DNV·GL

STANDARD

DNVGL-ST-0262 Edition March 2016

Lifetime extension of wind turbines

DNV GL AS

FOREWORD

DNV GL standards contain requirements, principles and acceptance criteria for objects, personnel, organisations and/or operations.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

General

This is a new document.

CONTENTS

SECTION 1 INTRODUCTION

1.1 General

1.1.1

This DNV GL Standard provides principles, technical requirements and guidance for extending the lifetime of wind turbines onshore and offshore.

When designing wind turbines, a design lifetime of 20 years is generally assumed as a basis for dimensioning. Extension of lifetime for existing wind turbines can be justifiable from both a technical and an economic point of view.

1.1.2

This standard shall be used as a basis for the lifetime extension of wind turbines.

1.1.3

This standard focusses on technical issues in order to ensure a safe operation of the wind turbine when exceeding the original design lifetime.

1.1.4

This standard may also be applied for answering specific questions concerning a continuation of operation of wind turbines during their design lifetime. For example, this is the case for a wind turbine that is relocated to a new site or for a turbine where the site conditions have changed.

1.2 Objectives

The objectives of this standard are to:

- allow the assessment of wind turbines in order to ascertain whether they are fit for lifetime extension
- provide an acceptable level of safety (in combination with referenced standards, recommended practices, guidelines, etc.)
- serve as a standard for operators, manufacturers and experts for lifetime extension
- specify requirements for lifetime extension of wind turbines subject to DNV GL certification
- serve as a contractual reference document related to all questions concerning lifetime extension of wind turbines.

1.3 Scope and application

1.3.1

This standard is applicable to all types of wind turbines.

1.3.2

This standard defines the assessment methods to extend the lifetime of a wind turbine or wind farm according to the current state of the art. It must be noted that the level of safety regarding the statement on the structural integrity depends on the scope and selection of the assessment methods.

1.3.3

The focus on the assessment lies on all load transferring components and assemblies that are relevant for the structural integrity of the wind turbine as well as on control and protection system.

1.3.4

The entire wind turbine shall be assessed, see Table 2-1.

1.4 Certification

Certification principles and procedures related to certification services for an extension of lifetime of wind turbines are specified in the relevant service specification DNVGL-SE-0263 Certification of lifetime extension of wind turbines.

1.5 Normative references

1.5.1 General

1.5.1.1 The standards in Table 1-1 include provisions, which through reference in this text constitute provisions of this standard.

Table 1-1 Standards and Guidelines

Reference	*Title*
DNV GL-SE-0263	Certification of lifetime extension of wind turbines
GL-IV-1-12	GL Rules and Guidelines – IV Industrial Services – Part 1 – "12 Guideline for the Continued Operation of Wind Turbines" Edition 2009
GL-IV-1	GL Rules and Guidelines – IV Industrial Services – Part 1: "Guideline for the Certification of Wind Turbines" Edition 2010
GL-IV-2	GL Rules and Guidelines – IV Industrial Services – Part 2 "Guideline for the Certification of Offshore Wind Turbines" Edition 2012
ISO/IEC 17020	Conformity assessment - Requirements for the operation of various types of bodies performing inspection
ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories
ISO/IEC 17065	Conformity assessment - Requirements for bodies certifying products, processes and services
IEC 61400-1	Wind turbines – Part 1: Design requirements
IEC 61400-3	Wind turbines – Part 3: Design requirements for offshore turbines
IEC 61400-22	Wind turbines – Part 22: Conformity testing and certification

1.6 Definitions

1.6.1 Verbal forms

Table 1-2 Verbal Forms

Term	*Definition*
shall	verbal form used to indicate requirements strictly to be followed in order to conform to the document
should	verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required
may	Verbal form used to indicate a course of action permissible within the limits of the document

1.6.2 Terms

Table 1-3 Terms

Term	*Explanation*
(original) design lifetime	the time period that was considered for the strength verification when the device was designed
(original) design conditions	the parameters that were considered for the strength verification when the device was designed
environmental conditions (at a site)	external conditions like wind, waves as well as temperature, humidity, ice aggregation, salt content of the air etc. (at a site)
lifetime extension	additional lifetime beyond the (original) design lifetime
operating life / service life	lifetime from commissioning to decommissioning of a component or the wind turbine
state of the art	the state of the art is generally represented by the currently applicable version of the standards and guidelines that have been the basis for the original design of the wind turbine
total lifetime	lifetime after manufacturing of the component or asset until de-construction

1.6.3 Acronyms and abbreviations

Acronyms and abbreviations as shown in Table 1-4 are used in this standard.

