



Industrie Service

Choose certainty.
Add value.

DEPARTMENT WIND TURBINES

Certification Report

dated: 2017-04-03

Report no. 2648908-1-e

1. Subject

Project: Tower internals of the steel towers

Manufacturer of turbine: Vestas Wind Systems A/S
Hedeager 42
8200 Aarhus N
Denmark

Design and calculation: Vestas Wind Systems A/S
Hedeager 42
8200 Aarhus N
Denmark

Client: Vestas Wind Systems A/S
Hedeager 42
8200 Aarhus N
Denmark

Date: 2017-04-03

Our reference:
IS-ESW-MUC3/BO

Document:
2648908-1-e Tower Internals
PuE.docx

Report No. 2648908-1-e

This document consists of
5 Pages.
Page 1 of 5

Excerpts from this document may
only be reproduced and used for
advertising purposes with the
express written approval of
TÜV SÜD Industrie Service GmbH.

The test results refer exclusively
to the units under test.



Headquarters: Munich
Trade Register Munich HRB 96 869
VAT ID No. DE129484218
Information pursuant to Section 2(1)
DL-InfoV (Germany) at
www.tuev-sued.com/imprint

Supervisory Board:
Karsten Xander (Chairman)
Board of Management:
Ferdinand Neuwieser (CEO),
Dr. Ulrich Klotz, Thomas Kainz

Phone: +49 89 5791-3146
Fax: +49 89 5791-2956
www.tuev-sued.de/is



TÜV SÜD Industrie Service GmbH
Energy and Systems
Wind Energy
Wind Turbines
Westendstrasse 199
80686 Munich
Germany

| Revision | Date | Comments |
|----------|------------|---------------|
| 0 | 2017-04-03 | First release |

2. Documentation

2.1 Documents reviewed

The following documents were submitted for assessment:

- [1] "Main principles internals LDST", issued by Vestas Wind Systems A/S, 2 pages, drawing no.: 0065-6173, Ver. 02, dated 2017-03-31
- [2] "Structural Design of Internals, Tubular steel towers, Vestas Modular Towers, Tower diameter up to 4.20 m", issued by Vestas Wind Systems A/S, 20 pages, document no.: 0001-4114, Ver. 05, dated 2017-03-28
- [3] "Structural Design of Internals, Large diameter steel towers, LDST, Steel tower diameters 4.20 - 6.50 m", issued by Vestas Wind Systems A/S, 21 pages, document no.: 0062-5835, Ver. 02, dated 2017-03-28

2.2 Documents noted

The following documents were taken for information only:

- [4] "General rules for Internals, Large Diameter Steel Towers (LDST)", issued by Vestas Wind Systems A/S, document no.: 0062-5084, Ver. 1, undated
- [5] "Technical purchase specification - Aluminium platforms", issued by Vestas Wind Systems A/S, document no.: 0006-5290, Ver. 01, dated 2015-05-11
- [6] "EC-Type Approval Certificate - PPE against fall from a height, Anchor Device EN 795 A/B - SÖLL EYE ANCHOR", issued by TÜV SÜD Product Service GmbH, Certificate no.: P5 09 12 69922 004, dated 2010-01-11

3. Basis of the assessment

- /1/ EN 1991-1-1:2002 + AC:2009 "Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings"
- /2/ EN 1993-1-1:2005 + AC:2009 + A1:2014 "Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings"
- /3/ EN 1993-1-8:2005 + AC:2009 "Eurocode 3: Design of steel structures – Part 1-8: Design of joints"
- /4/ EN 1993-1-9:2005 + AC:2009 "Eurocode 3: Design of steel structures – Part 1-9: Fatigue"
- /5/ EN 1993-1-10:2010 "Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties"
- /6/ EN 50308:2005 "Wind turbines - Protective measures – Requirements for design, operation and maintenance"
- /7/ EN ISO 14122-2:2016 „Safety of machinery – Permanent means of access to machinery – Part 2: Working platforms and walkways (ISO 14122-2:2016)“

/8/ EN 353-1:2014 "Personal fall protection equipment – Guided type fall arresters including an anchor line- Part 1: Guided type fall arresters including a rigid anchor line"

4. Scope of the assessment

The scope of this certification report is the review of the documents listed in section 2, based on the regulations listed in section 3, with regard to structural integrity of the tower internals of the steel towers.

Further assessments such as the assessment of the steel tower or the safety concept according to EN 50308 /6/ are not within the scope of this report. Neither are evacuation and access ways part of this report. Climbing facilities (ladders and staircases etc.) as well as the service lift are not part of this review.

Deviations from the approved documentation and referenced regulations regarding design or load assumptions render this report invalid and require a reassessment.

