



**AGMA**  
**Information Sheet**

**Gear Scoring Design Guide for  
Aerospace Spur and  
Helical Power Gears**

## FOREWORD

About four years ago, the AGMA Aerospace Gearing Committee established a gear scoring study project, which included the collecting of data on gear sets which scored and did not score in field operation and test stand operation, including gear rig testing.

Members of the committee, and a number of non-member observers, were asked to send the gear test data to Mr. J. C. Leming, Vice Chairman, Aircraft Power Gearing, who checked over the data and assigned a case or code number to each gear set to keep it unidentified. It was felt that more authoritative data would be made available without revealing the precise practice or problems of any particular company, or without revealing any classified military project data.

The Vice Chairman submitted the coded gear test data to Mr. A. J. Lemanski for calculation of the maximum flash temperature index and scoring index. The calculations were made, using a program written in the Fortran system, on an IBM 7070 Digital Computer at Lycoming Division, Avco Corporation, Stratford, Connecticut. The formula used in the program is an improved version of the Kelley formula by Mr. D. W. Dudley. This improved formula provides for adjustment of the tooth load to allow for load sharing by more than one pair of teeth, and an adjustment for tooth profile modifications.

This information sheet was first presented by Mr. A. J. Lemanski at the Aerospace Gearing Committee Meeting, Cherry Plaza Hotel, Orlando, Florida, February 27-29, 1964. It was approved by the committee September 17, 1964. Information Sheet AGMA 217.01 was approved by the AGMA membership as of May 25, 1965.

*Tables or other self-supporting sections may be quoted or extracted in their entirety. Credit lines should read: "Extracted from AGMA Information Sheet — Gear Scoring Design Guide for Aerospace Spur and Helical Power Gears (AGMA 217.01), with the permission of the publisher, the American Gear Manufacturers Association, 1901 North Fort Myer Drive, Arlington, Virginia 22209."*

COPYRIGHT, 1965, BY  
AMERICAN GEAR MANUFACTURERS ASSOCIATION

**Personnel of  
Aerospace Gearing Committee  
Technical Division  
January, 1965**

D. W. Dudley, Chairman, Mechanical Technology, Inc., Latham, New York  
J. C. Leming, Vice Chairman, Michigan Tool Company, Detroit, Michigan  
P. Levi, Vice Chairman, Radio Corporation of America, Moorestown, New Jersey  
J. K. Morris, Vice Chairman, Western Gear Corporation, Lynwood, California  
W. R. Alexander, Steel Products Engineering Company, Springfield, Ohio  
S. L. Crawshaw, Philadelphia Gear Corporation, King of Prussia, Pennsylvania  
D. A. Davis, Hughes Aircraft Company, Culver City, California  
P. M. Dean, Jr., General Electric Company, Schenectady, New York  
C. P. del Cano, International Business Machines Corporation, Owego, New York  
J. W. Dern, Steel Products Engineering Company, Springfield, Ohio  
A. Dugger, Jr., Equitable Engineering Company, Royal Oak, Michigan  
W. H. Glover, Indiana Gear Works, Indianapolis, Indiana  
M. A. Hartman, Rocketdyne Div., North American Aviation, Canoga Park, California  
R. H. Held, International Business Machines Corporation, Owego, New York  
S. Humphries, Lycoming Division, Avco Corporation, Stratford, Connecticut  
T. W. Khiralla, Curtiss-Wright Corporation, Caldwell, New Jersey  
J. C. Kievit, Curtiss-Wright Corporation, Caldwell, New Jersey  
L. Kingston, Vertol Division, The Boeing Company, Morton, Pennsylvania  
E. R. Kitchen, Farrel Corporation, Rochester, New York  
J. H. Krajewski, Dearborn Tool & Manufacturing, Inc., Chicago, Illinois  
G. A. Larson, Westinghouse Electric Corporation, Baltimore, Maryland  
E. D. Legg, Westinghouse Electric Corporation, Baltimore, Maryland  
A. J. Lemanski, Vertol Division, The Boeing Company, Morton, Pennsylvania  
N. E. Lopez, The Boeing Company, Seattle, Washington  
P. Lynwander, Lycoming Division, Avco Corporation, Stratford, Connecticut  
W. B. McCardell, Michigan Tool Company, Detroit, Michigan  
W. L. McIntire, Allison Division, General Motors Corp., Indianapolis, Indiana  
E. J. Merrick, National Tool Company, Cleveland, Ohio  
V. Moore, The Boeing Company, Seattle, Washington  
J. G. Morgan, Hupp Aviation Division, Hupp Corporation, Chicago, Illinois  
J. M. Olchawa, Hewitt-Robins, Inc., Chicago, Illinois  
C. H. Parker, The Fellows Gear Shaper Company, Springfield, Vermont  
C. A. Underwood, Raytheon Company, Wayland, Massachusetts  
L. B. Venable, General Electric Company, Cincinnati, Ohio  
C. S. Wilson, Gleason Works, Rochester, New York

