

OCTOBER 31, 2016

1

UL 4143

**Outline of Investigation for Wind Turbine Generator – Life Time Extension
(LTE)**

Issue Number: 1

October 31, 2016

Summary of Topics

This first issue of the Outline of Investigation for Wind Turbine Generator -Life Time Extension (LTE), UL 4143, defines the requirements for the life time extension of wind turbines.

These requirements are intended to facilitate a wide spectrum of assumptions and methods in the process of obtaining external conditions, technical characteristics and the calculation of the remaining useful life time of wind turbines and the confidence level on failure mode to the risk describing the uncertainty in the used methods and procedures. Commercial aspect of wind farm operation is not covered by these requirements.

UL's Outlines of Investigation are copyrighted by UL LLC. Neither a printed nor electronic copy of an Outline of Investigation should be altered in any way. All of UL's Outlines of Investigation and all copyrights, ownerships, and rights regarding those Outlines of Investigation shall remain the sole and exclusive property of UL LLC.

COPYRIGHT © 2016 UL LLC

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**



Documents
Document Sharing Hub

No Text on This Page

*UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL*



Documents

Document Sharing Hub

CONTENTS

INTRODUCTION

1 Scope	4
2 Glossary	4
3 Units of Measurement	5
4 Undated References	5

CONSTRUCTION

5 General	6
6 Requirements for life time extension certification	6
6.1 General	6
6.2 Step 1: Requirements for external conditions	6
6.3 Step 2: Requirements for operational conditions	9
6.4 Step 3: Requirements for wind turbine model	12
6.5 Step 4: Requirements for RUL (Remaining Useful Life)	13
6.6 Step 5: Requirements for the inspection	14
6.7 Step 6: Risk analysis	15

Appendix A

A1 Wind turbine control parameters & settings	A1
A2 Simulation model parameters (Onshore)	A2
A3 Inspection criteria	A4
A4 Risk Analysis	A7

.....

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**



Documents
Document Sharing Hub

INTRODUCTION

1 Scope

- 1.1 These requirements cover the rules and procedures for the life time extension of wind turbines (LTE).
- 1.2 These requirements covers the process to obtain risk by relating the severity to their confidence level on accuracy for the failure mode.
- 1.3 Commercial aspects of wind farm operation are not covered by this Outline of Investigation.
- 1.4 These requirements are applicable to the on-shore wind turbines.

2 Glossary

- 2.1 For the purpose of this document, the following terms and definitions apply. Further definitions can also be found in IEC 61400 series.
 - 2.2 CELL – Grouping of wind turbines. A cell defines a group of wind turbines within a wind farm.
 - 2.3 FL – Fatigue load on component
 - 2.4 LTE – Life time extension, a technical assessment that supports the continued use of a wind asset beyond a previously determined time-based limitation.
 - 2.5 MCP – Measure-correlate-predict
 - 2.6 MLC – Measurement load case
 - 2.7 OEM – Original equipment manufacturer
 - 2.8 RPN – Risk priority number, the RPN level of uncertainty in failure mode.
- NOTE: This RPN calculation differs from the method mentioned in Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA), IEC 60812
- 2.9 RUL – Remaining useful life, the time frame of a safe operation of wind turbine(s) or a wind farm.
 - 2.10 SCADA – Supervisory control and data acquisition.
 - 2.11 WTG – Wind turbine generator

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this Outline of Investigation shall be interpreted to the latest edition of that code or standard.

Table 4.1
Normative references

No.	Document number	Title
1	IEC 61400-1	Wind turbines – Part 1: Design requirements
2	IEC 61400-12-1	Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines
3	IEC 61400-22	Wind turbines – Part 22: Conformity testing and certification
4	ISO/IEC 17020	General criteria for the operation of various types of bodies performing inspection
5	ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories
6	ISO/IEC 17065	Conformity assessment - Requirements for bodies certifying products, processes and services
7	ISO 13849	Safety of machinery – Safety related parts of control systems
8	GL	Guideline for the Certification of wind turbines
9	UL 6142	Small Wind Turbine Systems
10	UL 6141	Large Wind Turbine Systems
11	IEC 60812	Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)
12	IEC 61400-13	Wind turbines – Part 13: Measurement of mechanical loads

