



American  
Gear Manufacturers  
Association

---

Technical Resources

Identical to ISO/TR 10064-6:2009

## **AGMA Information Sheet**

### **Code of Inspection Practice – Part 6: Bevel Gear Measurement Methods**

American  
Gear  
Manufacturers  
Association

***Code of Inspection Practice - Part 6: Bevel Gear Measurement Methods***

AGMA ISO 10064-6-A10

Identical to ISO/TR 10064-6:2009

**CAUTION NOTICE:** AGMA technical publications are subject to constant improvement, revision or withdrawal as dictated by experience. Any person who refers to any AGMA technical publication should be sure that the publication is the latest available from the Association on the subject matter.

[Tables or other self-supporting sections may be referenced. Citations should read: See AGMA ISO 10064-6-A10, *Code of Inspection Practice - Part 6: Bevel Gear Measurement Methods*, published by the American Gear Manufacturers Association, 1001 N. Fairfax Street, 5<sup>th</sup> Floor, Alexandria, Virginia 22314, <http://www.agma.org>.]

Approved August 24, 2010

**ABSTRACT**

This information sheet provides a discussion on measuring methods and practices of unassembled bevel and hypoid gears and gear pairs. It includes methods and practices, which permit the manufacturer and purchaser to conduct measuring procedures which are accurate and repeatable to a degree compatible with the specified tolerance grade of ISO 17485.

Published by

**American Gear Manufacturers Association**

**100 N. Fairfax Street, 5<sup>th</sup> Floor, Alexandria, Virginia 22314**

Copyright © 2010 by American Gear Manufacturers Association

All rights reserved.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without prior written permission of the publisher.

Printed in the United States of America

ISBN: 978-1-55589-994-3

## Contents

	Page
Foreword .....	v
1 Scope .....	1
2 Normative references .....	1
3 Terms, definitions and symbols .....	1
3.1 Terms and definitions .....	1
3.1.1 Toe .....	1
3.1.2 Heel .....	2
3.1.3 Tip .....	2
3.1.4 Root .....	2
3.1.5 Topland .....	2
3.1.6 Wheel .....	2
3.1.7 Pinion .....	2
3.2 Symbols .....	2
4 Bevel gear measurement .....	3
4.1 Manufacturing and purchasing considerations .....	3
4.2 Manufacturing documentation .....	3
4.3 Process control .....	3
4.4 Measurement methods .....	4
4.5 Additional considerations .....	4
4.5.1 General aspects .....	4
4.5.2 Backlash .....	4
4.5.3 Matching gears as sets .....	4
4.5.4 Reference gears for composite action tests .....	4
4.6 Acceptance criteria .....	5
5 Measuring methods and practices .....	5
5.1 Guidelines for measurement of gear characteristics .....	5
5.2 Measuring practices .....	5
5.2.1 Statistical sampling .....	5
5.2.2 First piece measurement .....	5
5.2.3 Measurement data references .....	6
5.3 Measurement of pitch deviations .....	7
5.3.1 Pitch deviation measurement .....	7
5.3.2 Pitch deviation measurement methods .....	7
5.3.3 Pitch measurement by indexing method .....	7
5.3.4 Pitch measurement by comparator method .....	9
5.4 Measurement of bevel gear runout .....	12
5.4.1 Runout of bevel gear teeth .....	12
5.4.2 The ball probe .....	12
5.5 Flank form measurement .....	13
5.5.1 Introduction .....	13
5.5.2 Grid point measurement of bevel pinion and wheel tooth flank geometry .....	14
5.5.3 Tooth trace measurement of bevel pinion and wheel tooth flank geometry .....	15
5.6 Contact pattern checking .....	18
5.6.1 Methods .....	18
5.6.2 Gear roll testing machine .....	19
5.6.3 Procedure .....	19
5.6.4 Interpreting results .....	20
5.6.5 Runout by contact pattern check .....	21
5.6.6 V and H check .....	21
5.6.7 Record of tooth contact patterns .....	22

5.7	Single-flank composite inspection .....	22
5.8	Double-flank composite testing .....	23
5.8.1	Method .....	23
5.8.2	Equipment requirements for double-flank composite testing .....	23
5.8.3	Reference gears .....	24
5.8.4	Method of conducting double-flank composite inspection .....	24
5.9	Tooth thickness measurement .....	24
5.9.1	Tooth thickness measurement by gear tooth caliper .....	24
5.9.2	Tooth thickness measurement by CNC and CMM .....	25
5.9.3	Tooth thickness measurement by backlash .....	25
5.9.4	Ball-probe comparison of tooth size .....	26
5.10	Manufacturing applications .....	26
6	Recommended datum surface tolerances .....	26
	Bibliography .....	28

### Tables

1	Alphabetical list of terms .....	2
2	Alphabetical list of symbols .....	3
3	Sample table with hypothetical deviation values obtained by pitch comparator (two-probe) .....	11
4	Sample table with hypothetical deviation values obtained by indexing (single-probe) device .....	11
5	Example of flank form evaluation .....	22

