping surfaces or proof bands, when available.

hub diameter runout: total deviation in radial distance of the hub periphery from the axis.

hub face: side surface of the hub.

hub face runout: total axial deviation of the hub face from a true plane of rotation.

key: mechanical member through which the turning force is transmitted to the hob.

keyway: slot through which the turning force is transmitted to the hob. May be either a longitudinal slot through the hole or a transverse slot across the hub face. If the latter, it is called a **face keyway**.

lead: axial advance of a thread for one complete turn or convolution.

lead angle: angle between any helix and a plane of rotation,. In a hob, **lead angle** usually refers specifically to the angle of thread helix measured on the **pitch cylinder**.

lead deviation: axial deviation of the hob teeth from the correct thread lead.

length: total distance from one end to the other including shanks and hubs.

normal circular pitch: see definition under **pitch**.

normal module: π (pi) times the **normal circular pitch**.

normal plane: plane perpendicular to a pitch cylinder helix.

normal pressure angle: see definition under **pressure angle**.

number of threads: in multiple thread hobs, number of parallel helical paths along which hob teeth are arranged, sometimes referred to as **number of starts**.

observed: Measuring of actual differences through testing.

offset: see preferred term **rake offset**.

outside diameter: diameter of the cylinder which contains the tops of the cutting edges of the hob teeth.

outside diameter runout: total deviation in the radial distance from the axis to the tops of the hob teeth.

pilot end: on shank type hobs, cylindrical or conical bearing surface opposite the driving end.

pitch: distance between corresponding, equally spaced hob thread elements along a given line or curve. Use of the single word pitch without qualification may be confusing. Specific terms such as **normal circular pitch** or **axial pitch** are preferred.

pitch, axial: pitch parallel to the axis in an axial plane between corresponding elements of adjacent hob thread sections. Use of the term **axial pitch** is preferred to the term **linear pitch**.

pitch, base: pitch on the base circle or along the line of action.

pitch, normal circular: distance between corresponding elements on adjacent hob thread sections measured along a helix that is normal to the **thread helix** in the **pitch cylinder**.

pitch circle: transverse section of the hob pitch cylinder.

pitch cylinder: reference cylinder in a hob from which design elements, such as lead, lead angle, and tooth thickness are derived.

pitch diameter: diameter of the pitch cylinder.

pitch point: point at which a tooth profile intersects the **pitch cylinder**.

pressure angle: angle between a tooth profile and a line perpendicular to the **pitch cylinder** at the **pitch point**. In hobs, the **pressure angle** is usually specified in the **normal plane** or in the **axial plane**.

pressure angle, axial: pressure angle measured in an axial plane. Use of the term **axial pressure angle** is preferred to the term **linear pressure angle**.

pressure angle, normal: pressure angle measured in a normal plane.

profile: see **functional profile**.

protuberance: modification near the top of the hob tooth which produces undercut at the bottom of the tooth of the workpiece. See figure 4.

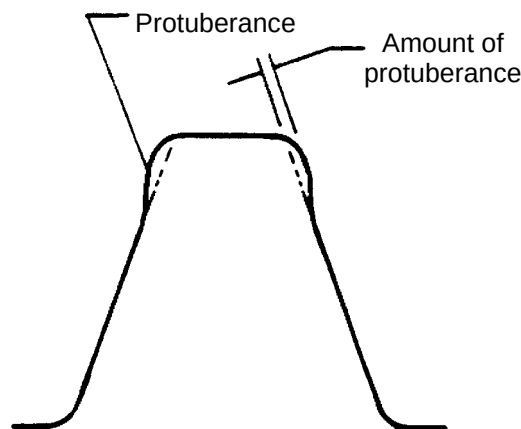


Figure 4 - Protuberance on a gear hob tooth

rake: angular relationship between the tooth face and a radial line intersecting the tooth face at the hob outside diameter, measured in a plane perpendicular to the axis.

rake, negative: condition wherein the peripheral cutting edge lags the tooth face in rotation. See figure 5.

