



American
Gear Manufacturers
Association

ANSI/AGMA 6034-C21
(Revision of ANSI/AGMA 6034-B92)

American National Standard

Practice for Enclosed Cylindrical Wormgear Speed Reducers and Gearmotors

ANSI/AGMA 6034-C21

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National
Standard*****Practice for Enclosed Cylindrical Wormgear Speed Reducers and Gearmotors***

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[Revision of ANSI/AGMA 6034-B92]

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ABSTRACT

This standard gives a method for rating and design of specific enclosed cylindrical wormgear reducers and gear motors at speeds not greater than 3600 rpm or mesh sliding velocities not more than 6000 ft/min. It contains power, torque and efficiency equations with guidance on component design, thermal capacity, service factor selection, lubrication, and self-locking features of wormgears. Annexes are supplied on service factors, user recommendations.

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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 6034-C21, *Practice for Enclosed Cylindrical Wormgear Speed Reducers and Gearmotors*.]

The purpose of this document is to provide rating and general design specifications for enclosed speed reducers incorporating cylindrical wormgearing in single or multiple reductions. It covers types of speed reducer designs most commonly made by a number of manufacturers.

The formulas presented in this standard contain terms whose individual values can vary significantly depending on application, system effects, accuracy, and manufacturing method. Proper evaluation of these terms is essential for realistic rating. The knowledge and judgment required to properly evaluate the various rating factors come primarily from years of accumulated experience in designing, testing, manufacturing, and operating similar gear units. The detailed treatment of the general rating formulas for specific product applications is best accomplished by those experienced in the field.

ANSI/AGMA 6034-A87 was a revision of AGMA 440.04 (1971), and in addition contained information for cylindrical wormgear hollow output shaft speed reducers and for cylindrical wormgear gearmotors previously contained in AGMA 442.01 (1965) and AGMA 461.01 (1966). These two standards have been withdrawn.

AGMA 6034-A87 power rating formulas were unchanged from those provided in the now withdrawn AGMA 440.04 (1971).

Service factors which appeared in AGMA 440.04 and AGMA 461.01 were revised and placed in the annex rather than the body of AGMA 6034-A87. These factors for modification of basic power ratings have been determined through experience and are intended as a guide. Suggested service factors for various applications were shown in Appendix A of ANSI/AGMA 6034-A87 as an additional aid.

A draft of ANSI/AGMA 6034-A87 was made in October 1982, and that version was approved by the AGMA membership in October 1987. In March 1988, it was approved as an American National Standard.

ANSI/AGMA 6034-B92 is a revision of ANSI/AGMA 6034-A87 which updates lubricant recommendations, removes bronze specifications by referring to ANSI/AGMA 2004-B89, *Gear Materials and Heat Treatment Manual*, and includes other minor editorial changes.

ANSI/AGMA 6034-B92 was approved as a revision by the AGMA membership in October 1991.

ANSI/AGMA 6034-C21 is a revision of ANSI/AGMA 6034-B92. It updates the rating and lubrication sections of the standard. The tabulated values for rating factors have been eliminated and replaced by equations from the previous Annex C which was eliminated. Rating equations have had a lubricant factor and strength capacity equations added. Terminology in the lubrication section has been updated.

The first draft of ANSI/AGMA 6034-C21 was created in September 2015. It was approved by the membership in September 2020 and as an American National Standard on April 9, 2021.

Suggestions for improvement of this standard will be welcome. They may be submitted to tech@agma.org.

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American National Standard –

Practice for Enclosed Cylindrical Wormgear Speed Reducers and Gearmotors

1 Scope

1.1 Applicability

This standard covers the wear rating and strength rating of wormgearing. This standard applies to the rating and design of enclosed cylindrical wormgear speed reducers and gearmotors having either solid or hollow output shafts and single or multiple reductions that may include other types of gearing used in conjunction with cylindrical wormgearing. The rating and design considerations contained in this standard are valid for rotational speeds of the worm not greater than 3600 rpm and sliding velocities at the mesh of not more than 6000 ft/min.

