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Wind turbines –
Part 4: Design requirements for wind turbine gearboxes

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IEC 61400-4

Edition 1.0 2012-12

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XG**

ICS 27.180

ISBN 978-2-83220-506-8

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CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references.....	10
3 Terms, definitions and conventions.....	12
3.1 Terms and definitions.....	12
3.2 Conventions.....	15
4 Symbols, abbreviations and units.....	17
4.1 Symbols and units.....	17
4.2 Abbreviations.....	21
5 Design for reliability.....	23
5.1 Design lifetime and reliability.....	23
5.2 Design process.....	24
5.3 Documentation.....	26
5.4 Quality plan.....	26
6 Drivetrain operating conditions and loads.....	27
6.1 Drivetrain description.....	27
6.1.1 General.....	27
6.1.2 Interface definition.....	27
6.1.3 Specified requirements across interfaces.....	28
6.2 Deriving drivetrain loads.....	28
6.2.1 Wind turbine load simulation model.....	28
6.2.2 Wind turbine load calculations.....	29
6.2.3 Reliability of load assumptions.....	29
6.3 Results from wind turbine load calculations.....	29
6.3.1 General.....	29
6.3.2 Time series.....	30
6.3.3 Fatigue load.....	30
6.3.4 Extreme loads.....	31
6.4 Operating conditions.....	31
6.4.1 General.....	31
6.4.2 Environmental conditions.....	31
6.4.3 Operating strategies.....	32
6.5 Drivetrain analysis.....	32
7 Gearbox design, rating, and manufacturing requirements.....	32
7.1 Gearbox cooling.....	32
7.2 Gears.....	33
7.2.1 Gear reliability considerations.....	33
7.2.2 Gear rating.....	33
7.2.3 Load factors.....	34
7.2.4 Gear materials.....	36
7.2.5 Subsurface initiated fatigue.....	37
7.2.6 Gear accuracy.....	37
7.2.7 Gear manufacturing.....	37
7.3 Bearings.....	38
7.3.1 General.....	38

7.3.2	Bearing reliability considerations	38
7.3.3	Bearing steel quality requirements	39
7.3.4	General design considerations	39
7.3.5	Bearing interface requirements	42
7.3.6	Bearing design issues	43
7.3.7	Bearing lubrication	46
7.3.8	Rating calculations	47
7.4	Shafts, keys, housing joints, splines and fasteners	50
7.4.1	Shafts	50
7.4.2	Shaft-hub connections	50
7.4.3	Flexible splines	51
7.4.4	Shaft seals	51
7.4.5	Fasteners	51
7.4.6	Circlips (snap rings)	52
7.5	Structural elements	52
7.5.1	Introduction	52
7.5.2	Reliability considerations	53
7.5.3	Deflection analysis	53
7.5.4	Strength verification	53
7.5.5	Static strength assessment	54
7.5.6	Fatigue strength assessment	58
7.5.7	Material tests	62
7.5.8	Documentation	63
7.6	Lubrication	63
7.6.1	General considerations	63
7.6.2	Type of lubricant	64
7.6.3	Lubricant characteristics	65
7.6.4	Method of lubrication	66
7.6.5	Oil quantity	67
7.6.6	Operating temperatures	68
7.6.7	Temperature control	68
7.6.8	Lubricant condition monitoring	69
7.6.9	Lubricant cleanliness	69
7.6.10	Lubricant filter	70
7.6.11	Ports	71
7.6.12	Oil level indicator	71
7.6.13	Magnetic plugs	71
7.6.14	Breather	72
7.6.15	Flow sensor	72
7.6.16	Serviceability	72
8	Design verification	72
8.1	General	72
8.2	Test planning	72
8.2.1	Identifying test criteria	72
8.2.2	New designs or substantive changes	73
8.2.3	Overall test plan	73
8.2.4	Specific test plans	73
8.3	Workshop prototype testing	74
8.3.1	General	74