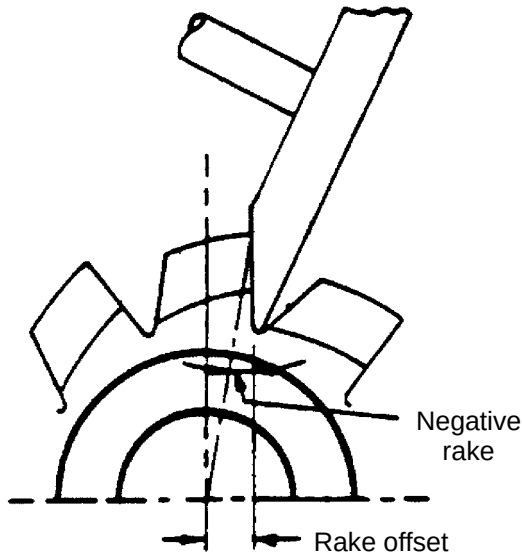


Figure 5 - Negative rake

rake, positive: condition wherein the peripheral cutting edge leads the tooth face in rotation. See figure 6.

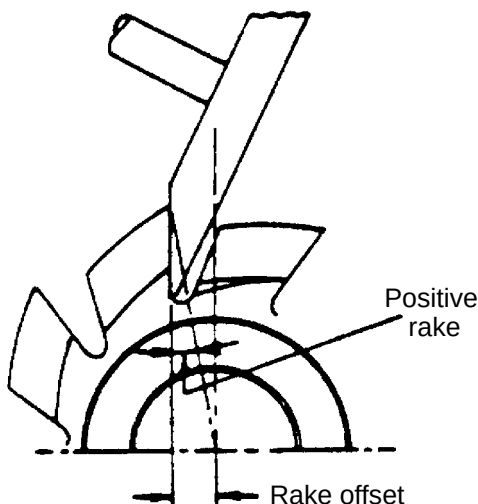


Figure 6 - Positive rake

rake, zero: condition wherein the tooth face coincides with a radial line. See figure 7.

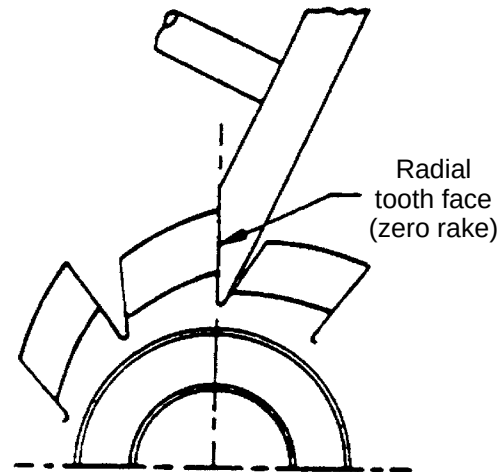


Figure 7 - Zero rake

rake offset: distance between the tooth face and a radial line parallel to the tooth face. Used for checking rake. See figures 5 and 6.

ramp: modification at the bottom of the hob tooth which produces a chamfer at the top corners of the tooth of the workpiece.

reference diameter: synonymous with the nominal hob pitch diameter. It is the diameter at which hob tooth thickness is defined and controlled. It is also, by convention, the diameter at which various other hob geometry parameters are evaluated, including flute lead, flute index, and thread lead.

relief: result of the removal of tool material behind or adjacent to a cutting edge to provide clearance and prevent rubbing (heel drag).

relief, cam: relief from the cutting edges to the back of the tooth produced by a cam actuated cutting tool or grinding wheel on a relieving (back-off) machine.

relief, side: relief provided at the sides of the teeth behind the cutting edges. The amount depends upon the radial relief, axial relief, and nature of the tooth profile.

root diameter: in topping hobs, the outside diameter minus (2) whole depths.

shank: projecting portion of a hob which locates and drives the hob in the machine spindle or adapter.

short (or long) lead: special design wherein the hob lead is made shorter (longer) than the normal or theoretical lead, to generate at a lower (higher) diameter on the workpiece, to meet a particular fillet, undercut or generating requirement.

side relief: see definition under **relief**.

stock allowance: amount of a modification of the hob tooth to leave material on the workpiece tooth form for subsequent finishing.

thread: a helical ridge, generally of constant form or profile. In a hob, unlike a worm or screw, the thread is not continuous and exists only at the cutting edges of the hob teeth. Therefore, it is sometimes referred to as the **thread envelope**.

thread envelope: see preferred term **thread**.

thread helix: helix of the hob thread in the **pitch cylinder**.

thread spacing: difference in the average deviations obtained by traversing along the desired helical path of one thread, indexing and traversing in a similar manner on another thread.

tip radius: radius of the arc joining the top and a side cutting edge of a hob tooth.

tip relief: gear tooth modification in which a small amount of material is removed from the basic profile near the tip of the gear tooth. See figure 8.

tip relief modification: modification on the sides of the hob tooth near the bottom which produces tip relief on the gear tooth.