Table 1-4 Acronyms and abbreviations

Short form	*In full*
Cert.	certificate
CMS	condition monitoring system
FORM	first order reliability method
G function	limit state function / failure function, which is a mathematical definition of the failure event
Insp.	inspection
LEI	lifetime extension inspection
SCADA	supervisory control and data acquisition
SRA	structural reliability analysis

SECTION 2 ASSESSMENT METHODS

2.1 General

2.1.1 Methodology

2.1.1.1 Wind turbines are designed for a finite service life. As a rule, a design lifetime of 20 years is taken as a basis for the design.

2.1.1.2 If a wind turbine shall be operated beyond its design lifetime, the turbine shall be assessed with regard to its potential for lifetime extension.

2.1.1.3 The evaluation of a turbine with regard to an extension of service life shall always be based on a combination of an analytical part and a practical part.

2.1.1.4 Different approaches can be used to achieve the lifetime extension of a wind turbine. Guidance on possible approaches is provided in [2.2] and [2.3]. Application of approaches other than described in this standard shall be agreed on between the customer and DNV GL.

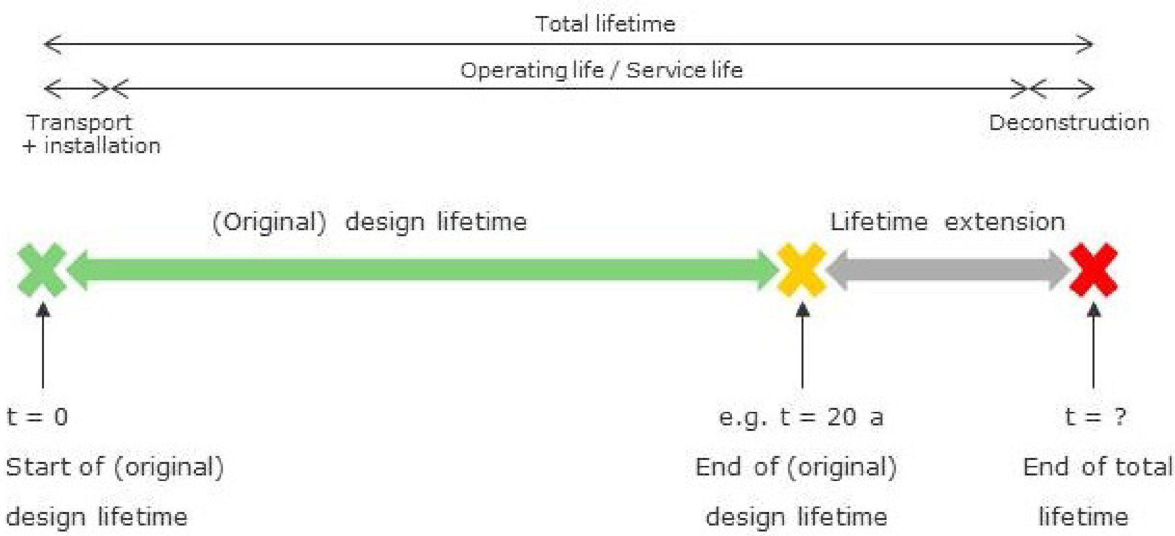

Figure 2-1 Lifetime of a wind turbine

2.1.2 Assessment scope

2.1.2.1 For an evaluation of a wind turbine with regard to an extension of its lifetime, the entire wind turbine shall be assessed. The assessment has to include the control and protection system as well as all load transferring components.

The following components as well as the connections between these components shall be part of the assessment for lifetime extension as a minimum.

