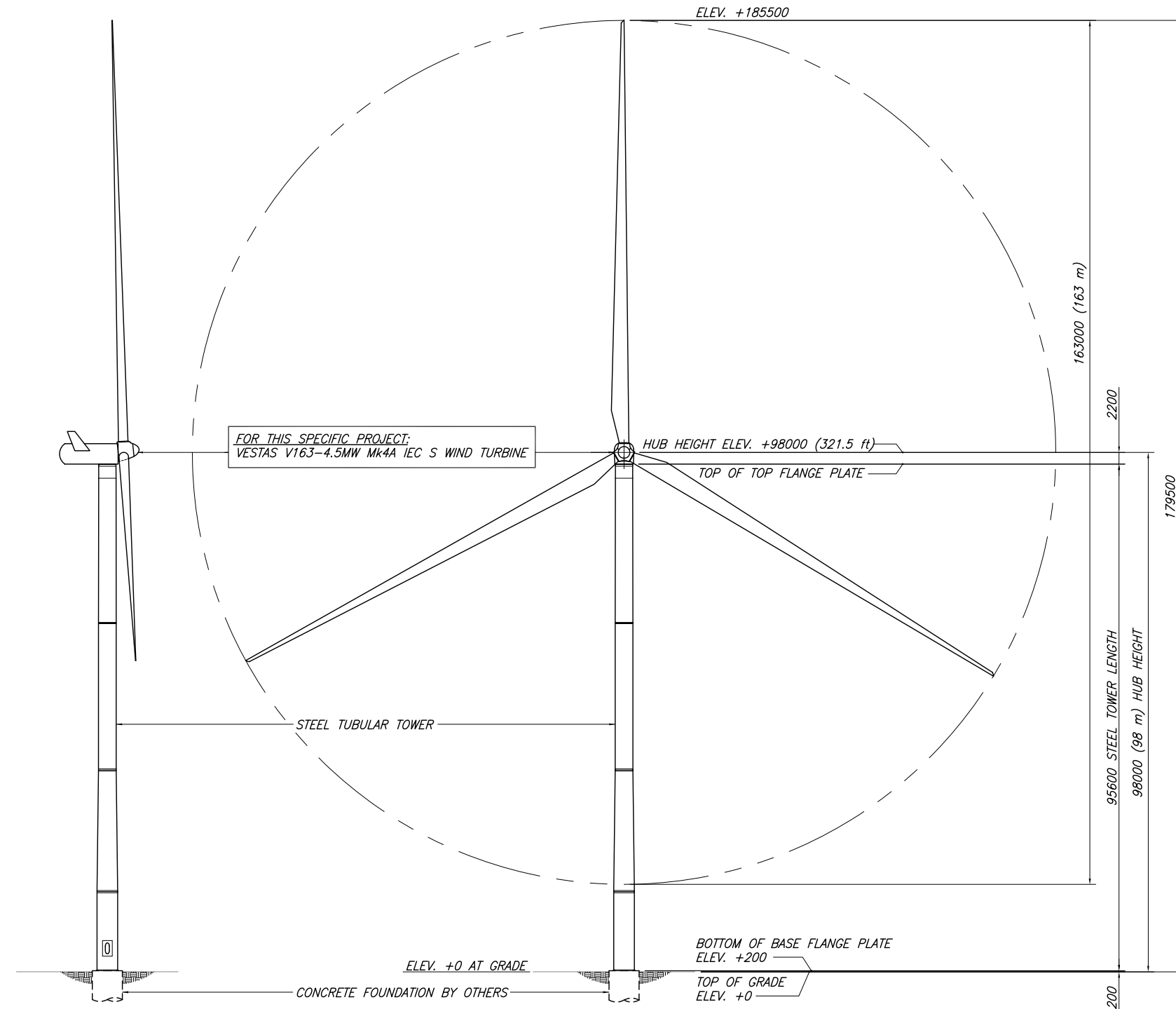


Appendix 3-2

Certificate of Structural Safety

VESTAS V163/V166-4.5MW Mk4 IEC S WIND TURBINE TUBULAR TOWER

HH98M-TA36200-A024-4468_V01 4 SECTION



ELEVATION

1:1000

SHEET INDEX

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3	S1.1	GENERAL NOTES
TOWER STRUCTURAL DETAILS		
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5	S3.1	TOWER SECTIONS AND DETAILS
TOWER SECTIONS AND DETAILS		
6	S3.4	TOWER SECTIONS AND DETAILS
7	S4.0	TOWER SECTIONS AND DETAILS
8	S4.1	TOWER STANDARD DETAILS
9	S5.0	DENT TOLERANCES

APPROXIMATE WEIGHTS

WIND TURBINE WEIGHTS (VERIFY WITH MANUFACTURER)		
NACELLE	131300 kg	289500 lbs
ROTOR	99700 kg	219800 lbs
TOTAL	231000 kg	509300 lbs
TOWER WEIGHTS (INCLUDING INTERNALS)		
SECTION 4 (TOP)	50700 kg	111900 lbs
SECTION 3	66100 kg	145600 lbs
SECTION 2	69900 kg	154100 lbs
SECTION 1 (BOTTOM)	70200 kg	154800 lbs
TOTAL	256900 kg	566400 lbs
TOWER AND TURBINE SYSTEM WEIGHT		
TOTAL	487900 kg	1075700 lbs

NOTE:
TOWER WEIGHTS ABOVE INCLUDE AN ESTIMATED WEIGHT FOR TOWER MISC. INTERNAL COMPONENTS.

WIND DATA SUMMARY

$$V_{e50} = 46.1 \text{ m/s (*)}$$

NOTES:
(*) 2020 NBCC VALUE EXPRESSED AS AN EQUIVALENT V_{e50} VALUE ADJUSTED TO THE SITE-SPECIFIC AIR DENSITY AND ADJUSTED TO HUB HEIGHT.

SEE GENERAL NOTES - CODE DESIGN DATA FOR MORE INFO. SEE CALCULATIONS SECTION 0 SUMMARY AND SECTION 8 FOR MORE INFO.

SEVEN STARS WIND ENERGY PROJECT
NEAR WEYBURN, SASKATCHEWAN, CANADA
FIFTY (50) x HH98M-TA36200 TOWERS

VESTAS-CANADIAN WIND TECHNOLOGY, INC.
1417 NW EVERETT STREET PORTLAND, OREGON 97209
TEL: (503) 327-2000 FAX: (503) 327-2001



SIGNATURE NESTOR A. AGBAYANI, SK PE 12590

12.18.2025

DATE OF SIGNING

12.31.2026

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- REFER TO THE TURBINE OEM'S AND/OR THE TOWER PROCUREMENT AGENT'S PROPRIETARY SPECIFICATIONS FOR THE COMPLETE TOWER SPECIFICATION.

TITLE SHEET

AGBAYANI STRUCTURAL ENGINEERING
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VESTAS V163/V166 Mk4
4.5MW IEC S WIND TURBINE
HH98M-TA36200-A024-4468_V01 4 SECTION

JOB NO. 25-033	DATE 2025-12-18	SHEET
DRAWN N. Agbayani	CHECKED N. Agbayani	SO.0
DESIGNED N. Agbayani	APPROVED N. Agbayani	

GENERAL NOTES

SCOPE OF TOWER DESIGN

These are design drawings for permit purposes only. These are NOT shop drawings, fabrication drawings, assembly drawings, or erection drawings, and they shall not be used as such or for such purposes.

The scope of these design drawings is limited to the steel tower and its primary structural components including: the tower shell; the base flange; the intermediate splice flanges; the top flange; and the reinforced shell penetrations such as the tower entry doorway or cable openings.

Where an embedded steel foundation mounting piece (FMP) is used, it shall be considered part of the foundation design scope and not included in the tower scope of work, unless explicitly detailed in these drawings.

THE FOLLOWING ITEMS ARE BY OTHERS:

Reinforced concrete foundation including anchor rods (bolts), the embedded anchor plate, and the baseplate grout; internal details; the door mechanism; protective finishes; fabrication tolerances not shown, etc.

THE TOWER PROCUREMENT AGENT

References in this drawing to the "turbine manufacturer" or "turbine original equipment manufacturer (OEM)" may depend on context alternatively refer to the Tower Procurement Agent (TPA), especially in cases where the Turbine OEM is not involved in the subject tower procurement. Where the meaning is otherwise unclear or for matters referring to the Engineer, the Tower Procurement Agent shall be contacted for clarification and/or informational requests to be routed to the Engineer

COORDINATION OF QUALITY CONTROL

1. The tower fabricator shall coordinate all quality control (testing and inspection) requirements with these design drawings, the turbine manufacturer and the project special inspector (if the project special inspector is known) prior to fabrication.

2. As a minimum requirement, all quality control shall comply with Code, AISC, and AWS requirements. However, for specific cases of conflict and/or where by prior agreement the more stringent requirements shall apply from the following sources:

- A. Code/AISC/AWS requirements interpreted to the satisfaction of the turbine manufacturer (and project special inspector, if known).
- B. Turbine manufacturer's requirements.
- C. Project special inspector's requirements, if defined prior to fabrication.

3. In the event of disagreement on the implementation or interpretation of any aspect of the quality control requirements, an independent opinion shall be obtained at the fabricator's expense from a mutually agreed third party professional with expertise in the testing or inspection methods being disputed.

4. Weld repairs to tower primary complete joint penetration (CJP) welds shall not be performed unless the proposed repair procedure is approved by the turbine manufacturer and engineer. The repair procedures shall be introduced before tower fabrication. Examples of tower primary CJP welds include tower circumferential joints, tower longitudinal joints, shell-to-flange joints, and tower wall-to-stiffener joints at openings.

5. The turbine manufacturer at its expense may at any time send its Certified Welding Inspector to confirm and witness material, fabrication, inspection practices, personnel certifications, and equipment calibration and records on towers covered by these specifications and the tower specifications from the turbine manufacturer's engineering department.

COORDINATION OF FABRICATION TOLERANCES

1. These are structural design drawings and shall not be used as fabrication or "shop" drawings. These drawings do not show all required fabrication tolerances. Fabrication tolerances not shown on these drawings shall be obtained from the turbine manufacturer or engineer prior to fabrication. Default fabrication tolerance values shall not be assumed and used unless first approved in writing by the turbine manufacturer or engineer.

2. The tower design may have certification by foreign, e.g., European, certification agency. For this reason the fabricator shall coordinate all fabrication tolerances with the turbine manufacturer prior to fabrication.

3. In cases of conflict, the more stringent tolerance shall govern between the Code/AISC/AWS tolerances and the turbine manufacturer's tolerances.

4. In cases where the applicable tolerance is unclear to the fabricator or conflicting requirements are found, the fabricator shall contact the turbine manufacturer and/or engineer to obtain in writing an approved tolerance value before proceeding further.

CODE DESIGN DATA STATEMENT OF DESIGN CODE COMPATIBILITY:

THE TERM "IBC" USED HEREIN SHALL IMPLY THE FOLLOWING:
 "THE US STATE BUILDING CODE BASED ON THE INTERNATIONAL BUILDING CODE (IBC)."
 THE TERM "NBCC" USED HEREIN SHALL IMPLY THE FOLLOWING:
 "THE BUILDING CODE REGULATIONS BASED ON THE 2020 NBC OF CANADA (NBCC)."
 LOAD CALCULATIONS ARE IN ACCORDANCE WITH ASCE 7 FOR COMPATIBILITY WITH THE 2021/2018/2015/2012/2009/2006 INTERNATIONAL BUILDING CODE (IBC). THE DESIGN IS ALSO COMPATIBLE WITH 2020 NATIONAL BUILDING CODE (NBC) OF CANADA DESIGN WIND AND EARTHQUAKE PARAMETERS AS SHOWN IN THE TABLES BELOW AND IN SECTION 8 OF THE STRUCTURAL CALCULATIONS.

WIND DESIGN DATA: PER IEC 61400-1 EQUIVALENT TO SITE CLASS: S (V_{e50}=52.5 m/s)

NO.	ITEM	DESIGN VALUE	SITE VALUE	COMMENT
1	REFERENCE WIND SPEED V (m/s)	29.7@10m	28.6@10m	SEE CALCS. SECTION 8
2	WIND IMPORTANCE FACTOR I	1.0	SAME	
3	EXPOSURE	A	SAME	
	EXPOSURE COEFFICIENT (MAX.) C _e	1.579	SAME	
4	FORCE COEFFICIENT FOR SOLID ROUND TOWERS C _f	0.724	SAME	
5	[NOT USED]	N/A	N/A	
6	OTHER WIND DESIGN DATA:			
	TOPOGRAPHIC FACTOR (MAX.) C _t	1.0	1.0	SEE CALCS. SECTION 8
	VELOCITY PRESSURE (10m) q _{ref} (Pa)	517	480	
	GUST EFFECT FACTOR C _g	2.000	SAME	BASELINE
	AIR DENSITY ρ (kg/m ³)	1.225	1.2929	STANDARD SITE SPECIFIC

NOTES:

1. DESIGN VALUES ARE EQUIVALENT TO TURBINE IEC SITE CLASS WIND.
2. WIND DESIGN LOAD COMBINATIONS (FOR STRENGTH DESIGN):
 $U = (0.9 \text{ OR } 1.25)D + (1.10 \text{ OR } 1.35 \text{ OR } 1.4 - \text{Equiv. OR } 1.6 - \text{Equiv.})W$
3. OPERATIONAL LOADS, EMERGENCY STOP LOADS, AND FATIGUE LOADS ARE PROVIDED BY THE TURBINE MANUFACTURER.

EARTHQUAKE DESIGN DATA – PER IBC/ASCE 7-16 WITH COMPARISON TO 2020 NBCC

NO.	ITEM	DESIGN VALUE	SITE VALUE	COMMENT
1	SEISMIC IMPORTANCE FACTOR I	1.0	SAME	
2	MAPPED SPECTRAL RESPONSE ACCELERATIONS			
	SHORT PERIOD S _s (g)	1.500	N/A	
	1-SECOND PERIOD S ₁ (g)	0.599	N/A	
3	SITE CLASS	Ddefault	XD	
4	SPECTRAL RESPONSE COEFFICIENTS (AT 5% DAMPING)			
	SHORT PERIOD SDS (g)	1.000	0.290	NBCC S(0.2, XD)
	1-SECOND PERIOD SD1 (g)	0.599	0.116	NBCC S(1.0, XD)
5	SEISMIC DESIGN CATEGORY SDC	D	SC2	
6	BASIC SEISMIC-FORCE-RESISTING SYSTEM			NONBUILDING TUBULAR STEEL CANTILEVER MAST
7	DESIGN BASE SHEAR V (kip)	136	74	See Calculation Section 8 for project-specific earthquake calcs.
8	SEISMIC RESPONSE COEFFICIENT C _s	0.127	0.069	
9	RESPONSE MODIFICATION FACTOR R	1.5	1.0	See Note 1.
10	ANALYSIS PROCEDURE			MODAL RESPONSE SPECTRUM ANALYSIS
11	OTHER:			
	TOWER FUNDAMENTAL FREQUENCY (SOFT ESTIMATE) f (Hz)	0.186	SAME	@ K _φ
	FOUNDATION ROTATIONAL STIFFNESS (NOMINAL) K _φ (GN-m/radian)	500	SAME	

NOTES:

1. SEISMIC DESIGN LOAD COMBINATIONS (FOR STRENGTH DESIGN):
 PER IBC: $U = (0.9 \text{ OR } 1.2)D \pm 1.0E @ R=1.5, 1\% \text{ Damping}$
 PER IEC: $U = (0.9 \text{ OR } 1.2)D \pm 0.75(1.0E \pm 1.0M) @ R=1.5, 5\% \text{ Damping}$
 PER NBCC: $U = (1.0)D \pm (1.0)E @ R=RoRd=1.0, 5\% \text{ Damping}$

STRUCTURAL STEEL

Item ASTM No. (U.N.O.)

Tower Shell: (Can numbering starts at 1 at bottom of each section)

- Section 1: Cans 1-5 S355 J2
- Can 6 S355 J0
- Section 2: S420 N
- Sections 3 & 5: S355 J0

(Equivalent: A709, Grade 50. See "Tower Shell" Note below for supplementary requirements)

Tower Forged Flanges:

- Top Flange S355 NL (See "Forged Flanges" Note below for equivalent material)
- Other Flanges S355 NL (See "Forged Flanges" Note below for equivalent material)

Door Frame Plate S355 NL (Equivalent: A709, Grade 50. See "Door Frame Plate" Note below for supplementary requirements)

High Strength Tower Splice Bolts DIN 6914/15/16 Grade 10.9 tzn or EN 14399-4/6, DAST Guideline 021

Hardened Steel Washers F436 or EN equivalent

Tower Shell: ASTM A709 Grade 50, or A572 Grade 50 in lieu of S355 steel or ASTM A572 Grade 65 steel in lieu of S420 steel modified as follows:
 Material spec. modifications shall be per the TPA's specifications.

Forged Flanges: It is generally intended that forged flanges shall be compliant with EN 10025-3. In the U.S., the equivalent steel for forged flanges shall comply with ASTM A694 GR F42 (normalized) in lieu of S355 NL or GR F50 (normalized) in lieu of S420 NL. The A694 steel shall be modified as follows:
 Material spec. modification shall be per the TPA's specification.

Door Frame Plate: It is generally intended that the door plate shall be compliant with S355 NL EN 10025-3. In the U.S., an equivalent steel for the door frame shall comply with the following:

ASTM No. (U.N.O.)
 Cut or Rolled from A709 Plate A709 Grade 50, modified per: Supplementary Requirements: Material spec. modification shall be per the TPA's specifications.

Fabrication and erection: Conform to latest AISC Specifications
Welding: Submerged Arc Welding process
CJP: CJP denotes complete joint penetration groove welds in AISC/AWS prequalified welded joints. All welds between flanges, shells, and frames shall be CJP groove welds and shall be welded from both sides in a flat or horizontal position. Any proposed alternatives to the specified AISC/AWS prequalified welded joints shall either be prequalified or qualified in accordance with AWS D1.1. Weld procedure specifications (WPS) and procedure qualification records (PQR) shall be submitted to the Owner & Engineer. Alternative welds shall be reviewed & approved by the Engineer. In addition, weld quality shall also comply with the Turbine Manufacturer's specification.

Weld Electrodes: AWS low hydrogen electrodes compatible with base metal.
Welders: Shall be certified and work done in accordance with the Structural Welding Code AWS D1.1. Submit Certification copies.

Surface Treatment:
 Minimum of SSPC-SP-6 Commercial Sandblast in accordance with paint manufacturer's specifications.
 Paint system to be designed to satisfy at least the minimum requirements of ISO 12944 Corrosivity Category C3 "High Durability" requirements for both tower interior and exterior tower surfaces. Turbine manufacturer must approve paint system before any coating operation. Paint system shall have a minimum 20 year life span.
 Flange contact surfaces to be coated with electrically conductive material. Do not paint lightning conductor brackets.

FATIGUE DETAIL NOTES

All fatigue detail categories shall be per Eurocode 3, i.e., EN 1993-1-9, as cited in the structural design calculations.

Surface finish for any machining or grinding shall be per AWS D1.1 Section 5.2.4.2. Where machining or grinding of weld and/or plate surfaces is indicated, smooth transitions shall always be provided. "Smooth" does not necessarily mean "flush." "Smooth" describes the surface finish, whereas "flush" describes the weld reinforcement's convexity profile. Where the particular detail category allows a maximum weld reinforcement height to remain, the remaining reinforcement need not be ground flush, but the remaining profile shall be nevertheless smooth, with no sharp edges, no notches, nor any abrupt transitions. Restated in other words for clarity: "grind smooth" does not necessarily mean "grind flush." All grinding shall be "smooth" in surface finish, but not all grinding indicates a "flush" profile. Whether to grind "flush" for a flat profile or to leave some remaining reinforcement height is a requirement of the specified detail category. Contact the turbine manufacturer's engineering department if further clarification is needed.

COLD WEATHER APPLICATIONS

Above 0° F no Charpy V-Notch (CVN) testing is required. Below 0° F the Turbine OEM's CVN toughness requirements shall apply.