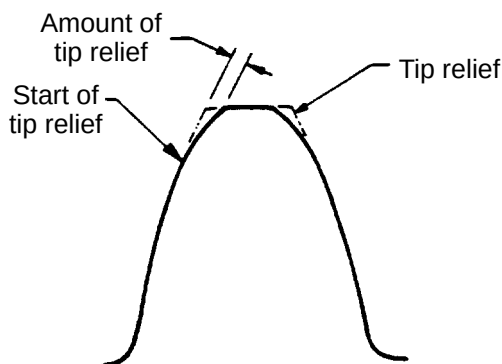


Figure 8 - Tip relief on a gear tooth

tooth: projection on a hob which carries a cutting edge.

tooth face: tooth surface against which the chips impinge.

tooth face index: deviation from the desired position between tooth faces measured in the plane of rotation.

tooth thickness: actual width or thickness of the hob tooth at the pitch cylinder. Use of the single term tooth thickness without qualification may be confusing. The specific terms **normal tooth thickness** and **axial tooth thickness** are preferred.

tooth thickness, axial: tooth thickness as measured in an axial plane.

tooth thickness, normal: tooth thickness as measured along a helix normal to the thread helix.

whole depth: radial depth which the hob is designed to produce on the workpiece.

4 Hob classifications, drawings, and identification markings

4.1 Coverage

Hobs covered by this standard are classified and shall be marked with reference to the classification.

4.2 Drawings

This standard enumerates minimum drawing data and format for conveying information about a hob design. The minimum informational requirement should not be construed as precluding more detailed data from being presented on a hob drawing.

4.2.1 Normal section

The tooth form on the hob shall be illustrated on the hob drawing in the normal plane and in such an attitude as having the tooth face top coming. Minimum dimensioning in the normal section shall include:

- normal circular pitch;
- normal pressure angle;
- nominal hob tooth design;
- normal tooth thickness;
- hob addendum (a basic dimension at which the tooth thickness has been specified).

Where there are modifications to the functional profile of the hob, the following additional information shall also be shown on the normal section to define the range for profile inspection:

- depth to tip relief modification
- depth to hob tip modification

4.2.2 Standard format

Figure 9 illustrates the standard format to be used to present the normal section dimensions.

4.2.3 Minimum hob data

Minimum hob data listed on the drawing shall include the hob's elements as follows:

4.2.3.1 Physical data

- bore diameter or shank diameter;
- nominal outside diameter;
- nominal hub diameter;
- nominal hub width;
- keyway depth;
- keyway width;
- nominal length.

4.2.3.2 Lead data

- number of threads;
- lead (axial);
- hand of lead.

4.2.3.3 Flute data

- number of flutes;
- flute lead;
- hand of flute lead;
- rake.

4.2.3.4 General data

- accuracy grade;
- nominal cam;
- normal module.

4.3 Identification

All hobs covered by this standard shall be marked for identification.

4.3.1 Hob markings

As may be appropriate, values for hob elements or features and standard marking symbols from table 1 are to be used.

