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AMERICAN GEAR MANUFACTURERS ASSOCIATION

Effect of Lubrication on Gear Surface Distress

AGMA 925-A03

AGMA INFORMATION SHEET

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American Gear Manufacturers Association

Effect of Lubrication on Gear Surface Distress
AGMA 925–A03

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Approved March 13, 2003

ABSTRACT

AGMA 925–A03 is an enhancement of annex A of ANSI/AGMA 2101–C95. Various methods of gear surface distress are included, such as scuffing and wear, and in addition, micro and macropitting. Lubricant viscometric information has been added, as has Dudley's regimes of lubrication theory. A flow chart is included in annex A, Gaussian theory in annex B, a summary of lubricant test rigs in annex C, and an example calculation in annex D.

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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 925–A03, *Effect of Lubrication on Gear Surface Distress.*]

The purpose of this information sheet is to provide the user with information pertinent to the lubrication of industrial metal gears for power transmission applications. It is intended that this document serve as a general guideline and source of information about conventional lubricants, their properties, and their general tribological behavior in gear contacts. This information sheet was developed to supplement ANSI/AGMA Standards 2101–C95 and 2001–C95. It has been introduced as an aid to the gear manufacturing and user community. Accumulation of feedback data will serve to enhance future developments and improved methods to evaluate lubricant related wear risks.

It was clear from the work initiated on the revision of AGMA Standards 2001–C95 and 2101–C95 (metric version) that supporting information regarding lubricant properties and general tribological knowledge of contacting surfaces would aid in the understanding of these standards. The information would also provide the user with more tools to help make a more informed decision about the performance of a geared system. This information sheet provides sufficient information about the key lubricant parameters to enable the user to generate reasonable estimates about scuffing and wear based on the collective knowledge of theory available for these modes at this time.

In 1937 Harmon Blok published his theory about the relationship between contact temperature and scuffing. This went largely unnoticed in the U.S. until the early 1950's when Bruce Kelley showed that Blok's method and theories correlated well with experimental data he had generated on scuffing of gear teeth. The Blok flash temperature theory began to receive serious consideration as a predictor of scuffing in gears. The methodology and theories continued to evolve through the 1950's with notable contributions from Dudley, Kelley and Benedict in the areas of application rating factors, surface roughness effects and coefficient of friction. The 1960's saw the evolution of gear calculations and understanding continue with computer analysis and factors addressing load sharing and tip relief issues. The AGMA Aerospace Committee began using all the available information to produce high quality products and help meet its long–term goal of manned space flight. R. Errichello introduced the SCORING+ computer program in 1985, which included all of the advancements made by Blok, Kelley, Dudley and the Aerospace Committee to that time. It became the basis for annex A of ANSI/AGMA 2101–C95 and 2001–C95 which helped predict the risk of scuffing and wear. In the 1990s, this annex formed the basis for AGMA's contribution to ISO 13989–1.

Just as many others took the original Blok theories and expanded them, the Tribology Subcommittee of the Helical Gear Rating Committee has attempted to expand the original annex A of ANSI/AGMA 2001–C95 and 2101–C95. Specifically, the subcommittee targeted the effect lubrication may have on gear surface distress. As discussions evolved, it became clear that this should be a stand alone document which will hopefully serve many other gear types. This should be considered a work in progress as more is learned about the theories and understanding of the various parameters and how they affect the life of the gear. Some of these principles are also mentioned in ISO/TR 13989–1.

AGMA 925–A03 was approved by the AGMA Technical Division Executive Committee on March 13, 2003.

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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Effect of Lubrication on Gear Surface Distress

1 Scope

This information sheet is designed to provide currently available tribological information pertaining to oil lubrication of industrial gears for power transmission applications. It is intended to serve as a general guideline and source of information about gear oils, their properties, and their general tribological behavior in gear contacts. Manufacturers and end–users are encouraged, however, to work with their lubricant suppliers to address specific concerns or special issues that may not be covered here (such as greases).

The equations provided herein allow the user to calculate specific oil film thickness and instantaneous contact (flash) temperature for gears in service. These two parameters are considered critical in defining areas of operation that may lead to unwanted surface distress. Surface distress may be scuffing (adhesive wear), fatigue (micropitting and macropitting), or excessive abrasive wear (scoring). Each of these forms of surface distress may be influenced by the lubricant; the calculations are offered to help assess the potential risk involved with a given lubricant choice. Flow charts are included as aids to using the equations.

This information sheet is a supplement to ANSI/AGMA 2101–C95 and ANSI/AGMA 2001–C95. It has been introduced as an aid to the gear manufacturing and user community. Accumulation of feedback data will serve to enhance future developments and improved methods to evaluate lubricant related surface distress.

It was clear from the work on the revision of standard ANSI/AGMA 2001–C95 (ANSI/AGMA 2101–C95, metric version) that supporting information regarding lubricant properties and general tribological understanding of contacting surfaces would aid in understanding of the standard and provide the user with more tools to make an informed decision about the performance of a geared system. One of the key parameters is the estimated film thickness. This is not a trivial calculation, but one that has significant impact on overall performance of the gear pair. It is considered in performance issues such as scuffing, wear, and surface fatigue. This information sheet provides sufficient information about key lubricant parameters to enable the user to generate reasonable estimates about surface distress based on the collective knowledge available.

Blok [1] published his contact temperature equation in 1937. It went relatively unnoticed in the U.S. until Kelley [2] showed that Blok's method gave good correlation with Kelley's experimental data. Blok's equation requires an accurate coefficient of friction. Kelley found it necessary to couple the coefficient of friction to surface roughness of the gear teeth. Kelley recognized the importance of load sharing by multiple pairs of teeth and gear tooth tip relief, but he did not offer equations to account for those variables.

Dudley [3] modified Kelley's equation by adding derating factors for application, misalignment and dynamics. He emphasized the need for research on effects of tip relief, and recommended applying Blok's method to helical gears.

In 1958, Kelley [4] changed his surface roughness term slightly.

Benedict and Kelley [5] published their equation for variable coefficient of friction derived from disc tests.

The AGMA Aerospace Committee began investigating scuffing in 1960, and Lemanski [6] published results of a computer analysis that contains data for 90 spur and helical gearsets, and formed the terms for AGMA 217.01 [7], which was published in 1965. It used Dudley's modified Blok/Kelley equation and included factors accounting for load sharing and tip relief.