SEVEN STARS WIND ENERGY PROJECT
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SIGNATURE NESTOR A. AGBAYANI, SK PE 12590

12.18.2025

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VESTAS V163/V166 Mk4
 4.5MW IEC S WIND TURBINE
 H98M-TA36200-A024-4468_V01 4 SECTION

JOB NO. 25-033	DATE 2025-12-18	SHEET
DRAWN <u>Agbayani</u>	CHECKED <u>Agbayani</u>	S1.0
DESIGNED <u>Agbayani</u>	APPROVED <u>Agbayani</u>	

GENERAL NOTES

HIGH STRENGTH BOLTS (Tower Splice Bolts)

Type
Tower splice bolts (other than top splice bolts) shall be Grade 10.9 tzn DIN 6914/15/16. ALI: EN 14399-4/6, DAST Guideline 021.
Tower top splice bolts shall be M30 bolts conforming to ISO 4014 tzn with washers conforming to ISO 7416 tzn.

Approval
All hardware purchased under DIN 6914/15/16 shall be purchased only through an approved supplier with permission from the turbine manufacturer.

Bolt Threads
All bolt threads shall be excluded from the shear planes.

Pretension
The minimum required pretension is:

Size	Minimum Tension (kips)
M30	79
M36	115
M42	160
M48	210
M56	288
M64	379
M72	490
Other metric bolts	Per turbine manufacturer specifications

Installation, Calibration, and Pretension Verification
Installation, calibration, and pretension verification shall be performed in accordance with manufacturer specifications and in accordance with the RCSC specification.

Installation
The torque necessary to provide the required minimum pretension to the bolts shall be determined at the job site by means of a Skidmore-Wilhelm bolt tension calibrator.

Hardened washers shall be used under the nuts and under the bolt heads. All high strength bolts shall be tightened by means of calibrated wrench tightening. Alternatively, the turn-of-nut method may be used. The pretension shall be verified after bolt tightening.

Calibration
The torque necessary to provide the required minimum pretension to the bolts shall be determined at the job site by means of a Skidmore-Wilhelm bolt tension calibrator with a calibration procedure conforming to the RCSC specification.

Pretension Verification
Verify that high-strength bolts have been properly pretensioned by means of a calibrated manual torque wrench. The wrench shall be calibrated by means of a Skidmore-Wilhelm Bolt Tension Calibrator. Check at least 10% of all the bolts in the splice flange.

ALTERNATIVE-DESIGN FASTENERS
Use of Turbine OEM's proprietary stud bolts is permitted in lieu of conventional high-strength bolts. Stud bolts are permitted in accordance with RCSC Section 2.8, Alternative-Design Fasteners. When stud bolts are used, Skidmore calibration is not applicable and is therefore not required.

When stud bolts are used, special inspection is still required. A modified version of the special inspections applicable to the Turbine OEM's proprietary alternative-design fastener shall be provided by the Engineer.

PERMANENT TOWER MARKINGS

All permanent markings on towers and the method of marking shall be approved by the turbine manufacturer and/or engineer. Permanent tower markings done by stamp impression, including but not limited to serial numbers, alignment marks, material ID marks, etc., shall be made with approved rounded LOW-STRESS stamps. Existing permanent marks such as steel plate ID numbers shall be repaired by welding or grinding or both at the discretion and approval of the turbine manufacturer and/or engineer. The wind turbine tower structure is a fatigue loaded structure that is sensitive to the notches and discontinuities introduced by stamped impressions that may unintentionally serve as crack initiation/propagation points.

SHOP DRAWINGS

Shop drawings for the steel tower are not required under this scope of work, and the extent and requirements of the shop drawing review and approval process shall be as agreed between the Owner and the Turbine OEM or the TPA.

TOWER HANDLING

The tower shall be handled with care during fabrication, shipping and erection to prevent dents, misshaping, scratching of finishes, and other damage. In general, the tower shall be handled and supported by direct attachments to the tower flanges and not the shell. Temporary supports shall have sufficient strength, stiffness, and padding to prevent damage to the tower and finishes. The tower flanges shall be stiffened as required to avoid misshaping.

Damaged tower sections shall not be used on this project, unless repairs are completed to the satisfaction of the Owner and the Engineer.

GENERAL NOTES

Typical Details and General Notes apply in all cases unless specifically shown otherwise on the drawings. Where No Detail is Shown, construction shall be as shown for other similar work. No Deviations from the Design Drawings are permitted without the permission of the Engineer.

TESTING

Structural Steel
Tower Flanges – Perform ultrasonic test inspections for laminations in the region of the shell to flange weld. This region shall include the full thickness of the flange within the portion bounded by the flange O.D. and the bolt line along the entire 360° extent of the flange plate ring. As an alternative to this inspection, steel material that meets ASTM A770 through-thickness testing requirements or EN Z15 or Z25 requirements may be exempt from this inspection at the discretion of the turbine manufacturer's engineering department. Regardless of ASTM A770 or EN Z25/Z15 compliance, the shell to flange welds shall always meet the inspection requirements specified below under "Welding Inspection." Coordinate these requirements with the turbine manufacturer's specification for UT inspection of the base material.

Doorway Stiffener Plates – Perform ultrasonic tests as noted above. Tension tests shall be made on the high-strength bolts & all structural steel.

Bolt Torque – After high-strength bolts have been torqued, test approximately 10% (min.) of the bolts for correct pretension using a torque wrench which has been calibrated in a Skidmore-Wilhelm bolt tension calibrator.

WELDING INSPECTION

Weld inspection shall be per AWS D1.1 Section 6.8 and turbine manufacturer's QS990508.

Ultrasonic or RT inspection (using acceptance criteria for cyclically loaded connections) is required on all complete penetration welds where noted on the plans. Copies of these weld inspection reports shall be mailed to the Owner and Engineer. Testing frequency shall be according to the Turbine Manufacturer's specification. The European requirements shall be determined by Fabricator coordination with the Turbine Manufacturer. The following testing frequencies shall be used as a baseline standard when no guidance is available:

Test 100% of Top Flange, Bottom Flange, and Splice Flange Circumferential Welds; 100% of Shell Circumferential Welds where Detail Category (DC) 112 is specified; 100% of Shell Circumferential Welds where DC 147V is specified; 20% (EN) or 30% (US) of Shell Circumferential Welds; 10% (EN) or 15% (US) of Shell Longitudinal Welds; 100% of Door Stiffener Welds. 100% of Fillet Welds. 100% VT of All Welds.

STATEMENT OF STRUCTURAL OBSERVATIONS

Where the 2006 IBC is the applicable basis for the local building code, refer to Section 1709 for structural observation requirements or to the equivalent section in the local building code.

Where the 2009 IBC is the applicable basis for the local building code, refer to Section 1710 for structural observation requirements or to the equivalent section in the local building code.

Where the 2012 IBC is the applicable basis for the local building code, refer to Section 1704.5 for structural observation requirements or to the equivalent section in the local building code.

Where the 2015 IBC is the applicable basis for the local building code, refer to Section 1704.6 for structural observation requirements or to the equivalent section in the local building code.

Where the 2018 IBC is the applicable basis for the local building code, refer to Section 1704.6 for structural observation requirements or to the equivalent section in the local building code.

Where the 2021 IBC is the applicable basis for the local building code, refer to Section 1704.6 for structural observation requirements or to the equivalent section in the local building code.

STATEMENT OF SPECIAL INSPECTIONS

The following items require Special Inspection per IBC, Chapter 17. Where the 2006 IBC is the basis for the local building code, the following items may be used without modification or adjusted accordingly where there is minor variation in requirements. These lists are general and match the extent of the IBC tables. All items are not necessarily applicable to this project. Where the local building code is based on another standard or an earlier edition of the IBC, the equivalent sections shall apply.

STEEL PER 2009 IBC TABLE 1704.3 REFERENCED FOR CLARITY. FOR 2012 IBC AND LATER USE EQUIVALENT REQUIREMENTS IN AISC 360-16.

Verification and Inspection Task	Continuous	Periodic
1. Material verification of high-strength bolts, nuts and washers: <ul style="list-style-type: none"> a. Identification markings to conform to ASTM standards specified in the approved construction documents. b. Manufacturer's certificate of compliance req'd. 		X
2. Inspection of high-strength bolting: <ul style="list-style-type: none"> a. Snug-tight joints. b. Pretensioned and slip-critical joints using turn-of-nut with matchmarking, twist-off bolt or direct tension indicator methods of installation. c. Pretensioned and slip-critical joints using turn-of-nut without matchmarking or calibrated wrench methods of installation. 	X	X
3. Material verification of structural steel and cold-formed steel deck: <ul style="list-style-type: none"> a. For structural steel, identification markings to conform to AISC 360. b. For other steel, identification markings to conform to ASTM standards specified in the approved construction documents. c. Manufacturer's certified test reports. 	X	X
4. Material verification of weld filler materials: <ul style="list-style-type: none"> a. Identification markings to conform to AWS specification in the approved construction documents. b. Manufacturer's certificate of compliance req'd. 		X
5. Inspection of welding: <ul style="list-style-type: none"> a. Structural steel and cold-formed steel deck: <ul style="list-style-type: none"> 1) Complete & partial penetration groove welds. X 2) Multipass fillet welds. X 3) Single-pass fillet welds > 5/16" X 4) Plug and slot welds. X 5) Single-pass fillet welds <= 5/16" X 6) Floor and roof deck welds. X b. Reinforcing steel: <ul style="list-style-type: none"> 1) Verification of weldability of reinforcing steel other than ASTM A706. X 2) Reinforcing steel-resisting flexural and axial forces in intermediate and special moment frames, and boundary elements of special reinforced concrete shear walls and shear reinforcement. X 3) Shear reinforcement. X 4) Other reinforcing steel. X 		
6. Inspection of steel frame joint details for compliance with approved construction documents: <ul style="list-style-type: none"> a. Details such as bracing and stiffening. X b. Member locations. X c. Application of joint details at each connection. X 		

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SIGNATURE NESTOR A. AGBAYANI, SK PE 12590
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**VESTAS V163/V166 Mk4
4.5MW IEC S WIND TURBINE
HH98M-TA36200-A024-4468_V01 4 SECTION**

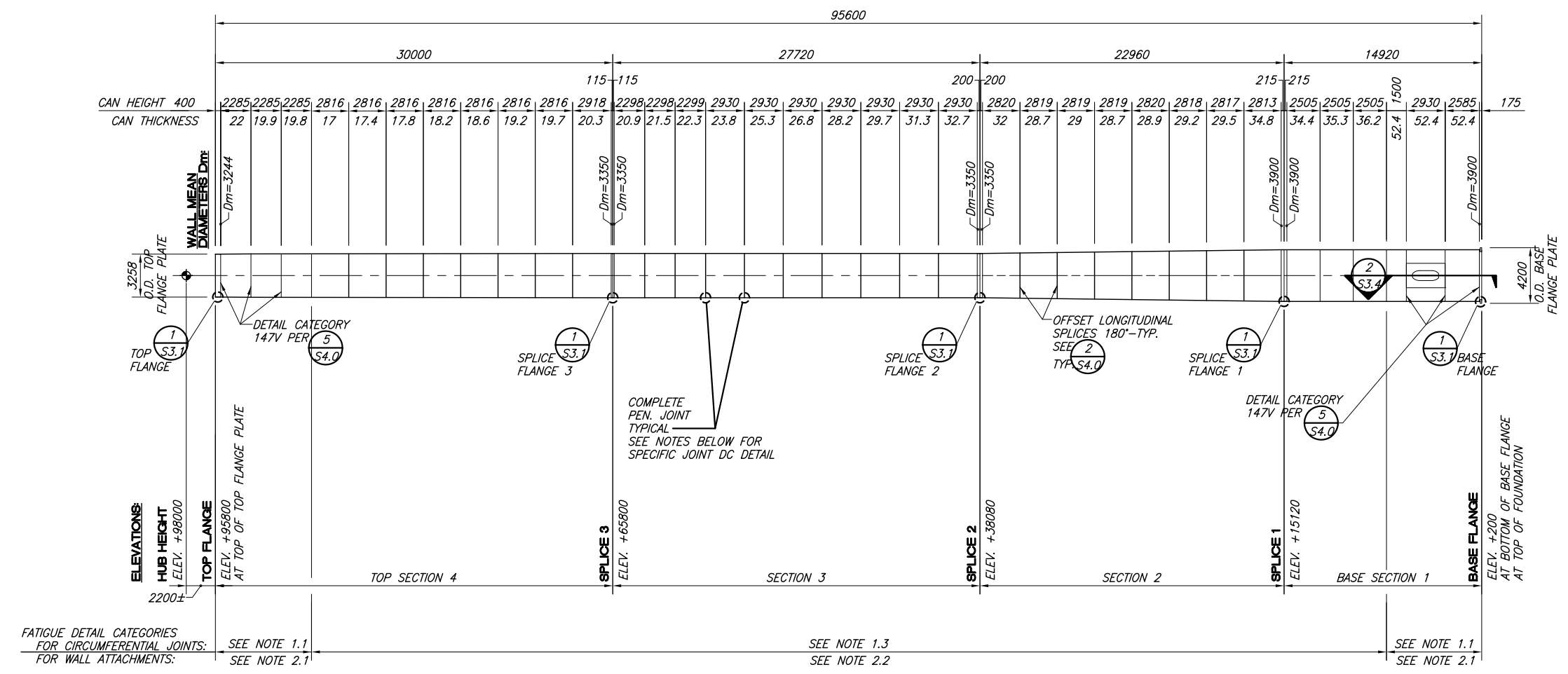
JOB NO. 25-033	DATE 2025-12-18	S11
DRAWN N. Agbayani	CHECKED N. Agbayani	
DESIGNED N. Agbayani	APPROVED N. Agbayani	



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 DATE OF SIGNING 12.18.2025
 DATE OF LICENSE EXPIRATION 12.31.2026

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FATIGUE DETAIL CATEGORIES FOR CIRCUMFERENTIAL JOINTS: SEE NOTE 1.1
 FOR WALL ATTACHMENTS: SEE NOTE 2.1

SEE NOTE 1.3
 SEE NOTE 2.2

SEE NOTE 1.1
 SEE NOTE 2.1

1 TOWER ELEVATION

1-400

Dm = MEAN DIAMETER OF SHELL PLATE. WHERE Dm IS NOT SHOWN, USE LINEAR INTERPOLATION BETWEEN KNOWN POINTS.

NOTES:

- TOWER FATIGUE DETAIL CATEGORIES (DC) FOR CIRCUMFERENTIAL JOINTS:
 - MIN. DC 80 AT CAN-TO-CAN OR CAN-TO-FLG JOINT WELDS PER U.N.O.
 - MIN. DC 90 AT CAN-TO-CAN OR CAN-TO-FLG JOINT WELDS PER U.N.O.
 - MIN. DC 147V AT CAN-TO-CAN OR CAN-TO-FLG JOINT WELDS PER U.N.O.

SEE NOTE 3 BELOW WHERE APPLICABLE TO CAN-TO-CAN OR CAN-TO-FLG JOINT WELDS.
 SEE "FATIGUE DETAIL NOTES" ON GENERAL NOTES SHEET.
- TOWER FATIGUE DETAIL CATEGORIES (DC) FOR WALL ATTACHMENTS:
 - MIN. DC 80 AT WELDED ATTACHMENTS PER DETAIL
 - NO WELDED ATTACHMENTS PERMITTED

SEE "FATIGUE DETAIL NOTES" ON GENERAL NOTES SHEET.
- ANY LARGE SHELL THICKNESS TRANSITION OR SURFACE TRANSITION AT WELDED JOINTS SHALL BE MADE WITH 1:4 SLOPE PER

(CONTINUED)

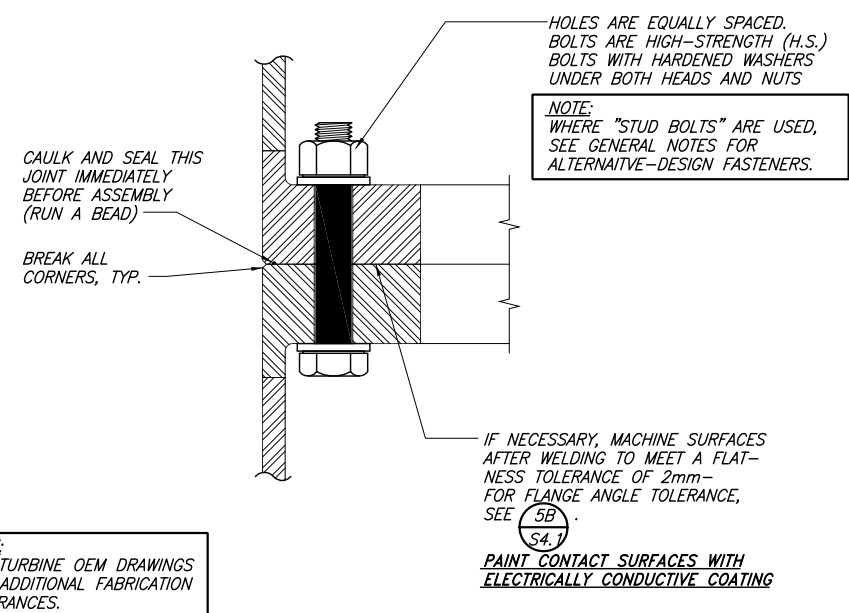
- SEE SHEET S4.1 FOR STANDARD DETAILS.
- SEE SHEET S5.0 FOR DENT TOLERANCES.
- SEE TURBINE MANUFACTURER SPECIFICATIONS FOR FABRICATION TOLERANCES.
- [NOT USED.]

TOWER ELEVATION, SECTIONS AND DETAILS

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 BAKERSFIELD, CALIFORNIA 93301 USA
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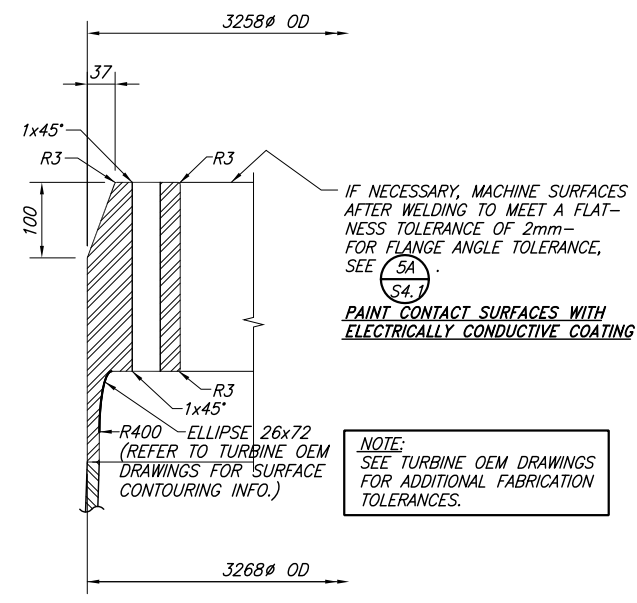
**VESTAS V163/V166 Mk4
 4.5MW IEC S WIND TURBINE
 H98M-TA36200-A024-4468_V01 4 SECTION**

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DESIGNED <i>N.Agbayani</i>	APPROVED <i>N.Agbayani</i>	

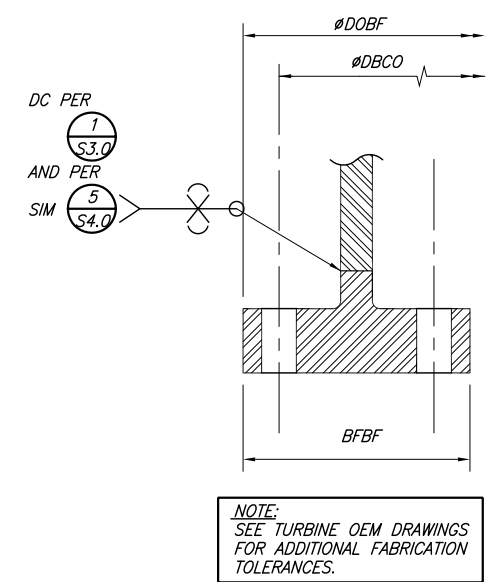


NOTE:
 SEE TURBINE OEM DRAWINGS FOR ADDITIONAL FABRICATION TOLERANCES.