8.3.2	Component testing	74
8.3.3	Workshop testing of a prototype gearbox	74
8.3.4	Lubrication system testing	75
8.4	Field test	75
8.4.1	General	75
8.4.2	Validation of loads	75
8.4.3	Type test of gearbox in wind turbine	76
8.5	Production testing	77
8.5.1	Acceptance testing	77
8.5.2	Sound emission testing	77
8.5.3	Vibration testing	77
8.5.4	Lubrication system considerations	77
8.5.5	System temperatures	77
8.6	Robustness test	77
8.7	Field lubricant temperature and cleanliness	77
8.8	Bearing specific validation	78
8.8.1	Design reviews	78
8.8.2	Prototype verification/validation	78
8.9	Test documentation	79
9	Operation, service and maintenance requirements	79
9.1	Service and maintenance requirements	79
9.2	Inspection requirements	79
9.3	Commissioning and run-in	79
9.4	Transport, handling and storage	80
9.5	Repair	80
9.6	Installation and exchange	80
9.7	Condition monitoring	80
9.8	Lubrication	80
9.8.1	Oil type requirements	80
9.8.2	Lubrication system	80
9.8.3	Oil test and analysis	81
9.9	Operations and maintenance documentation	81
Annex A (informative)	Examples of drivetrain interfaces and loads specifications	82
Annex B (informative)	Gearbox design and manufacturing considerations	93
Annex C (informative)	Bearing design considerations	96
Annex D (informative)	Considerations for gearbox structural elements	122
Annex E (informative)	Recommendations for lubricant performance in wind turbine gearboxes	125
Annex F (informative)	Design verification documentation	140
Annex G (informative)	Bearing calculation documentation	143
Bibliography	151
Figure 1	– Shaft designation in 3-stage parallel shaft gearboxes	15
Figure 2	– Shaft designation in 3-stage gearboxes with one planet stage	16
Figure 3	– Shaft designation in 3-stage gearboxes with two planet stages	17
Figure 4	– Design process flow chart	25
Figure 5	– Examples of bearing selection criteria	39

Figure 6 – Blind bearing assembly	45
Figure 7 – Definition of section factor $n_{pl,\sigma}$ of a notched component	56
Figure 8 – Idealized elastic plastic stress-strain curve	57
Figure 9 – Synthetic S/N curve (adapted from Haibach, 2006)	60
Figure A.1 – Modular drivetrain	82
Figure A.2 – Modular drivetrain with 3-point suspension	83
Figure A.3 – Integrated drivetrain	83
Figure A.4 – Reference system for modular drivetrain	85
Figure A.5 – Rear view of drivetrain	86
Figure A.6 – Reference system for modular drivetrain with 3-point suspension	87
Figure A.7 – Reference system for integrated drivetrain	88
Figure A.8 – Example of rainflow counting per DLC	90
Figure A.9 – Example of load revolution distribution (LRD)	91
Figure C.1 – Load bin reduction by lumping neighbouring load bins	97
Figure C.2 – Consumed life index (CLI)	99
Figure C.3 – Time share distribution	99
Figure C.4 – Effects of clearance and preload on pressure distribution in radial roller bearings (from Brandlein et al, 1999)	102
Figure C.5 – Nomenclature for bearing curvature	103
Figure C.6 – Stress distribution over the elliptical contact area	105
Figure C.7 – Examples of locating and non-locating bearing arrangements	114
Figure C.8 – Examples of locating bearing arrangements	114
Figure C.9 – Examples of accommodation of axial displacements	114
Figure C.10 – Examples of cross-locating bearing arrangements	115
Figure C.11 – Examples of bearing arrangements with paired mounting	115
Figure D.1 – Locations of failure for local (A) and global (B) failure	123
Figure D.2 – Local and global failure for two different notch radii	123
Figure D.3 – Haigh-diagram for evaluation of mean stress influence (Haibach, 2006)	124
Figure E.1 – Viscosity requirements versus pitch line velocity	126
Figure E.2 – Test apparatus for filterability evaluation	134
Figure E.3 – Example for circuit design of combined filtration and cooling system	138
Table 1 – Symbols used in the document	18
Table 2 – Abbreviations	21
Table 3 – Mesh load factor K_γ for planetary stages	35
Table 4 – Required gear accuracy	37
Table 5 – Temperature gradients for calculation of operating clearance	44
Table 6 – Bearing lubricant temperature for calculation of viscosity ratio, κ	46
Table 7 – Guide values for maximum contact stress at Miner's sum dynamic equivalent bearing load	49
Table 8 – Minimum safety factors for the different methods	50
Table 9 – Partial safety factors for materials	55
Table 10 – Partial safety factors γ_m for synthetic S/N-curves of cast iron materials	61
Table 11 – Recommended cleanliness levels	70

