

AMERICAN GEAR MANUFACTURERS ASSOCIATION

***Method for Specifying the Geometry of
Spur and Helical Gears***

AGMA 913-A98



AGMA INFORMATION SHEET

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American
Gear

Manufacturers
Association

Method for Specifying the Geometry of Spur and Helical Gears
AGMA 913-A98

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ABSTRACT

This information sheet provides information to translate tooth thickness specifications which are expressed in terms of tooth thickness, center distance or diameter into profile shift coefficients, as that term is used in international standards.

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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 Information Sheet 913-A98, *Method for Specifying the Geometry of Spur and Helical Gears*.]

This information sheet is intended to provide sufficient information to allow its users to be able to translate tooth thickness specifications which are expressed in terms of tooth thickness, center distance or diameter into profile shift coefficients, as that term is used in international standards.

This AGMA information sheet and related publications are based on typical or average data, conditions or application.

AGMA 913-A98 was approved by the AGMA membership on March 13, 1998.

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

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Method for Specifying the Geometry of Spur and Helical Gears

1 Scope

This information sheet provides a general method for specifying profile shift and rack shift, with gear nomenclature and definitions. This document describes the effect that profile shift has on the geometry and performance of gears, but does not make specific design recommendations.

The equations in the first part of this document (clauses 3 and 4) apply to external gear pairs only. The corresponding equations for internal gear pairs are contained in clause 5.

Annexes A and B provide practical examples on the calculation of tool proportions and profile shift.

2 Terms and symbols

2.1 Terms

The terms used, wherever applicable conform to the following standards.

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

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

2.2 Symbols

This information sheet uses the ISO symbols in table 1. In cases where there are no ISO symbols, or the definitions are different, other symbols are used.

NOTE: The symbols, definitions and terminology used in this information sheet may differ from other AGMA publications. The user should not assume that familiar symbols can be used without a careful study of these definitions.

Table 1 - Symbols used in equations

ISO Symbols	Other Symbols	Terms	Units	Where first used
	C_1	Distance to SAP	mm	Eq 23
	C_2, C_3, C_4	Distances along line of action	mm	Eq 27
	C_5	Distance to EAP	mm	Eq 23
	C_6	Distance between interference points	mm	Eq 23
	Y_{J1}, Y_{J2}	Bending strength geometry factor, pinion and gear	--	Eq 30
	a_{ref}	Reference center distance	mm	Eq 5
a_w		Operating center distance	mm	Eq 16
c		Root clearance	mm	Eq 42
c_{i2}		Required clearance at the tooth root of the internal gear	mm	Eq 70
d		Diameter	mm	Eq 4
h_{a0}		Addendum of the tool	mm	Eq 22
h_{a1}, h_{a2}		Addendum, pinion and gear	mm	Eq 34
h_{aP0}		Distance on the cutting tool from the reference line to the point near the tooth tip where the straight part of the profile ends and the circular tip begins	mm	Eq 21

(continued)



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Table 1 (concluded)

ISO Symbols	Other Symbols	Terms	Units	Where first used
j_n		Normal operating circular backlash	mm	Eq 31
k		Tip-shortening coefficient	--	Eq 32
m		Module	mm	Eq 3
p		Circular pitch	mm	Eq 1
r_1, r_2		Reference radius, pinion and gear	mm	Eq 5
r_{a1}, r_{a2}		Outside radius, pinion and gear	mm	Eq 25
r_{b1}, r_{b2}		Base circle radius, pinion and gear	mm	Eq 13
r_{f1}, r_{f2}		Root radius, pinion and gear	mm	Eq 42
r_{fp1}		Radius of the pinion fillet circle	mm	Eq 60
s		Tooth thickness	mm	Eq 2
s_{n1}, s_{n2}		Reference normal circular tooth thickness, pinion and gear	mm	Eq 7
u		Gear ratio ≥ 1.0	--	Eq 10
	x_{E1}, x_{E2}	Generating rack shift coefficient, pinion and gear	--	Eq 46
x_1, x_2		Profile shift coefficient, pinion and gear	--	Eq 6
	x_{1min}	Minimum pinion profile shift coefficient to avoid undercut	--	Eq 20
	y	Profile shift	mm	Eq 6
	y_E	Rack shift	--	Eq 8
	y_{1min}	Minimum pinion profile shift to avoid undercut	mm	Eq 20
z_1, z_2		Number of teeth, pinion and gear	--	Eq 4
α_n		Reference normal pressure angle	--	Eq 7
α_t		Reference transverse pressure angle	--	Eq 9
α_{wt}		Operating transverse pressure angle	--	Eq 9
β		Reference helix angle	--	Eq 1
Δa_{ref}		Center distance modification	mm	Eq 32
Δs_n		Amount of tooth thinning	mm	Eq 8
$\Delta s_{n1}, \Delta s_{n2}$		Tooth thinning for backlash, pinion and gear	mm	Eq 31
ρ_{a0}		Radius of the circular tip of the tool	mm	Eq 22
ρ_p		Fillet radius of the basic rack	mm	Fig 1
Σx		Sum of profile shift coefficients	--	Eq 53
	Σx_E	Sum of generating rack shift coefficients	--	Eq 52
	σ_{F1}, σ_{F2}	Allowable bending stress, pinion and gear	MPa	Eq 30
Subscript conversion				
(none)		At reference diameter		
a		At addendum (tip) diameter		
b		At base cylinder diameter		
f		At root diameter		
n		Normal plane		
t		Transverse plane		
w		Operating, running or working		
y		At any (undefined) diameter		
0		Tool dimensions		
1		Pinion		
2		Gear or rack		