A SPLICE CONNECTION DETAIL NO SCALE



B TOP FLANGE PLATE CONNECTION DETAIL NO SCALE
 SEE 1 AND A FOR ADDITIONAL INFORMATION



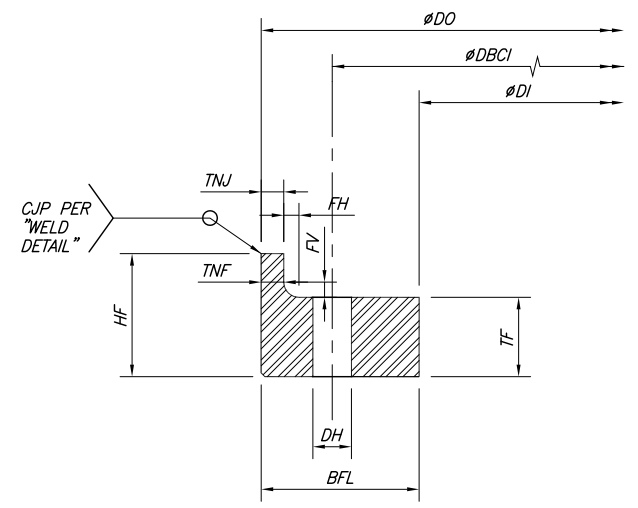
C TOWER BASE CONNECTION DETAIL NO SCALE
 SEE 1 AND A FOR ADDITIONAL INFORMATION



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1 SPLICE CONNECTION DETAIL NO SCALE

	FLANGE										NECK		FILLET				BOLTS				WELD
	SEE DETAIL	DO (mm)	DBCI (mm)	DI (mm)	DOBF (mm)	DBCO (mm)	HF (mm)	TF (mm)	BFL (mm)	BFBF (mm)	TNJ (mm)	TNF (mm)	FH (mm)	FV (mm)	SHAPE	DH (mm)	NBOLTS (no.)	DBOLT (mm)	GRADE	WELD DETAIL	
TOP FLANGE	B	3100	3010	n/a	n/a	400	200	124	n/a	24	24	B	B	B	33	120	M30	10.9	5 S4.0		
SPLICE 3	A	3373	3224	3043	n/a	n/a	115	85	165	n/a	23	23	10	10	CIRCLE	45	116	M42	10.9	5 S4.0	
SPLICE 2	A	3391	3147	2863	n/a	n/a	200	150	264	n/a	41	41	10	10	CIRCLE	75	72	M72	10.9	5 S4.0	
SPLICE 1	A	3942	3695	3398	n/a	n/a	215	165	272	n/a	42	42	10	10	CIRCLE	75	84	M72	10.9	5 S4.0	
BASE FLANGE	C	3956	3706	3600	4200	4094	175	110	n/a	300	56	56	20	20	CIRCLE	49	92 IN 92 OUT	n/a	n/a	5 S4.0	

NOTES:
 DO = DIAMETER OUTSIDE = OUTSIDE DIAMETER OF L-FLANGE
 DBCI = DIAMETER BOLT CIRCLE INSIDE = DIAMETER OF THE INTERIOR BOLT CIRCLE
 DI = DIAMETER INSIDE = INSIDE DIAMETER OF FLANGE
 DOBF = DIAMETER OUTSIDE BASE FLANGE = OUTSIDE DIAMETER OF THE BASE FLANGE
 DBCO = DIAMETER BOLT CIRCLE OUTSIDE = DIAMETER OF THE EXTERIOR BOLT CIRCLE
 HF = HEIGHT FLANGE INCLUDING WELDNECK
 TF = THICKNESS FLANGE EXCLUDING WELDNECK
 BFL = WIDTH OF L-FLANGE
 BFBF = WIDTH OF T-FLANGE
 TNJ = THICKNESS NECK AT JOINT = WELDNECK THICKNESS AT THE WELDED JOINT
 TNF = THICKNESS NECK AT FILLET = WELDNECK THICKNESS AT THE FILLET
 FH = FILLET HORIZONTAL DIMENSION
 FV = FILLET VERTICAL DIMENSION
 SHAPE = SHAPE OF THE FILLET CONTOUR
 DH = DIAMETER HOLE = DIAMETER OF THE BOLT HOLE
 NBOLTS = TOTAL NUMBER OF BOLTS
 DBOLT = DIAMETER BOLT = NOMINAL BOLT DIAMETER
 GRADE = GRADE OF BOLT

NO SCALE

TOWER SECTIONS AND DETAILS

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VESTAS V163/V166 Mk4
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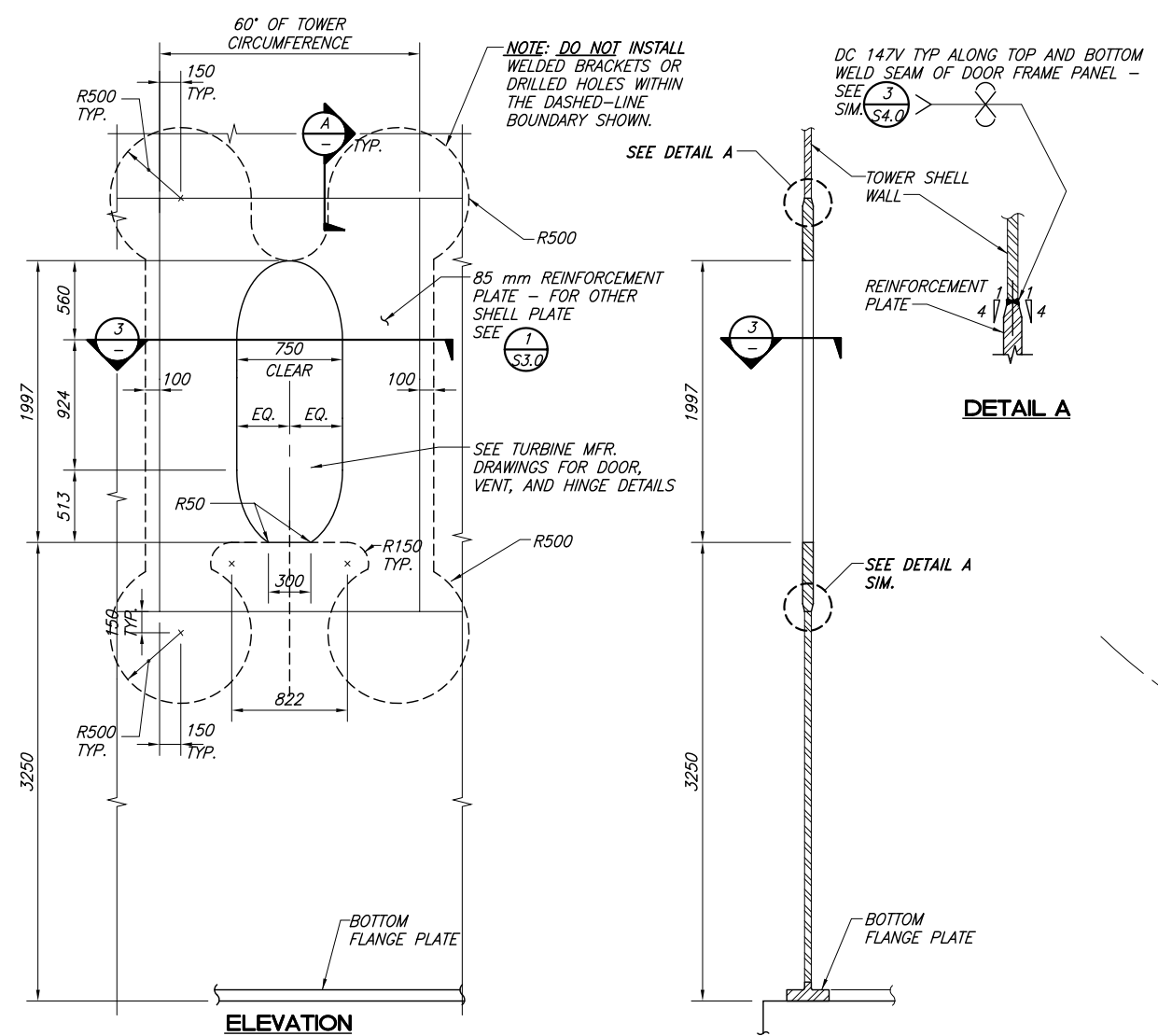
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DESIGNED N. Agbayani	APPROVED N. Agbayani	



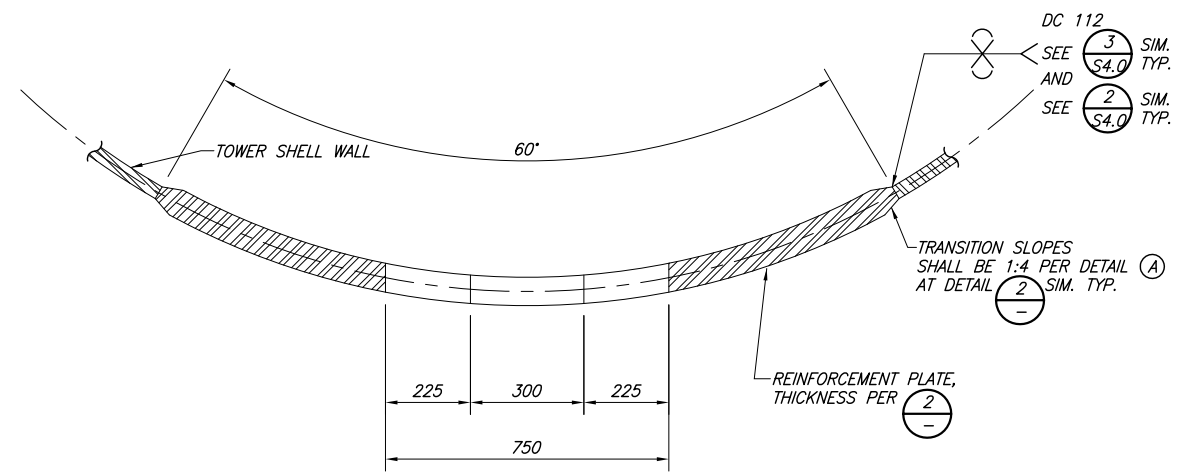
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(2) S3.4 DOORWAY DETAIL 1=50±



(3) S3.4 SECTION DOOR OPENING REINFORCING NO SCALE

ANY ATTACHMENT TO THE TOWER WALL BY OTHERS IS SUBJECT TO GENERAL BRACKET DETAIL (1) S4.1

TOWER SECTIONS AND DETAILS

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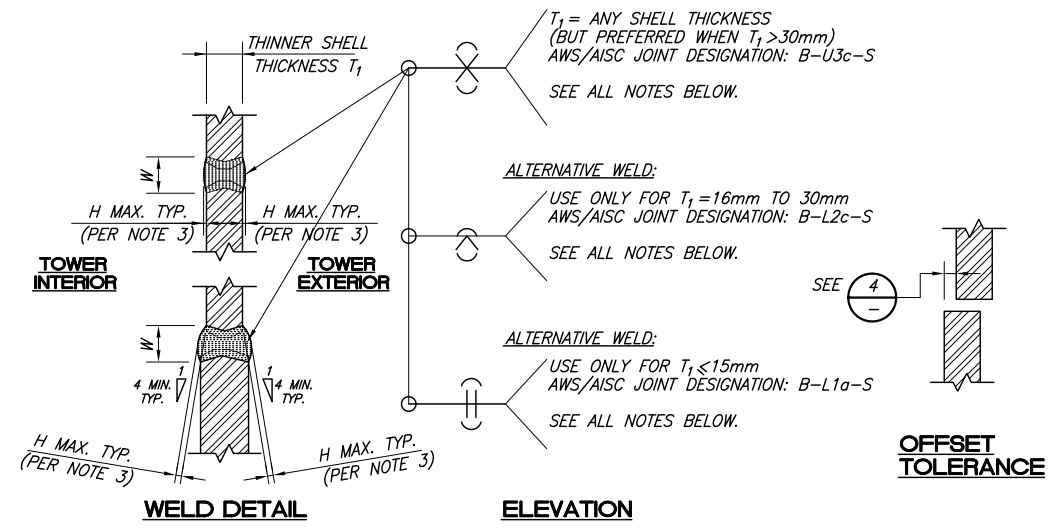
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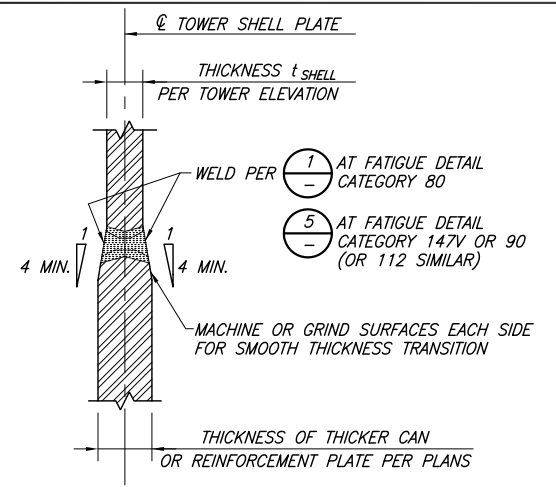
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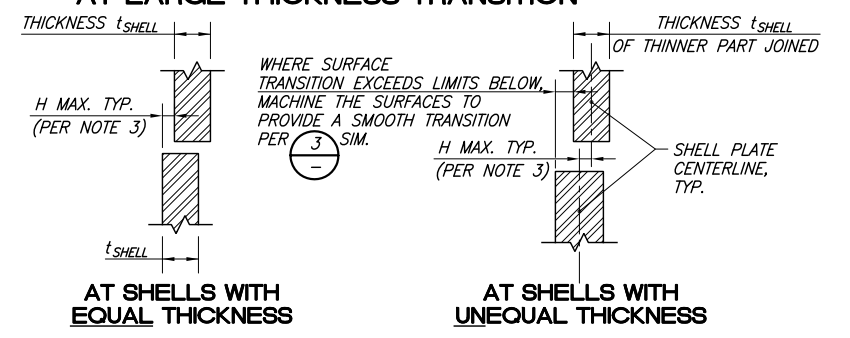
FATIGUE DETAIL CATEGORY 80

- NOTES:**
- CJP. SAW. ULTRASONIC OR RT TEST REQUIRED. PREHEAT PER AWS. SEE "CJP" NOTE IN THE GENERAL NOTES.
 - BACKGOUGE.
 - WELD SURFACE CONVEXITY PROFILE H SHALL NOT EXCEED THE LESSER OF 0.2W OR 3mm WHERE W=WELD WIDTH (AS SHOWN IN THE DETAIL). IN NO CASE SHALL H EXCEED 3mm. WHERE WELD OCCURS AT A SHELL-TO-FLANGE JOINT H SHALL NOT EXCEED THE LESSER OF 0.1W OR 3mm.
 - SEE "FATIGUE DETAIL NOTES" ON GENERAL NOTES SHEET.
 - REQUIREMENTS OF ISO 5817 QUALITY CLASS B SHALL APPLY.

1 SHELL SPLICE WELD JOINT AT TOWER TRANSVERSE (CIRCUMFERENTIAL) JOINT NO SCALE

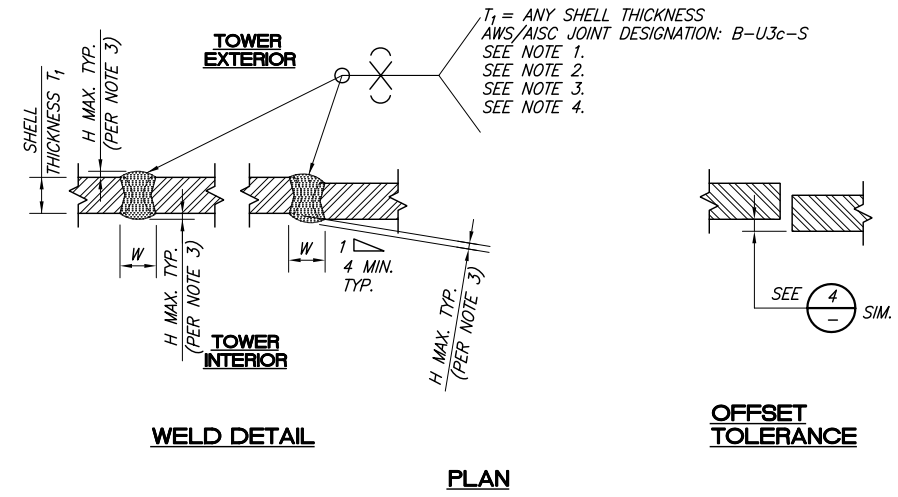


3 SHELL/PLATE SPLICE WELD JOINT AT LARGE THICKNESS TRANSITION NO SCALE



- NOTE:**
- THE BUTT JOINT ALIGNMENT SHALL COMPLY WITH AWS D1.1/D1.1M:2004 SECTION 5.22.3 (AND NOT 5.22.3.1).
 - [NOTE NOT USED.]
 - OFFSET H AND THE SURFACE TRANSITION SHALL NOT EXCEED THE LESSER OF (0.1 t_{shell}) OR 3mm WHERE t_{shell} = THICKNESS OF THE THINNER SHELL (AS SHOWN IN THE DETAIL). IN NO CASE SHALL H EXCEED 3mm. REQUIREMENTS OF ISO 5817 QUALITY CLASS B SHALL APPLY.
 - SEE "FATIGUE DETAIL NOTES" ON GENERAL NOTES SHEET.

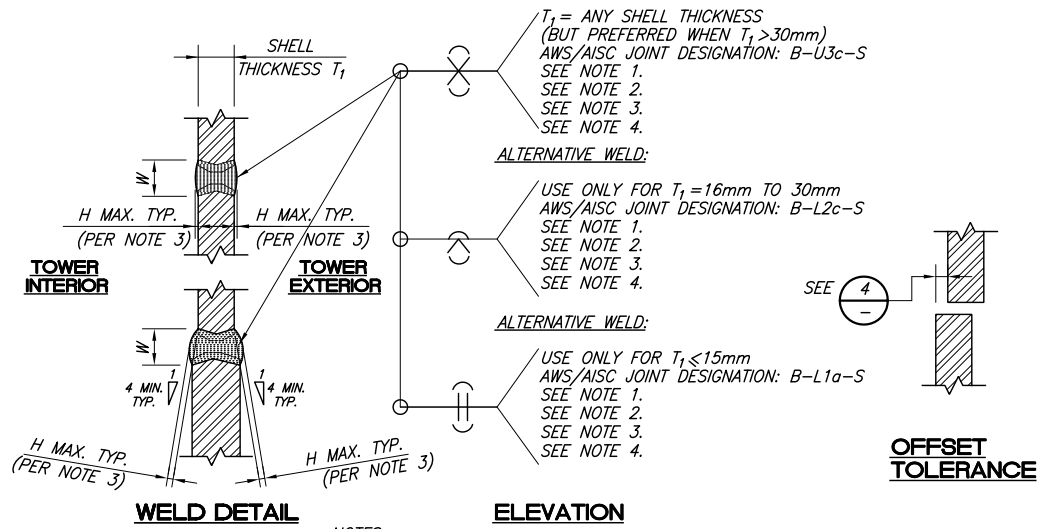
4 OFFSET TOLERANCE NO SCALE



FATIGUE DETAIL CATEGORY 112

- NOTES:**
- CJP. SAW. ULTRASONIC OR RT TEST REQUIRED. PREHEAT PER AWS. SEE "CJP" NOTE IN THE GENERAL NOTES.
 - BACKGOUGE.
 - WELD SURFACE CONVEXITY PROFILE H SHALL NOT EXCEED THE LESSER OF 0.1W OR 3mm WHERE W=WELD WIDTH (AS SHOWN IN THE DETAIL). IN NO CASE SHALL H EXCEED 3mm.
 - [NOTE NOT USED.]

2 SHELL SPLICE WELD JOINT AT TOWER LONGITUDINAL (VERTICAL) JOINT NO SCALE



FATIGUE DETAIL CATEGORY 90

FATIGUE DETAIL CATEGORY 147V (SEE NOTE 4)

- NOTES:**
- CJP. SAW. ULTRASONIC OR RT TEST REQUIRED. PREHEAT PER AWS. SEE "CJP" NOTE IN THE GENERAL NOTES.
 - BACKGOUGE.
 - WELD SURFACE CONVEXITY PROFILE H SHALL NOT EXCEED THE LESSER OF 0.1W OR 3mm WHERE W=WELD WIDTH (AS SHOWN IN THE DETAIL). IN NO CASE SHALL H EXCEED 3mm.
 - VERIFY SUPPLEMENTARY WELD REQUIREMENTS WITH TURBINE MFR. FOR FATIGUE DETAIL CATEGORY (DC) 147V QUALIFICATION.