Table A.1 – Drivetrain elements and local coordinate systems	84
Table A.2 – Drivetrain element interface dimensions	85
Table A.3 – Interface requirements for modular drivetrain	86
Table A.4 – Interface requirements for modular drivetrain with 3-point suspension	87
Table A.5 – Interface requirements for integrated drivetrain	88
Table A.6 – Engineering data and required design load descriptions.....	89
Table A.7 – Rainflow matrix example	89
Table A.8 – Example of load duration distribution (LDD)	91
Table A.9 – Extreme load matrix example	92
Table B.1 – Recommended gear tooth surface roughness.....	94
Table C.1 – Guide values for basic rating life L_{h10} for preliminary bearing selection.....	96
Table C.2 – Static load factors for radial bearings	101
Table C.3 – Bearing types for combined loads with axial loads in double directions	110
Table C.4 – Bearing types for combined loads with axial loads in single direction	111
Table C.5 – Bearing types for pure radial load	112
Table C.6 – Bearing types for axial load.....	113
Table C.7 – Bearing selection: Legend.....	116
Table C.8 – Bearing selection: Low speed shaft (LSS) / planet carrier	117
Table C.9 – Bearing selection: Low speed intermediate shaft (LSIS).....	118
Table C.10 – Bearing selection: High speed intermediate shaft (HSIS)	119
Table C.11 – Bearing selection: High speed shaft (HSS).....	120
Table C.12 – Bearing selection: Planet bearing.....	121
Table D.1 – Typical material properties	122
Table E.1 – Viscosity grade at operating temperature for oils with $VI = 90$	127
Table E.2 – Viscosity grade at operating temperature for oils with $VI = 120$	128
Table E.3 – Viscosity grade at operating temperature for oils with $VI = 160$	129
Table E.4 – Viscosity grade at operating temperature for oils with $VI = 240$	130
Table E.5 – Standardized test methods for evaluating WT lubricants (fresh oil).....	132
Table E.6 – Non-standardized test methods for lubricant performance (fresh oil)	133
Table E.7– Guidelines for lubricant parameter limits	136
Table F.1 – Design validation and verification documentation	140

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINES –

Part 4: Design requirements for wind turbine gearboxes

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61400-4 has been prepared by IEC technical committee 88: Wind turbines, in co-operation with ISO technical committee 60: Gears.

It is published as a double logo standard.

This first edition cancels and replaces ISO 81400-4 published in 2005. It constitutes a technical revision of ISO 81400-4 with extended content and changes in all pertinent sections.

This edition includes the following significant technical changes with respect to the previous edition:

- a) extension of the scope to wind turbines above 2 MW rated power;
- b) considerations for converging differing approaches to reliability in gear, bearing and wind turbine standards;
- c) a new clause on wind turbine loads specific to drivetrains;
- d) new clause on testing and validation of new gearbox designs;

- e) updated bearing selection tables for different locations in a wind turbine gearbox;
- f) expanded design considerations on the use of bearings based on avoiding standard failures;
- g) a new clause on considerations and requirements in the design and analysis of gearbox structural elements;
- h) updated considerations and requirements on lubricants and lubrication systems.

The text of this standard is based on the following documents of IEC:

FDIS	Report on voting
88/438/FDIS	88/441/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table. In ISO, the standard has been approved by 11 P-members out of 12 having cast a vote.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61400 series, published under the general title *Wind turbines*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
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A bilingual edition of this document may be issued at a later date.

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INTRODUCTION

IEC 61400-4 outlines minimum requirements for specification, design and verification of gearboxes in wind turbines. It is not intended for use as a complete design specification or instruction manual, and it is not intended to assure performance of assembled drive systems. It is intended for use by experienced gear designers capable of selecting reasonable values for the factors, based on knowledge of similar designs and the effects of such items as lubrication, deflection, manufacturing tolerances, metallurgy, residual stress and system dynamics. It is not intended for use by the engineering public at large.

Any of the requirements of this standard may be altered if it can be suitably demonstrated that the safety and reliability of the system is not compromised. Compliance with this standard does not relieve any person, organization, or corporation from the responsibility of observing other applicable regulations.

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WIND TURBINES –

Part 4: Design requirements for wind turbine gearboxes

1 Scope

This part of the IEC 61400 series is applicable to enclosed speed increasing gearboxes for horizontal axis wind turbine drivetrains with a power rating in excess of 500 kW. This standard applies to wind turbines installed onshore or offshore.

This International Standard provides guidance on the analysis of the wind turbine loads in relation to the design of the gear and gearbox elements.

The gearing elements covered by this standard include such gears as spur, helical or double helical and their combinations in parallel and epicyclic arrangements in the main power path. This standard does not apply to power take off gears (PTO).

The standard is based on gearbox designs using rolling element bearings. Use of plain bearings is permissible under this standard, but the use and rating of them is not covered.

Also included is guidance on the engineering of shafts, shaft hub interfaces, bearings and the gear case structure in the development of a fully integrated design that meets the rigours of the operating conditions.

Lubrication of the transmission is covered along with prototype and production testing. Finally, guidance is provided on the operation and maintenance of the gearbox.

