



Edition 1.0 2025-03

# TECHNICAL SPECIFICATION

Wind energy generation systems — Standards
Part 28: Through-life management and life extension of wind power assets

(https://standards.iteh.ai)

**Document Preview** 

IEC TS 61400-28:2025

https://standards.iteh.ai/catalog/standards/iec/da3ch50c-12f5-4718-81ch-677447600cdf/iec-ts-61400-28-2026





#### THIS PUBLICATION IS COPYRIGHT PROTECTED Copyright © 2025 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

**IEC Secretariat** 3, rue de Varembé CH-1211 Geneva 20 Switzerland

Tel.: +41 22 919 02 11 info@iec.ch

www.iec.ch

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

#### IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

#### Electropedia - www.electropedia.org

Preview

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.



## IEC TS 61400-28

Edition 1.0 2025-03

# TECHNICAL SPECIFICATION

Wind energy generation systems – tandards

Part 28: Through-life management and life extension of wind power assets

## **Document Preview**

IEC TS 61400-28:2025

https://standards.iteh.ai/catalog/standards/iec/da3ch50c-12f5-4718-81ch-677447600cdf/iec-ts-61400-28-2026

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 27.180 ISBN 978-2-8327-0295-6

Warning! Make sure that you obtained this publication from an authorized distributor.

### CONTENTS

	UCTION	
1 Scc	pe	10
2 Nor	mative references	10
3 Ter	ms, definitions and abbreviated terms	11
3.1	Terms and definitions	11
3.2	Abbreviated terms	16
4 Use	er guidance: Concept of through-life management and lifetime extension	18
4.1	Overview	18
4.2	Data management	24
4.3	Reading guideline	24
5 Dat	a management, requirements and uncertainty	28
5.1	Preamble	28
5.2	Data management	
5.3	Data and information definition	
5.4	Data / information sources	
5.4.	1 Design information	30
5.4.	2 Meteorological data	31
5.4.		31
5.4	4 Extreme site conditions	32
5.4.	4 Extreme site conditions	32
5.4.	6 Instrumentation	
5.4.	7 Operational experience	33
5.4	8 Maintenance and field history	33
5.4.	9 Inspection history IEC 18 61400-28:2025	33
standard 5.5	Data requirements for components in the primary load path	8-61400-28-2 34
5.6	Data uncertainty	35
5.7	Classification of uncertainty	36
5.8	Data requirements for new wind farms	36
6 Ris	k management process	36
6.1	General approach	36
6.2	Scope of risk assessment	
6.3	Life extension risk assessment	39
7 Win	d farm operation, maintenance and inspections	39
7.1	Name plate and design class requirements	39
7.2	Replacement of structural or major components	
7.3	Operation and maintenance	
7.4	Physical inspections	
7.5	Scheduling of physical inspections	
7.5.		
7.5.		
7.5.		
7.5	,	-
	operational life)	43
8 Cor	ndition and structural health monitoring	44
8.1	Purpose	44

8.2	CMD minimum necessary requirement	46
8.2.1	General	46
8.2.2	Vibration monitoring system (VMS)	46
8.2.3	Temperature monitoring	46
8.2.4	Oil and grease wear particle analysis	47
8.2.5	Site (wind) condition monitoring	48
8.3	Structural health and load monitoring	
8.4	Data acquisition	48
	Integration to asset management	
8.5.1	General	49
8.5.2	Documentation	49
8.5.3	Business procedures	49
9 Healt	h and safety information	
	tical assessment of turbine lifetime	
10.1	Overview	50
	Methods to determine loads	
10.2.		
10.2.2		
10.2.3		
	Model data, input data and their uncertainties	
	nformative) Health and safety – inspection and performance criteria	
-	General	
A.2	Content and format of any reports issued	56
	Operation and maintenance data	
	nformative) Data requirements for primary load path	
B.1	Input data requirements	58
B.2	Condition monitoring data requirements 28:2025	65
https://Annex C (	informative) Physical inspections – best practice for documentation of	
	dings and insights	
	Physical inspections	
	Inspection scope	
	Highly recommended inspections	
C.3.1	Tower	
C.3.2		_
C.3.3	9	
C.3.4	5	
C.3.5		
C.3.6	,	
C.3.7		
C.3.8	Hub	77
C.3.9		78
C.3.1	0 Safety systems	78
C.3.1	ŭ	79
C.3.1	2 Main shaft	79
C.4	Recommended inspections	79
C.4.1	Gearbox inspections	79
C.4.2	Generator inspection	79
C.4.3	Yaw drives	80