5 SHELL SPLICE WELD JOINT AT TOWER TRANSVERSE (CIRCUMFERENTIAL) JOINT NO SCALE


TOWER SECTIONS AND DETAILS

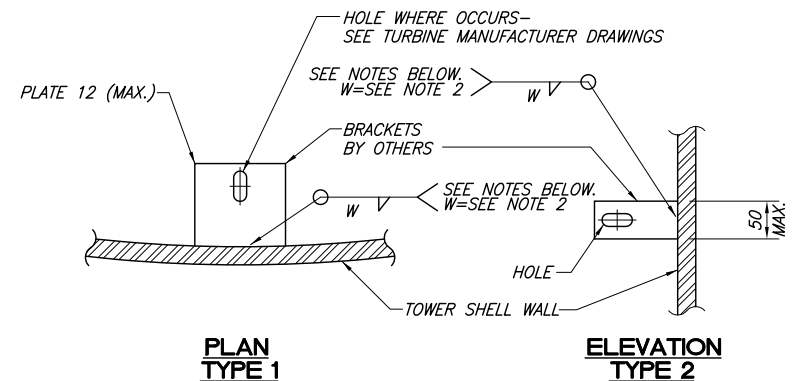
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DESIGNED N. Agbayani	APPROVED N. Agbayani	

ANY ATTACHMENT TO THE TOWER WALL BY OTHERS IS SUBJECT TO GENERAL BRACKET DETAIL 

ANY CIRCULAR HOLE BY OTHERS DRILLED IN THE TOWER WALL IS SUBJECT TO GENERAL CIRCULAR HOLE DETAIL 



FATIGUE DETAIL CATEGORY 80

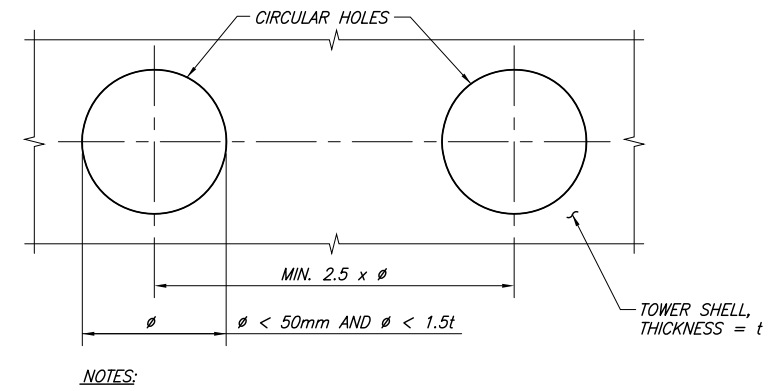
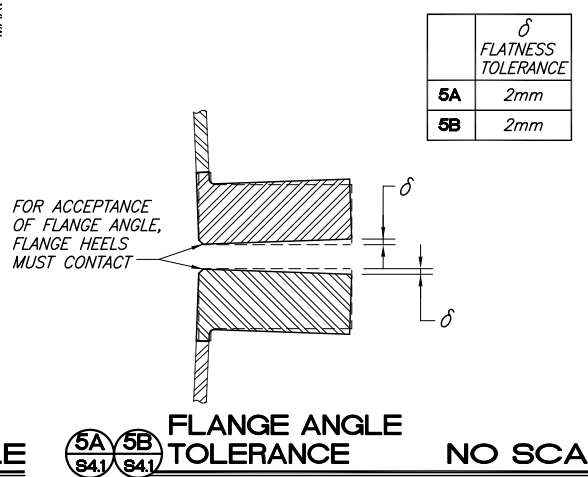
PLAN TYPE 1

ELEVATION TYPE 2

NOTES:

- MIN. 100mm DISTANCE BETWEEN OTHER WELDINGS AND WELDING OF BRACKETS.
- REQUIRED WELD SIZE SHALL BE DETERMINED BY ENGINEERING DESIGN BY OTHERS. THE FOLLOWING ARE MINIMUM SIZES ONLY:
 W=6 MIN. @ BRACKET OR WALL PLATE THICKNESS ≤ 19.
 W=8 MIN. @ BRACKET OR WALL PLATE THICKNESS > 19.
- THIS DETAIL SHALL BE USED ONLY AT PORTIONS OF THE TOWER INDICATED AS FATIGUE DETAIL CATEGORY (DC) 80 ON THE STRUCTURAL "TOWER ELEVATION." NO WALL ATTACHMENTS ARE PERMITTED WHERE FATIGUE DC 147V, DC 112, OR DC 100 IS INDICATED.

1 **GENERAL BRACKET DETAIL NO SCALE**



FATIGUE DETAIL CATEGORY 90

NOTES:

- THESE ARE GENERAL REQUIREMENTS FOR PLACEMENT AND GEOMETRY OF HOLES IN THE TOWER SHELLS. THE PLACEMENT OF HOLES SHALL RECEIVE ENGINEERING REVIEW & APPROVAL PRIOR TO PLACEMENT.
- t = TOWER SHELL THICKNESS
- DETAIL CATEGORY 90. DETAIL IS FOR USE ONLY AT TOWER SHELL LOCATIONS DESIGNATED AS DETAIL CATEGORY 90, 80, OR LOWER.
- MIN. 100mm DISTANCE FROM OTHER WELDINGS TO HOLES.
- A MAXIMUM OF TWO HOLES AT EACH LEVEL THROUGHOUT THE TOWER IS ALLOWED.

6 **GENERAL CIRCULAR HOLE DETAIL NO SCALE**




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TOWER STANDARD DETAILS

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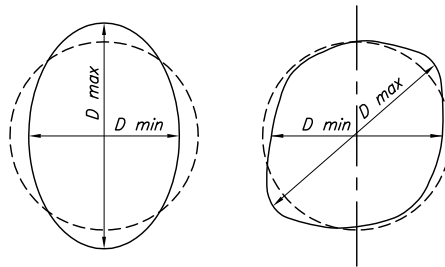
NOTES:

1. ALL DENTS THAT EXCEED THE MAXIMUM PERMITTED DEVIATION SHOWN IN THE FIGURES SHALL BE REPORTED TO THE TURBINE MANUFACTURER AND ENGINEER. ANY DENT IN EXCESS OF THESE LIMITS SHALL BE REPAIRED BY CORRECTIVE MEASURES SPECIFIED BY THE TURBINE MANUFACTURER AND THE ENGINEER.

2. ALL DENT MEASUREMENTS SHALL BE MEASURED RELATIVE TO THE UN-DENTED TOWER SURFACE.

3. WHERE TOWER CIRCUMFERENTIAL OR LONGITUDINAL WELDS FALL WITHIN A DENTED AREA OR ARE WITHIN 150mm OF A DENTED AREA, AFTER REPAIRS THE WELD SHALL BE INSPECTED BY NDT METHODS.

4. ALL DENTS SHALL BE MEASURED IN BOTH A LONGITUDINAL AND CIRCUMFERENTIAL DIRECTION. EACH OF THE APPLICABLE CASES SHOWN BELOW APPROPRIATE FOR THE DIRECTION OF MEASURE SHALL BE CHECKED. FAILURE OF ANY ONE CASE REQUIRES DENT REPAIR. FAILURE OF MULTIPLE CASES REQUIRES DENT REPAIR.



CASE 5: SECTION - TOWER SHELL

MAX PERMITTED DEVIATION AT CASE 5:

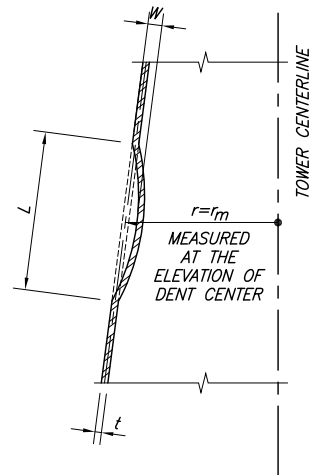
OUT-OF-ROUNDNESS:

$$\frac{(D_{max} - D_{min})}{(D_{nom})} \leq 0.010$$

WHERE
 "D" VALUES ABOVE ARE THE MEASURED INTERNAL DIAMETER OF THE TOWER.

D_{nom} MAY BE TAKEN AS THE AVERAGE OF THE MEASURED D_{max} AND D_{min}.

NOTE: THIS CASE SHALL NOT BE USED TO ASSESS LOCALIZED DENTS.



MAX. PERMITTED DEVIATION AT CASE 1:

MEASURE:

W = MEASURED MAXIMUM DENT DEPTH (mm)
 L = MEASURED DENT LONGITUDINAL LENGTH (mm) AT W

CALCULATE:

$$L_{max} = 4 \times \text{SQRT}(r \cdot t)$$

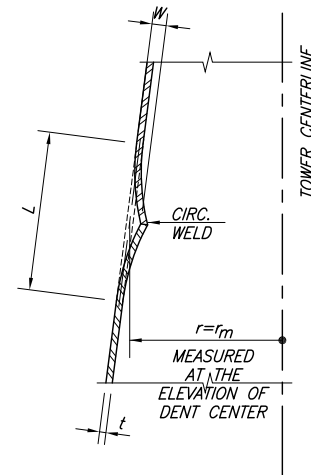
$$W_{max} = 0.01 \times L_{max}$$

COMPARE:

L SHALL BE LESS THAN OR EQUAL TO: L_{max} OR (0.95 X Can Height), WHICHEVER IS LESS
 W SHALL BE LESS THAN OR EQUAL TO: W_{max} OR 6mm, WHICHEVER IS LESS.

FAILING ONE OR MORE COMPARISONS REQUIRES DENT REPAIR - SEE OTHER NOTES.

CASE 1: ELEVATION - TOWER SHELL



MAX. PERMITTED DEVIATION AT CASE 3:

MEASURE:

W = MEASURED MAXIMUM DENT DEPTH (mm)
 L = MEASURED DENT LONGITUDINAL LENGTH (mm) AT W

CALCULATE:

$$L_{max} = 25 \times t \text{ (mm)}$$

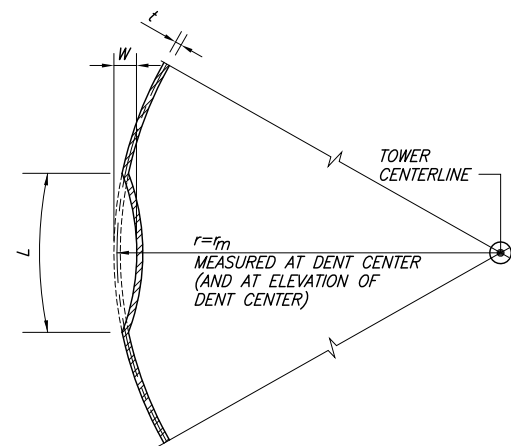
$$W_{max} = 0.01 \times L_{max}$$

COMPARE:

L SHALL BE LESS THAN OR EQUAL TO: L_{max} OR 500mm, WHICHEVER IS LESS.
 W SHALL BE LESS THAN OR EQUAL TO: W_{max} OR 5mm, WHICHEVER IS LESS.

FAILING ONE OR MORE COMPARISONS REQUIRES DENT REPAIR - SEE OTHER NOTES.

CASE 3: ELEVATION - AT CIRCUMFERENTIAL WELD



MAX. PERMITTED DEVIATION AT CASE 2:

MEASURE:

W = MEASURED MAXIMUM DENT DEPTH (mm)
 L = MEASURED DENT CIRCUMFERENTIAL LENGTH (mm) AT W

CALCULATE:

$$L_{max} = 4 \times \text{SQRT}(r \cdot t)$$

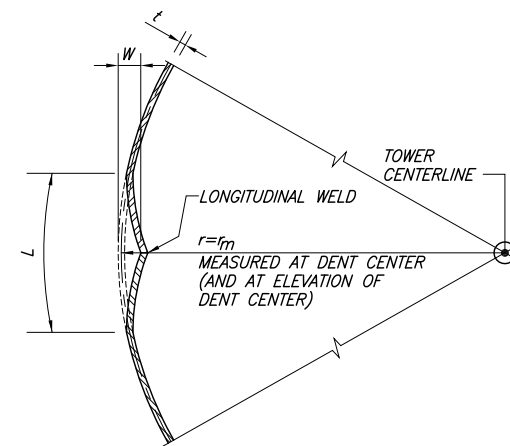
$$W_{max} = 0.01 \times L_{max}$$

COMPARE:

L SHALL BE LESS THAN OR EQUAL TO: L_{max} OR 2000mm, WHICHEVER IS LESS
 W SHALL BE LESS THAN OR EQUAL TO: W_{max} OR 6mm, WHICHEVER IS LESS.

FAILING ONE OR MORE COMPARISONS REQUIRES DENT REPAIR - SEE OTHER NOTES.

CASE 2: SECTION - TOWER SHELL



MAX. PERMITTED DEVIATION AT CASE 4:

MEASURE:

W = MEASURED MAXIMUM DENT DEPTH (mm)
 L = MEASURED DENT CIRCUMFERENTIAL LENGTH (mm) AT W

CALCULATE:

$$L_{max} = 25 \times t \text{ (mm)}$$

$$W_{max} = 0.01 \times L_{max}$$

COMPARE:

L SHALL BE LESS THAN OR EQUAL TO: L_{max} OR 500mm, WHICHEVER IS LESS.
 W SHALL BE LESS THAN OR EQUAL TO: W_{max} OR 5mm, WHICHEVER IS LESS.

FAILING ONE OR MORE COMPARISONS REQUIRES DENT REPAIR - SEE OTHER NOTES.

CASE 4: SECTION - AT LONGITUDINAL WELD



SIGNATURE NESTOR A. AGBAYANI, SK PE 12590

12.18.2025

DATE OF SIGNING

12.31.2026

DATE OF LICENSE EXPIRATION

ONE (1) INCH LONG AT 11X17 PAPER FORMAT-OTHERWISE ADJUST SCALE

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- THIS DRAWING SHALL NOT BE USED AS THE SOLE BASIS FOR DETERMINING THE FULL EXTENT OF QA/QC REQUIREMENTS.
- REFER TO THE TURBINE OEM'S AND/OR THE TOWER PROCUREMENT AGENT'S PROPRIETARY SPECIFICATIONS FOR THE COMPLETE TOWER SPECIFICATION.

DENT TOLERANCES

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VESTAS V163/V166 Mk4
 4.5MW IEC S WIND TURBINE
 H98M-TA36200-A024-4468_V01 4 SECTION

JOB NO. 25-033	DATE 2025-12-18	SHEET
DRAWN N. Agbayani	CHECKED N. Agbayani	S5.0
DESIGNED N. Agbayani	APPROVED N. Agbayani	



STRUCTURAL CALCULATIONS

DATE: January 12, 2026 (Rev. 2)

ASE JOB NO.: 25-033

TITLE: **STRUCTURAL CALCULATIONS:**
HH98M-TA36200-A024-4468_V01 Tubular Tower for use with:
Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine

PROJECT: Vestas V163-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower
SEVEN STARS WIND ENERGY PROJECT
Fifty (50) Towers
Near Weyburn, Saskatchewan, Canada

CLIENT: Vestas—American Wind Technology, Inc.
1417 NW Everett Street
Portland, OR 97209 USA

CONTACT: Sidharth (“Sid”) George
Turbine Structural Specialist

DOCUMENT STATUS: 01-12-2026:.....Rev. 2 remnant “Texas” data corrected to Saskatchewan.
12-18-2025:.....Rev. 1 released to Client: project re-use document.
12-07-2025:.....Rev. 0 un-released: baseline generic document.
See “Notice and Disclaimers” for important notes.

APPROVAL(S):

DIGITAL SIGNATURE:

SIGNATURE: *Nestor A. Agbayani*
Nestor A. Agbayani
Saskatchewan Professional Engineer 12590

DATE OF SIGNING: 01.12.2026

DATE OF LICENSE EXPIRATION: 12.31.2026



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SUMMARY

This summary section is provided for convenience. Readers are encouraged to review the entire document for details and context.

Sections 1 to 7 contain calculations for generic (baseline) conditions, while Section 8 contains calculations for project-specific conditions.

This summary contains the following information extracted from Section 8:

- V_{e50} Design Data, Table 8.4-1
 - Site Layout—General Information
- FOR US PROJECTS:
- Wind Design Data, Table 8.4-2
 - Earthquake Design Data, Table 8.4-3
- FOR CANADIAN PROJECTS:**
- Code Load Comparison 2020 NBCC

V_{e50} DESIGN DATA

DESIGN PARAMETER			DESIGN VALUE [Note 1]	SITE VALUE [Note 2]	2020 NBCC ADJUSTED DESIGN VALUE	2020 NBCC VALUE
3-sec, 50-year Wind Speed at Hub Height	V_{e50}	(m/s)	52.5	50.7	52.7 [Note 3]	46.1 [Note 4]
2020 NBCC 50-yr MRI Wind Speed at reference height of +10m	V_{NBCC}	(m/s)	-	-	29.7	28.6
Air Density	ρ	(kg/m ³)	1.225	1.173	1.173	1.173

Note 1. Provided by the Turbine OEM. These parameters are the basis for the “generic” tower design.

Note 2. Provided by the Turbine OEM. These parameters are project site-specific values.

Note 3. This is the design V_{e50} design value adjusted with the site-specific air density.

Note 4. This is the **2020 NBCC** value expressed as an equivalent V_{e50} value adjusted to the site-specific air density and adjusted to hub height.

Table 8.4-1. Summary and Comparison of V_{e50} Parameters

SUMMARY (Continued)

WIND & EARTHQUAKE DESIGN DATA

CODE LOAD COMPARISON					
DESIGN PARAMETER			EXISTING DESIGN	NEW RE-USE	COMMENT
DESCRIPTION	SYMBOL	UNITS			
Design Code or Standard			IEC S (Wind) ASCE 7-16 (Seismic)	2020 NBCC	
Site Air Density	ρ_{AIR}	(kg/m ³)	1.225	1.173	
Reference Wind Speed (at 10m)	V_{ref}	(m/s)	N/A	29.651	> 27.249 m/s, PASS
Reference Wind Pressure (at 10m)	q	(Pa)	N/A	516	> 405, PASS
Hub Height	H_{HUB}	(m)	98	Same	
Wind Importance Factor	I		1.0	Same	
Exposure	$Exposure$		N/A	Open	
Exposure Coefficient (maximum)	C_e		N/A	1.579	
Topographic Factor (maximum)	C_t		1.00	1.000	
Reference Wind Speed (at Hub)	$V_{ref/hub}$	(m/s)	52.5	N/A	
Reference Wind Pressure (at Hub)	q	(Pa)	1688	813.9	Design is okay (see hub-height design wind pressure).
Wind Load Factor	LF		1.35	1.40	
Dynamic Factor (Gust Effect)-Baseline	C_g		1.00	2.000	
Design Wind Pressure (at Hub Height) with design wind load factor	$q_u G_f$	(Pa)	2279	2279	IEC Hub Height design pressure equivalence condition with respect to NBCC.
Seismic Importance Factor	I		N/A	1.0	
0.2-sec Mapped Spectral Response Acceleration (SRA) @ 5% damped	S_5	(g's)	1.500	N/A	
1.0-sec Mapped Spectral Response Acceleration (SRA) @ 5% damped	S_1	(g's)	0.599999 < 0.6	N/A	
Site Class	$SiteClass$		$D_{default}$	XD	
Design 0.2-sec SRA @ 5% = S_{DS} / B_5	S_{DS} / B_5	(g's)	1.200	0.290	= NBCC $S(0.2, XD) / B_5$ Design is Conservative
Design 1.0-sec SRA @ 5% = S_{D1} / B_1	S_{D1} / B_1	(g's)	1.020	0.116	= NBCC $S(1.0, XD) / B_5$ Design is Conservative
Seismic Design Category	SDC		D	SC2	
Structural System Ductility Factor	R		1.5	1.0	$R_o R_d$ per NBCC
Analytical Fundamental Period	T_B	(sec)	5.375	Same	
Seismic Response Coefficient (at 5% damping)	C_S	(g's)	0.127	0.069	
Seismic Base Shear	V	(kip)	137	74	NBCC V is much lower than the ASCE 7-16 base shear, and $R_o R_d = 1.0$ is conservative.