Table 2-1 Assessment scope

Component/System	*Parts*
Rotor Blade	Blade
Machinery components	Hub Main shaft Torque arm Main bearing housing Main frame Rear frame Spinner and nacelle cover Pitch system Main shaft bearing Gearbox Bolt connections Yaw system
Tower	Tower segments Tower connections Door opening
Foundation	Anchor bolt connection Embedded steel section Slab foundation Pile foundation Jacket structure (offshore) Monopile structure (offshore) Grouted connection
Control and protection system	Sensors Braking systems Control software
Electrical Equipment	Generator Lightning protection

2.2 Analytical part

2.2.1 General

2.2.1.1 The analytical part is an assessment conducted by means of new/additional calculations for the wind turbine, taking into account the site-specific installation and its local conditions.

2.2.1.2 In the analytical part, the lifetime extension of the wind turbine is calculated. Different approaches can be applied, see [2.2.3] to [2.2.5].

2.2.1.3 The analytical part should be supplemented by taking into account the field experience with the turbine type (e.g. weak points, known failures, retrofits etc.)

2.2.2 Basis for the analytical part

2.2.2.1 For the evaluation of a wind turbine with regard to an extension of lifetime the current state of the art shall be considered.

Modifications to the wind turbine in order to fulfill the current state of the art and in order to ensure a safe operation are not required, as long as the following conditions are fulfilled:

— the turbine is operated under operating and environmental conditions that comply with or are more benign than the original design conditions.

  and

— the turbine type does not have any generally known deficiencies being a danger for life and limb or the environment.

For the certification of lifetime extension it is assumed, that the wind turbine at the date of its erection fulfilled all applicable guidelines and standards valid at that time.

Guidance note:

The assessment of a wind turbine always has to be performed using the most recent methodologies that are commonly used in wind energy industry and that are to be seen as state of the art.

Consequently, an assessment for lifetime extension shall not be performed based on old versions of standards and guidelines that have been the basis for the original design neglecting the currently available knowledge which is represented by the latest version of the standard or guideline. If older versions of standards are used for the assessment, it shall be verified, that the approach is equivalent to currently applied methods (state of the art) and/or that the approach reflects reality sufficiently.

The assessment of lifetime extension focusses on fatigue-related issues. Therefore it is not required to modify or adjust existing wind turbines in order to fulfil all requirements specified in the currently valid standards or guidelines.

Example:

Performing a static blade test for rotor blades is to be seen as state of the art, as this is a requirement of current guidelines. If an existing wind turbine (without static blade test) is to be assessed with regard to lifetime extension, the static blade test does not have to be carried out, as fatigue properties are not subject of the static blade test.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.2.2 The focus is on the structural integrity of the wind turbine prior to economic interests. Personal safety requirements (e.g. assessment of ladders, attachment points, etc.) are not part of the assessment for lifetime extension.

2.2.2.3 Country-specific regulations should be considered in addition.

2.2.3 Simplified approach

2.2.3.1 The simplified approach may be used for the assessment of the extension of the lifetime of a turbine, especially when the original design documentation of a turbine is not available.

2.2.3.2 The simplified approach compares the original design conditions with the environmental conditions at the site. This is done by means of load simulations applying both sets of before mentioned environmental conditions.

2.2.3.3 Measurements - both of the turbine response (e.g. component load measurements) and of the local site conditions (e.g. from met-mast) – may also be considered in the assessment

2.2.3.4 The focus of the assessment is the fatigue limit state. An assessment of the extreme loads is not required, as soon as the environmental conditions at the site are more benign than the original design conditions.

2.2.3.5 Verification of the structural integrity shall be provided for all components and their connections as per [2.1.2] based on a comparison of the fatigue loads.

2.2.3.6 The fatigue load calculations mentioned in paragraph [2.2.3.2] shall be performed based on the current state of the art.

2.2.3.7 The load calculations may be performed with a generic load simulation model of the wind turbine. For the load simulations it shall be ensured that the load simulation model chosen and controller settings are used in combination with a state of the art aero-elastic simulation code. The dynamic load behavior shall be reflected. The use of any generic model in the load analysis for the simplified approach shall always include an evaluation of the uncertainty of the respective model which then shall be considered in the evaluation of the assessment results.

2.2.3.8 Both the fatigue loads based on the original design conditions (e.g. 20 years of operation according to applied standard) and the environmental conditions at the site (extended lifetime considered) shall be calculated using the same turbine model, aeroelastic code and controller settings. It shall be ensured that by comparison of both load sets a valid assessment of the environmental conditions at the site and for design is achieved.