5. Technical description

The inner platforms are split in two categories:

- Inner platforms up to 4.20 m tower diameter
- Inner platforms with a tower diameter of 4.20 m to 6.50 m (LDST).

Both categories can be carried out with two U-beams bent out of aluminium sheets which are placed between the rectangular and circular platform segments.

For inner platforms with a maximum tower diameter of 4.20 m an additional execution is possible: Construction of the platform with rectangular and circular platform segments without U-beams.

Principally all elements of the inner platforms are connected with bolts M16, 8.8 with a maximum distance of 25 cm.

The structure of the inner platforms for the steel tower can be described as follows:

- Tear drop plate $t = 5/7$ mm, edged to single platform segments and fixed to the steel tower wall by connecting plates or fixed to the tower flange by hangers
- Connecting plates $h/t = 50/8$ mm, directly welded to the tower wall (support of the inner platforms)
- Hangers $\varnothing 16$ mm fixed to the tower flange by a blind hole connection and fixed to the platform by bolts (hanging support of the inner platforms)

There is a lift in the tower. The lift cross beam is a T140 T-profile (or alternatively a welded T-profile with the same cross section values) steel girder and is directly welded to the tower wall.

For vertical load transfer, the ladder is attached to each platform by brackets. It is also fixed to the tower wall by magnets for the horizontal load transfer.

All platforms are performed with an access opening at the ladder. The platforms above the lift entrance also have openings for the service lift.

For tubular steel towers with a maximum diameter of 4.20 m, the railing consists of a beam and post construction using rectangular hollow section aluminium profiles 50x50x3 mm. Rectangular hollow section aluminium profiles 40x40x2,5 mm are used for the railing of the LDST-towers.

6. Design loads

The loads on the inner platforms are assumed according to EN ISO 14122-2 /7/:

- Single load 1.5 kN at most unfavourable location
- Distributed load 2.0 kN/m²
- Additional loads are specified in the calculation

The fixing points are calculated with singular loads of 22 kN.

The dimensioning loads for the lift cross-beam were applied according to the load tables of the supplier in [2].

For the railings following loads in [2] were assumed:

- Horizontal load hand rail 0.30 kN/m

The loads on the ladder are assumed according to EN 50308 /6/ and EN 353-1 /8/:

- Deviating from /6/: Two single loads on the ladder segment, each 1.5 kN
- Safety catch with a single load of 6 kN according to /6/ (equal to 15 kN static loading resulting from a maximum arrest load of 6 kN according to /8/)

Dead loads are considered according to EN 1991-1-1 /1/ and manufacturer's information.

7. Construction materials

| | |
|-------------------------------------|---|
| Floor sheets (plate) | EN AW 5754 H114 - EN 1386 |
| Sheet for fixing ladder to platform | EN AW 6082 T6 - EN 573-3 |
| Reinforcement, railing | EN AW 6060 T6 - EN 573-3 |
| Steel sheets, brackets (ladder) | S235JR - EN 10025-2 |
| Lift cross beam and hanger | S355J0 - EN 10025-2 |
| Bolts (steel construction) | grade 8.8 acc. to EN 14399-4 and EN 14399-6 |

8. Comments

The submitted calculations were reviewed in general by carrying out our own parallel calculations. Sufficient safety margins are confirmed based on our parallel calculations and on the calculations presented for review.

For the fixing points an EC-Type Approval Certificate [6] was submitted.

9. Result of the Assessment

The design calculation is in conformity with the standards and guidelines listed in section 3 and it is essentially complete and correct.

The requirements concerning the structural integrity of the tower internals are met, provided that the requirements listed below and all requirements and remarks included in the corresponding reports and approvals are being observed and implemented.

The approval of the technical documentation of the tower internals is herewith completed.



Industrie Service

Requirements

1. After extreme load conditions for the single parts (sudden stop of the lift, activation of the safety catch of the ladder and fixing points) the components shall be checked visually for any defects.
2. The connecting elements of all parts welded to the tower shell (e.g. gusset plates or ascending facilities) shall correspond at least to the detail category as specified in the tower drawing.
3. Deviating from EN 1991-1-1 /1/ reduced live loads according to EN ISO 14122-2 /7/ were considered for the platforms. It shall be ensured that all personnel with access to the tower have knowledge of the maximum permissible loads on the platforms.
4. According to the structural calculation [2] the number of persons for each ladder segment is limited to two persons. It shall be ensured that all personnel with access to the tower have knowledge of the maximum permissible loads on the ladder.

TÜV SÜD Industrie Service GmbH
Department Wind Turbines

Chief engineer

A handwritten signature in blue ink, appearing to read 'F. Singer'.

F. Singer

Expert engineer

A handwritten signature in blue ink, appearing to read 'B. Ober'.

B. Ober