SUMMARY (Continued)

PROJECT SITE PLAN—GENERAL INFORMATION

1. SITE LAYOUT

1.1. PROJECT SITE PLAN(S):



Saskatchewan, CAN¹



RM of Weyburn No. 67, SK²



RM of Griffin No. 66, SK³

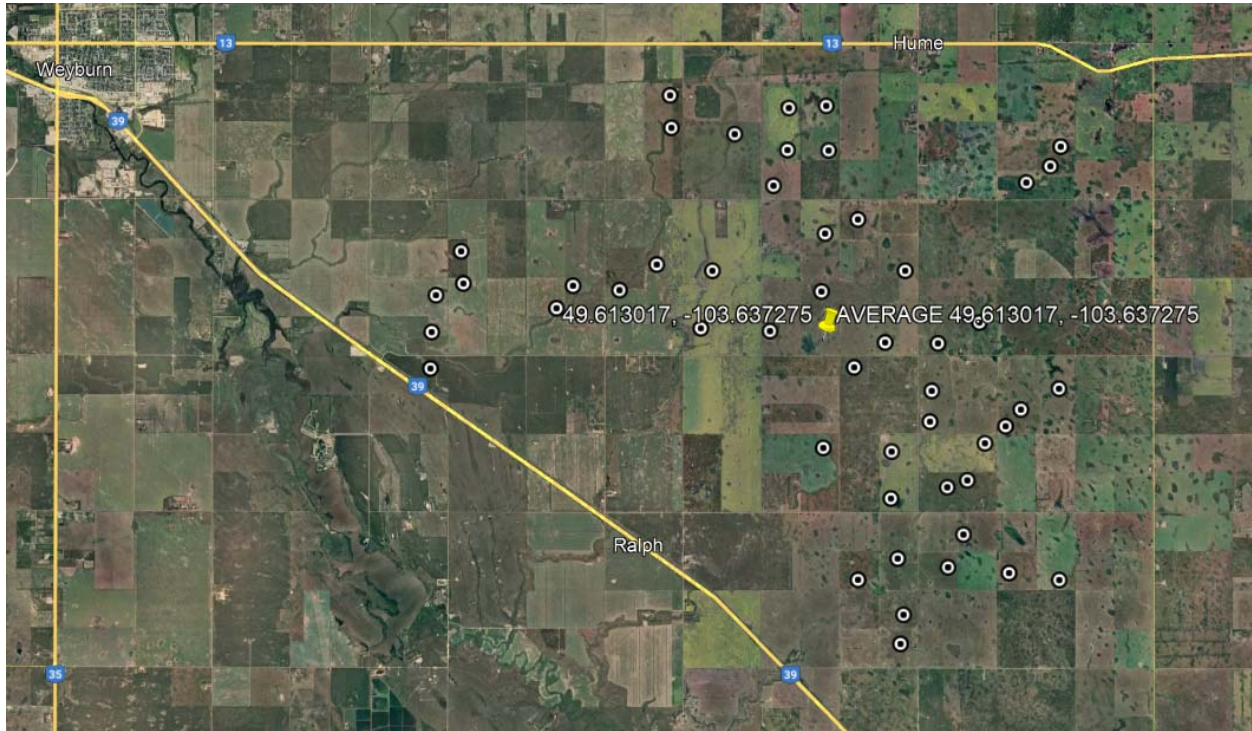
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SUMMARY (Continued)

1.1. PROJECT SITE PLAN(S): (Continued)



Project Site Plan⁴

⁴ Screenshot from Google Earth

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SECTION 2:	Resonance Analysis
SECTION 3:	Tower Shell Design
SECTION 4:	Tower Splice Flanges and Bolts Design
SECTION 5:	Tower Base Flange Design
SECTION 6:	Tower Shell Penetrations
SECTION 7:	Earthquake Design
SECTION 8:	Project Site Parameters

NATIONAL BUILDING CODE OF CANADA:

GENERAL NOTES

1. For projects in Saskatchewan, Canada, it is acknowledged that the building code compliance is based on Saskatchewan Regulations 124/2021, *The Building Code Regulations* adopting the 2020 National Building Code (NBC) of Canada. The “2020 NBC” is generically referenced herein, in lieu of the specific name of the provincial code.
2. The primary calculations in Sections 1 through 7 are in accordance with wind industry IEC standards and US design standards. However, reconciliation to Canadian calculations are contained in Section 8:

For Canadian code compliance, see Section 8 for 2020 NBCC calculations.

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SECTION 1

DATE: December 7, 2025 (Rev. 0)

ASE JOB NO.: 25-031

PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

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SECTION 1—GENERAL INFORMATION

1. SECTION 1

1.1. GENERAL

1.1.1. Document Usage for Design Reviewers and Plan Checkers.

This document is intended and formatted for use on multiple projects in different jurisdictions. For this reason, these calculations are based on assumed design parameters (i.e., “generic parameters”) that most likely do not match the design parameters of the specific project site (i.e., “site parameters”). Therefore, a comparison is made between the generic parameters and the site parameters in a later section below titled “Comparison of Generic Parameters Versus Site Parameters.” The comparisons have the following possible outcomes:

1.1.1.1. All generic parameters govern the design over the site parameters.

In this case, by inspection it may be concluded that the structure design is acceptable at the project site since the generic parameters meet or exceed the required site parameters. In other words, the generic parameters have enveloped the site parameters.

1.1.1.2. One or more site parameters govern the design over the generic parameters.

In this case, these are the following possible outcomes:

1.1.1.2.1. Despite exceeding a generic parameter, the governing site parameter nevertheless results in an acceptable design.

This case would remain acceptable for design permitting. Calculations using the governing site parameters would be documented and presented later in this report’s Section 8 titled “Project Site Parameters.”

1.1.1.2.2. One or more site parameters result in an unacceptable design exceedance, e.g., overload or overstress.

This case would not be acceptable for design permitting and presumably would not be presented for design review or plan check.

1.1.2. Purpose.

The purpose of these structural design calculations is to establish that the subject wind turbine generator system (WTGS) support structure (“tower”) design is building code compliant for the purpose of obtaining a building permit from the Authority Having Jurisdiction (AHJ) at the project site.

1.1.3. Scope.

1.1.3.1. This structural calculation document applies only to the following wind tower:

Turbine Make & Model:....Vestas V163/V166-4.5MW Mk4A Wind
Turbine
Tower Model:TA36200-A024-4468_V01 Tower
Hub Height (HH):.....98 m

1.1.3.2. This document is a design document for permit purposes only. This document shall not be used for fabrication or cost estimation purposes.

1.1.3.3. These structural design calculations address the following primary structural components:

- Tower shell.
- Tower splice flanges and bolts. These calculations do not address the top flange as part of the turbine yaw system. The justification of the mechanical operation of the turbine yaw system is by others (the turbine OEM).
- Tower reinforced doorway opening.

1.1.3.4. These calculations do not address the reinforced concrete foundation and items embedded in concrete such as anchor rods (bolts) and the embedded anchor plate. These items are by others, e.g., the foundation design engineer.

1.1.4. Statement of Compliance (SOC).

Structural design calculations have been performed on the subject WTGS tower, and it is found to be in substantial conformance with the requirements of the local building code and the more general model building code. Tower design DCRs (demand over capacity ratios) are acceptable, therefore the structural design of the tower is adequate for the project site. See Section 1.2 below.

1.2. CALCULATIONS—DESCRIPTIONS AND SUMMARIES

1.2.1. Codes, Standards, and Design Criteria.

1.2.1.1. General (Model) Building Code. The structural calculations are in substantial conformance with the following codes:

1. 2006 International Building Code (IBC) (ICC, 2006)
2. 2009 IBC (ICC, 2009)
3. 2012 IBC (ICC, 2012)
4. 2015 IBC (ICC, 2015)
5. 2018 IBC (ICC, 2017)
6. 2021 IBC (ICC, 2020)

7. ASCE/SEI 7-05 *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2005)
8. ASCE/SEI 7-10 *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010)
9. ASCE/SEI 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE, 2017)

1.2.1.2. Project Site Local Building Code.

The local building code is typically an adoption by the AHJ of a version of the State building code. For the specific project site, see Section 8 Project Site Parameters.

1.2.1.3. Useful Reference Documents.

WTGS Loading:

1. IEC 61400-1 (IEC, 2003)
2. IEC 61400-1 (IEC, 2019)
3. GL Rules (GL, 2010)

Steel Design:

4. ANSI/AISC 360-05, *Specification for Structural Steel Buildings* (AISC, 2005)
5. ANSI/AISC 360-10, *Specification for Structural Steel Buildings* (AISC, 2010)
6. ANSI/AISC 360-16, *Specification for Structural Steel Buildings* (AISC, 2016)
7. ASME STS-1-2006 *Steel Stacks* (ASME, 2006)
8. Eurocode 3 Section 6 (EC3-6, 2007)
9. *Tubular Steel Structures* (Troitsky, 1990)
10. *Guide to Stability Design Criteria for Metal Structures* (Ziemian, 2010)

Concrete Design

11. *Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary* (ACI, 2014)
12. *Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary* (ACI, 2019)

Fatigue Design

13. Eurocode 3 Section 9 (EC3-9, 2005)

14. Document XIII-1965-03/XV-1127-03, *Recommendations for Fatigue Design of Welded Joints and Components* (IIW, 2003)
15. “Megacycle Fatigue Analysis Demystified: Examples from Wind Farm Tower Design” (Agbayani, 2008)
16. “Fatigue-driven Wind Farm Towers: A Practical Introduction to Fatigue Calculations” (Agbayani, 2009)

General Wind Industry Design Practice:

17. RP2011 *ASCE/AWEA Recommended Practices for Compliance of Large Land-based Wind Turbine Support Structures* (AWEA, 2011)
18. “Wind Farm Tower Design: Introducing ASCE/AWEA RP2011” (Agbayani, 2013a)
19. “An Overview of Modern Wind Farm Tower Design: Recommended Practices and the State of the Art” (Agbayani, 2013b)

Turbine OEM Documents

20. Turbine OEM loads document (Vestas, 2023a)
21. Turbine OEM tower approval drawing (Vestas, 2023b)

1.2.2. Resonance Analysis.

See Section 2 “General Notes” for a description of the analysis procedure and design criteria. The following table summarizes the results. It may be concluded that the design is acceptable.

ITEM		MAX. DCR	COMMENT
$f_{R,2}$	1xP rated Speed separation from $f_{1,LOW}$ Soft Mode 1 ($f_{NAT,7}$)	14%	> 7% and > 10%, PASS
$f_{R,3}$	3xP _{min} separation from $f_{1,HIGH}$ Rigid Mode 1 ($f_{NAT,1}$)	21%	> 10% and > 20%, PASS
$f_{R,4}$	3xP rated separation from $f_{2,LOW}$ Soft Mode 2 ($f_{NAT,10}$)	53%	> 10% and > 20%, PASS
$f_{R,4}$	3xP rated separation from $f_{1,HIGH}$ Rigid Mode 1 ($f_{NAT,1}$)	155%	> 10% and > 20%, PASS
$f_{R,1}$	1xP min separation from $f_{1,LOW}$ Soft Mode 1 ($f_{NAT,7}$)	59%	> 7% and > 10%, PASS

Table 1.2.2. Summary of Resonance Analysis

1.2.3. Tower Shell Design

See Section 3 “General Notes” for a description of the analysis procedure and design criteria. The following table summarizes the results. It may be concluded that the design is acceptable.

ITEM	MAX. DCR	COMMENT
Tower Shell (Strength Design, USM)	0.906	≤ 1.0, PASS
Tower Shell (Fatigue Design) @ DC 80 bracket weldments (Damage D)	0.977	≤ 1.0, PASS
Tower Shell (Fatigue Design) @ DC 80 circumferential joints (Damage D)	N/A	N/A
Tower Shell (Fatigue Design) @ DC 147V circumferential joints (Damage D)	0.394	≤ 1.0, PASS
Tower Shell (Fatigue Design) @ DC 112 longitudinal welds (Damage D)	0.937	≤ 1.0, PASS

Table 1.2.3. Summary of Tower Shell Design

1.2.4. Tower Splice Flanges and Bolts Design

See Section 4 “General Notes” for a description of the analysis procedure and design criteria. The following table summarizes the results. It may be concluded that the design is acceptable.

ITEM	MAX. DCR	COMMENT
Top Flange (Strength)	0.811	≤ 1.0, PASS
Flange 3 (Strength)	0.983	≤ 1.0, PASS
Flange 2 (Strength)	0.941	≤ 1.0, PASS
Flange 1 (Strength)	0.943	≤ 1.0, PASS
Top Flange (Fatigue damage D)	0.047	≤ 1.0, PASS
Flange 3 (Fatigue damage D)	0.731	≤ 1.0, PASS
Flange 2 (Fatigue damage D)	0.806	≤ 1.0, PASS
Flange 1 (Fatigue damage D)	0.851	≤ 1.0, PASS

Table 1.2.4. Summary of Splice Flanges Design

1.2.5. Tower Base Flange Design

See Section 5 “General Notes” for a description of the analysis procedure and design criteria. The following table summarizes the results. It may be concluded that the design is acceptable.

ITEM	MAX. DCR	COMMENT
Tower Base Flange Plate	0.511	≤ 1.0, PASS
ITEMS BELOW ARE FOR INFORMATION ONLY. FOUNDATION DESIGN IS BY OTHERS.		
Anchor Rods (Strength Design)	0.931	≤ 1.0, PASS
Anchor Rods (Fatigue damage D)	0.676	≤ 1.0, PASS
Max. fatigue versus PT	0.748	≤ 1.0, PASS
Max. service versus PT	0.839	≤ 1.0, PASS
Grout Under Base Plate	0.951	≤ 1.0, PASS
Concrete Under Grout	0.951	≤ 1.0, PASS
Concrete Above Embed. Anchor Plate	0.886	≤ 1.0, PASS

Table 1.2.5. Summary of Tower Base Flange Design

1.2.6. Tower Shell Penetration Design

See Section 6 “General Notes” for a description of the analysis procedure and design criteria. The following table summarizes the results. It may be concluded that the design is acceptable.

ITEM	MAX. DCR	COMMENT
Doorway Reinforcement (Strength)	0.835	≤ 1.0, PASS
Doorway Shell Hotspot (Strength, at F_y)	1.017	≈ 1.0, Accept since highly localized hotspot
Doorway Shell Hotspot (Fatigue damage D)	0.888	≤ 1.0, PASS
Circumferential Weld (Fatigue damage D)	0.549	≤ 1.0, PASS

Table 1.2.6. Summary of Tower Shell Penetration Design

1.2.7. Earthquake Design

See Section 7 “General Notes” for a description of the analysis procedure and design criteria. The following table summarizes the results. It may be concluded that the design is acceptable.

ITEM	MAX. DCR	COMMENT
Tower Shell at EQ1 Load Combination	0.958	≤ 1.0, PASS
Tower Shell at EQ3 Load Combination	0.689	≤ 1.0, PASS
Tower Shell at EQ5 Load Combination	0.673	≤ 1.0, PASS

Table 1.2.7. Summary of Earthquake Design

The design earthquake moment is generally less than the loads document design moment, so the DCRs remain less than 1.0. Therefore, no further assessment is performed.

1.2.8. Comparison of Generic Parameters Versus Site Parameters

See Section 8 Project Site Parameters of this report.

1.3. REFERENCES

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- GL (2010). *Germanischer Lloyd Rules and Guidelines, IV–Industrial Services, Part 1–Wind Energy, Guidelines for the Certification of Wind Turbines*, 2010, Germanischer Lloyd WindEnergie GmbH, Hamburg, Germany.
- Troitsky, M. S. (1990). *Tubular Steel Structures—Theory and Design*, Second Edition, 1990, James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

Ziemian, R. D., Ed. (2010). *Guide to Stability Design Criteria for Metal Structures*, Sixth Edition, 2010, John Wiley & Sons, Inc., Hoboken, New Jersey.

TURBINE OEM CONFIDENTIAL DOCUMENTS:

The following confidential documents are proprietary and Top Secret. They may be obtained only under Non-disclosure Agreement/Confidentiality Agreement with the Turbine OEM.

Vestas (2023a). *Tower Design Loads V163/V166-4.5 MW, Mk4A, IECS, HH98 m, TA36200 50/60 Hz, GS*, document: 0139-0349 VER 01, February 13, 2023, Vestas Wind Systems A/S, Hedeager 42, DK-8200 Aarhus N, Denmark.

Vestas (2023b). Vestas approval drawing “TA36200-V163/V166 4.5 MW Mk4A HH98.0 IECS,” Drawing no. A024-4468 Version 1, April 3, 2023, Vestas Wind Systems A/S, Hedeager 42, DK-8200 Aarhus N, Denmark.

1.4. CLOSING

This structural design calculation document is a professional engineering report documenting the structural design calculations for the subject tower. These calculations were performed in accordance with generally accepted engineering principles and practices. The calculations were performed with a standard of care consistent with that degree of care and skill ordinarily exercised by professional engineers currently practicing under similar circumstances at the same time and in the same or similar locality. This report is based on professional opinions informed by technical calculations, professional experience, and engineering judgment and does not constitute a guarantee or warranty, expressed or implied.

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SECTION 2

DATE: December 7, 2025 (Rev. 0)

ASE JOB NO.: 25-031

PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

CONTENTS: SECTION 2—RESONANCE ANALYSIS

General Notes.....	1
Frequency Separation Checks and Resonance Diagrams	2
RISA-3D COMPUTER OUTPUT:	
STIFF Case Natural Frequencies	6
SOFT/NOMINAL Case Natural Frequencies.....	7

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SECTION 2—RESONANCE ANALYSIS:

GENERAL NOTES

1. DEMAND

The “demand” values are the turbine operational frequencies specified by the turbine original equipment manufacturer (OEM). These usually include at least the rotor average operating speed (in rpm), designated $1 \times P$, and the blade pass speed, designated $n \times P$, e.g., $3 \times P$ where typically $n=3$ for a 3-bladed horizontal axis wind turbine (HAWT).

2. CAPACITY

The “capacity” values for comparison to or assessment of the demand values include the following items:

2.1. System natural frequencies. The natural frequencies are evaluated considering the properties of the “system,” which is defined to include the turbine, tower, and foundation. Two cases are calculated:

2.1.1. Stiff Case. The upper bound of system natural frequency is calculated based on a tower with minimum weight (i.e., bare structural weight with no miscellaneous internal weight) and a rigid base condition, i.e., foundation rotational stiffness is

$$k_{\theta} = \infty \text{ GN-m/radian}$$

2.1.2. Soft Case. The nominal system natural frequency is calculated based on a tower with maximum weight (i.e., miscellaneous internal weight is included) and a base condition with a nominal foundation rotational stiffness of

$$k_{\theta} = 500 \text{ GN-m/radian}$$

2.2. OEM tolerances (if any). Where applicable, the turbine OEM may specify a range (tolerance) of system natural frequencies for which the loads document is valid.

3. DESIGN CRITERIA

Frequency separation criteria were obtained from RP2011 (AWEA, 2011) Section 5.4.7 and the GL Rules (GL, 2010) Section 6.6.5.1.

In cases where turbine OEM separation criteria are provided, those are used and considered as the governing criteria, such as for this turbine:

Minimum separation from $1 \times P$	7%
Minimum separation from $3 \times P$	20%

FREQUENCY SEPARATION

BY: NAA

PAGE 1 OF 4

PROJECT: VESTAS V163V166 HH98M-TA38200 TOWER

DATE: 12/4/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_FREQUENCY SEPARATION CHECK_2017-11-10.xlsx

FREQUENCY SEPARATION CHECK

0139-0349 VER 01 (2023.02.13) = Reference Loads Document

ROTOR SPEEDS OF INTEREST:

<i>i</i> (no.)	$f_{R,i}$ (rpm)	$f_{R,i}$ (Hz)	DESCRIPTION
1	4.540	0.076	1P min Speed
2	9.550	0.159	1P Rated Speed
3	13.620	0.227	3P min
4	28.650	0.478	3P_Rated
5			

SYSTEM NATURAL FREQUENCIES OF INTEREST:

<i>j</i> (no.)	TOL Δ_{TOL} (%)	SEP Δ_{SEP} (%)	$EMRSEP$ Δ_{EMRSEP}	$f_{NAT,j}$ (Hz)	DESCRIPTION
1				0.187	Rigid Mode 1
2	-5%	-2%	0.930	0.174	Rigid Mode 1; EMRSEP=0.93005
3	5%	2%	1.070	0.200	Rigid Mode 1; EMRSEP=1.06995
4				1.019	Rigid Mode 2
5	-5%	-15%	0.800	0.815	Rigid Mode 2; EMRSEP=0.7995546
6	5%	15%	1.200	1.223	Rigid Mode 2; EMRSEP=1.19996
7				0.186	Soft Mode 1
8	-5%	-2%	0.930	0.173	Soft Mode 1; EMRSEP=0.93005
9	5%	2%	1.070	0.199	Soft Mode 1; EMRSEP=1.06995
10				1.013	Soft Mode 2
11	-5%	-15%	0.800	0.810	Soft Mode 2; EMRSEP=0.7995546
12	5%	15%	1.200	1.216	Soft Mode 2; EMRSEP=1.19996
13					
14					
15					

Notes: "TOL" = Tolerance

The tolerances account for uncertainties in the calculation of the natural frequencies.