2.2.3.9 The following information about the environmental conditions at the site shall be provided as a minimum:

Report for the site on the environmental conditions based on the current state of the art including influence from wakes and reported for each wind turbine location. Effective turbulence intensity values for all material relevant slope-parameters of S/N curves shall be stated. Depending on the analysis approach the turbulence intensity shall be given as uni-directional or sector-wise data set.

2.2.3.10 Based on the environmental conditions of the site the loads shall be calculated for each component taking into account the extended lifetime of the wind turbine. A verification of all components taking into account the extension of lifetime shall be conducted based on a comparison of loads. Based on the results of these verifications conditions on operation/maintenance/inspection of the turbine may be defined, for example if a component shall be monitored by a CMS system.

2.2.3.11 The possible extension of lifetime of the turbine has to be specified based on the calculation results.

2.2.3.12 General requirements for the inspections (practical part) can be found in [2.3].

2.2.4 Detailed approach

2.2.4.1 The detailed approach is a deterministic approach. The scope can be compared to the analysis performed for the original design of a wind turbine. Access to the original design documentation is required.

2.2.4.2 The scope of the detailed approach are load calculations taking into account the environmental conditions at the specific site and the extended lifetime of the turbine as well as verifications of all load transferring components for these loads.

2.2.4.3 Measurements - both of the turbine response (e.g. component load measurements) and of the local site conditions (e.g. from met-mast) – may also be considered in the assessment.

2.2.4.4 The focus of the assessment is the fatigue limit state. An assessment of the extreme loads is not required, as long as the environmental conditions at the site are more benign than the original design conditions.

2.2.4.5 Verification of the structural integrity shall be provided for all components as well as for the connections between these components as per [2.1.2].

2.2.4.6 Environmental conditions of the site shall be the basis for the detailed approach for lifetime extension.

2.2.4.7 The analytical assessment may be performed in two steps:

In a first step the analytical part is performed independently from a specific site. The environmental conditions for which the approach shall be valid shall be defined. This step is called 'analytical part type-specific'.

In a second step a specific site is assessed regarding a possible lifetime extension. It has to be verified and confirmed, that the environmental conditions at the site are more benign than the environmental conditions that have been defined in the first step ('analytical part type-specific'). This step is called 'analytical part site-specific'.

2.2.4.8 The following parameters have to be investigated as a basis for the Detailed Approach:

- environmental conditions (wind, waves)
- soil conditions
- influence of wind farm configuration
- other environmental conditions, if applicable (e.g. temperature, humidity, ice aggregation, salt content of the air etc.)

2.2.4.9 In case that the fatigue verification for a component cannot be fulfilled for the extended lifetime, it shall be evaluated, whether a safe operation of the unit for the extended lifetime can be achieved by other suitable measures, e.g. by component exchange, by condition monitoring or by defining a specific inspection scope.

2.2.4.10 Design optimization of e.g. the controller software or the maintenance strategy may be performed.

2.2.4.11 Modifications of controller that have been made shall be considered in the assessment.

2.2.4.12 Based on the outcome of the calculations, a turbine-specific inspection program describing inspection scope and intervals shall be developed.

2.2.4.13 The following information shall be evaluated as a part of the assessment:

- operational history (SCADA data)
- maintenance history. The following documents shall be reviewed as minimum:
    - commissioning record
    - maintenance records
    - reports from inspections
    - failure reports/reports on extraordinary maintenance activities
    - documentation on exchange of components
    - field experience with turbine type.

2.2.5 Probabilistic approach

2.2.5.1 The probabilistic approach for lifetime extension allows for the use of stochastic methods in the assessment of structural integrity.

2.2.5.2 In the simplified and detailed approaches described in [2.2.3] and [2.2.4] respectively, turbine model and the site conditions parameters are quantified using deterministic values. Alternatively, in the probabilistic approach, uncertainty in models and model inputs may be characterized by appropriate probability distributions.

2.2.5.3 The choice of stochastic parameters (i.e. probability distribution types, expected values, coefficients of variation, correlation coefficients, etc.) in the limit state formulations shall be explained and justified by applying stochastic methods to ensure that these do not introduce weaknesses in the approach.