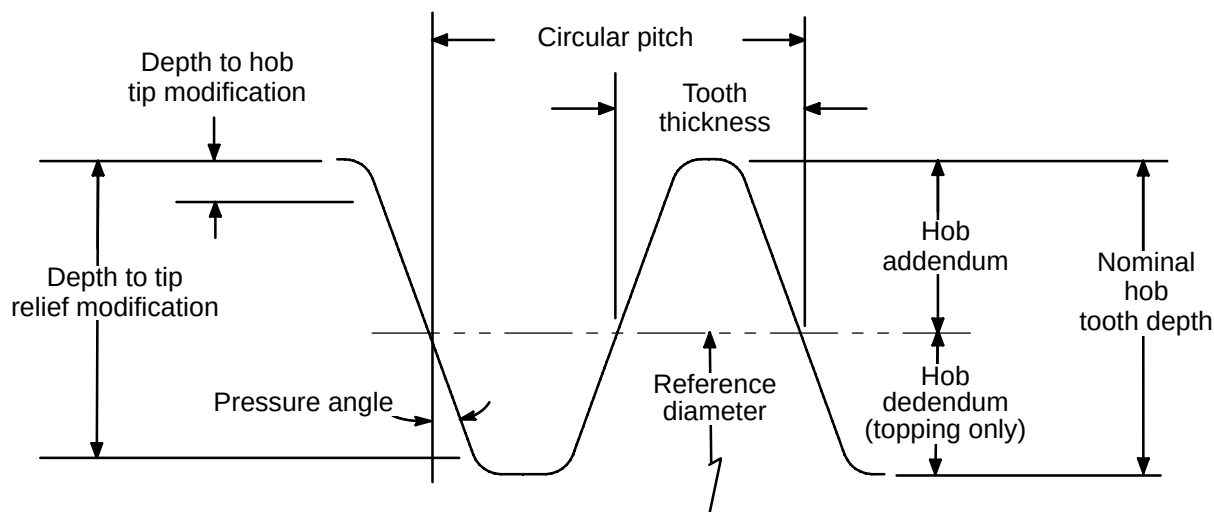


Figure 9 - Normal section

Table 1 - Hob markings

Element or feature	Standard marking abbreviations
Normal module	xx.xxxx NMOD
Normal pressure angle	xx.xxxx NPA
Hob normal module ^{a)}	xx.xxxx HNMOD
Hob normal pressure angle ^{a)}	xx.xxxx HNPA
Number of threads	x THD
Hand of threads	x H
Hob tooth depth	xx.xxx HTD
Lead angle	x.xxx° or x°xx' LA
Flute lead ^{b) c)}	x.xx° FL
Positive rake ^{d)}	xx°-xx.xxx RAKE
Negative rake ^{d)}	NEG xx°-xx.xxx RAKE
Class (grade)	CL xxx
Pre-shave	PRE-S
Pre-roll	PRE-R
Pre-grind	PRE-G
Pre-skive	PRE-K
Tip mod	TPREL
Flank mod	FLREL
Full topping ^{e)}	F-TOP
Semi-toppling ^{e)}	S-TOP
Roughing	RGH
Finishing	FIN
NOTE: a) Only show if different than gear data block value. b) Do not mark if straight. c) Straight gash may be denoted by ∞FL. d) If not marked, assume "zero" rake offset (not used in this table). e) If not marked, assume Non-toppling (not used in this table).	

4.3.2 Additional hob markings

The following additional markings and identification shall be considered optional and based on purchaser's or manufacturer's requirements:

- purchaser's tool or part number, or both;
- manufacturer's code, or serial number;
- hob material identification;
- setting angle;
- date of manufacture.

5 Manufacturing and purchasing considerations

This standard provides classification tolerances and measurement methods for gear hobs. This clause presents considerations for control of the various phases of hob manufacturing, including the recommended process controls and measurement methods.

These methods provide the hob manufacturer and purchaser with recommendations for verifying the accuracy of a hob, 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 hob manufacturing processes. Specific requirements are to be stated in the contractual documents.

In the previous classification system (AGMA 120.01), hob accuracy grades were specified by letter, ranging from Class D through Class AA, in order of increasing precision. In this standard, accuracy grades are also specified by letter, ranging from grade D through grade AAA, in order of increasing precision. However, it is important to understand that the tolerance structures of the two standards are not related.

5.1 Manufacturing certification

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

Manufacturing of hobs to a specified accuracy may or may not include specific measurements. When applications warrant, it may be necessary to establish detailed acceptance criteria for a hob including specifications concerning measurements, data analysis, and any additional considerations. Specific methods of measurement, documentation of accuracy grade, and other geometric tolerances of a hob are normally considered items that are to be mutually agreed upon between hob manufacturer and purchaser.

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

5.2 Process control

Process control is defined as the method by which hob accuracy is maintained through control of each

individual step of the hob manufacturing process. Upon completion of all manufacturing operations, a specific hob has been given an inherent level of accuracy; this level of accuracy was established during the manufacturing process, and is totally 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 quality assurance programs, as needed, to achieve and maintain the necessary hob accuracy. When properly applied, hobs manufactured by specific control techniques will be found to be of very uniform quality. Therefore, little or no final inspection may be necessary for a hob, particularly in some accuracy levels; assurance of the necessary accuracy having been manufactured through careful control at each step.