3 Definitions

This information sheet provides definitions of profile shift and rack shift and shows the relations between them and other gear quantities. The terms profile shift and rack shift are used in this information sheet for standardization. The intention is to replace the similar or related terms listed in table 2.

3.1 Basic rack

The standard basic rack tooth profile is the tooth profile normal section through the teeth of a basic rack which corresponds to an external gear with number of teeth $z = \infty$ and diameter $d = \infty$, see figure 1.

A gear with normal module, m_n , and normal pressure angle, α_n , has a basic rack whose normal circular pitch, p_n , is πm_n and whose normal pressure angle is α_n .

The reference plane of the basic rack is parallel to its tooth tip plane and is the plane on which the normal circular tooth thickness, s_n , is equal to one half the normal circular pitch. From this definition it follows that the normal circular tooth thickness on the reference plane is equal to the normal circular space width.

Table 2 - Obsolete terms

Addendum correction
Addendum elongation
Addendum increment
Addendum modification
Addendum ratio
Basic rack offset
Cutter offset
Delta addendum
Delta teeth
Drop-tooth design
Enlargement/reduction
Enlarged/reduced center distance
Enlarged/reduced number of teeth
Half pitch hob pull
High/low addendum
Hob offset
Hob pull
Increase/decrease
Involute shift
Long/short addendum
Nonstandard addenda
Over/undersize
Profile displacement
Profile withdrawal
Rack withdrawal
Tool shift
Tool withdrawal
Unequal addenda
X factor