2.2.5.4 A structural reliability analysis (SRA) generally comprises the following steps:

- selection of a target reliability level
- identification of failure modes in the system
- development of limit state functions (g-functions) for each failure mode based on engineering theory
- quantification of the deterministic and stochastic variables within the limit state function, and their correlations
- use of appropriate methods (e.g. first order reliability method – FORM) to compute reliability indices or probabilities of failure for the structural components
- comparison of the computed component reliability with the target reliability level for each component
- analysis of results using sensitivity analyses.

2.2.5.5 Probability distributions may be used to describe the aleatoric and epistemic uncertainty in both the mathematic models and the input parameters to the models. The nature of the uncertainty being described by each distribution in their model set-up shall be clarified by the expert.

2.2.5.6 Measurements - both of the turbine response (e.g. component load measurements) and of the local site conditions (e.g. from met-mast and/or SCADA data) – may be used to refine or update probability distributions of key model parameters in the analysis. In all cases, the statistical techniques (e.g. Bayesian updating, optimal estimation etc.) used to characterize the distribution of stochastic parameters for the structural reliability analysis shall be documented.

2.2.5.7 In cases where the actual aero-elastic model of the wind turbine and/or resistance models of the components to be analyzed are not available, the use of generic load and resistance models is allowed. The use of any generic model in a stochastic structural reliability analysis shall always include an evaluation of the uncertainty of the respective model which then is to be considered for the assessment results.

2.2.5.8 In conjunction with the probabilistic approach, risk-based inspection methods may be developed.

2.2.5.9 Design optimization of e.g. the controller software or the maintenance strategy may be performed.

2.2.5.10 Modifications of controller that have been made shall be considered in the assessment.

2.2.5.11 In case that the fatigue verification for a component is not fulfilled for the extended lifetime, it shall be evaluated, whether a safe operation of the unit for the extended lifetime can be achieved by other suitable measures, e.g. by component exchange, by condition monitoring or by defining a specific inspection scope.

2.3 Practical part

2.3.1 General

2.3.1.1 The practical part is an assessment through inspections of the wind turbine taking into account the maintenance / operational history and the turbine-type-related field experience

2.3.1.2 The objective of the inspection is to assess the wind turbine with regard to its suitability for lifetime extension; the inspection shall include all load transferring components as well as the control and protection system (see Table 2-1).

2.3.1.3 The target of the inspection is to detect any fatigue damage of a load-transferring component already at an early point of time in order to avoid failures that put into question the structural integrity of the turbine. Inspection intervals have to be defined accordingly.

2.3.1.4 Precondition for inspection is the availability of the documents listed in [2.4.1]. The documents should be submitted in time prior to the inspection in order to allow getting an overview about the turbine's operation history and take into account relevant information and/or adjust the inspection scope if required.

2.3.2 General inspection scope

2.3.2.1 An inspection list describing the general scope of a lifetime extension inspection (LEI) is given in Appendix B of this standard. The scope of this inspection covers the scope of periodic monitoring.

2.3.2.2 As a result of the inspection, additional examinations of components may be required.

2.3.3 Specific inspection scope

2.3.3.1 If a specific inspection program for the wind turbine has been defined in the analytical part, the inspections shall be performed in accordance with this inspection program.

2.3.3.2 Prior to the inspection, it shall be ensured, that the respective wind turbine corresponds with the turbine variant that has been subject of the analytical part.

2.3.3.3 Any further measures such as for example the installation of a CMS system or the exchange of a component has to be conducted based on the requirements that have been specified in the analytical part.

2.3.3.4 As a result of the inspection, additional examinations of components may be required.

2.3.4 Inspection report

2.3.4.1 Inspection results shall be summarized in an inspection report. The inspection report shall at least contain the following information:

- manufacturer, type and serial number of the wind turbine
- location and operator of the wind turbine
- operating hours / produced energy
- date and weather on the day(s) of the inspection
- persons present at the inspection
- inspection plan / description of inspection scope

- remarks about damages/deficiencies etc.
- inspection result
- inspection interval until next inspection.

2.3.4.2 The inspection report may contain recommendations and/or conditions for more detailed examinations, inspection procedures and/or other measures.