This standard applies only to cylindrical worm gear meshes where the worm is made of surface hardened steel and the worm wheels are made of bronze provided that all limits of application as outlined in 1.2 are adhered to.

The knowledge and judgment required to evaluate the various rating factors come from years of accumulated experience in designing, manufacturing, and operating gear units. Empirical factors given in this standard are suited to the particular use shown. This standard is intended for use by the experienced gear designer, capable of selecting reasonable values for the factors. It is not intended for use by the engineering public at large.

No limitation is placed on the method of producing the worms and gears, but the tooth form of the gear must be conjugate to the thread form of the worm. See ANSI/AGMA 6022, *Design Manual for Cylindrical Worm Gearing*.

1.2 Limits on the application of this standard

The equations and tables in this clause result in wear and strength ratings for wormgearing at a 1.0 service factor provided that:

- The worm and gear design guidelines specified in ANSI/AGMA 6022 are followed;
- The gear ratio is greater than or equal to 3.0;
- The rotational speed of the worm does not exceed 3600 rpm;
- Steel worms have a surface hardness and typical material found in Table 1;

Table 1 – Worm surface hardness and materials

Heat Treat	Hardness min/max	Typical Material
Carburized	58/62 HRC	8620/4320
Flame or Induction Hardened	50/62 HRC	4140/4150

- Steel worms are ground, polished, or rolled to a maximum surface roughness Ra of 16 microinches;

- f) The center distance of the mesh is at the standard center distance value of:

$$a = \frac{d_1 + d_2}{2} \quad (1)$$

where

- a is the mesh center distance, in;
 d_1 is the pitch diameter of the worm, in, see 4.4;
 d_2 is the pitch diameter of the gear, in, see 4.4.

NOTE: If the mesh center distance deviates from this value, the rating results may differ significantly from those calculated by this standard.

- g) Steel worms have a pitch diameter within the range:

$$0.333 a^{0.875} \leq d_1 \leq 0.625 a^{0.875} \quad (2)$$

- h) Steel worms have a maximum radial deflection of:

$$\Delta y_{1\max} \leq 0.005 \sqrt{p_{x1}} \quad (3)$$

where

- $\Delta y_{1\max}$ is the radial deflection of the worm under load, maximum, in;
 p_{x1} is the axial pitch of the worm, in, see 4.5.

NOTE: The calculation method for worm deflection can be found in ANSI/AGMA 6022.

- i) Gears are made of bronze. Allowable alloys are:

- UNS C90700;
- UNS C91700;
- UNS C67300.

NOTE: UNS 67300 is normally forged and is typically used for smaller size gear blanks where sliding velocities are less than 1000 feet per minute.

Allowable casting methods are:

- sand;
- static chill;
- centrifugal.

1.3 Exceptions

This standard does not apply to cylindrical wormgear reducers which are designed or used as speed increasers.

The rating method described by this standard does not apply to worm wheels made of ductile iron, aluminum bronze, manganese bronze, complex copper alloys, and plastics; although such materials are commonly used in worm gearing. Ductile iron can present additional challenges for the gear designer that are not covered by this standard including increased risks for fretting with the steel worm when vibration is present.

1.4 System considerations

This standard does not attempt to address complete drive systems, torsional vibration, critical speeds, or other types of vibrations which may affect operation of enclosed cylindrical worm gear reducers.

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.

ANSI/AGMA 6022, *Design Manual for Cylindrical Worm Gearing*

ANSI/AGMA 2004, *Gear Materials and Heat Treatment Manual*

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

ANSI/AGMA 6001, *Design and Selection of Components for Enclosed Gear Drives*

ANSI/AGMA 6013, *Standard for Industrial Enclosed Gear Drives*

ANSI/AGMA 9005, *Industrial Gear Lubrication*

3 Definitions and symbols

The symbols used in this standard are shown in Table 2.

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

The terms used, wherever applicable, conform to ANSI/AGMA 1012, *Gear Nomenclature, Definitions of Terms with Symbols*.