### Figures

1	Nomenclature of bevel and hypoid gear teeth .....	2
2	Example reference surfaces .....	6
3	Tooth identification terminology from apex end .....	7
4	Schematic diagram of single-probe device .....	8
5	Pitch data from single-probe device .....	9
6	Pitch measurements with a pitch comparator .....	10
7	Single pitch deviation, two-probe device .....	10
8	Sample graphical representation of single pitch deviations, $f_{pt}$ .....	12
9	Sample graphical representation of index deviations .....	12
10	Single-probe runout check .....	13
11	Measurement traces .....	13
12	Measurement grid .....	14
13	Three-dimensional coordinates .....	15
14	Example of three-dimensional graphical output .....	16
15	Traces of hypoid pinion and wheel after cutting .....	17
16	Tooth profiles of lapped hypoid set .....	17
17	Relative tooth deviation and tooth contact analysis .....	18
18	Schematic diagram of a typical test machine and tooth contact pattern V and H movements .....	19
19	Tooth contact patterns .....	20
20	Runout contact pattern variation .....	21
21	Schematic diagram of bevel gear double-flank tester .....	23
22	Double-flank test data –12-tooth gear .....	25
23	Measurement of tooth thickness by means of a gear tooth calliper .....	25
24	Measurement of backlash in a pair of gears by means of a dial indicator .....	26
25	Axial movement per 0.025 mm change in backlash .....	27

## 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 ISO Information Sheet 10064-6-A10, *Code of Inspection Practice - Part 6: Bevel Gear Measurement Methods*.]

The measurement and tolerance specification of bevel gears are very complex subjects that were in need of international standardization. For these and other reasons, ISO/TC 60 approved the project based on a proposed document, ANSI/AGMA 2009-B01, *Bevel Gear Classification, Tolerances, and Measuring Methods*.

At an early stage it was decided to develop two documents: ISO 17485, with accuracy grades and definitions, and a separate Technical Report, ISO/TR 10064-6, containing inspection practice and measuring methods. These practices and measuring methods included topics such as manufacturing considerations, CMM measurements, contact pattern checking, and advance topics such as bevel gear flank form analysis.

AGMA ISO 10064-6-A10 represents an identical adoption of ISO/TR 10064-6:2009.

The first draft of AGMA ISO 10064-6-A10 was made in March, 2010. It was approved by the AGMA Technical Division Executive Committee on August 24, 2010.

Suggestions for improvement of this document will be welcome. They should be sent to the American Gear Manufacturers Association, 1001 N. Fairfax Street, 5<sup>th</sup> Floor, Alexandria, Virginia 22314.

## **PERSONNEL of the AGMA Gear Accuracy Committee**

Chairman: Edward Lawson . . . . . Gleason M&M Precision Systems Corporation

Vice Chairman: Steven A. Lindley . . . . . Rexnord Gear Group

## **ACTIVE MEMBERS**

W.A. Bradley, III . . . . . Consultant

Z.J. Cichon . . . . . Innovative Rack & Gear Co.

B.L. Cox . . . . . BWXTY-12, LLC

M. Crossman . . . . . Caterpillar, Inc.

S. Doubler . . . . . GM Powertrain Global Headquarters

R. Frazer . . . . . University of Newcastle-Upon-Tyne, Design Unit

G. Gates . . . . . RotoMetrics

D. Hepker . . . . . Great Lakes Industry, Inc.

D. Hoying . . . . . Gleason M&M Precision Systems Corporation

T. Klaves . . . . . Milwaukee Gear Company

R. Kleiss . . . . . Kleiss Gears, Inc.

R. Layland . . . . . Precision Gage Company

M. May . . . . . The Gleason Works

C. Norwood . . . . . Martin Sprocket & Gear, Inc.

E. Reiter . . . . . Web Gear Services, Ltd.

J.M. Rinaldo . . . . . Atlas Copco Comptec, LLC

B. Schultz . . . . . Great Lakes Industry, Inc.

R.E. Smith . . . . . R.E. Smith & Co., Inc.

T. Thompson . . . . . GM Powertrain Global Headquarters

## American Gear Manufacturers Association –

# Code of Inspection Practice – Part 6: Bevel Gear Measurement Methods

## 1 Scope

This part of ISO/TR 10064 provides information on measuring methods and practices of unassembled bevel and hypoid gears and gear pairs.

Tolerances are provided in Clause 5 of ISO 17485:2006, for calculating the maximum values allowed by the specific tolerance grade.

Measuring methods and practices are included in order to promote uniform inspection procedures (see Clause 5). These methods permit the manufacturer and purchaser to conduct measuring procedures which are accurate and repeatable to a degree compatible with the specified tolerance grade of ISO 17485.

See Clause 6 of ISO 17485:2006 for required and optional measuring methods.

This part of ISO/TR 10064 applies to bevel gear components as defined in ISO 17485. It does not apply to enclosed gear unit assemblies, including speed reducers or increasers, gear motors, shaft mounted reducers, high speed units, or other enclosed gear units which are manufactured for a given power, speed, ratio or application.

The use of the accuracy grades for the determination of gear performance requires extensive experience with specific applications. Therefore, users are cautioned against the direct application of

tolerance values to a projected performance of unassembled gears when they are assembled.

Tolerance values for gears outside the limits stated in ISO 17485 are established by determining the specific application requirements. This possibly requires setting a tolerance smaller than that calculated by the formulae in ISO 17485.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1122-1, *Vocabulary of gear terms – Part 1: Definitions related to geometry*

ISO 17485:2006, *Bevel gears – ISO system of accuracy*

ISO 23509, *Bevel and hypoid gear geometry*

## 3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 17485 and the following terms, definitions and symbols apply. See Figure 1.

NOTE 1 Some of the terms, definitions and symbols contained in this Technical Report may differ from those used in other documents. Users of this Technical Report can be assured that they are using the terms, definitions and symbols in the manner indicated herein.

NOTE 2 The general wording “gear” or “bevel gear”, depending on the context, can refer to the “wheel” or the “pinion”.

NOTE 3 For other geometric, measurement and tolerance terms and definitions related to gearing, see ISO 1122-1 and ISO 23509.

### 3.1 Terms and definitions

#### 3.1.1 Toe

portion of the bevel gear tooth surface at the inner end.