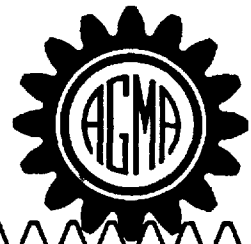


AGMA 910-C90
(Revision of AGMA 114.02)

June 1990

AMERICAN GEAR MANUFACTURERS ASSOCIATION

Formats for Fine-Pitch Gear Specification Data



AGMA INFORMATION SHEET

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Formats for Fine-Pitch Gear Specification Data

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ABSTRACT

Formats for Fine-Pitch Gear Specification Data consists of a series of printed forms for gear drawings that contain the appropriate data to be tabulated by the gear designer for the gear manufacturer. Also included are a series of definitions of the various tabulated items. For an appendix, there are blank, pre-printed forms that can easily be copied for the user's drawings.

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FOREWORD

[The foreword, footnotes, and appendices, if any, are provided for informational purposes only, and should not be construed as a part of American Gear Manufacturers Association 910-C90, *Formats for Fine-Pitch Gear Specification Data*.]

Gathering of data for this Information Sheet, including questionnaires and surveys, was begun in the spring of 1953. The committee recognized at that time the need for standardized fine-pitch gear drawing format data. Individual sections on spur, helical, straight bevel, spiral and Zerol bevel gears; worm and wormgears; face gears and pinions; and spur and helical racks were first prepared by the Task Committee on Drawing Formats.

Each section was carefully reviewed by the Fine-Pitch Gearing Committee. Certain sections were reworked to bring them in line with the work being done by the Aerospace Gearing Committee in the field of angular accuracy specification. The formats for spur and helical gears were published as Appendix C of AGMA Standard 207.04 in June, 1956. The formats for worm and wormgears were published as Appendix B of AGMA Standard 374.03 in July, 1956. The early development work, continued review and revision, and field testing has resulted in this Information Sheet which the committee feels is based on sound gear engineering and one which can be easily understood by both the shopman and inspector.

The first complete draft of this Information Sheet was prepared in September, 1957. It was approved by the AGMA membership in February, 1961. Printing of the Information Sheet was held up in order to make it conform to AGMA 390.03, *AGMA Gear Handbook, Volume 1, Gear Classification, Materials and Measuring Methods for Unassembled Gears*.

AGMA 114.02 was a revision of 114.01 which was approved by the AGMA membership in July, 1972.

AGMA 910-C90 is a revision of AGMA 114.02 which updates the style and formats for spur gears, helical gears, bevel gears, wormgearing, face gears and racks. It was approved by the members of the Fine-Pitch Gearing Committee on February 27, 1990. It was recommended by the Technical Division Executive Committee for publication and approved by the members on June 10, 1990.

Formats for Fine-Pitch Gear Specification Data

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Formats for Fine-Pitch Gear Specification Data

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Formats for Fine-Pitch Gear Specification Data

1. Scope

The formats supplied are intended as guides in the preparation of fine-pitch (20 diametral pitch or finer) gear drawings. They show the proper data to be placed on drawings of gears which are to be used for general purpose light loads or control gear applications. In each case the data shown indicates the minimum or basic number of items that should be specified for each type of gearing.

2. Definitions of Terms

Addendum, a . Addendum is the height by which a tooth projects beyond (outside for external, or inside for internal) the standard pitch circle or pitch line; also the radial distance between the pitch circle and the addendum circle.

Addendum is a reference dimension shown on drawings as an engineering convenience.

In a bevel gear, addendum is the height by which a tooth projects beyond the pitch cone and is measured at the outer end of the teeth.

In wormgearing, addendum is the radial distance between the standard pitch cylinder and the outside circle of the worm and wormgear. Its actual value is dependent on the specification of outside diameter of the worm. In the case of throated wormgears the addendum is the radial distance from the pitch cylinder to the deepest portion of the throat.

Backlash, B . Backlash is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the operating pitch circles.

As actually indicated by measuring devices, backlash may be determined variously in the transverse, normal, or axial planes, and either in the direction of the pitch circles, or on the line of action. Such measurements may be converted to corresponding values on transverse pitch circles for general comparisons.

Backlash can also be determined from measurements made on a variable center distance fixture.

Chordal Addendum, a_c . Chordal addendum is the height from the top of the tooth to the chord subtending the circular thickness arc. This dimension is required when making chordal tooth thickness measurements of the gears.

Chordal Thickness, t_c . Chordal Thickness is the length of the chord subtending a circular thickness arc. It is generally difficult to make chordal tooth measurements on gears of diametral pitches finer than 48 or worms finer than 0.065 circular pitch. Other means of specifying gear tooth thickness may be required for very fine diametral pitch gears.