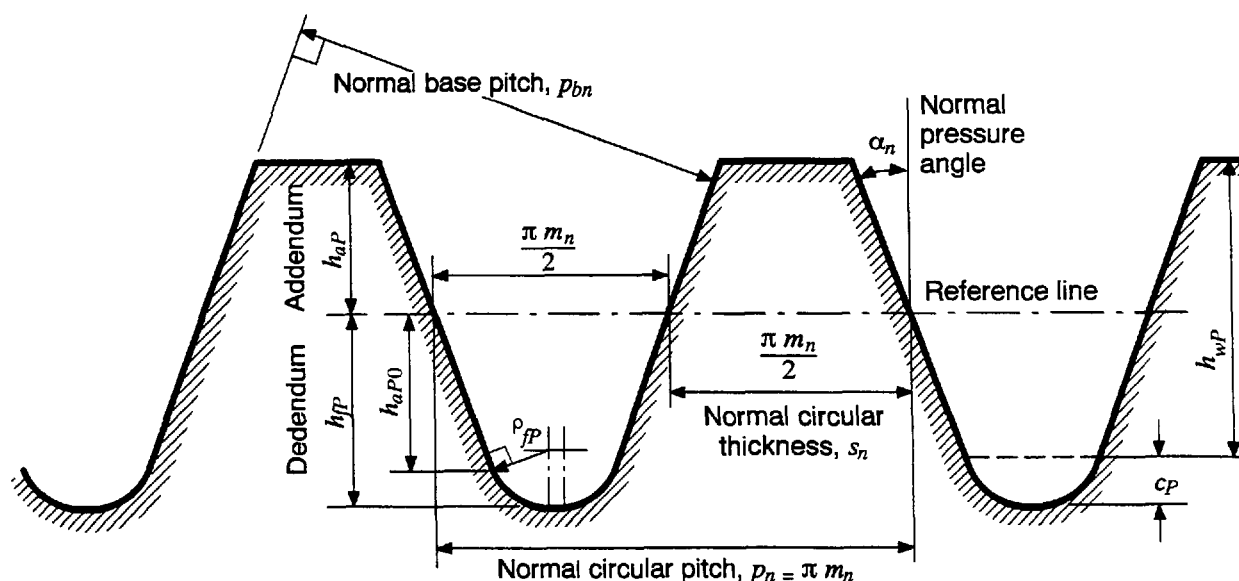


Figure 1 - The basic rack

If the basic rack is oriented so that its teeth make an angle β with the gear axis, see figure 3, the section *through the basic rack perpendicular to the gear axis* is called the transverse section. On this section, the transverse circular pitch, p_t , and the transverse tooth thickness, s_t , are given by:

$$p_t = \frac{p_n}{\cos \beta} \quad \dots(1)$$

$$s_t = \frac{s_n}{\cos \beta} \quad \dots(2)$$

and the transverse module, m_t , is defined by:

$$m_t = \frac{m_n}{\cos \beta} \quad \dots(3)$$

The basic rack represents the theoretical gear tooth form, not the form of the cutting tool. No allowance is made for backlash, finishing stock or manufacturing method.

The standard 20° normal pressure angle basic rack of ISO 53 is commonly used. This document is valid for that basic rack and for any other basic rack which meets the criteria of figure 1.

3.2 Reference cylinder of the gear (standard pitch cylinder)

The reference cylinder of a gear is defined as the pitch cylinder where circular pitch of the gear is equal to circular pitch of the basic rack. If the gear has z teeth and the rack is oriented with its teeth making an angle β with the gear axis, then the diameter, d , of the reference cylinder is given by

$$d = \frac{z m_n}{\cos \beta} \quad \dots(4)$$

The pitch plane of the basic rack is parallel to the reference plane and is the plane that is tangent to the reference cylinder of the gear. The helix angle of the gear at its reference cylinder is equal to β .

3.3 Reference center distance

The reference center distance of an external gear pair is defined as half the sum of the reference diameters.

$$a_{\text{ref}} = \frac{(d_1 + d_2)}{2} = r_1 + r_2 \quad \dots(5)$$

where r_1 and r_2 are the radii of the reference cylinders.

The reference center distance is not necessarily equal to the operating center distance. It is one of the advantages of involute gears, that the operating center distance can vary from the reference center distance without change in operation.

3.4 Hypothetical tool

The hypothetical tool is the complement of the basic rack as shown in figure 2. The reference line of the hypothetical tool is the line at which its normal circular tooth thickness is equal to $\frac{\pi m_n}{2}$.

The use of the phrase "hypothetical tool" in this document refers to a rack-type cutter. For additional information and an example calculation, see annexes A and B.

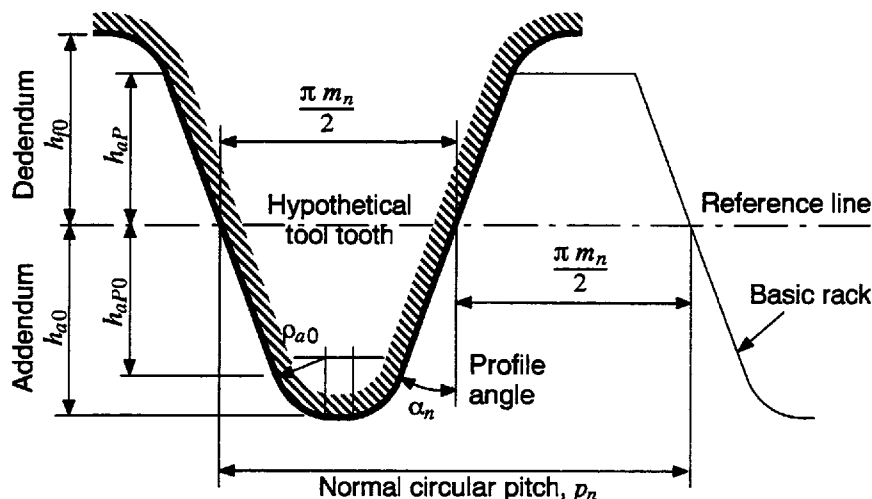


Figure 2 - Hypothetical tool