2.3.4.3 The inspection report may contain restrictions for the extended lifetime, as for example required exchanges of components.

2.3.4.4 In the inspection report an interval shall be specified for the next inspection. This interval shall take into account the results of the analytical part as well as the findings in the inspection itself.

2.4 Documentation

2.4.1

The following documentation should be available to serve as a basis for an assessment for lifetime extension. In case that not all of these documents are available it shall be evaluated, whether/how the assessment can be conducted without these documents:

- technical information of the wind turbine (turbine type, manufacturer, configuration, control and braking system, rotor blade type, design lifetime, wind class)
- building permit
- approval documents (type approval / type certificate / site specific design assessment or equivalent)
- site map
- site-specific wind conditions including turbulence intensity
- commissioning documentation
- documentation of operational data/energy yield data/wind statistics
- operating and maintenance manual
- maintenance records
- documentation on failures and incidents as well as modifications / repairs /exchange of components
- inspection reports (periodic monitoring and other inspections).

2.4.2

The following documentation should be available especially as a basis for the detailed approach as per [2.2.4] and the probabilistic approach as per [2.2.5]:

- technical documentation on the wind turbine (design calculations, design drawings, design specifications)
- assessment and certification reports (load assumptions / rotor blades / machinery components / control and protection system / tower / foundation / electrical installation)
- geotechnical report.

2.5 Decommissioning

If deficiencies endanger the structural integrity of the wind turbine partly or completely, or if deficiencies are expected to result in damages, the decommissioning of the turbine shall be recommended. Decommissioning shall then be carried out by the operator.

APPENDIX A METHODS FOR LIFETIME EXTENSION

Table A-1 Methods for lifetime extension assessment

Method	*Scope*	*Main outcome*	
Lifetime extension inspection (LEI)	— visual inspection of all load-transferring and safety-relevant components — review of maintenance reports and inspection reports for specific turbine — consideration of SCADA data — consideration of wind turbine type related field experience — simple tests	evaluation, if turbine is suitable for lifetime extension	
Simplified approach for lifetime extension	Analytical part: — load calculation, may be performed using generic turbine model — calculation of possible extension of lifetime based on environmental conditions as per original design vs. environmental conditions at the site — possibly accompanied by load measurements Practical part: — inspection based on general inspection plan — visual inspection of all load-transferring and safety-relevant components — review of maintenance reports and inspection reports for specific turbine — consideration of SCADA data — consideration of wind turbine type related field experience — performance of tests	— specification of possible lifetime extension — specification of required inspection scope and intervals based on inspection results and results analytical part — specification of restrictions/conditions (.e.g. component exchange, installation of CMS, etc.) if required	Proof of strength and stability
Detailed approach for lifetime extension	Analytical part: — load calculation based on specific turbine model — calculation of possible extension of lifetime based on environmental conditions as per original design vs. site specific environmental conditions and utilization rate of components — reserve calculations on load-transferring components — possibly accompanied by load measurements — possibly optimization of control system — consideration of turbine type related field experience — development of turbine-specific inspection plan Practical part: — inspection as per turbine-specific inspection plan that has been developed in the analytical part — visual inspection of all load-transferring and safety-relevant components — review of maintenance reports and inspection reports for specific turbine — consideration of SCADA data — consideration of wind turbine type related field experience — performance of tests	— specification of possible lifetime extension — specification of required inspection scope and intervals based on inspection results and results analytical part — specification of restrictions/conditions (.e.g. component exchange, installation of CMS, etc.) if required	
Probabilistic approach for lifetime extension	Analytical part: — structural reliability analysis (stochastic approach) — calculations based on generic or specific turbine model — selection of reliability levels — identification of failure modes — possibly accompanied by load measurements — possibly optimization of control system — consideration of turbine type related field experience — development of turbine or site-specific inspection plan Practical part: — inspection as per turbine-specific inspection plan that has been developed in the analytical part — visual inspection of all load-transferring and safety-relevant components — review of maintenance reports and inspection reports for specific turbine — consideration of SCADA data — consideration of wind turbine type related field experience — performance of tests	— specification of possible lifetime extension respectively reliability level — specification of required inspection scope and intervals based on inspection results and results analytical part — specification of restrictions/conditions (.e.g. component exchange, installation of CMS, etc.) if required	Proof of strength and stability