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

With proper application of process control, relatively few measurements may be made on any one hob. Hobs made in production quantities may be inspected at various steps in their manufacturing process on a statistical basis. Thus, it is possible that a specific hob can pass through the entire production process without ever having been measured. However, based on appropriate confidence in the applied process control, the manufacturer of that hob must be able to certify that it meets the specified accuracy level.

5.3 Measurement methods

Hob geometry may be measured by a number of alternate methods as shown in table 2. The selection of the particular method depends on the magnitude of the tolerance, production quantities, equipment available, and measurement costs.

The manufacturer or purchaser may wish to measure one or more of the geometric features of a hob to verify its accuracy grade. However, a hob that is specified to an AGMA accuracy grade must meet all applicable individual tolerance requirements. Normally, the tolerances apply to both sides of the teeth.

When prior agreement between the hob manufacturer and purchaser specifies measurement of hobs, the manufacturer may select:

- the measurement method to be used from among the applicable methods described in this standard and summarized in table 2;
- the piece of measurement equipment to be used by the selected measurement method, provided it is in proper calibration;
- the individual teeth to be measured, as long as they are approximately equally spaced.

NOTE: No particular method of measurement or documentation is considered mandatory unless specifically agreed upon between hob manufacturer and purchaser. When applications require measurements beyond those recommended in this standard, special measurement methods must be negotiated prior to manufacturing the hob.

Table 2 - Reference for measurement methods

Test description	Test method	Test number ^{a)}	
		Elemental tests	Composite tests
Hub diameter runout	7.3	1	1
Hub face runout	7.3	2	2
Outside diameter runout	7.4	3	3
Rake offset	7.7	4	4
Tooth face index, adjacent	7.5	5	5
Tooth face index, total	7.5	6	6
Flute lead	7.6	7	7
Tooth profile	7.10	8	8A
Tooth thickness	7.11	9	9
Thread lead, adjacent	7.8	10	10
Thread lead in 1 axial pitch	7.8	11	11A
Thread lead in 3 axial pitches	7.8	12	12
Line of action, adjacent	7.12	b)	13
Line of action, total	7.12	b)	14
Thread spacing, adjacent	7.9	15	15A
Thread spacing, total	7.9	16	16A
Bore diameter	7.2	17	17
NOTES:			
a) See clause 6			
b) Test does not apply for elemental method			

5.3.1 Considerations for hob measurements

Before hob measurement values can be compared with tolerance values, certain operational parameters of the measurement instrument must be known. This includes:

- datum axis;
- measurement location;
- direction of measurement;
- direction of tolerancing;
- hob geometry system.

In some cases, measurement instruments follow the minimum requirements by default. When other conditions exist, it is required that causes of the resulting measurement differences are known and compensated.

5.3.1.1 Reference axis

Specification of hob geometry requires definition of an appropriate reference axis of rotation, called the reference axis. It is defined by specification of the reference surfaces. See 7.1.2.

The reference axis determines tooth geometry, thereby being the reference for measurements and associated tolerances. See AGMA 915-3-A99.

5.3.1.2 Measurement location

The location of hob measurements can affect both the resulting values and relevance of those values to the proper functioning of the hob. Also, measurement locations must be clearly defined if different measurement operations are to achieve satisfactory correlation.

The specification of measurement location may include a number of possible parameters including diameter, axial position, distance behind the cutting edge (on the tooth flank), and whether testing is carried out on the flank or over the cutting edge. Hob measurements should be carried out at the default locations specified in this standard. Reports of hob measurement results must include descriptions of any test locations that deviate from these default locations.

Test 1, Hub Diameter Runout, requires specification of the axial position of testing. The default position is one millimeter from the adjacent hub face.

Test 2, Hub Face Runout, requires specification of the testing diameter. The default position is one millimeter in from the hub outside diameter.

Test 3, Outside Diameter Runout, requires specification of the axial position of testing. The default position is at the centers of the tooth tips, midway between the cutting edges of each given tooth.