Composite Action Test (Double Flank). The composite action test is a method of inspection in which the work gear is rolled in tight double flank contact with a master or a specified gear, in order to determine composite variations. The composite action test must be made on a variable center distance composite action test device.

Composite Tolerance, Tooth-to-Tooth (Double Flank), V_{qT} . The permissible amount of tooth-to-tooth composite variation.

Composite Tolerance, Total (Double Flank), V_{cqT} . The permissible amount of total composite variation.

Composite Variation (Double Flank). Composite variation is the total change in center distance when a gear is inspected by a composite action test.

Composite Variation, Tooth-to-Tooth (Double Flank), V_q . The greatest change in center distance while the gear being tested is rotated through 360 degree/ N during a double flank composite action test.

Composite Variation, Total (Double Flank), V_{cq} . The total change in center distance while the gear being tested is rotated one complete revolution during a double flank composite action test.

Control Gear Part Number. Control gear part number is a reference to the specific gear to be used to control the tooth thickness of the gear under consideration. Since master gears are not commonly available for bevel gears, it is customary to use a control gear, which is obtained

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by selection, when inspecting subsequent gears of a given gear tooth design.

Cutter Number. Cutter number is a specification of the cutter to be used to cut the face gear. The correct generation of a face gear tooth profile is dependent upon the correct selection of the cutter.

Dedendum, b . Dedendum is the depth of a tooth space below the standard (reference) pitch circle or pitch line; also the radial distance between the pitch circle and the root circle.

Dedendum in bevel gearing is the portion of the tooth extending below the pitch cone and is measured at the outer end of the teeth.

Face Angle, Γ_o . Face angle, in a bevel or hypoid gear, is the angle between an element of the face cone and its axis. The face cone is customarily defined by the top lands of the teeth. In some designs of bevel gearing the face cone elements do not pass through the apex.

Grinding Wheel or Cutter Diameter. Grinding wheel or cutter diameter is a necessary specification of the size of the cutter required to produce the desired worm thread profile. The thread profile can be shown to vary depending on the diameter of the cutter used to produce the thread.

Hand of Helix. Hand of helix is the direction in which the teeth twist as they recede from an observer looking along the axis. A right hand helix twists clockwise and a left hand helix twists counterclockwise.

A left hand helical rack has teeth which recede toward the left when viewed perpendicularly to the face of the rack; that is, when viewed in a direction parallel to the theoretical axis of the rack. A right hand helical rack has teeth which recede toward the right when viewed perpendicularly to the face of the rack; that is, when viewed in a direction parallel to the theoretical axis of the rack.

Hand of Spiral. Hand of spiral is the direction in which the teeth twist from an observer looking along the axis toward the face of the bevel gear. A right hand spiral twists clockwise; left hand, counterclockwise.

Helix Angle, ψ . Helix angle is the angle between any helix and an element of its cylinder. In helical gears and worms, it is at the standard pitch circle unless otherwise specified.

Initial Contact Area. Initial contact area is a specification of the amount of the area of contact between master and gear. An initial area of contact of approximately 50 percent is generally considered satisfactory.

Inner Diameter. Inner diameter is the diameter of the cylinder bounding the inner ends of the face gear teeth. This diameter is given a plus tolerance.

Lead. Lead is the axial advance of a helix for one complete revolution (360 degrees), as in the threads of cylindrical worms, and the teeth of helical gears. It also applies to the teeth of a wormgear.

Lead Angle, λ . Lead angle is the angle between any helix and a plane of rotation. It is the complement of the helix angle and is used for convenience in worms and hobs. It is understood to be at the pitch diameter unless otherwise specified.

Lead Tolerance. Lead tolerance is the allowable departure from the theoretical lead. In the case of a single thread worm the lead tolerance is customarily specified over one turn and over three turns of the thread. In the case of multiple thread worms, lead tolerance is specified over 1 axial pitch and over three axial pitches. **Note:** The term lead tolerance does not apply to helical gears. **Tooth Alignment Tolerance** is the proper term. See ANSI/AGMA 2000-A88 for a more complete discussion.

Machine Set-up Summary. Machine set-up summary is the information required to make machine settings. While the information for machine settings may be shown on the part drawing, it is customary, and usually preferred, to have a separate data sheet giving this information. When a separate data sheet is used, its summary drawing number should be given on the part drawing.

Master Gear Specification. Master gear specification is a specific reference to the master required to inspect a gear. This may be

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referenced in one of the following manners: number of teeth and basic tooth thickness, tool number, or the code number of the master gear required.

Mating Gear Part Number. Mating gear part number may be shown as a convenient reference.

Maximum Root Diameter. Maximum root diameter is specified to assure adequate clearance for the outside diameter of the mating gear.