| <b>TABLE OF CONTENTS</b>  | <i>Page</i> |
|---|-------------|
| 1. Purpose .....  | 5           |
| 2. Resistance to Scoring and Surface Deterioration.....   | 5           |
| 3. Calculation of Flash Temperature Index .....   | 5           |
| 4. Analysis of Calculated Index Values .....  | 6           |
| 5. Design Guide for Maximum Flash Temperature Index .....   | 7           |
| 6. Scoring Probability .....  | 7           |
| 7. Effect of Surface Finish Number .....  | 7           |
| 8. Acknowledgments .....  | 8           |
| <br><b>APPENDIX</b> .....   |             |
|   | A1          |
| 1. Flash Temperature Index Formula .....  | A2          |
| 2. Scoring Index Formula .....  | A3          |
| 3. Statistical Analysis of Flash Temperature Index Distribution.....  | A4          |
| Table A-1 Summary of Scoring Data Modified Tooth Profiles.....<br>Lubricant: MIL-L-7808 Oil.  | A6          |
| Table A-2 Summary of Scoring Data Modified Tooth Profiles.....<br>Lubricant: MIL-O-6081, Grade 1005 Oil.  | A8          |
| Table A-3 Summary of Scoring Data Modified Tooth Profiles.....<br>Lubricant: 6081, Grade 1010, 6086, 25336, 6082, 15016 and 2104 Oils.              | A9          |
| Figure A-1 Graph of Maximum Flash Temperature Index Modified Tooth Profiles<br>Lubricant: MIL-L-7808 Oil.   | A10         |
| Figure A-2 Graph of Maximum Flash Temperature Index Modified Tooth Profiles<br>Lubricant: MIL-O-6081, Grade 1005 Oil.                               | A11         |
| Figure A-3 Graph of Maximum Flash Temperature Index Modified Tooth Profiles<br>Lubricant: 6081, Grade 1010, 6086, 25336, 6082, 15016 and 2104 Oils. | A12         |

AGMA Standards are subject to constant improvement, revision or withdrawal as dictated by experience. Any person who refers to AGMA technical publications should satisfy himself that he has the latest information available from the Association on the subject matter.

## AGMA INFORMATION SHEET GEAR SCORING DESIGN GUIDE FOR AEROSPACE SPUR AND HELICAL POWER GEARS

### 1. Purpose

1.1 This information sheet covers all aerospace spur and helical power gears lubricated with MIL-L-7808 and MIL-O-6081, Grade 1005 Oils.

1.2 The purpose of this information sheet is to present an improved flash temperature index formula and a recommended operating index range which will serve as a guide to designers for determining the scoring resistance of spur and helical gear sets intended for use in aerospace applications.

### 2. Resistance to Scoring and Surface Deterioration

2.1 Modern aerospace power gearing must be very reliable and also light weight in construction for the high tooth loads carried. In addition, this gearing is required to operate over a very wide temperature range, which dictates the use of low viscosity, high capacity lubricants. The usual high operating speeds further complicate the problem.

2.2 In the past, it was standard practice to consider the Hertz contact stress as the most significant parameter for surface durability (resistance to surface deterioration) in gear designs. In present day applications, the highly loaded gear teeth are not separated by a fully hydrodynamic oil film during all phases of engagement. It is believed that part of the

tooth action takes place under boundary film conditions. The combination of high loads and sliding action at the tips of driving pinion teeth, and flanks of the driven gear teeth, impose the most severe conditions for the lubricating oil.

2.3 The usual operating conditions require mating gear teeth to be modified (tip and/or flank relief) from a true involute form to account for elastic deflections under load and tooth position errors. In actual practice, manufacturing processes produce tooth profile modifications with variations from tooth-to-tooth and small surface irregularities (lay of surface). These conditions lower the oil viscosity and film strength due to frictional heat and dynamic loads in the critical contact areas. The net result is a breakdown of the lubricating film which permits metal-to-metal contact and a welding and tearing apart action. This type of surface deterioration (scoring) occurs very rapidly and can reach severe proportions.

2.4 Therefore, present day aerospace gearing requires an additional design parameter to define gear tooth surface loading. To date, the flash temperature concept has proven to be the most reliable method for proportioning gear tooth geometry, so as to obtain maximum overall resistance to scoring or surface deterioration.

### 3. Calculation of Flash Temperature Index

3.1 The flash temperature index was calculated at five specific points on the operating line of action