"SEP" = Minimum required separation

"EMRSEP" = Effective minimum required separation

FREQUENCY INDEX LINES (ISOPLETHS) OF INTEREST:

n for $n \times P$:

1	3			
---	---	--	--	--

FREQUENCY SEPARATION

BY: NAA

PAGE 2 OF 4

PROJECT: VESTAS V163V166 HH98M-TA38200 TOWER

DATE: 12/4/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_FREQUENCY SEPARATION CHECK_2017-11-10.xlsx

FREQUENCY SEPARATION CHECKS OF INTEREST:

CHECK DESCRIPTION	
(no.)	
1	1P Rated Speed versus Soft Mode 1
2	3P min versus Rigid Mode 1
3	3P Rated versus Soft Mode 2
4	3P Rated versus Rigid Mode 1
5	1P min Speed versus Soft Mode 1

	$f_{R,i}$ (Hz)	f_{NAT} (Hz)	Δ_{EMRSEP} (%)	<=> ?	$\Delta_{PROVIDED}$ (%)	STATUS
1	0.159	0.186	7.0%	<	14%	PASS
2	0.227	0.187	20.0%	<	21%	PASS
3	0.478	1.013	20.0%	<	53%	PASS
4	0.478	0.187	20.0%	<	155%	PASS
5	0.076	0.186	7.0%	<	59%	PASS

FREQUENCY SEPARATION

BY: NAA

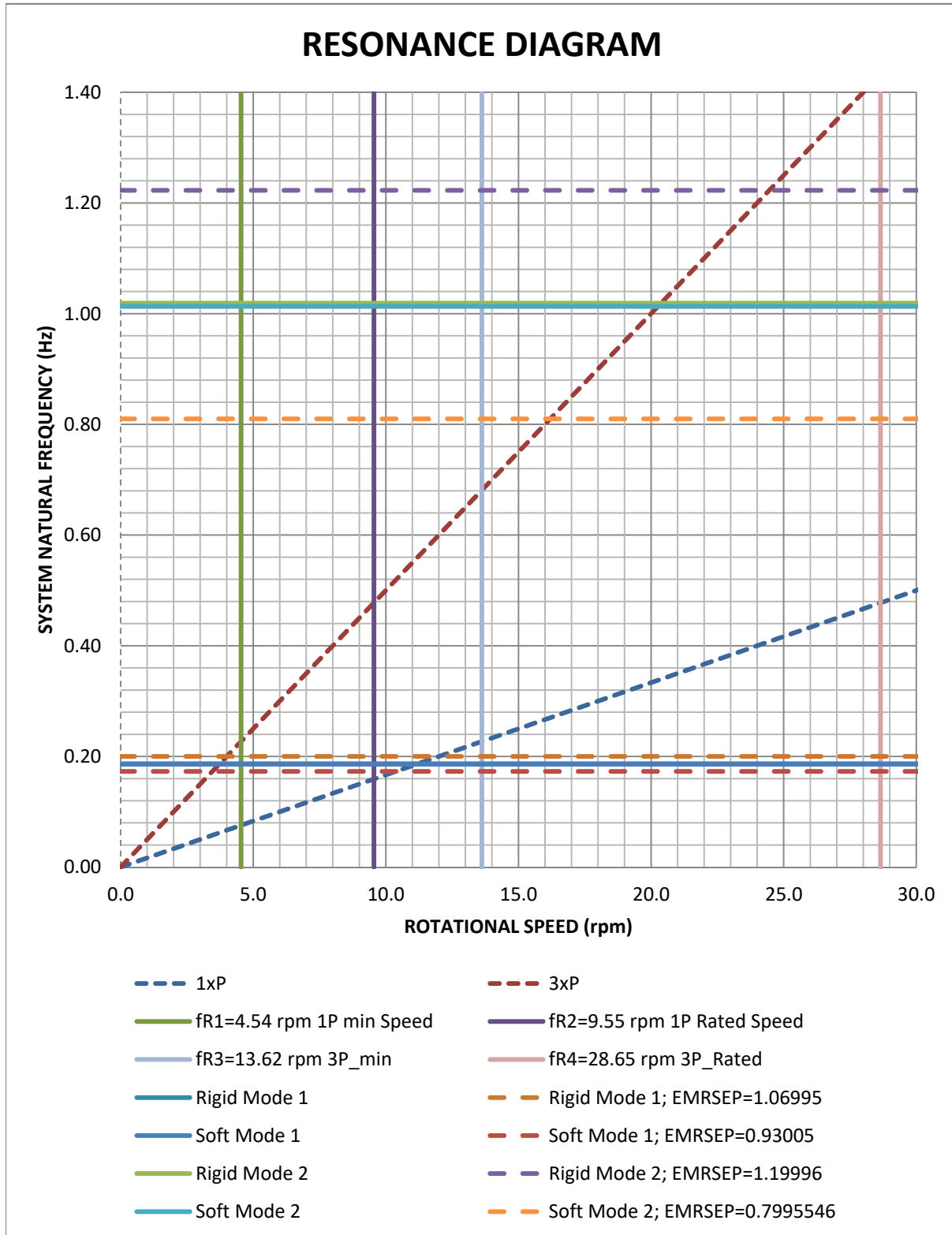
PAGE 3 OF 4

PROJECT: VESTAS V163V166 HH98M-TA38200 TOWER

DATE: 12/4/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_FREQUENCY SEPARATION CHECK_2017-11-10.xlsx



FREQUENCY SEPARATION

BY: NAA

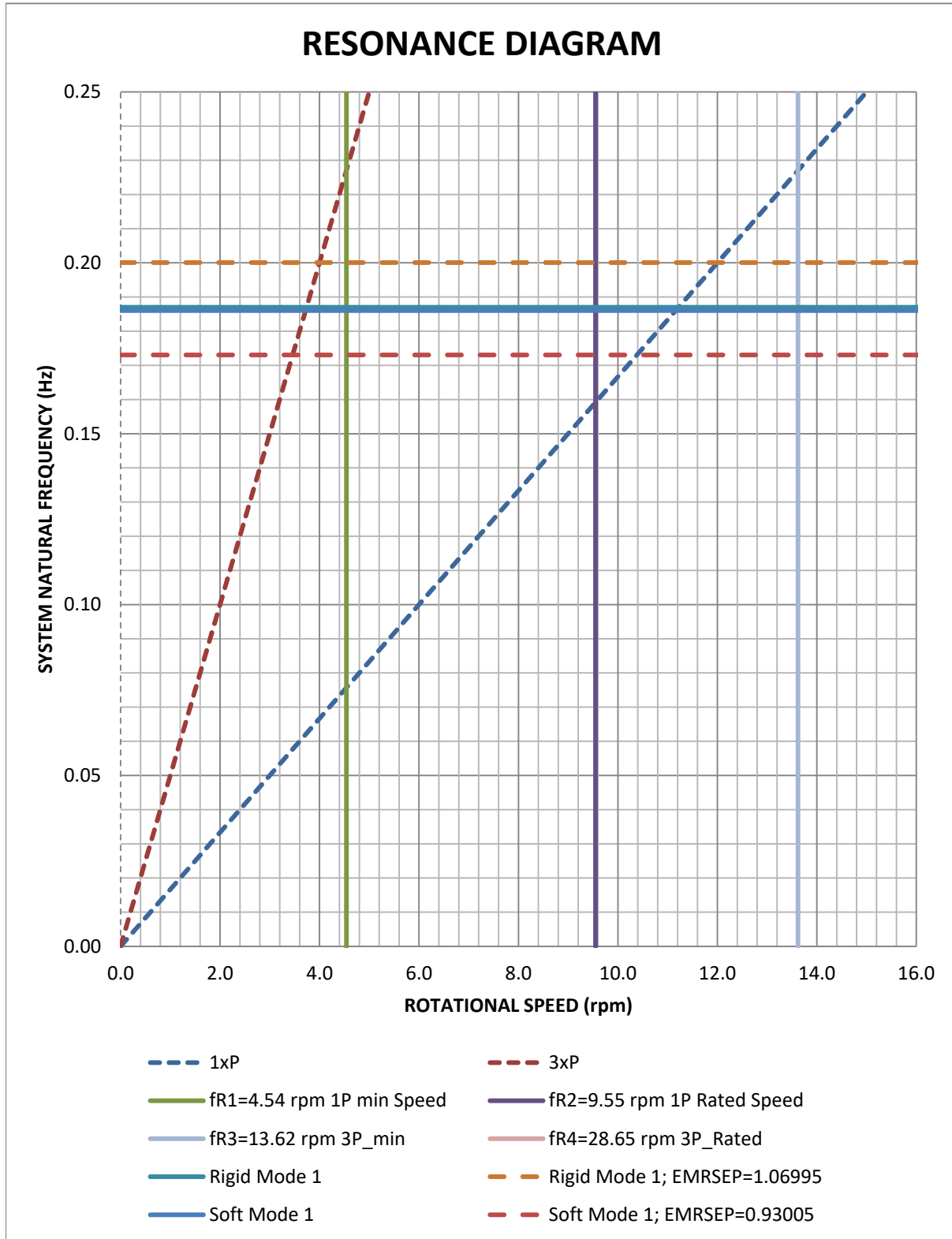
PAGE 4 OF 4

PROJECT: VESTAS V163V166 HH98M-TA38200 TOWER

DATE: 12/4/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_FREQUENCY SEPARATION CHECK_2017-11-10.xlsx





Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

Response Spectra Data

Y Direction Spectra	ASCE 2010, Parametric Design Spectra
Modes Used	All 6 modes
Mode No. for Signs	
Modal Combination Method	SRSS
Damping Ratio	5 Percent

Frequencies / Participation

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation		
			X Spectra	Y Spectra	Z Spectra
1	.187	5.348		61.193	
2	1.019	.982		12.057	
3	2.829	.353		8.723	
4	6.864	.146		4.531	
5	12.969	.077		3.267	
6	20.111	.05		1.888	
Totals :				91.659	

STIFF CASE: This model considers minimum system weight (which excludes miscellaneous internal weight) and rigid foundation rotational stiffness. These natural frequencies are upper bound estimates of the system natural frequency.



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

Response Spectra Data

X Direction Spectra	ASCE 2010, Parametric Design Spectra
Modes Used	All 6 modes
Mode No. for Signs	
Modal Combination Method	SRSS
Damping Ratio	5 Percent

Frequencies / Participation

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation		
			X Spectra	Y Spectra	Z Spectra
1	.186	5.375	61.232		
2	1.013	.988	12.202		
3	2.789	.359	8.854		
4	6.737	.148	4.688		
5	12.676	.079	3.403		
6	19.689	.051	1.924		
Totals :			92.302		

SOFT/NOMINAL CASE: This model considers maximum system weight (which includes miscellaneous internal weight) and the minimum foundation rotational stiffness. These natural frequencies are lower bound (or nominal) estimates of the system natural frequencies.

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SECTION 3

DATE: December 7, 2025 (Rev. 0)

ASE JOB NO.: 25-031

PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

CONTENTS: SECTION 3—TOWER SHELL DESIGN

DESIGN WIND COMPARISON:

General Notes.....	1
ASCE 7-05 Basic Wind Speed Map.....	3
IEC and ASCE 7-05 Design Wind Force Equivalence.....	5
ASCE 7-10 Basic Wind Speed Map.....	6
IEC and ASCE 7-10 Design Wind Force Equivalence.....	8
ASCE 7-16 Basic Wind Speed Map.....	9
IEC and ASCE 7-16 Design Wind Force Equivalence.....	10

LOAD AND RESISTANCE FACTOR (LRFD) DESIGN:

General Notes.....	11
Strength Design Calculations.....	12

FATIGUE DESIGN:

General Notes.....	28
Fatigue Design Calculations	30

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DESIGN WIND COMPARISON

GENERAL NOTES

1. DESIGN WIND

1.1. Turbine OEM's design wind definition:

1.1.1. IEC Class:..... III/S ($V_{e50} = 52.5$ m/s)

1.2. The approximately equivalent IBC/ASCE 7 wind load parameters:

- ASCE 7-16 (ASCE, 2017) is compatible with 2018 and 2021 IBC (ICC, 2017, 2020)
- ASCE 7-10 (ASCE, 2010) is compatible with 2012 and 2015 IBC (ICC, 2012, 2015)
- ASCE 7-05 (ASCE, 2005) is compatible with 2006 and 2009 IBC (ICC, 2006, 2009)

1.2.1. Basic Wind Speed and Wind Design Load Factor:

1.2.1.1. Per ASCE 7-05:

V = Basic wind speed (to get service load wind W):..... 94 mph

Use of V in the pressure equation gives an unfactored service load wind denoted W , i.e., the load factor is 1.0. The strength design wind load is obtained by applying a load factor of 1.6 to get $1.6W$.

Wind service load factor on W 1.0

Wind design load factor on W 1.6

1.2.1.2. Per ASCE 7-10:

V = Ultimate wind speed (to get strength design wind $1.0W$):... 119 mph

Use of V in the pressure equation gives a strength design wind load denoted $1.0W$, i.e., the load factor is 1.0 since W already includes the 1.6 design load factor. The service level wind load is obtained by applying a load factor of $1/1.6 \approx 0.6$ to get $0.6W$ since this removes the included 1.6 load factor.

Wind service load factor on W $1/1.6 \approx 0.6$

Wind design load factor on W 1.0

1.2.1.3. Per ASCE 7-16:

V = Basic wind speed (to get strength design wind $1.0W$):..... 116 mph

Use of V in the pressure equation gives a strength design wind load denoted $1.0W$, i.e., the load factor is 1.0 since W already includes the 1.6 design load factor. The service level wind load is obtained by applying a load factor of $1/1.6 \approx 0.6$ to get $0.6W$ since this removes the included 1.6 load factor.

Wind service load factor on W $1/1.6 \approx 0.6$

Wind design load factor on W 1.0

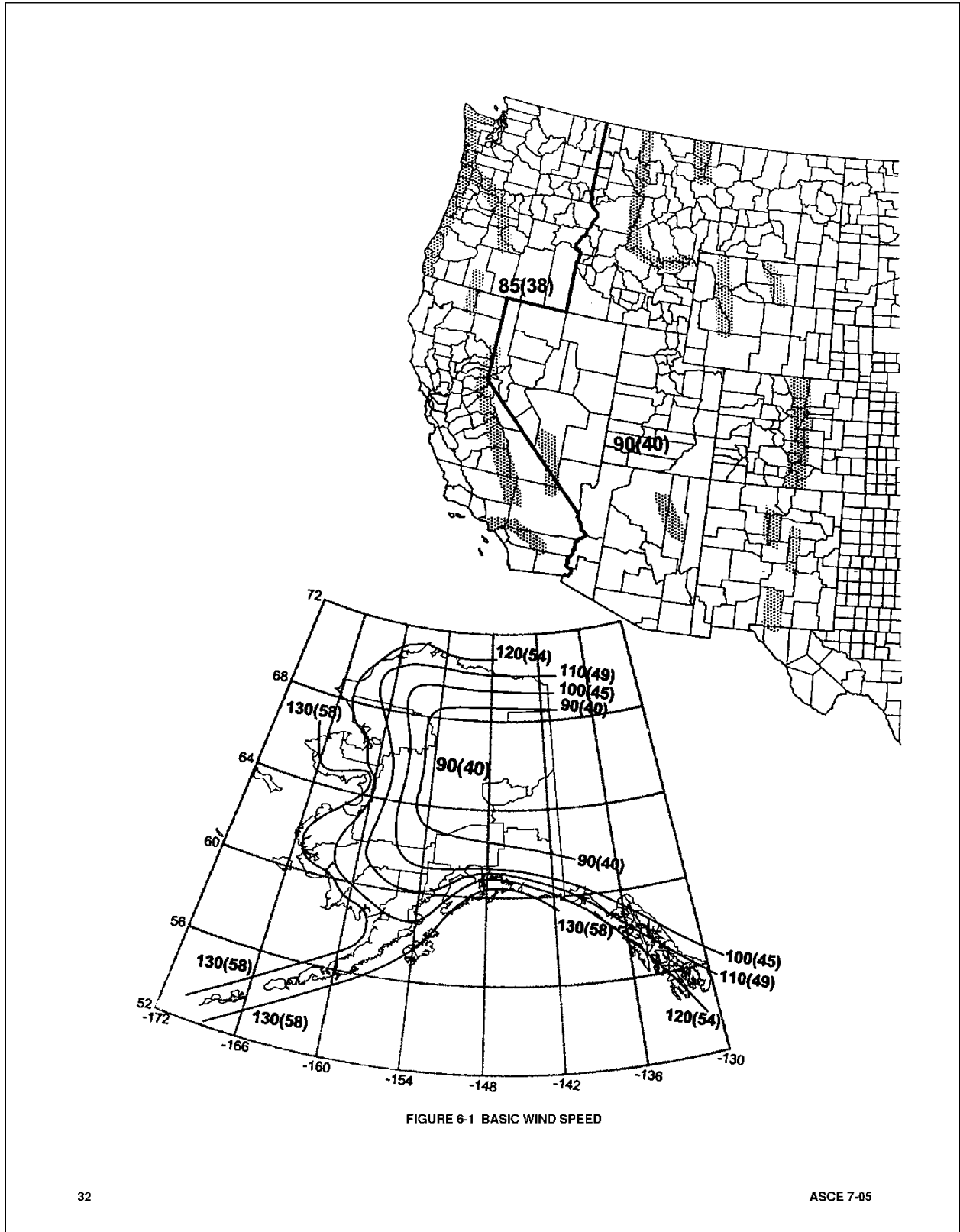
1.2.2. Exposure	C
1.2.3. $1/\alpha =$ Power law exponent derived from $\sqrt{K_z}$:.....	$1/9.5 = 0.105 \approx 0.11$
1.2.4. Occupancy and Risk Categories:	
1.2.4.1. Per ASCE 7-16: Risk Category	II
1.2.4.2. Per ASCE 7-10: Risk Category	II
1.2.4.3. Per ASCE 7-05: Occupancy Category:	II
1.2.4.4. Per ASCE 7-05: $I =$ Wind Importance Factor:	1.0
1.2.5. $K_{zt} =$ Topographic Factor:.....	1.0
1.2.6. $K_d =$ Wind Directionality Factor:	
1.2.6.1. Per ASCE 7-16	1.0
1.2.6.2. Per ASCE 7-10	0.95
1.2.6.3. Per ASCE 7-05	0.95
1.2.7. $\rho_{std} =$ Standard air density:.....	1.225 kg/m^3
$\rho_{loads \text{ doc. ext}} =$ Air density (used in the tower design) for extreme:.....	1.225 kg/m^3

1.3. The wind parameters above are for the baseline (generic) calculations that follow in this section. See the comparison of the project-specific wind parameters in Section 8 of this calculation booklet.