Measurement Over Pins. Measurement over pins is the measurement of the distance over a pin positioned in a tooth space and a reference surface. The reference surface may be the reference axis of the gear, a datum surface or either one or two pins positioned in a tooth space or spaces opposite the first. This measurement is used to determine tooth thickness and is not applicable to face gears, bevel gears, or throated wormgears.

Worms are usually checked over 3 wires. Balls may be used for larger size internal helical gears.

Minimum Backlash at Assembly. Minimum backlash at assembly is often specified to assist in the assembly operation when adjustable centers are used.

Minimum Operating Mounting Distance. Minimum operating mounting distance is often specified to eliminate the necessity of getting prints of the mating gear and assemblies for checking the design specifications, interference, backlash and determination of master gear specification.

Mounting Distance. Mounting distance is the distance from the axis of the mating part to the mounting surface of the part under consideration in gearing on perpendicular axes.

In bevel gearing, the mounting distance of the gear is the distance from the axis of the pinion to the surface of the gear that controls its axial position. The mounting distance of the pinion is the distance from the axis of the gear to the surface of the pinion that controls its axial position.

In face gearing, the mounting distance of the face gear is the distance from the axis of the pinion to the surface on the gear that controls its axial position.

In wormgearing, the mounting distance is a specification that controls the position of the worm in the throat of the wormgear teeth.

Normal Chordal Addendum, a_{nc} . Normal chordal addendum is the chordal addendum in the plane normal to the pitch helix at the center of the tooth. Any convenient measuring diameter may be selected, not necessarily the pitch diameter.

Normal Chordal Thickness, t_{nc} . Normal chordal thickness is the chordal thickness in the plane normal to the pitch helix or the tooth trace at the center of the tooth. Any convenient measuring diameter may be selected, not necessarily the pitch diameter.

Number of Teeth, N . The number of teeth in 360 degrees of gear circumference. In case of a sector gear, both the actual number of teeth in the sector and the theoretical number of teeth in 360 degrees should be given.

Number of Threads. The number of threads in a worm is the number of threads contained in the whole circumference of the pitch circle. The term "starts" is sometimes used to differentiate between the number of convolutions along the length of the worm, and individual number of threads.

Number of Threads or Teeth. Number of threads or teeth in mating part is shown for reference purposes only.

Outer Cone Distance, A_o . The outer cone distance in bevel gears is the distance from the apex of the pitch cone to the outer ends of the teeth. When not otherwise specified, the short term *cone distance* is assumed to be outer cone distance. It is customary to give the diametral pitch, tooth thickness, addendum, and dedendum in bevel gears at the outer cone distance and, although not essential, to make the elements of the back cone perpendicular to the elements of the pitch cone.

Outer Diameter. Outer diameter is the diameter of the cylinder bounding the outer ends of the

face gear teeth. This diameter is given a minus tolerance.

Outside Diameter, D_o . Outside diameter is the diameter of the addendum (outside) circle. In a bevel gear it is the diameter of the crown circle. In a throated wormgear it is the maximum diameter of the blank. The term applies to external gears.

Outside diameter is usually shown on the drawing of the gear together with other blank dimensions so that it will not be necessary for machine operators to search gear tooth data for this dimension. Since outside diameter is also used in the manufacture and inspection of the teeth, it may be included in the data block with other tooth specifications if preferred. To enable use of topping hobs for cutting gears on which the tooth thickness has been modified from standard, the outside diameter should be related to the specified equivalent testing radius. See **test radius**.

Pitch, Axial. Axial pitch is the pitch of a gear parallel to the axis of rotation.

Pitch, Circular, p . Circular pitch is the distance along a specified pitch circle or pitch line between corresponding profiles of adjacent teeth. Unless otherwise specified it is given on the standard pitch circle.

Pitch, Diametral, P_d . Diametral pitch is the ratio of the number of teeth to the pitch diameter in the transverse plane. It is also defined from the pitch of the basic rack.

$$P_d = N / D \quad \text{or} \quad P_d = \pi / p$$

Pitch, Normal Diametral, P_{nd} . The normal diametral pitch is a ratio of the pitch diameter to the number of teeth corrected by the helix angle. In helical gearing, the diametral pitch can be referenced to the normal plane by applying the cosine of the helix angle.

$$P_{nd} = P_d / \cos \psi = N / D \cos \psi$$

Pitch Angle, Γ . The pitch angle in bevel gears is the angle between an element of a pitch cone and its axis. In external and internal gears, the pitch angles are respectively less than and greater than 90 degrees. The sum of the pitch angles of the

gear and its mate should equal the shaft angle of the pair. Although pitch angle cannot be directly measured, it is a convenience when considering the engineering aspect of the gear.

Pitch Plane to Reference Surface Dimension.

Pitch plane to reference surface dimension of a spur or helical rack is that dimension used to establish location of the pitch plane. The reference surface usually is, but may or may not be, the mounting surface.