APPENDIX B INSPECTION LIST FOR LIFETIME EXTENSION INSPECTION (LEI)

1	**Tower**	**Inspection**
1.a	Tower structure	D,Co,C,Sp
1.b	Ladder, fallprotection	D,Co,F,Sp
1.c	Bolted connections	Co,Ps,C
1.d	Foundation, embedded section	D,Co,C
1.e	Foundation	D,C,
1.f	Grounding/Earthing strip	Cf,D,Co
2	**Nacelle**	
2.a	Yaw bearing	T,N,Co,L
2.b	Gear	F,L,W,C
2.c	Nacelle foundation/main frame	D,Co,C
2.d	Nacelle cover	D,Co,C
3	**Drive train**	
3.a	Hub	D,Co,C
3.b	Main shaft	D,Co,C
3.c	Coupling	D,C
3.d	Main shaft bearings	T,N,L
3.e	Gearbox	T,N,L,W
3.f	Torque support	D,Co,C
3.g	High speed shaft	D,Co,C
3.i	Generator	D,N,L
3.j	Cooling system/circuit	Cf,D,T,C
3.k	Bolted connections	Co,Ps
3.l	Protective covers	D,Co
4	**Rotor Blades**	
4.a	Blade structure	D,C
4.b	Blade connection	D,T,Co,C
4.c	Bolted connections	Co,Ps
5	**Pitch Mechanism**	
5.a	Blade tip brakes	D,F,Co
5.b	Blade adjustment	T,F,N,L,W
5.c	Blade bearing	T,N,W
5.d	Coupling elements	D,Co,L,C
5.e	Pitch mechanism	D,F,N,Co,L,C
5.f	Hydraulic components	D,T,F,Co
6	**Safety system**	
6.a	Rotor locking device	D,Co,Sp
6.b	Yaw locking device	D,Co,Sp,C
6.c	Mechanical brake	F,Co,C,W,C
6.d	Hydraulic components	D,T,F,Co
6.e	Vibration switch	Cf,D,F
6.f	Overspeed gauge	F
6.g	Emergency push buttons	F
6.h	Cable twist sensor	F
6.i	Short circuit protection	F
6.j	Fire extinguisher, first aid box	E

7	**Wind sensors**	**Inspection**
7.a	Anemometer	D,F,Co
7.b	Windvane	D,F,Co
8	**Yaw Mechanism**	
8.a	Yaw drive, gear, pinion	D,F,N,Co,L
8.b	Brake	F,C,W,Ps
8.c	Hydraulic components	D,T,F,Co
9	**Hydraulics**	
9.a	Pump	T,F,Co
9.b	Accumulator	T,Co,L,Ps
9.c	Hoses including couplings	D,T,Co,C
10	**Control and Electrical Installations**	
10.a	Cabling	Cf,D,C
10.b	Grounding, machine compon.	Cf,D
10.c	Grounding, lightning protection	Cf,D
10.d	Sliding contacts, main shaft	Cf,D,W
10.f	Hazard beacon	F
10.g	Emergency light, tower	Cf,D,F
10.h	Switch cabinet	D,T,Co,Sp
10.i	Control system	F
10.j	Grid loss	F
10.k	Converter	Sp, D, Cf, T
10.l	Transformer station	Cf,D,T,Sp
10.m	Medium-voltage system	D,Co,Sp
10.n	Power transformer	Cf,D,T,Sp
11	**Manuals and documents**	
11.a	Operating manual	E
11.b	Maintenance duty book	E
11.c	Maintenance reports	E
11.d	Commissioning report	E
11.e	Building permit	E
11.f	Certification reports	E
11.g	Analysis of oil sample	E
11.h	Inspection papers elevator (pers.)	E
11.i	Inspection papers crane (material)	E
11.j	Certificate of conformance	
		E

Tested for:

Damage	D	Connection/fitting	Cf
Examined	E	Tightness	T
Noise	N	Function	F
Cracks	C	Corrosion	Co
Safety sign plates	Sp	Oil level	L
Prestress	Ps	Wear	W