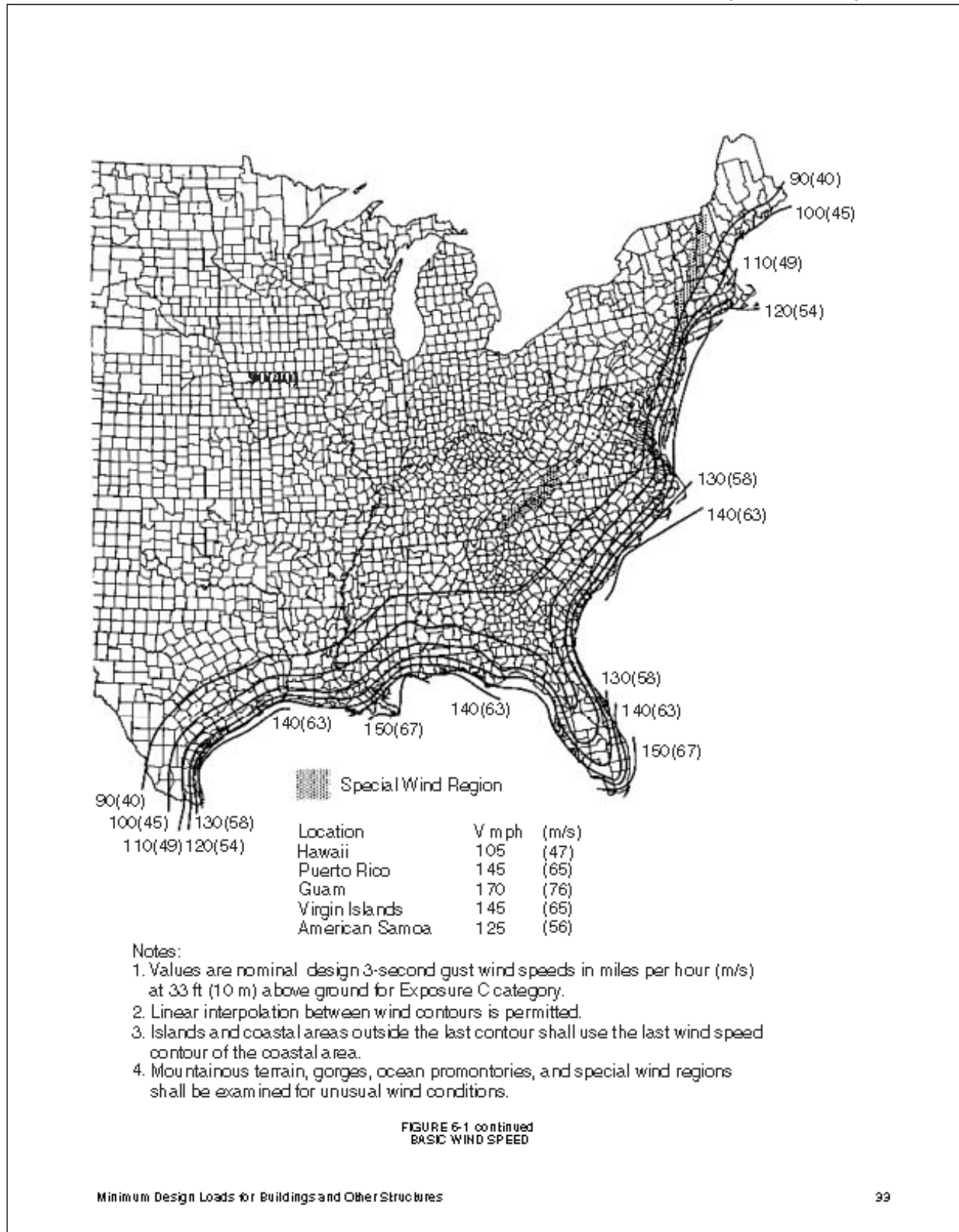
2. TURBINE OEM’S LOADS

The turbine OEM’s tower loads document is a confidential document. It must be requested from the turbine OEM subject to a signed confidentiality agreement (CA) or non-disclosure agreement (NDA). These calculations are based on the loads document or envelope of loads documents described in Section 1 of this calculation booklet.

EXCERPT: BASIC WIND SPEED MAP—ASCE 7-05 FIGURE 6-1



EXCERPT: BASIC WIND SPEED MAP—ASCE 7-05 FIGURE 6-1 (Continued)



V 3-sec ASCE 7-05

BY: NAA

PAGE 1 OF 1

PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 03_W_GENERIC_IEC_to_ASCE7-05_VER2011-05-17.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS		
2	CALCULATE $V_{3\text{-sec ASCE 7-05}} (V_3)$ USING FORCE EQUIVALENCE				
3					
4	IEC Parameters:				
5	Hub Height	H_{HUB}	(m)	98	
6	IEC Standard Air Density	ρ_{IEC}	(kg/m ³)	1.225	
7	Site Air Density	ρ_{SITE}	(kg/m ³)	1.225	
8	Air Density for Force Equivalence, i.e., choose the air density of interest for this calculation.	ρ	(kg/m ³)	1.225	@ DESIGN air density
9	IEC Loads Document Wind Speed	V_{IEC}	(m/s)	52.5	@ IEC S
10	Manufacturer Dynamic Factor	DAF		1.00	
11	Natural frequency increase factor	NIF		1.00	
12	IEC extreme wind pressure	q_{IEC}	(pa)	1688.20	
13	$q_{IEC} = \frac{1}{2}\rho V_{e50}^2 (DAF)(NIF)$	q_{IEC}	(psf)	35.26	
14					
15	ASCE 7 Parameters:				
16	Exposure	$Exposure$		C	
17	3-sec Gust Power Law Exponent	α		9.5	
18	Nominal Boundary Layer Height	z_g	(ft)	900	
19	Velocity Pressure Exposure Coefficient	K_z		1.618	
20	Wind Directionality Factor	K_d		0.95	
21	Topographic Factor	K_{zt}		1.00	
22	Wind Importance Factor	I		1.00	Occupancy Category II
23					
24	V_3 and G_f				
25	Basic Wind Speed (3 sec.)	V_3	(mph)	94.3	giving service load wind
26	Gust Response Factor	G_f		1.237	G_f at V_3
27					
28	Force equivalence is based on factored forces and is defined as follows:				
29	Set $(LF_{IEC})F_{XY,IEC} = (LF_{ASCE})F_{XY,ASCE7}$				
30	IEC wind load factor	LF_{IEC}		1.35	@ DLC 6.1
31	ASCE wind load factor	LF_{ASCE}		1.60	
32	$(LF_{IEC})\frac{1}{2}\rho V_{IEC}^2 (DAF)(NIF)A_{EFF} = (LF_{ASCE})0.00256K_z K_{zt} K_d (V_3)^2 I G_f A_{EFF}$				
33	Then solve for (and iterate to find) V_3 and G_f				

EXCERPT: BASIC WIND SPEED MAP—ASCE 7-10 FIGURE 26.5-1A

CHAPTER 26 WIND LOADS: GENERAL REQUIREMENTS

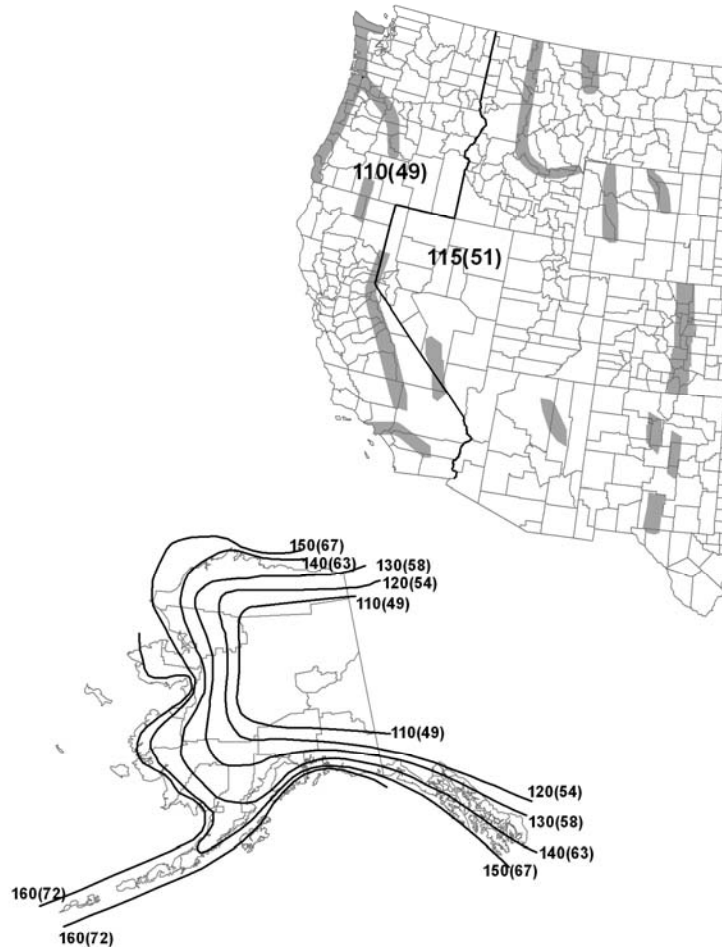


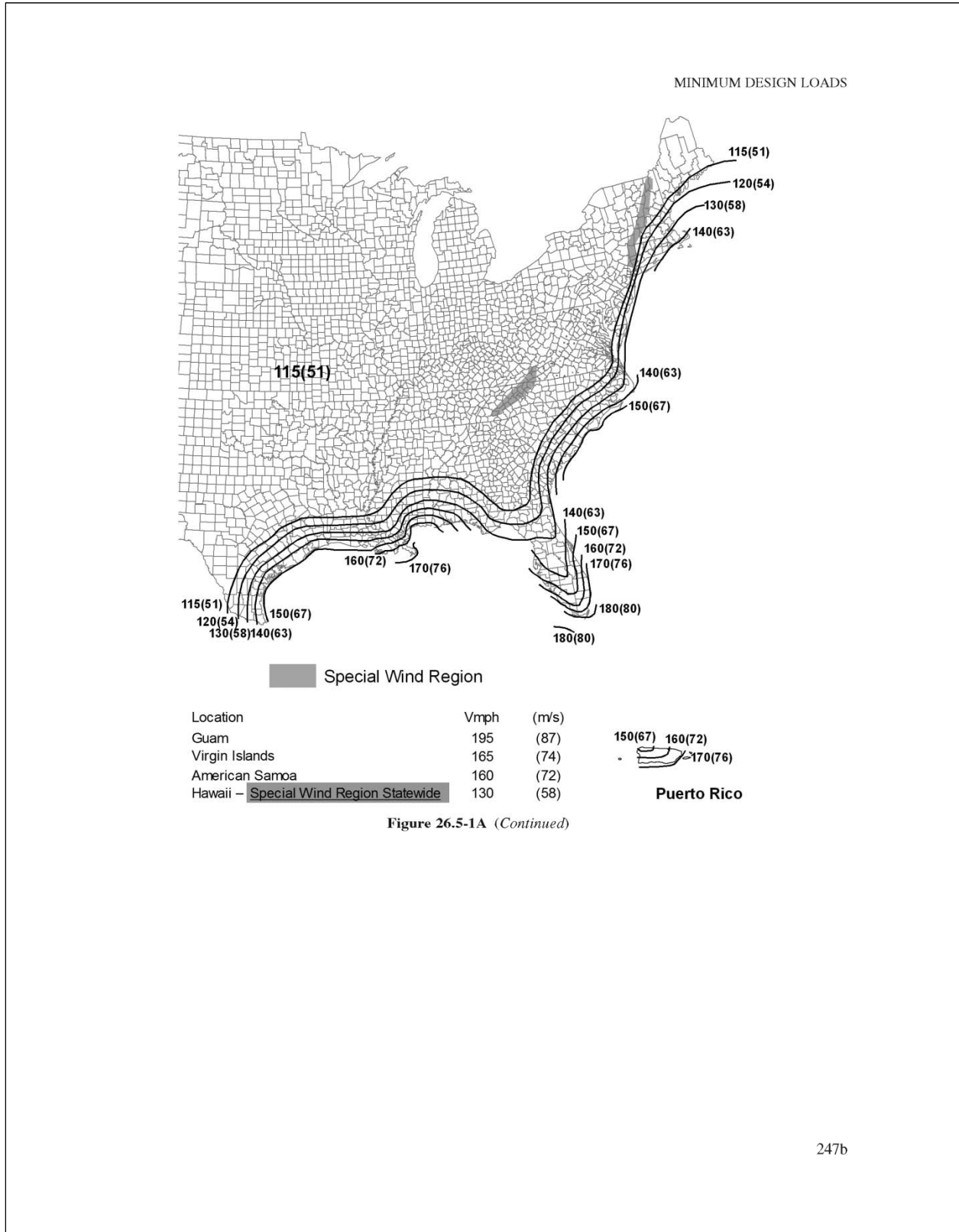
Figure 26.5-1A Basic Wind Speeds for Occupancy Category II Buildings and Other Structures.

Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 Years).

247a

EXCERPT: BASIC WIND SPEED MAP—ASCE 7-10 FIGURE 26.5-1A (Continued)



247b

V 3-sec ASCE 7-10

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

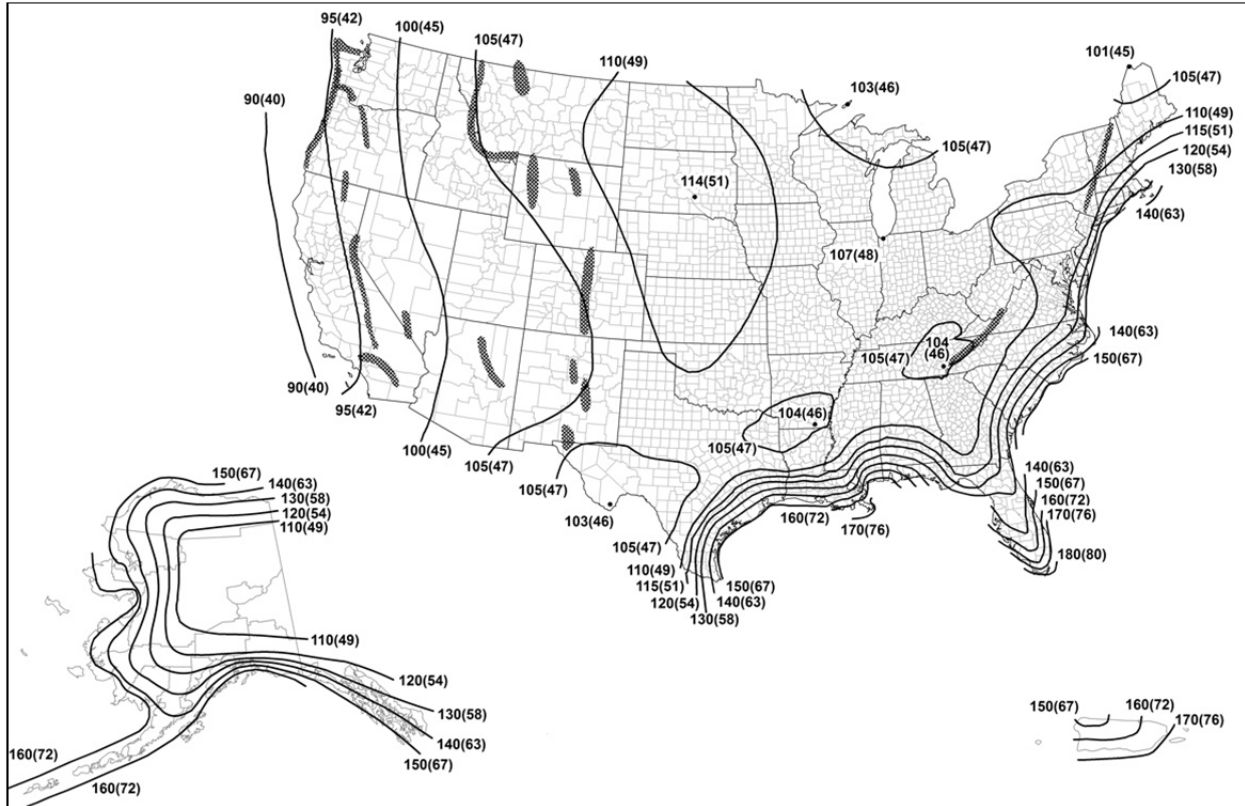
DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 05_W_GENERIC_IEC_to_ASCE7-10_VER2014-02-07.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS		
2	CALCULATE $V_{3\text{-sec ASCE 7-10}} (V_3)$ USING DESIGN FORCE EQUIVALENCE				
3	REF: ASCE 7-10 Chapter 29				
4	IEC Parameters:				
5	Hub Height	H_{HUB}	(m)	98	
6	IEC Standard Air Density	ρ_{IEC}	(kg/m ³)	1.225	
7	Site Air Density	ρ_{SITE}	(kg/m ³)	1.225	
8	Air Density for Force Equivalence, i.e., choose the air density of interest for this calculation.	ρ	(kg/m ³)	1.225	@ DESIGN air density
9	IEC Loads Document Wind Speed	V_{IEC}	(m/s)	52.5	@ IEC S
10	Manufacturer Dynamic Factor	DAF		1.00	
11	Natural frequency increase factor	NIF		1.00	
12	IEC extreme wind pressure	q_{IEC}	(pa)	1688.20	
13	$q_{IEC} = \frac{1}{2}\rho V_{e50}^2 (DAF)(NIF)$	q_{IEC}	(psf)	35.26	
14					
15	ASCE 7 Parameters:				
16	Exposure	$Exposure$		C	
17	3-sec Gust Power Law Exponent	α		9.5	
18	Nominal Boundary Layer Height	z_g	(ft)	900	
19	Velocity Pressure Exposure Coefficient	K_z		1.618	
20	Wind Directionality Factor	K_d		0.95	
21	Topographic Factor	K_{zt}		1.00	
22	Risk Category			II	
23					
24	V_3 and G_f				
25	Basic Wind Speed (3 sec.)	V_3	(mph)	119.3	giving a strength level wind
26	Gust Response Factor	G_f		1.330	G_f at V_3
27					
28	Force equivalence is based on factored forces and is defined as follows:				
29	Set $(LF_{IEC})F_{XY_{IEC}} = (LF_{ASCE})F_{XY_{ASCE7}}$				
30	IEC wind load factor	LF_{IEC}		1.35	@ DLC 6.1
31	ASCE wind load factor	LF_{ASCE}		1.00	where W_{ASCE} is strength level
32	$(LF_{IEC})\frac{1}{2}\rho V_{IEC}^2 (DAF)(NIF)A_{EFF} = (LF_{ASCE})0.00256K_z K_{zt} K_d (V_3)^2 G_f A_{EFF}$				
33	Then solve for (and iterate to find) V_3 and G_f				

EXCERPT: BASIC WIND SPEED MAP—ASCE 7-16 FIGURE 26.5-1B



V 3-sec ASCE 7-16

BY: NAA

PAGE 1 OF 1

PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 07_W_GENERIC_IEC_to_ASCE7-16_VER2019-01-02.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS		
2	CALCULATE $V_{3\text{-sec ASCE 7-16}} (V_3)$ USING DESIGN FORCE EQUIVALENCE				
3	REF: ASCE 7-16 Chapter 29				
4	IEC Parameters:				
5	Hub Height	H_{HUB}	(m)	98	
6	IEC Standard Air Density	ρ_{IEC}	(kg/m ³)	1.225	@ DESIGN air density
7	IEC Loads Document Wind Speed	V_{IEC}	(m/s)	52.5	@ IEC S
8	Manufacturer Dynamic Factor	DAF		1.00	
9	Natural frequency increase factor	NIF		1.00	
10	IEC extreme wind pressure	q_{IEC}	(pa)	1688.20	
11	$q_{IEC} = \frac{1}{2}\rho V_{e50}^2 (DAF)(NIF)$	q_{IEC}	(psf)	35.26	
12					
13	ASCE 7 Parameters:				
14	Site Air Density	ρ_{SITE}	(kg/m ³)	1.225	
15	Exposure	$Exposure$		C	
16	3-sec Gust Power Law Exponent	α		9.5	
17	Nominal Boundary Layer Height	z_g	(ft)	900	
18	Velocity Pressure Exposure Coefficient	K_z		1.618	
19	Wind Directionality Factor	K_d		1.000	
20	Topographic Factor	K_{zt}		1.000	
21	Ground Elevation Factor	K_e		1.000	= $\rho_{SITE} / 1.225$
22	Risk Category			II	
23					
24	V_3 and G_f				
25	Basic Wind Speed (3 sec.)	V_3	(mph)	116.3	giving a strength level wind
26	Gust Response Factor	G_f		1.32	G_f at V_3
27					
28	Force equivalence is based on factored forces and is defined as follows:				
29	Set $(LF_{IEC})F_{XY_{IEC}} = (LF_{ASCE})F_{XY_{ASCE7}}$				
30	IEC wind load factor	LF_{IEC}		1.35	@ DLC 6.1
31	ASCE wind load factor	LF_{ASCE}		1.00	where W_{ASCE} is strength level
32	$(LF_{IEC})\frac{1}{2}\rho V_{IEC}^2 (DAF)(NIF)A_{EFF} = (LF_{ASCE})0.00256K_zK_{zt}K_dK_e(V_3)^2 G_fA_{EFF}$				
33	Then solve for (and iterate to find) V_3 and G_f				
34					

LOAD AND RESISTANCE FACTOR (LRFD) DESIGN

GENERAL NOTES

1. DEMAND

Design by the LRFD method is strength design and uses factored loads that include a design load factor.

1.1. Governing extreme loads are obtained from the turbine OEM's loads document.

1.2. The following load combination provides the maximum compressive stress on the tower shell:

$$1.2D + W_{u,IEC}$$

where $W_{u,IEC}$ is a factored load that includes the IEC design load factor.