Point Width of Grinding Wheel or Cutter.

Point width of grinding wheel or cutter is a specification controlling the space width and the whole depth of the thread of the worm.

Pressure Angle, ϕ , is in general the angle at a pitch point between the line of pressure which is normal to the tooth surface, and the plane tangent to the pitch surface. The pressure angle gives the direction of the normal to the tooth profile. The pressure angle is equal to the profile angle at the standard pitch circle and can be termed the "standard" pressure angle at that point.

Profile Angle, Normal, ϕ_n . The normal profile angle is the angle at a point on the pitch cylinder between the line of action which is normal to the tooth surface and the plane tangent to the pitch cylinder.

Profile Angle, Transverse, ϕ_t . The transverse profile angle is the profile angle in a transverse plane.

Quality Number, AGMA, Q . AGMA quality number is specified for convenience when talking or writing about the accuracy of the gear. These classes are defined in ANSI/AGMA 2000-A88 and AGMA 390.03a.

Root Angle, Γ_R . Root angle, in a bevel or hypoid gear, is the angle between an element of the root cone and its axis. The root cone is customarily defined by the bottom lands of the teeth; however, in some designs of straight bevel gears the bottom lands are not straight line elements, and in other designs the root cone elements do not pass through the pitch cone apex.

Shaft Angle, Σ . The shaft angle is the angle between the axes of two non-parallel gear shafts. In a pair of crossed helical gears, the shaft angle lies between the oppositely rotating portions of the

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two shafts. This applies also in the case of wormgearing. In bevel gears, the shaft angle is the sum of the two pitch angles. In hypoid gears, the shaft angle is given when starting a design, and it does not have a fixed relation to the pitch angles and spiral angles.

Spiral Angle, ψ . Spiral angle, in a spiral bevel gear, is the angle between the tooth trace and an element of the pitch cone, and corresponds to the helix angle of helical teeth. Unless otherwise specified, the spiral angle is understood to be at the mean cone distance.

Standard Pitch Diameter, D . The standard pitch diameter is the diameter of the standard pitch circle. In spur and helical gears, unless otherwise specified, pitch diameter is related to the number of teeth and the standard transverse pitch. It is obtained as:

$$D = N / P_d = N \times p / \pi$$

Surface Texture. Surface texture on functional profile surfaces is a measure of the quality of the surface finish of the tooth. It is very difficult to accurately determine the surface roughness of fine pitch gears. For many applications it is considered to be acceptable on gears which meet the maximum tooth-to-tooth composite tolerance specification.

Test Radius, R_t . The test radius is a number used as an arithmetic convention established to simplify the determination of the proper test distance between a master and a work gear for a composite action test. It is used as a measure of the effective size of a gear. The test radius of the master, plus the test radius of the work gear is the set-up center distance of a composite action test device. Test radius is not the same as the operating pitch radii of the two tightly meshing gears unless both are perfect and to basic or standard tooth thickness.

Testing dimension of a face gear is the distance from the mounting surface of the face gear to the standard pitch line of a standard master when in intimate contact under recommended load on a variable center distance running gage.

Testing Load. Testing Load is the recommended load between the work and the master gear when performing the rolling test as specified in ANSI/AGMA 2000-A88. Incorrect testing load will result in incorrect measurement of testing radius.

Tooth Contact Pattern Displacement. The tooth contact pattern of face gears is very sensitive to small changes in mounting distance. In cases where smooth operation is critical, it is desirable not to depart more than +0.001 inches from the nominal setting. The shape and location of the tooth contact pattern is influenced by cutter size, cutter tilt, and blank proportions.

Tooth Form. Tooth form defines the pinion or gear tooth profile, and may be specified as standard addendum, long addendum, short addendum, modified involute, or special. In case a modified involute or special tooth form is required, a detailed view should be shown on the drawing.

Tooth form on worms and wormgears is a specification of the profile of the thread or the wormgear tooth. The section in which the tooth form is specified should be noted. The worm thread profile is usually controlled by a specification of the cutter, and the wormgear tooth profile may be controlled by a reference to either the mating worm or preferably to the hob designed to cut the wormgear. Special cases should be controlled by reference to a tooth profile chart.

Tooth Thickness. Tooth thickness is the thickness of a tooth at a specified diameter or tooth height.

Maximum calculated circular thickness on the standard pitch circle is the tooth thickness which will provide the desired minimum backlash when the gear is assembled in mesh with its mate on minimum mounting distance. It is best controlled by testing in tight mesh with a master which integrates all the tolerances in the several teeth in the mesh through the arc of action. It is independent of the effects of runout. Circular thickness is used for calculating purposes and is not directly measured.

Maximum calculated normal circular thickness is the circular tooth thickness in the