2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary*
Available at <<http://www.electropedia.org>>

IEC 61400-1:2005, *Wind turbines – Part 1: Design requirements*

IEC 61400-3, *Wind turbines – Part 3: Design requirements for offshore wind turbines*

IEC/TS 61400-13:2001, *Wind turbine generator systems – Part 13: Measurement of mechanical loads*

IEC 61400-22:2010, *Wind turbines – Part 22: Conformity testing and certification*

ISO 76, *Rolling bearings – Static load ratings*

ISO 281:2007, *Rolling bearings – Dynamic load ratings and rating life*

ISO 683 (all parts), *Heat-treatable steels, alloy steels and free-cutting steels*

ISO 1328-1, *Cylindrical gears – ISO system of accuracy – Part 1: Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth*

ISO 4287, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – terms, definitions and surface texture parameters*

ISO 4288, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – rules and procedures for the assessment of surface texture*

ISO 4406, *Hydraulic fluid power – Fluids– Method for coding the level of contamination by solid particles*

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic methods for the determination of repeatability and reproducibility of a standard measurement method*

ISO 6336 (all parts), *Calculation of load capacity of spur and helical gears*

ISO 6336-1:2006, *Calculation of load capacity of spur and helical gears – Part 1: Basic principles, introduction and general influence factors*

ISO 6336-2:2006, *Calculation of load capacity of spur and helical gears – Part 2: Calculation of surface durability (pitting)*

ISO 6336-3:2006, *Calculation of load capacity of spur and helical gears – Part 3: Calculation of tooth bending strength*

ISO 6336-5:2003, *Calculation of load capacity of spur and helical gears – Part 5: Strength and quality of materials*

ISO 6336-6:2006, *Calculation of load capacity of spur and helical gears – Part 6: Calculation of service life under variable load*

ISO/TR 10064-3, *Cylindrical gears – Code of inspection practice – Part 3: Recommendations relative to gear blanks, shaft centre distance and parallelism of axes*

ISO 12925-1, *Lubricants, industrial oils and related products (class L). Family C (Gears) – Part 1: Specifications for lubricants for enclosed gear systems*

ISO/TR 13593, *Enclosed gear drives for industrial applications*

ISO/TR 13989-1, *Calculation of scuffing load capacity of cylindrical, bevel and hypoid gears – Part 1: Flash temperature method*

ISO/TR 13989-2, *Calculation of scuffing load capacity of cylindrical, bevel and hypoid gears – Part 2: Integral temperature method*

ISO 14104, *Gears – Surface temper etch inspection after grinding*

ISO 14635-1:2000, *Gears – FZG test procedures – Part 1: FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils*

ISO 15243:2004, *Rolling bearings – Damage and failures – Terms, characteristics and causes*

ISO/TS 16281:2008, *Rolling bearings – Methods for calculating the modified reference rating life for universally loaded bearings*

AGMA 9005, *Industrial Gear Lubrication*

ANSI/AGMA 925-A02, *Effect of lubrication on gear surface distress*

ANSI/AGMA 6001-E10, *Design and selection of components for enclosed gear drives*

ANSI/AGMA 6123, *Design manual for enclosed epicyclic gear drives*

ASTM E1049-85, *Standard practices for cycle counting in fatigue analysis*

DIN 471, *Circlips (retaining rings) for shafts: Normal type and heavy type*

DIN 472, *Circlips (retaining rings) for bores: Normal type and heavy type*

DIN 743:2000, *Shafts and axles, calculations of load capacity, Parts 1, 2, 3*

DIN 3990-4, *Calculation of load capacity of cylindrical gears: calculation of scuffing load capacity*

DIN 6885-2, *Parallel Key Geometries*

DIN 6892, *Mitnehmerverbindungen ohne Anzug – Passfedern – Berechnung und Gestaltung* (available in German only)

DIN 7190, *Interference fits – Calculation and design rules*

DIN 51517-3, *Lubricants: Lubricating oils – Part 3: Lubricating oils CLP; Minimum requirements*

EN 12680-3:2003, *Ultrasonic examination. Spheroidal graphite cast iron castings*

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3 Terms, definitions and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61400-1:2005 and IEC 60050-415 as well as the following apply.

NOTE The definitions in this standard take precedence.

3.1.1

bearing manufacturer

legal entity supplying bearings for the wind turbine gearbox, and who is responsible for the design and the application engineering of the bearing

Note 1 to entry: Typically, the bearing supplier will also manufacture the bearing.

3.1.2

certification body

entity that conducts certification of conformity of the wind turbine gearbox in accordance with IEC 61400-22

3.1.3

characteristic load

load value having a prescribed probability of not being exceeded