In many instances, the additional subscript “k” is added to indicate that the characteristic is associated with either the worm with $k = 1$, or the worm wheel (gear) with $k = 2$. When the characteristic is common to both components, the subscript k is omitted.

Table 2 – Symbols and terminology

Symbol	Definition	Units	Where first used
a	Mesh center distance	in	Eq. 1
D_k	Pitch diameter of the sprocket, gear or pulley mounted on “k”	in	Eq. 27
D_1	Pitch diameter of the sprocket, gear or pulley mounted on the worm	in	Eq. 27
D_2	Pitch diameter of the sprocket, gear or pulley mounted on the wormgear	in	Eq. 27
d_{f2}	Root diameter of the gear at the throat	in	Eq. 12
d_k	Pitch diameter of “k”	in	Eq. 6
d_1	Pitch diameter of the worm	in	Eq. 1
d_2	Pitch diameter of the gear	in	Eq. 1
F_{e2}	Effective face width of the gear	in	Eq. 11
F_2	Actual face width of the gear	in	Eq. 11
K_d	Materials factor based only on casting method and pitch diameter	--	Table 3
K_m	Ratio correction factor	--	Table 4
K_n	Gear speed factor	--	Table 6
K_O	Overhung load factor	--	Eq. 27
K_s	Materials factor	--	Eq. 13
K_v	Sliding velocity factor	--	Table 5
l_{f2}	Length of the gear tooth root	in	Eq. 12

Symbol	Definition	Units	Where first used
m_G	Gear ratio	--	Eq. 8
n_1	Rotational speed of the worm	rpm	Eq. 9
n_2	Rotational speed of the gear	rpm	Eq. 10
P_{Fw}	Power loss in the mesh due to frictional tooth wear	hp	Eq. 18
P_{IB}	Input power rating due to bending	hp	Eq. 26
P_{Iw}	Input power rating based on wear	hp	Eq. 19
P_{nd}	Normal diametral pitch	in ⁻¹	Eq. 5
P_{Ow}	Allowable output power on the gear based on tooth wear	hp	Eq. 17
P_{xd1}	Axial diametral pitch of the worm	in ⁻¹	Eq. 5
P_{xd2}	Axial diametral pitch of the wormgear	in ⁻¹	Eq. 5
p_{x1}	Axial pitch of the worm	in	Eq. 3
T_{B2}	Allowable bending torque on the gear based on bending	in-lb	Eq. 25
T_k	Torque on “k”	in-lb	Eq. 27
T_{w2}	Allowable torque on the gear based on wear	in-lb	Eq. 20
T_1	Torque on the worm	in-lb	Eq. 27
T_2	Torque on the wormgear	in-lb	Eq. 27
v_1	Sliding velocity of the worm	fpm	Eq. 9
W_{Fw2}	Friction force based on the allowable tangential load on the gear tooth due to wear	lb	Eq. 16
W_{Ok}	Overhung load of “k”	lb	Eq. 27
W_{O1}	Overhung load of the worm	lb	Eq. 27
W_{O2}	Overhung load of the wormgear	lb	Eq. 27
W_{TB2}	Allowable tangential load on the gear tooth due to bending	lb	Eq. 24
W_{Tw2}	Allowable tangential load on the gear tooth due to wear	lb	Eq. 15
$Z_{oil-wear}$	Oil type factor for wear	--	Table 7
$Z_{oil-\mu}$	Oil type factor for dynamic coefficient of friction	--	Table 7
z_k	Number of teeth (starts) on “k”	--	Eq. 6
z_1	Number of starts on the worm	--	Eq. 6
z_2	Number of teeth on the wormgear	--	Eq. 6
α_n	Normal pressure angle of the mesh	degrees	Eq. 16
β_k	Helix angle of “k” at the pitch diameter	degrees	Eq. 4
β_1	Helix angle of worm at the pitch diameter	degrees	Eq. 4
β_2	Helix angle of wormgear at the pitch diameter	degrees	Eq. 4
η_{fwd}	Forward drive efficiency with the worm driving	--	Eq. 21
η_{back}	Back drive efficiency with the gear driving	--	Eq. 22
λ_k	Lead angle of “k” at the pitch diameter	degrees	Eq. 4
λ_1	Lead angle of the worm at the pitch diameter	degrees	Eq. 4
λ_2	Lead angle of the wormgear at the pitch diameter	degrees	Eq. 4
μ	Dynamic coefficient of friction	--	Eq. 14

