

# ISO/TR 10064-1:2017-07 (E)

## Code of inspection practice - Part 1: Measurement of cylindrical gear tooth flanks

---

<b>Contents</b>		<b>Page</b>
Foreword .....		vi
<b>1</b>	<b>Scope .....</b>	<b>1</b>
<b>2</b>	<b>Normative references .....</b>	<b>1</b>
<b>3</b>	<b>Terms, definitions, symbols and abbreviated terms .....</b>	<b>1</b>
<b>4</b>	<b>General considerations .....</b>	<b>5</b>
4.1	Background .....	5
4.2	Required inspection information .....	5
4.3	Measurement selection .....	5
4.3.1	Substitution of measurement methods .....	5
4.3.2	First piece inspection .....	5
4.3.3	Sampling and statistical process control .....	5
<b>5</b>	<b>Conventions and measurement positions .....</b>	<b>6</b>
5.1	General .....	6
5.2	Datum axis .....	6
5.3	Left or right flank .....	6
5.4	Left hand or right hand helical gears .....	7
5.5	Numbering of teeth and flanks .....	7
5.6	Numbering of pitches .....	8
5.7	Number of pitches "k" in a deviation symbol subscript .....	8
<b>6</b>	<b>Types of measuring equipment and principle .....</b>	<b>8</b>
6.1	General .....	8
6.2	Measurement methods .....	14
6.2.1	Generative measurement methods .....	14
6.2.2	Non-generative measurement methods .....	16
6.2.3	Pitch measurement methods .....	17
6.2.4	Hand-held pitch measuring devices .....	18
6.2.5	Radial runout measurement .....	20
6.2.6	Computer tomography methods for small gears .....	21
6.2.7	Optical devices for small spur gears .....	21
6.3	Calibration of equipment .....	22
6.4	Tooth thickness, differences between CNC/CMM and manual measurement .....	22
6.5	"In-process" gear measurement on manufacturing machines .....	23
6.6	Gear mounting .....	23
6.7	Example output format from a CNC GMM .....	24
6.7.1	General .....	24
6.7.2	Example evaluations of modified helices and profiles .....	27
<b>7</b>	<b>Recommended measurement procedure and good measurement practice .....</b>	<b>28</b>
7.1	Measurement procedure .....	28
7.2	Probe problems when measuring aluminium parts .....	30
7.3	Suitable artefacts for calibration of measuring machines .....	30
<b>8</b>	<b>Inspection procedures for gears that are too large for gear inspection machines .....</b>	<b>31</b>
8.1	General .....	31
8.2	Profile inspection using portable device .....	31
8.2.1	Disassembly of segments .....	31

8.2.2	Measurement by portable gear inspection device using coordinates .....	31
8.2.3	Profile inspection by gear tooth caliper .....	32
8.3	Inspection of helix form deviation .....	36
8.3.1	Inspection of helix form deviation on the gear cutting machine .....	36
8.3.2	Straightness inspection using a cylinder .....	37
8.3.3	Inspection of the tooth contact pattern .....	37
8.4	Inspection of the pitch .....	38
8.4.1	Calculation of pitch .....	38
8.4.2	Inspection using an automatic device on the cutting machine: inspection of the single circular pitch and the cumulative pitch deviation .....	38
8.4.3	Manual inspection: inspection of base pitch, pb, and base pitch deviations, fpb .....	39
8.5	Measuring tooth thickness .....	39
8.6	Measuring gear radial runout and axial runout of reference surfaces .....	39
9	Measurement analysis -- Profile, helix, pitch and radial runout .....	39
9.1	Profile .....	39
9.1.1	Profile deviation .....	39
9.1.2	Profile deviation diagram .....	40
9.1.3	Evaluation of profile diagrams .....	41
9.1.4	Algebraic signs of fH, fb and f .....	42
9.1.5	Mean profile slope deviation, fHm .....	42
9.2	Helix .....	43
9.2.1	General .....	43
9.2.2	Helix deviation diagram .....	44
9.2.3	Evaluation of helix diagrams .....	45
9.2.4	Algebraic signs of fH and f .....	46
9.2.5	Machine corrections based on mean helix slope deviation, fHm .....	47
9.3	Pitch .....	48
9.3.1	Pitch deviation .....	48
9.3.2	Pitch deviation measurement .....	48
9.3.3	Relationships of pitch parameters and measuring methods .....	48
9.3.4	Calculation of cumulative pitch (index), Fp .....	49
9.3.5	Calculation of single pitch, fpi .....	50
9.3.6	Calculation of total cumulative pitch deviation, Fp .....	50
9.3.7	Calculation of sector pitch deviation, Fpk .....	50
9.3.8	Segment gear measurement .....	50
9.4	Radial runout, determining eccentricity .....	51
9.4.1	Measuring principle .....	51
9.4.2	Evaluation of measurement .....	51
10	Interpretation of profile, helix, pitch and radial runout results .....	52
10.1	Interpreting measurement results .....	52
10.2	Procedure for interpreting measurement results .....	52
10.3	Recognition of common manufacturing errors .....	53
10.3.1	General .....	53
10.3.2	Example of a profile with pressure angle deviation .....	53
10.3.3	Example of profile deviations with varying pressure angle deviation .....	53
10.3.4	Hob runout or shaping cutter deflection .....	54
10.3.5	Consistent mean helix slope deviation .....	55
10.3.6	Helix slope variation .....	55
10.3.7	Profile control diameter not achieved .....	56
10.3.8	Variation in profile non-clean up and profile control diameter not achieved .....	56
10.3.9	Pitch results with radial runout of the gear blank .....	58
10.3.10	Pitch with indexing deviations .....	58
10.3.11	Pitch with repeating deviation patterns that may cause noise .....	61
11	Single flank composite testing .....	61
11.1	Single flank composite testing principle .....	61
11.2	Single flank composite test .....	62
11.2.1	Single flank test setup .....	62
11.2.2	Single flank composite deviations .....	64