Test 4, Rake Offset, requires specification of the axial position of testing. The default position is at the centers of the tooth faces, midway between the cutting edges of each given tooth.

Tests 5 and 6, Tooth Face Index, require specification of the diameter and the axial position of testing. The default diameter is the reference diameter as specified in clause 3. The default axial position is at the centers of the tooth faces, midway between the cutting edges of each given tooth.

Test 7, Flute Lead, requires specification of the testing diameter. The default position is the reference diameter as specified in clause 3.

Tests 8, 8A, Tooth Profile, require specification of whether testing is carried out on the flank or over the cutting edge and, if testing will be on the flank, the distance behind the cutting edge. The default is on the flank for test 8 and over the cutting edge for test 8A.

Test 9, Tooth Thickness, requires specification of the testing diameter. The default position is the hob reference diameter as defined in clause 3.

Tests 10, 11, 11A, and 12, Thread Lead, require specification of the diameter and whether testing is carried out on the flank or over the cutting edge. The default position is over the cutting edge, at the hob reference diameter as defined in clause 3.

Tests 13 and 14, Line of Action, require testing over the cutting edge.

Tests 15, 15a, 16 and 16a, Thread Spacing, are based upon data derived from testing of Thread Lead. The same measurement location specifications, as in tests 10 through 12, are therefore applicable.

Test 17, Bore diameter, requires the specification of the method of testing.

5.3.1.3 Direction of measurement

Measurements of the shape or the position of any surface can be made in a direction normal to that surface or inclined to the surface at some angle.

Common metrology practice is to measure in a direction normal to the surface being tested. This holds true for some hob parameters including hub faces, hub diameters, and outside diameters. It may or may not be true for hob flute faces and is rarely true for all remaining hob tooth parameters. It is important to understand that various hob measuring instruments use different testing procedures, some measuring given parameters in the normal direction, others measuring in other directions.

If the direction of measurement and direction of tolerancing are different, original measurement values must be compensated before test values can be compared to the tolerances.

5.3.1.4 Direction of tolerancing

Tolerances on the shape or the position of hob surfaces must specify the direction in which given measurements are to be considered. This specified direction, called the tolerancing direction, may be normal to that surface or inclined at some angle.

In this standard, the tolerancing direction varies with the given toleranced parameter. Tolerancing direction requirements are listed in clause 7. Original measurement values must be compensated if the actual measurement direction and the tolerancing direction specified for the given parameter are different.

The specified direction of tolerancing for runout of hub faces is axial and for runout of hub diameters and outside diameters is radial. The direction of tolerancing for hob flute face parameters is normal to those surfaces.

The specified direction of tolerancing for remaining hob parameters is normal to the involute helicoid surface approximated by the hob cutting edges. At any point on a hob tooth surface, that normal vector is oriented 1) tangent to the base cylinder of the hob, and 2) inclined relative to the transverse plane at the base helix angle.

Measurements taken in the tolerance direction have the following characteristics:

- Measurements will always be the smallest when the direction of measurement is normal to the surface. Measurements at any other inclination will be larger;

- Measurements made normal to the involute helicoid surface approximated by the hob cutting edges are not affected by the tolerance diameter selected by the test operator;

- As the hob proceeds through mesh with the mating gear, the points of contact between the hob cutting edges and gear tooth profile occur along a line of action, which is oriented normal to the involute helicoid tooth surfaces of both the hob and gear. Measurements reported in this normal direction coincide with the cutting engagement between hob and gear teeth. Such hob measurements thus correlate well with normal direction measurements of the gear tooth profiles produced by that hob.

5.4 Additional considerations

When specifying a hob, there may be additional or special considerations such as:

- modified AGMA accuracy grade;
- hob geometry system.

These and other special considerations are to be reviewed and agreed upon by the manufacturer and purchaser.

5.4.1 Modified AGMA accuracy grade

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

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

5.4.2 Hob geometry system

Hobs may be specified with either involute helicoid (straight profile in the plane of action) or Archimedes helicoid (straight profile in the axial plane) geometry systems. While the involute helicoid system is technically most correct, the Archimedes helicoid system may be used because it is more economical to produce and, for most applications, the differences in gear profiles produced are not significant. See Annex C.

5.5 Acceptance criteria

Tolerances, methods, and definitions contained in this standard prevail unless contractual agreements