Symbol	Definition	Units	Where first used
σ_{AB}	Allowable wormgear bending stress	psi	Eq. 23
$\Delta y_{1\max}$	Radial deflection of the worm under load, maximum	in	Eq. 3
Subscripts			
1	Relating to the worm		
2	Relating to the wormgear		
k	Subscript whose value is 1 for the worm, or 2 for the gear		

4 Preliminary calculations

4.1 Conventions used in this standard

The conventions used in this standard are:

- Equations with a subscript “k” are used to indicate that the characteristic is associated with either the worm with $k = 1$, or the gear (worm wheel) with $k = 2$. When the characteristic is common to both components, the subscript k is omitted.
- Terms labeled as factors are dimensionless.

There can be issues with accuracy when using computing devices. It is recommended that enough significant digits (at least double precision) be used in the calculations to obtain an accurate result.

4.2 Helix angle

The helix angle is the compliment of the lead angle. The lead angle is usually specified instead of helix angle for cylindrical worms. The helix angle, in degrees, calculated from the lead angle is:

$$\beta_k = 90^\circ - \lambda_k \quad (4)$$

where

- β_k is the helix angle of “k” at the pitch diameter, degrees;
- β_1 is the helix angle of worm at the pitch diameter, degrees;
- β_2 is the helix angle of wormgear at the pitch diameter, degrees;
- λ_k is the lead angle of “k” at the pitch diameter, degrees;
- λ_1 is the lead angle of the worm at the pitch diameter, degrees;
- λ_2 is the lead angle of the wormgear at the pitch diameter, degrees.

4.3 Conversion to normal diametral pitch

This standard is based on the use of normal diametral pitch as an input value. Some designers prefer to use either the axial diametral pitch of the worm, wormgear or the axial pitch of the worm as the input value. The following conversion equation can be used to convert either of these approaches to normal diametral pitch:

$$P_{nd} = \frac{P_{xd1}}{\cos \beta_2} = \frac{P_{xd2}}{\sin \beta_2} = \frac{\pi}{p_{x1} \sin \beta_1} \quad (5)$$

where

- P_{nd} is the normal diametral pitch, in^{-1} ;
- P_{xd1} is the axial diametral pitch of the worm, in^{-1} ;
- P_{xd2} is the axial diametral pitch of the wormgear, in^{-1} .

4.4 Pitch diameter

The pitch diameter is:

$$d_k = \frac{z_k}{P_{nd} \cos \beta_k} \quad (6)$$

where

- d_k is the pitch diameter of “k”, in;
- z_k is the number of teeth (starts) on “k”;
- z_1 is the number of starts on the worm;
- z_2 is the number of teeth on the wormgear.

4.5 Axial pitch of the worm

The axial pitch of the worm is:

$$p_{x1} = \frac{\pi}{P_{nd} \sin \beta_1} \quad (7)$$

4.6 Gear ratio

The gear ratio is:

$$m_G = \frac{z_2}{z_1} \quad (8)$$

where

- m_G is the gear ratio.

4.7 Sliding velocity

The sliding velocity at the worm pitch diameter is:

$$v_1 = \frac{\pi n_1 d_1}{12 \cos \lambda_1} \quad (9)$$

where

- v_1 is the sliding velocity of the worm, fpm;
- n_1 is the rotational speed of the worm, rpm.

4.8 Rotational speed of the gear

The rotational speed of the gear is:

$$n_2 = \frac{n_1}{m_G} \quad (10)$$

where

- n_2 is the rotational speed of the gear, rpm.

4.9 Effective face width of the gear

The effective face width of the gear is the lessor of either the gear's actual face width or two-thirds of the pitch diameter of the worm and can be calculated as: