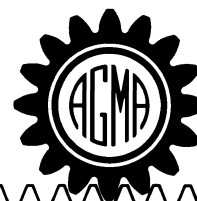


AMERICAN GEAR MANUFACTURERS ASSOCIATION

Specifications for Molded Plastic Gears

AGMA 909-A06



AGMA INFORMATION SHEET

(This Information Sheet is NOT an AGMA Standard)

American
Gear
Manufacturers
Association

Specifications for Molded Plastic Gears
AGMA 909-A06

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Approved July 18, 2006

ABSTRACT

The objective of this information sheet is to inform the plastic gear designer of the importance to clearly and thoroughly define the gear specifications to the plastic gear producer. This information sheet discusses the specifications for gear tooth geometry, inspection, other gear features and manufacturing.

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Contents

	Page
Foreword	iv
1 Scope	1
2 Normative references	1
3 Symbols	1
4 Gear tooth geometry data	1
5 Inspection data	3
6 Other gear feature specifications	5
7 Manufacturing specifications	6

Bibliography	25
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Annexes

A Plastic gear specifications	7
B Simplified approach to plastic gear specifications	15
C An alternative method for specifying molded plastic gears	23

Tables

1 Symbols	2
2 Basic gear data for external and internal spur gears	2
3 Basic gear data for external and internal helical gears	2
4 Tooth proportions data for external spur and helical gears	3
5 Tooth proportions data for internal spur and helical gears	3
6 Basic rack data for spur and helical gears	3
7 Composite inspection data	4
8 Master gear data	4
9 Alternate tooth thickness inspection data	5

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 Information Sheet 909-A06, *Specifications for Molded Plastic Gears*.]

The committee, responding to the widely recognized need for improving the technical communication between molded plastic gear purchasers and producers, developed this specification information sheet. The primary objective of this information sheet is to increase understanding by the gear purchaser of the responsibility to thoroughly define the gear requirements to the gear producer.

Plastic gear transmission design and manufacturing must consider the relationship of gear geometry, layout, housings, shafts, bearings, and materials. Molded plastic gears offer considerable design flexibility. However, physical properties and dimensions will vary over the range of operating conditions. To accommodate these variations and the molding process, the plastic gear designer must create detailed gear specifications for producing prototype or production gears. This information must clearly communicate to the gear producer what the gear designer specifies.

The first draft of AGMA 909-A06 was made in June, 2001. It was approved by the AGMA membership in July 18, 2006.

Suggestions for improvement of this document 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 Gear Manufacturers Association –

Specifications for Molded Plastic Gears

1 Scope

This information sheet is intended to aide the designer to select an appropriate set of specifications that will clearly convey to the producer what is required. Implications and reasons for the design specifications are discussed. Suggested data forms are given in annexes A, B and C.

1.1 Types of gears and processes

These specifications cover the types of plastic gears commonly manufactured by injection molding. Specifications are described for involute external and internal spur and helical gears. Less common bevel and face gears are not covered here because their specifications are significantly different, although they can be injection molded. Gears made by methods other than injection molding may require other specifications or practices.

2 References

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

ANSI/AGMA 1106-A97, *Tooth Proportions for Plastic Gears (Metric Edition)*

AGMA 2000-A88, *Gear Classification and Inspection Handbook – Tolerances and Measuring Methods for Unassembled Spur and Helical Gears (Including Metric Equivalents)*

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

ANSI/ASME Y14.5M (1994), *Geometric Dimensioning and Tolerancing*

3 Symbols

The symbols used in this information sheet are shown in table 1.

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

4 Gear tooth geometry data

The common method of specifying gear tooth geometry is through a complete list of detailed data, which are unique to gear technology. In engineering drawings part geometry is described in a direct manner, usually with a combination of lines, arcs, and special curves described by a series of data point coordinates. In contrast to this, the size and shape of gear outlines are described by indirect means. These indirect data are based on traditional methods of manufacturing and inspecting gears with some changes or additions associated with the injection molding process. Omission of any of the essential data in the gear designer's specifications may affect performance, cost, and delivery.

Gear tooth geometry data is often supplied on gear drawings in special tables or formats. The data in such formats are often grouped in categories to convey the different functions of the data. The set of categories described in this section, as listed, and the data assigned to each category, represents one type of specification format among others in common use:

- basic gear data;
- tooth proportions data;
- basic rack data.

