

TECHNICAL SPECIFICATION

IEC TS 61400-23

First edition
2001-04

Wind turbine generator systems –

Part 23: Full-scale structural testing of rotor blades

Aérogénérateurs –

Partie 23: Essais en vraie grandeur des structures des pales

© IEC 2001 — Copyright - all rights reserved

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 the publisher.

International Electrotechnical Commission 3, rue de Varembé Geneva, Switzerland
Telefax: +41 22 919 0300 e-mail: inmail@iec.ch IEC web site <http://www.iec.ch>



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XB

For price, see current catalogue

CONTENTS

FOREWORD	4
INTRODUCTION	6
1 Scope	7
2 Normative references	7
3 Definitions	8
4 Notation	11
4.1 Symbols	11
4.2 Greek symbols	11
4.3 Subscripts	11
4.4 Abbreviations	12
5 General principles	12
5.1 Purpose of tests	12
5.2 Limit states	12
5.3 Practical constraints	13
5.4 Results of test	13
6 Blade data	14
6.1 General	14
6.2 External dimensions and interfaces	14
6.3 Blade characteristics	15
6.4 Material data	16
6.5 Design loads and conditions	16
6.6 Areas to be tested	18
6.7 Special blade modifications	18
6.8 Root fixing	18
6.9 Mechanisms	18
7 Differences between design and test load conditions	18
7.1 General	18
7.2 Load introduction	19
7.3 Bending moments and shear	19
7.4 Flatwise and edgewise combinations	20
7.5 Radial loads	20
7.6 Torsion loads	20
7.7 Mechanisms	20
7.8 Environmental conditions	20
7.9 Load spectrum and sequence	21
8 Test loading	21
8.1 General	21
8.2 Load-based testing	21
8.3 Strength-based testing	22
8.4 Static-test load aspects	23
8.5 Fatigue-test load aspects	24
8.6 Sequence of static and fatigue tests	25
8.7 Mechanisms	26

9	Load factors for testing.....	26
9.1	General.....	26
9.2	Partial safety factors used in the design.....	26
9.3	Test load factors	27
9.4	Application of load factors to obtain the target load	28
10	Evaluation of test load distribution in relation to design requirements	29
10.1	General.....	29
10.2	Influence of load introduction.....	29
10.3	Static tests	29
10.4	Fatigue tests	33
11	Failure modes	36
11.1	General.....	36
11.2	Catastrophic failure	37
11.3	Functional failure.....	37
11.4	Superficial failure	37
12	Test procedures and methods	38
12.1	General.....	38
12.2	Test stand and root fixture requirements.....	38
12.3	Load introduction fixtures	38
12.4	Static strength test	39
12.5	Fatigue testing	40
12.6	Advantages and disadvantages of test alternatives	43
12.7	Deterministic corrections	43
12.8	Data collection	44
13	Other tests determining blade properties	46
13.1	General.....	46
13.2	Test stand deflections	46
13.3	Deflection.....	46
13.4	Stiffness distribution.....	46
13.5	Strain distribution measurements.....	47
13.6	Natural frequencies	48
13.7	Damping	48
13.8	Mode shapes.....	48
13.9	Mass distribution	48
13.10	Creep.....	48
13.11	Other non-destructive testing.....	48
13.12	Blade sectioning.....	49
14	Reporting	49
14.1	General.....	49
14.2	Content	49
	Annex A (normative) Partial safety factors considerations	51
	Annex B (normative) Sensitivity of the evaluation to fatigue formulation.....	52
	Annex C (normative) Loading angle change considerations	54
	Annex D (informative) Examples of test set-ups	56
	Bibliography	63

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINE GENERATOR SYSTEMS –**Part 23: Full-scale structural testing of rotor blades**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this technical specification may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

IEC 61400-23, which is a technical specification, has been prepared by IEC Technical Committee 88: Wind turbine systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
88/116/CDV	88/137/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until 2003. At this date, the publication will be

- transformed into an International Standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

Annexes A, B and C form an integral part of this technical specification.

Annex D is for information only.

Compliance with this technical specification does not relieve any person, organization or corporation of the responsibility of observing other applicable regulations.

INTRODUCTION

The blades of a wind turbine rotor are generally regarded as the most critical components of the wind turbine system. Many national standards address the blades separately in the design, but few require the testing of blades as a requisite for certification. Nevertheless, blade testing laboratories are currently operating in many countries throughout the world. Each laboratory has independently developed a unique set of test equipment, procedures and terminology that are used to test blades. Though each laboratory's techniques may be valid, the results of blade tests done at different facilities may be difficult to compare and evaluate.

The primary emphasis of the IEC TC 88 Working Group 8 effort was to identify commonly accepted practices among the various laboratories and to give guidance in establishing blade test criteria. Due to the wide range of methods (dictated by the test system hardware) used by the various laboratories, writing a restrictive standard that favoured one method to the exclusion of all others would not have been equitable. Therefore, the present technical specification has been written to provide guidelines on recommended practices. Many different methods are included.

The full collection of tests described in this specification should not be considered a requirement for every blade design. The need for tests will depend on the level of uncertainty in the design assessment due to the use of new materials, new design concepts, new production processes, etc. and the possible impact on the structural integrity. In some cases, alternative ways to perform a test are commonly used (see annex D). For the alternatives discussed in this specification, the advantages and disadvantages are noted.

WIND TURBINE GENERATOR SYSTEMS –

Part 23: Full-scale structural testing of rotor blades

1 Scope

This technical specification provides guidelines for the full-scale structural testing of wind turbine blades and for the interpretation or evaluation of results, as a possible part of a design verification of the integrity of the blade.

The following tests are considered in this technical specification:

- static strength tests;
- fatigue tests;
- other tests determining blade properties.

It is assumed that the data required to define the parameters of the test are available. In this technical specification, the design loads and blade material data are considered starting points for establishing and evaluating the test loads. The evaluation of the design loads with respect to the actual loads is outside the scope of this technical specification.

The technical specification is **not** intended to:

- form a detailed specification for the procurement of the test equipment;
- be a detailed work instruction covering all aspects of conducting a strength test;
- be used for establishing basic material strength or fatigue design data for blades and/or components;
- replace a rigorous design process;
- address the testing of mechanism function.

At the time this technical specification was drawn up, full-scale tests were carried out on blades of horizontal axis wind turbines. The blades were mostly made of fibre reinforced plastics and wood/epoxy. However, most principles would be applicable to any WTGS configuration, size and material.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this technical specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical specification are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050-415:1999, *International Electrotechnical Vocabulary – Part 415: Wind turbine generator systems*

IEC 61400-1:1999, *Wind turbine generator systems – Part 1: Safety requirements*

ISO 2394:1998, *General principles on reliability for structures*

ISO/IEC 17025:1999, *General requirements for the competence of calibration and testing laboratories*