American
Gear Manufacturers
Association

Technical Resources

Revision of ANSI/AGMA 2001–C95
Reaffirmed January 2010

American National Standard

Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth

ANSI/AGMA 2001-D04

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[Revision of ANSI/AGMA 2001–C95]

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[Tables or other self–supporting sections may be referenced. Citations should read: See ANSI/AGMA 2001–D04, *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth,* published by the American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314, http://www.agma.org.]

Approved December 28, 2004

ABSTRACT

This standard specifies a method for rating the pitting resistance and bending strength of spur and helical involute gear pairs. A detailed discussion of factors influencing gear survival and calculation methods are provided.

Published by

American Gear Manufacturers Association
500 Montgomery Street, Suite 350, Alexandria, Virginia 22314

Printed in the United States of America

ISBN: 1–55589–839–4

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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 2001-D04, *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth*.]

This standard presents general formulas for rating the pitting resistance and bending strength of spur and helical involute gear teeth, and supersedes ANSI/AGMA 2001-C95.

The purpose of this standard is to establish a common base for rating various types of gears for differing applications, and to encourage the maximum practical degree of uniformity and consistency between rating practices within the gear industry. It provides the basis from which more detailed AGMA application standards are developed, and provides a basis for calculation of approximate ratings in the absence of such standards.

The formulas presented in this standard contain factors whose values vary significantly depending on application, system effects, gear accuracy, manufacturing practice, and definition of gear failure. Proper evaluation of these factors is essential for realistic ratings. This standard is intended for use by the experienced gear designer capable of selecting reasonable values for rating factors and aware of the performance of similar designs through test results or operating experience.

In AGMA 218.01 the values for Life Factor, C_L and K_L, Dynamic Factor, C_v and K_v, and Load Distribution Factor, C_m and K_m, were revised. Values for factors assigned in standards prior to that were not applicable to 218.01 nor were the values assigned in 218.01 applicable to previous standards.

The detailed information on the Geometry Factors, I and J, were removed from ANSI/AGMA 2001-B88, the revision of AGMA 218.01. This material was amplified and moved to AGMA 908-B89, *Geometry Factors for Determining the Pitting Resistance and Bending Strength for Spur, Helical and Herringbone Gear Teeth.* The values of I and J have not been changed from previous Standards.

In ANSI/AGMA 2001-B88 the Allowable Stress Number section was expanded. Metallurgical quality factors for steel materials were defined, establishing minimum quality control requirements and allowable stress numbers for various steel quality grades. Additional higher allowable stress numbers for carburized gears were added when made with high quality steel. A new rim thickness factor, K_B, was introduced to reduce allowable bending loads on gears with thin rims. Material on scuffing (scoring) resistance was added as an annex. ANSI/AGMA 2001-B88 was first drafted in January, 1986, approved by the AGMA Membership in May 1988, and approved as an American National Standard on September 30, 1988.

ANSI/AGMA 2001-C95 was a revision of the rating method described in its superseded publications. The changes included: the Miner's rule annex was removed; the analytical method for load distribution factors, C_m and K_m, was revised and placed in an annex; nitrided allowable stress numbers were expanded to cover three grades; nitrided stress cycle factors were introduced; through hardened allowable stresses were revised; application factor was replaced by overload factor; safety factors S_H and S_F were introduced; life factor was replaced by stress cycle factor and its use with service factor redefined; and, the dynamic factor was redefined as the reciprocal of that used in previous AGMA standards and was relocated to the denominator of the power equation.

This standard, ANSI/AGMA 2001-D04, is a revision of its superseded version. Clause 8 was changed to incorporate ANSI/AGMA 2015-1-A01 and the K_v method using AGMA 2000-A88 was moved to Annex A. References to old Annex A, "Method for Evaluating the

Risk of Scuffing and Wear" were changed to AGMA 925–A03. It also reflects a change to clause 10, dealing with the relationship between service factor and stress cycle factor. Editorial corrections were implemented to table 8, figure 14 and table E–1, and style was updated to latest standards.

This AGMA Standard and related publications are based on typical or average data, conditions, or applications. The Association intends to continue working to update this Standard and to incorporate in future revisions the latest acceptable technology from domestic and international sources.

The first draft of ANSI/AGMA 2001–D04 was completed in February 2002. It was approved by the AGMA membership on October 23, 2004. It was approved as an American National Standard on December 28, 2004.

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 –

Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth

1 Scope

1.1 Rating formulas

This standard provides a method by which different gear designs can be theoretically rated and compared. It is not intended to assure the performance of assembled gear drive systems.

These fundamental rating formulas are applicable for rating the pitting resistance and bending strength of internal and external spur and helical involute gear teeth operating on parallel axes. The formulas evaluate gear tooth capacity as influenced by the major factors which affect gear tooth pitting and gear tooth fracture at the fillet radius.

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 general in nature. AGMA application standards may use other empirical factors that are more closely suited to the particular field of application. 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.

1.2 Exceptions

The formulas of this standard are not applicable to other types of gear tooth deterioration such as plastic yielding, wear, case crushing and welding. They are also not applicable when vibratory conditions exceed the limits specified for the normal operation of the gears (see ANSI/AGMA 6000-A88, *Specification for Measurement of Lateral Vibration on Gear Units*).

The formulas of this standard are not applicable when any of the following conditions exist:

- Damaged gear teeth.
- Spur gears with transverse contact ratio, m_p, less than 1.0.
- Spur or helical gears with transverse contact ratio, m_p, greater than 2.0.
- Interference exists between tips of teeth and root fillets.
- Teeth are pointed.
- Backlash is zero.
- Undercut exists in an area above the theoretical start of active profile. The effect of this undercut is to move the highest point of single tooth contact, negating the assumption of this calculation method. However, the reduction in tooth root thickness due to protuberance below the active profile is handled correctly by this method.
- The root profiles are stepped or irregular. The J factor calculation uses the stress correction factors developed by Dolan and Broghamer [19]. These factors may not be valid for root forms which are not smooth curves. For root profiles which are stepped or irregular, other stress correction factors may be more appropriate.
- Where root fillets of the gear teeth are produced by a process other than generating.
- The helix angle at the standard (reference) diameter* is greater than 50 degrees.

Scuffing criteria are not included in this standard. A method to evaluate scuffing risk can be found in AGMA 925-A03. This information is provided for

[ ] Numbers in brackets refer to the reference number listed in the Bibliography.
* Refer to ANSI/AGMA 1012-F90 for further discussion of standard (reference) diameters.