Adherence to these formats is optional provided adequate specifications are supplied. For additional information on these features, see ANSI/AGMA 1106-A97.

Table 1 - Symbols

Symbol	Definition	Units	Where first used
D_b	Base diameter	mm	Table 2
d	Standard pitch diameter	mm	Table 2
L	Lead	mm	Table 3
m	Module	mm	4.1
m_n	Normal module	mm	Table 3
m_t	Transverse module	mm	Table 3
N	Number of teeth	- -	Table 2
P_d	Diametral pitch	mm	4.1
p_b	Base pitch	mm	Table 2
p_N	Normal base pitch	mm	Table 3
ϕ	Pressure angle	degrees	Table 2
ϕ_n	Normal pressure angle	degrees	Table 3
ϕ_t	Transverse pressure angle	degrees	Table 3
ψ	Helix angle	degrees	Table 3

4.1 Basic gear data

These data describe the gear in basic terms. They directly describe the gear itself and do not include data that apply to generating or inspection tooling. None of the data are accompanied by tolerances. Any permitted variations from the described geometry or tolerances are expressed by separate data elsewhere in the specification. Several secondary basic gear data are often added to provide additional helpful information. These data can be calculated from the primary basic gear data, however, and do not necessarily need to be specified. See tables 2 and 3. When the diametral pitch, P_d , is specified, rather than module, m , replace m with $1/P_d$ in the equations.

Table 2 - Basic gear data for external and internal spur gears

Primary data	Units
Number of teeth, N	- -
Module, m	mm
Pressure angle, ϕ	degrees
Secondary data	
Standard pitch diameter, d $d = Nm$	mm
Base diameter, D_b $D_b = d \cos \phi$	mm
Base pitch, p_b $p_b = \pi \frac{D_b}{N}$	mm

Table 3 - Basic gear data for external and internal helical gears

Primary data	Units
Number of teeth, N	- -
Normal module, m_n	mm
Normal pressure angle, ϕ_n	degrees
Helix angle, ψ	degrees
Helix hand (left/right)	- -
Secondary data	
Transverse module, m_t $m_t = \frac{m_n}{\cos \psi}$	mm
Transverse pressure angle, ϕ_t $\phi_t = \tan^{-1} \left(\frac{\tan \phi_n}{\cos \psi} \right)$	degrees
Standard pitch diameter, d $d = N m_t$	mm
Base diameter, D_b $D_b = d \cos \phi_t$	mm
Normal base pitch, p_N $p_N = \pi m_n \cos \phi_n$	mm
Lead, L $L = \pi \frac{d}{\tan \psi}$	mm

4.2 Tooth proportions data

Complete gear tooth geometry cannot be fully defined by the basic gear data and basic rack data without additional tooth proportions data. Tables 4

and 5 list the tooth proportions data required to fully define gear tooth geometry for external and internal spur and helical gears. Note that these items require a tolerance range. Sometimes the tooth outline, including the fillet, is fully defined by the tooth proportions data. In that case, the basic rack data may be omitted, see 4.3.

Table 4 - Tooth proportions data for external spur and helical gears

Item	Tolerance, mm
Normal circular tooth thickness at standard pitch diameter	+/-
Outer diameter	+/-
Root diameter	+/-
Involute form diameter	max.
Normal tooth tip radius	+/-
Effective outer diameter	+/-
Normal tip relief at effective outside diameter	+/-
Diameter at start of tip relief	+/-
Normal root fillet radius (reference)	min.
For spur gears, where the helix angle equals zero, disregard the word "normal".	

Table 5 - Tooth proportions data for internal spur and helical gears

Item	Tolerance, mm
Normal circular tooth thickness at standard pitch diameter	+/-
Major diameter	+/-
Normal root fillet radius at major diameter (reference)	min.
Involute form diameter	min.
Minor diameter	+/-
Normal tooth tip radius at minor diameter (reference)	+/-
Effective minor diameter	+/-
For spur gears, where the helix angle equals zero, disregard the word "normal".	

The outside diameter of an external gear and the internal diameter of an internal gear are not defined by the rack form. Therefore, they are required to be directly specified as part of the tooth proportions data.

It is sometimes desirable to make modifications to the involute profile of a gear tooth, such as tip relief or lead crown. The tip relief, or other profile modification, is often not defined by specifying modifications to the basic rack form, but rather by a separate description included in the tooth proportions data.

4.3 Basic rack data

These data apply to a generating form, and therefore, only indirectly describe the gear. Basic rack data is included when the tooth outline, especially in the fillet area, is defined as if a generating form were used to create the outline. The basic rack data describes the outline of this generating form. This method is used to produce gear sets that are less likely to have root fillet interference than using circular arcs and straight lines to describe the root fillet.

There are a number of basic rack standards in use for plastic gearing. A basic rack specification consists of a reference to such a standard, and may include a supplementary detail drawing.

In some situations a standardized basic rack is not preferred, because the tooth outline it defines may not be optimal for a specific application. In such cases the actual basic rack data must be specified, see table 6.

Table 6 - Basic rack data for spur and helical gears

Primary data	Units
Profile (pressure) angle	degrees
Module	mm
Dedendum from reference line	mm
Tooth thickness at reference line	mm
Fillet radius	mm
Tip relief features (optional)	mm

5 Inspection data

These data consist of tolerances that serve as the basis for specifying the accuracy of the gear. Included are indicators of gear tooth shape, size, alignment, and other features. If any of the inspection data are based on the use of a master gear or other inspection gage, reference to that master gear or gage must be included. Furthermore, if any of the inspection data are to be evaluated with special statistical requirements, reference to such also should be included. Some inspection specifica-

tion data might be used only during a first-piece or mold-approval inspection, while others will be used in periodic process-control inspections.

5.1 Accuracy systems

Classifying gear accuracy by the use of an accuracy system, such as the AGMA system, is widely used in all parts of the gear industry. An accuracy level can conveniently identify the desired level of the following tolerances that are normally included in the inspection data:

- composite tolerances;
 - total composite tolerance;
 - tooth-to-tooth composite tolerance;
- elemental tolerances;
 - radial runout;
 - pitch tolerance;
 - profile tolerance;
 - helix (lead) tolerance.

The accuracy system was specifically designed for cut metal gears. It does not reflect the unique characteristics of injection molded gears. Some inspection tolerances are easier to achieve than are others depending on the manufacturing method. The accuracy of metal gears is primarily controlled by its machining tolerances; a plastic gear has the added variable of material shrinkage. Therefore, it may be preferred to specify an accuracy level and modify certain individual inspection tolerances to meet performance and cost requirements.

5.2 Composite inspection data

The simplest, most economical, and commonly used set of gear accuracy verifications is based on double flank composite testing in which composite measurements of tooth thickness, runout, profile, and pitch deviations are made while the test gear is rotated in tight mesh with a suitable master gear. A limiting test radius is a convenient way to specify gear size and errors when using double flank composite testing. See table 7.

The master gear must be fully specified. This specification is agreed upon between the designer and molder. See table 8.

Table 7 - Composite inspection data

Data	Tolerance ¹⁾
Accuracy level	- -
Total composite tolerance	max.
Tooth-to-tooth composite tolerance	max.
Test radius	min./max.
Test load	basic
NOTE	
1) For definition of basic, see ANSI Y14.5M:1994.	

Table 8 - Master gear data

Data	Tolerance ¹⁾
Master gear identification	
Class	- -
Module	basic
Pressure angle	basic
Helix angle/hand	basic
Number of teeth	basic
Tooth thickness	+/-
Outside diameter	+/-
Root diameter	max.
Test diameter	basic
NOTE	
1) For definition of basic, see ANSI Y14.5M:1994.	

5.3 Elemental inspection data

Another set of gear accuracy verifications is based on measurements of individual gear tooth elements. Elemental inspection provides greater detail of the individual gear tooth elements. These measurements are made on computer-controlled measuring machines operated with special software. This type of inspection is slower and more expensive than composite testing, and is typically used for first-piece or mold-approval inspection, or when special operating requirements justify the greater expense. There are several elemental inspection standards available. For example, AGMA 2000-A88 lists the following elemental inspection criteria:

- quality number (accuracy);
- radial runout;
- pitch variation;
- profile tolerance;
- tooth alignment (lead) tolerance.