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM



Documents

Document Sharing Hub

CONSTRUCTION

5 General

5.1 The process to establish a LTE and risk shall follow the steps described in Table 5.1.

5.2 The LTE strategy shall be considered successful if the value of RPZ is less than 50 for each failure mode.

Table 5.1
Procedure of LTE

Steps	Clause
Step 1: Requirement for external condition	6.2
Step 2: Requirement for operation condition	6.3
Step 3: Requirement for wind turbine model	6.4
Step 4: Requirement for remaining useful life	6.5
Step 5: Requirement for inspection	6.6
Step 6: LTE Risk Analysis	6.7

6 Requirements for life time extension certification

6.1 General

6.1.1 In order to extend the lifetime of a wind turbine, the wind turbine(s) in a wind farm shall comply with the requirements mentioned in Section 6.2 to 6.7.

6.2 Step 1: Requirements for external conditions

6.2.1 Operational historical data of external conditions relevant to the structural loading of the wind turbine(s) in the wind farm shall be used.

6.2.2 To assist in determining site external conditions SCADA data, met mast data, and/or public databases may be used. The respective source shall be named.

6.2.3 To cover the seasonal variations in wind characteristics, the measurement period shall cover at least 12 months.

6.2.4 The analysis of the measured data shall comply with Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines, IEC 61400-12-1 or other equivalent standard like MEASNET, as applicable.

6.2.5 The following information shall comply with the requirements outlined IEC 61400 series.

6.2.6.1 Site topography

- a) Details of the site/ wind farm;
- b) Details of the site lay-out and change in layout;
- c) Assessment of complexity; and

- d) Assessment of obstacles.

6.2.6.2 Measurement equipment

- a) Details of met mast;
- b) Details of measurement equipment; and
- c) Description of data logging.

6.2.6.3 Other information

- a) Filtering and other data verification analysis;
- b) Calibration details;
- c) Details of the extrapolation models including the model validation;
- d) Details of the wind modeling and uncertainties;
- e) Historical changes to the site/forestation; and
- f) Applicability of the measurements to past and future periods. In case of any possible changes to the site, these shall be considered in the extrapolation of data to future periods.

6.2.6.4 Wind speed and wind direction

a) General

- 1) The wind speed shall be at least of 2 m/s bins;
- 2) Wind direction shall cover at least 30 degree sectors; and
- 3) The wind speed average shall be 10 minutes average.

b) Methods for long term assessment

- 1) The long term measurements from met station along with an appropriate co-relation technique (e.g. MCP) may be used; and
- 2) The methods used for long term assessment shall comply with the Wind turbines – Part 1: Design requirements, IEC 61400-1.

6.2.6.5 Wind speed distribution

- 1) Probability distribution function from Cut-in wind speed V_{in} to $0.7 \times V_{ref}$ shall be used.

6.2.6.6 Turbulence

- a) Turbulence intensity values for 10 minute average bin with 30 degree sector and 2m/s bin (minimum) shall be used; or
- b) The effective turbulence intensity calculations from wake may be used;
- c) The methods used for turbulence determination shall comply with the Wind turbines – Part 1: Design requirements, IEC 61400-1;
- d) In case of a complex terrain, the site complexity shall be accounted in the turbulence intensity calculation.

6.2.6.7 Wind shear

- 1) The wind shear shall be derived for each wind turbine location based on flow modeling on two (2) anemometers – with a minimum vertical spacing of 20 m.

6.2.6.8 Density, temperature, pressure and humidity

- 1) In complex terrains, more than two (2) sensors per measurement parameters shall be used. The minimum, maximum and mean values of density, temperature, air pressure and humidity shall be used.

6.2.6.9 Flow inclination

- 1) The flow inclination angle shall be used in 30 degree sectors.

6.2.6.10 Electrical conditions

- a) The grid conditions of the site shall be evaluated for possible impact on the loads and performance of the wind turbines, following conditions shall be considered:
 - 1) Voltage/ frequency range;
 - 2) Total numbers of network outages during life time operation;
 - 3) Fault in currents during life time operation;
 - 4) Power factor control;
 - 5) Ramp rate;
 - 6) Fault ride through;
 - 7) Local grid compliance; and
 - 8) In case of other events like extreme temperature, earth quake, lightning, solar radiation, salinity, icing, hail or snow, possible impact on the loads and performance of the wind turbine shall be taken into account.