C.4.	.4 Nacelle condition	80
C.5	Scheduled service (change or prolong existing schedule service)	80
C.6	Additional inspections and testing	80
C.7	Inspection reporting	80
	(informative) Analytical assessment of turbine lifetime – relative approach uracy assessment	83
D.1	General	83
D.2	Sources of uncertainties	83
D.3	Input data uncertainty	83
D.4	Model sensitivity to input data	84
D.5	Model uncertainties	84
D.6	Uncertainty assessment by accuracy assessment numbers (AAN)	84
D.6.		
D.6.	.2 Example for the determination of AAN	87
D.7	Probabilistic assessment of remaining lifetime	89
	(informative) Minimal CMDs for rolling element bearings and hydraulic	90
E.1	Preamble	
E.2	Bearing failure modes	
E.3	The pragmatic approach	
E.4	vms	
E.5	Temperatures	93
E.6	Grease cleanliness	
E.7	Oil lubricant cleanliness (acceptable values over whole lifetime)	95
Annex F	(informative) Example of a methodology for assessment of risk	
F.1	Overview	
F.2	Application of failure modes and effects analysis	
starFd3rds	Using the potential failure (P-F) interval to assess detectability	
F.4	Summary	
	(informative) Through-life management and remaining useful life	
G.1	Through-life management	101
G.2	Life extension	
G.3	Remaining useful life	
Bibliogra	ıphy	107
•	- Updated assessments and estimates of component safety and remaining life	ə19
	<ul> <li>Illustration of how the level of confidence can be improved by applying</li> <li>31400-28 (for example, relating to the estimated RUL)</li> </ul>	20
Figure 3	- The 3 typical phases of operation of a wind turbine	21
	Effect on asset life due to improved strategies and increased levels of ce	22
Figure 5	<ul> <li>Process of through-life management and lifetime extension – Data</li> </ul>	
•	ment is the backbone of the process	
•	- Increase level of confidence, gradually by applying the methods	
•	- Iterative sequence in general risk assessment procedures	
ŭ	<ul> <li>Condition and structural health monitoring management process</li> </ul>	
Figure D	.1 – AAN levels	85

Figure D.2 – Load increase factors $\gamma$ depending weighted model uncertainty and weighted data uncertainty	86
Figure E.1 – Example of reduction in life with filter rating (note L50 is shown here for illustrative purposes, whereas L10 life is used for wind turbine applications)	96
Figure F.1 – Illustrative example showing the increase of RPN in later life due to increasing occurrence	98
Figure F.2 – Illustrative example of the management RPN by improving detectability in later life	99
Figure G.1 – Through-life management of a wind turbine	101
Figure G.2 – Through-life management of a wind farm	101
Figure G.3 – Life extension scenarios	103
Figure G.4 – Single component with no failures	104
Figure G.5 – Single component with symptom	105
Figure G.6 – Multiple components with symptoms	106
Table 1 – Comparison between definitions of remaining life used in this document	17
Table 2 – Classification of uncertainty	36
Table 3 – Key properties of failure mode and components of a risk priority number	38
Table 4 – Example of distinctions between data, information, advice and decision	
Table B.1 – Input data requirements	59
Table B.2 – Condition monitoring data requirements	
Table B.3 – Condition monitoring requirements for main bearings	67
Table B.4 – Condition monitoring requirements for gearbox	68
Table B.5 – Data requirements for yaw mechanism	69
Table B.6 – Data requirements for tower	70
Table B.7 - Data requirements for foundation	.470
Table B.8 – Data requirements from measurements and characterisation of site conditions	71
Table C.1 – Required physical inspections	72
Table C.2 – Reporting inspection findings	81
Table D.1 – Relationship between COV of data and uncertainty category	83
Table D.2 – Weighted uncertainty	85
Table D.3 – Assessment of weighted data uncertainty	87
Table D.4 – Assessment of weighted data model uncertainty	88