11.3	Single flank measurement with master gear .....	65
11.3.1	Master gear requirements .....	65
11.3.2	Influence of profile deviations .....	65
11.3.3	Influence of pitch deviations .....	66
11.3.4	Influence of helix deviations .....	66
11.4	Single flank measurement of product gear pair .....	69
11.4.1	Differences between tests with a master gear and between two product gears .....	69
11.4.2	Identification and location of defects .....	69
11.4.3	Selective meshing of gears .....	69
11.5	Data analysis by the Fourier transform method .....	70
12	Additional measurements .....	71
12.1	Flank measurements .....	71
12.1.1	General .....	71
12.1.2	Twist measurement .....	71
12.1.3	Topographical measurement .....	72
12.1.4	Undulations .....	73
12.2	Surface roughness measurement .....	74
12.3	Tooth root fillet radius measurement .....	74
13	Filters and data density .....	75
13.1	General .....	75
13.2	Examples of filtered results .....	75
13.3	Working principle of the Gauss 50 % filter .....	75
13.4	Filter limitations .....	81
14	Additional calculations .....	81
14.1	Calculation of single pitch deviation, $f_{pt}$ , from normal base pitch measurements .....	81
14.2	Additional calculations for normal base pitch measurements .....	82
14.2.1	Included parameters .....	82
14.2.2	Calculation of normal base pitch deviation, $f_{pbn}$ .....	82
14.2.3	Calculation of mean normal base pitch deviation, $f_{pbnm}$ .....	82
14.3	Additional calculations for profile measurements .....	82
14.3.1	Included parameters .....	82
14.3.2	Mean base diameter deviation and mean pressure angle deviation .....	83
14.3.3	Calculation of effective base diameter, $d_{b\text{ eff}}$ .....	84
14.3.4	Calculation of effective transverse pressure angle, $t_{\text{ eff}}$ .....	84
14.3.5	Calculation of effective normal pressure angle, $n_{\text{ eff}}$ .....	84
14.3.6	Calculation of mean transverse pressure angle deviation, $f_{mt}$ .....	85
14.3.7	Calculation of mean normal pressure angle deviation, $f_{mn}$ .....	85
14.4	Additional calculations for helix measurements .....	85
14.4.1	Included parameters .....	85
14.4.2	Required preliminary data .....	86
14.4.3	Calculation of effective helix angle at the measurement diameter, $M_{\text{ eff}}$ .....	86
14.4.4	Calculation of effective lead, $p_{z\text{ eff}}$ .....	86
14.4.5	Calculation of effective helix angle at the standard pitch diameter, $eff$ .....	87
14.4.6	Calculation of mean lead deviation, $f_{pzm}$ .....	87
14.4.7	Calculation of mean helix angle deviation, $f_m$ .....	87
	Bibliography .....	89