2. CAPACITY

The “capacity” values for comparison to or assessment of the demand values are calculated from the nominal compression strength of the tower shell multiplied by a capacity reduction factor.

3. DESIGN CRITERIA

Design criteria are taken from RP2011 (AWEA, 2011) Section 7.2 and are compatible with AISC 360 (AISC, 2005, 2010, 2016), ASME Steel Stacks (ASME, 2006), and Troitsky (Troitsky, 1990). Results tend to be conservative compared to those from Eurocode (EC3-6, 2007).

Alternatively, if the calculations that follow are designated “EN” for EN 1993-1-6 (EC3-6, 2007), then design criteria from Eurocode are being used, as is cited in RP2011 as an option for strength design.

Alternatively, if the calculations that follow are designated “RP2011 (Modified)” or “US Modified (USM)” then the flexural component of compression stress is handled in accordance with AISC flexural provisions. Further, axial and bending interaction is handled in accordance with AISC provisions for combined forces.

EX1=1.2D+1.35W (USM)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 1 OF 16

DATE: 12/5/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project										TOWER GEOMETRY									
25-031 = Job No.										7.218 = Hub Voffset (ft)									
0139-0349 VER 01 (2023.02.13) = Loads Doc.										313.648 = Tower Length (ft)									
VESTAS = Turbine Make										0.656 = Pedestal Voffset (ft)									
V163/V166-4.5MW Mk4A = Turbine Model										321.522 = Hub Height (ft)									
S = IEC Site Class										98.000 = Hub Height (m)									
98.000 = Hub Height (m)										3244 = Top Width (mm)									
A024-4468 ver. V01 = Tower Model										3900 = Base Width (mm)									
TOWER PROFILE										TOWER LAYOUT									
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN OD	t	D _m	H _{FLG-NECK}	H _{SHELLONLY}	OD	D _m	ID						
(mm)	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)						
1			7.218	321.522	98.000														
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	3244	400	29485	3266	3244	3222					
3	2285	19.9	7.497	305.495	93.115	10.813	0.7835	3276		27200	3296	3276	3256						
4	2285	19.8	7.497	297.999	90.830	10.833	0.7795	3282			3302	3282	3262						
5	2816	17.0	9.239	290.502	88.545	10.845	0.6693	3288			3308	3288	3269						
6	2816	17.4	9.239	281.263	85.729	10.870	0.6850	3296			3305	3288	3271						
7	2816	17.8	9.239	272.024	82.913	10.896	0.7008	3304			3313	3296	3279						
8	2816	18.2	9.239	262.785	80.097	10.923	0.7165	3311			3313	3296	3279						
9	2816	18.6	9.239	253.547	77.281	10.949	0.7323	3319			3321	3304	3286						
10	2816	19.2	9.239	244.308	74.465	10.976	0.7559	3327			3322	3304	3286						
11	2816	19.7	9.239	235.069	71.649	11.003	0.7756	3334			3329	3311	3294						
12	3033	20.3	9.951	225.830	68.833	11.029	0.7992	3342	115		3330	3311	3293						
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	3350	115	27405	3337	3319	3301					
14	2298	21.5	7.539	207.963	63.387	11.059	0.8465	3350			3338	3319	3300						
15	2299	22.3	7.543	200.423	61.089	11.061	0.8780	3350			3345	3327	3308						
16	2930	23.8	9.613	192.881	58.790	11.064	0.9370	3350			3346	3327	3308						
17	2930	25.3	9.613	183.268	55.860	11.069	0.9961	3350			3354	3334	3315						
18	2930	26.8	9.613	173.655	52.930	11.074	1.0551	3350			3354	3334	3315						
19	2930	28.2	9.613	164.042	50.000	11.079	1.1102	3350			3362	3342	3322						
20	2930	29.7	9.613	154.429	47.070	11.083	1.1693	3350			3362	3342	3322						
21	2930	31.3	9.613	144.816	44.140	11.088	1.2323	3350			3370	3350	3330						
22	3130	32.7	10.269	135.203	41.210	11.094	1.2874	3350	200		3371	3350	3329						
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	3350	200	22545	3371	3350	3329					
24	2819	28.7	9.249	115.026	35.060	11.311	1.1299	3419			3372	3350	3329						
25	2819	29.0	9.249	105.778	32.241	11.536	1.1417	3488			3372	3350	3328						
26	2819	28.7	9.249	96.529	29.422	11.762	1.1299	3556			3372	3350	3328						
27	2820	28.9	9.252	87.280	26.603	11.988	1.1378	3625			3374	3350	3326						
28	2818	29.2	9.245	78.028	23.783	12.214	1.1496	3694			3375	3350	3325						
29	2817	29.5	9.242	68.783	20.965	12.440	1.1614	3763			3375	3350	3325						
30	3028	34.8	9.934	59.541	18.148	12.667	1.3701	3831	215		3377	3350	3323						
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	3900	215	14530	3377	3350	3323					
32	2505	35.3	8.219	40.682	12.400	12.908	1.3898	3900			3378	3350	3322						
33	2505	36.2	8.219	32.464	9.895	12.911	1.4252	3900			3378	3350	3322						
34	1500	52.4	4.921	24.245	7.390	12.914	2.0630	3900			3380	3350	3320						
35	2930	52.4	9.613	19.324	5.890	12.967	2.0630	3900			3380	3350	3320						
36	2760	52.4	9.055	9.711	2.960	12.967	2.0630	3900	175		3381	3350	3319						
37	BOT_FLG			0.656	0.200	12.967			3900		3381	3350	3319						

EX1=1.2D+1.35W (USM)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

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DATE: 12/5/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project							SECTION PROPERTIES AT TOP AND BOTTOM ENDS OF CAN MEMBERS														
25-031 = Job No.							Display Convention: Properties at a joint row are for the top of the "member below."														
0139-0349 VER 01 (2023.02.13) = Loads Doc.																					
VESTAS = Turbine Make																					
V163/V166-4.5MW Mk4A = Turbine Model																					
S = IEC Site Class																					
98.000 = Hub Height (m)																					
A024-4468 ver. V01 = Tower Model																					
TOWER PROFILE							SECTION PROPERTIES														
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN OD	t	t _{MEMB}	t _{MEMB}	OD	ID	A	I _x , I _y	r _m	S _x , S _y	J/c	r	Z _x , Z _y			
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(mm)	(in)	(in)	(in)	(in ²)	(in ⁴)	(in)	(in ³)	(in ³)	(in)	(in ³)			
1			7.218	321.522	98.000																
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661													
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835													
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795													
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693													
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850													
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008													
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165													
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323													
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559													
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756													
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992													
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228													
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465													
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780													
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370													
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961													
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551													
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102													
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693													
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323													
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874													
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598													
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299													
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417													
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299													
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378													
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496													
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614													
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701													
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543													
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898													
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252													
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630													
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630													
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630													
37	BOT_FLG				0.656	0.200	12.967														

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EX1=1.2D+1.35W (USM)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

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DATE: 12/5/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project							BASIC LOAD CASE 1 OF 3 (MAX.)											
25-031 = Job No.							BASIC LOAD CASE											
0139-0349 VER 01 (2023.02.13) = Loads Doc.							D											
VESTAS = Turbine Make							LOAD FACTORS:											
V163/V166-4.5MW Mk4A = Turbine Model							LF _{Fz} 1.200											
S = IEC Site Class							LF _{Mz} 1.200											
98.000 = Hub Height (m)							LF _{Fxy} 1.200											
A024-4468 ver. V01 = Tower Model							LF _{Mxy} 1.200											
TOWER PROFILE							SERVICE LOADS					FACTORED LOADS						
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN OD	t	LOAD STA	F _Z	M _Z	F _{XY}	M _{XY}	1.200 F _Z	1.200 M _Z	1.200 F _{XY}	1.200 M _{XY,0.1}	LF _{FΔ}	M _{XY,0.2}
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)
1			7.218	321.522	98.000			98.000	2265	0.000	0.000	0.000	2718	0	0	0	1.000	
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	2308	0.000	0.000	0.000	2770	0	0	0	1.000	0
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	2350	0.000	0.000	0.000	2820	0	0	0	1.000	0
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	2387	0.000	0.000	0.000	2864	0	0	0	1.000	0
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	2425	0.000	0.000	0.000	2910	0	0	0	1.000	0
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	2465	0.000	0.000	0.000	2957	0	0	0	1.000	0
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	2505	0.000	0.000	0.000	3006	0	0	0	1.000	0
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	2547	0.000	0.000	0.000	3056	0	0	0	1.000	0
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	2589	0.000	0.000	0.000	3107	0	0	0	1.000	0
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	2633	0.000	0.000	0.000	3160	0	0	0	1.000	0
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	2678	0.000	0.000	0.000	3214	0	0	0	1.000	0
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	2727	0.000	0.000	0.000	3272	0	0	0	1.000	0
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	2795	0.000	0.000	0.000	3354	0	0	0	1.000	0
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	2836	0.000	0.000	0.000	3403	0	0	0	1.000	0
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	2878	0.000	0.000	0.000	3453	0	0	0	1.000	0
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	2928	0.000	0.000	0.000	3513	0	0	0	1.000	0
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	2987	0.000	0.000	0.000	3584	0	0	0	1.000	0
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	3050	0.000	0.000	0.000	3660	0	0	0	1.000	0
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	3116	0.000	0.000	0.000	3739	0	0	0	1.000	0
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	3186	0.000	0.000	0.000	3823	0	0	0	1.000	0
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	3259	0.000	0.000	0.000	3911	0	0	0	1.000	0
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	3339	0.000	0.000	0.000	4007	0	0	0	1.000	0
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	3481	0.000	0.000	0.000	4177	0	0	0	1.000	0
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	3555	0.000	0.000	0.000	4266	0	0	0	1.000	0
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	3625	0.000	0.000	0.000	4350	0	0	0	1.000	0
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	3696	0.000	0.000	0.000	4435	0	0	0	1.000	0
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	3768	0.000	0.000	0.000	4521	0	0	0	1.000	0
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	3842	0.000	0.000	0.000	4610	0	0	0	1.000	0
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	3918	0.000	0.000	0.000	4702	0	0	0	1.000	0
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	4007	0.000	0.000	0.000	4808	0	0	0	1.000	0
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	4181	0.000	0.000	0.000	5017	0	0	0	1.000	0
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	4267	0.000	0.000	0.000	5121	0	0	0	1.000	0
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	4353	0.000	0.000	0.000	5223	0	0	0	1.000	0
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	4433	0.000	0.000	0.000	5320	0	0	0	1.000	0
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	4544	0.000	0.000	0.000	5452	0	0	0	1.000	0
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	4685	0.000	0.000	0.000	5622	0	0	0	1.000	0
37	BOT_FLG				0.656	0.200	12.967	0.200	4785	0.000	0.000	0.000	5742	0	0	0	1.000	0

EX1=1.2D+1.35W (USM)

BY: NAA

PAGE 8 OF 16

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project								BASIC LOAD CASE 2 OF 3 (MAX.)											
25-031 = Job No.								BASIC LOAD CASE											
0139-0349 VER 01 (2023.02.13) = Loads Doc.								W											
VESTAS = Turbine Make								Estimate Uplift:											
V163/V166-4.5MW Mk4A = Turbine Model								-509 = Turbine (kip)											
S = IEC Site Class								-499 = F _z /Load Factor (kip)											
98.000 = Hub Height (m)								10.153 = F _{z,imp} (- Down)(kip)											
A024-4468 ver. V01 = Tower Model								LOAD FACTORS:											
								LF _{Fz} = 1.418 = L.F. * (1.05 per OEM)											
								LF _{Mz} = 1.418											
								LF _{Fxy} = 1.418											
								LF _{Mxy} = 1.418											
TOWER PROFILE								SERVICE LOADS					FACTORED LOADS						
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	LOAD STA	F _z	M _z	F _{XY}	M _{XY}	1.418 F _z	1.418 M _z	1.418 F _{XY}	1.418 M _{XY,0.1}	LF _{FΔ}	M _{XY,0.2}	
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)	
1			7.218	321.522	98.000			98.000	-45	1565	909	10718	-64.019	2218	1289	15193	1.000	15193	
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	-45	1565	909	11184	-64.019	2218	1289	15854	1.000	15854	
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	-45	1565	909	12145	-64.019	2218	1289	17216	1.000	17216	
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	-45	1565	909	13252	-64.019	2218	1289	18785	1.000	18785	
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	-45	1565	909	14584	-64.019	2218	1289	20672	1.000	20672	
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	-45	1565	909	16481	-64.019	2218	1289	23362	1.000	23362	
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	-45	1565	909	18607	-64.019	2218	1289	26376	1.000	26376	
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	-45	1565	909	20912	-64.019	2218	1289	29643	1.000	29643	
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	-45	1565	909	23352	-64.019	2218	1289	33102	1.000	33102	
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	-45	1565	909	25892	-64.019	2218	1289	36702	1.000	36702	
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	-45	1565	909	28501	-64.019	2218	1289	40401	1.000	40401	
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	-45	1565	909	31157	-64.019	2218	1289	44164	1.000	44164	
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	-45	1565	909	34046	-64.019	2218	1289	48261	1.000	48261	
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	-45	1565	909	36357	-64.019	2218	1289	51536	1.000	51536	
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	-45	1565	909	38560	-64.019	2218	1289	54659	1.000	54659	
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	-45	1565	909	40763	-64.019	2218	1289	57782	1.000	57782	
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	-45	1565	909	43568	-64.019	2218	1289	61757	1.000	61757	
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	-45	1565	909	46367	-64.019	2218	1289	65725	1.000	65725	
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	-45	1565	909	49162	-64.019	2218	1289	69687	1.000	69687	
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	-45	1565	909	51957	-64.019	2218	1289	73649	1.000	73649	
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	-45	1565	909	54756	-64.019	2218	1289	77617	1.000	77617	
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	-45	1565	909	57566	-64.019	2218	1289	81600	1.000	81600	
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	-45	1565	909	60585	-64.019	2218	1289	85880	1.000	85880	
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	-45	1565	909	63522	-64.019	2218	1289	90042	1.000	90042	
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	-45	1565	909	66288	-64.019	2218	1289	93963	1.000	93963	
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	-45	1565	909	69079	-64.019	2218	1289	97919	1.000	97919	
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	-45	1565	909	71895	-64.019	2218	1289	101911	1.000	101911	
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	-45	1565	909	74735	-64.019	2218	1289	105936	1.000	105936	
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	-45	1565	909	77587	-64.019	2218	1289	109980	1.000	109980	
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	-45	1565	909	80445	-64.019	2218	1289	114031	1.000	114031	
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	-45	1565	909	83506	-64.019	2218	1289	118369	1.000	118369	
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	-45	1565	909	86226	-64.019	2218	1289	122226	1.000	122226	
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	-45	1565	909	88688	-64.019	2218	1289	125715	1.000	125715	
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	-45	1565	909	91085	-64.019	2218	1289	129113	1.000	129113	
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	-45	1565	909	92479	-64.019	2218	1289	131089	1.000	131089	
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	-45	1565	909	95086	-64.019	2218	1289	134784	1.000	134784	
37	BOT_FLG				0.656	0.200	12.967	0.200	-45	1565	909	97360	-64.019	2218	1289	138008	1.000	138008	

EX1=1.2D+1.35W (USM)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project								BASIC LOAD CASE 3 OF 3 (MAX.)										
25-031		= Job No.						BASIC LOAD CASE										
0139-0349 VER 01 (2023.02.13)		= Loads Doc.						Not Used										
VESTAS		= Turbine Make						LOAD FACTORS:										
V163/V166-4.5MW Mk4A		= Turbine Model						LF _{Fz} 1.000										
S		= IEC Site Class						LF _{Mz} 1.000										
98.000 = Hub Height (m)								LF _{Fxy} 1.000										
A024-4468 ver. V01 = Tower Model								LF _{Mxy} 1.000										
TOWER PROFILE								SERVICE LOADS					FACTORED LOADS					
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN OD	t	LOAD STA	F _Z	M _Z	F _{XY}	M _{XY}	F _Z	M _Z	F _{XY}	M _{XY,0.1}	LF _{FΔ}	M _{XY,0.2}
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)
1			7.218	321.522	98.000			98.000	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0
37	BOT_FLG				0.656	0.200	12.967	0.200	0.000	0.000	0.000	0.000	0	0	0	0	1.000	0

EX1=1.2D+1.35W (USM)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project														
25-031 = Job No.														
0139-0349 VER 01 (2023.02.13) = Loads Doc.								Capacity Reduction Factors:						
VESTAS = Turbine Make								0.90 = ϕ_c						
V163/V166-4.5MW Mk4A = Turbine Model								0.90 = ϕ_v						
S = IEC Site Class								0.90 = ϕ_r						
98.000 = Hub Height (m)														
A024-4468 ver. V01 = Tower Model														
TOWER PROFILE								DESIGN STRESSES						
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN OD	t	f _a = σ_{FRC}	f _b = σ_{Maxy}	f _c =f _a +f _b	f _v = σ_{Maxy}	f _r = σ_{Max}	f _r =f _v +f _r	
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	
1			7.218	321.522	98.000									
2	TOP_FLG	22.0	8.809	314.304	95.800	10.715	0.8661	1.750	12.646	14.396	1.667	0.885	2.552	
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	1.766	13.465	15.231	1.651	0.867	2.518
4		2285	19.9	7.497	297.999	90.830	10.833	0.7795	1.952	14.886	16.838	1.825	0.959	2.784
5		2285	19.8	7.497	290.502	88.545	10.845	0.6693	1.979	16.182	18.161	1.822	0.955	2.777
6		2816	17.0	9.239	281.263	85.729	10.870	0.6850	1.989	16.263	18.253	1.831	0.960	2.791
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	2.018	17.830	19.847	1.827	0.957	2.784
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	2.350	20.766	23.116	2.128	1.114	3.242
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	2.384	23.359	25.743	2.123	1.109	3.232
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	2.329	22.822	25.151	2.075	1.083	3.158
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	2.363	25.647	28.010	2.070	1.078	3.148
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	2.310	25.071	27.380	2.023	1.054	3.077
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	2.344	28.046	30.389	2.019	1.049	3.068
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	2.292	27.429	29.721	1.974	1.026	3.000
15		2298	22.3	7.543	200.423	61.089	11.061	0.8780	2.326	30.489	32.815	1.970	1.022	2.991
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	2.276	29.833	32.109	1.927	1.000	2.927
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	2.310	32.926	35.235	1.923	0.995	2.918
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	2.238	31.897	34.134	1.863	0.964	2.827
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	2.272	34.950	37.222	1.858	0.959	2.818
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	2.214	34.063	36.277	1.811	0.935	2.746
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	2.250	37.066	39.315	1.807	0.931	2.738
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	2.183	35.970	38.153	1.754	0.903	2.657
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	2.233	39.121	41.354	1.750	0.899	2.649
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	2.169	37.997	40.167	1.699	0.873	2.573
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	2.202	40.576	42.778	1.699	0.873	2.573
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	2.140	39.443	41.584	1.652	0.849	2.501
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	2.172	41.834	44.006	1.652	0.849	2.501
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	2.094	40.333	42.427	1.593	0.818	2.411
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	2.131	42.638	44.769	1.593	0.818	2.411
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	1.997	39.950	41.948	1.492	0.767	2.259
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	2.038	42.699	44.737	1.492	0.767	2.259
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	1.918	40.167	42.085	1.404	0.721	2.125
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	1.959	42.748	44.707	1.404	0.721	2.125
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	1.849	40.355	42.204	1.325	0.681	2.006
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	1.890	42.788	44.678	1.325	0.681	2.006
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	1.896	42.788	44.678	1.325	0.681	2.006
37	BOT_FLG				0.656	0.200	12.967		1.796	40.664	42.460	1.259	0.647	1.907

EX1=1.2D+1.35W (USM)

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 14 OF 16
DATE: 12/5/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

Table with columns for TOWER PROFILE, JOINT, H_CAN, t, H_CAN, JOINT ELEV, JOINT ELEV, OD, CAN, t, L_SECTION, F_ax1, F_ax2, F_ax_MAX, F_ax, phi_F_ax, and DCR. It contains a large grid of structural data points for various joints and tower sections.

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FATIGUE DESIGN

GENERAL NOTES

1. DEMAND

1.1. Fatigue loads are provided by the turbine OEM in either or both of the following formats:

1.1.1. Fatigue damage equivalent loads (DEL) at reference slope parameter m and N_{del} reference cycles.

1.1.2. Markov matrices or matrices converted to a load spectrum of values:

$$(M_i, \Delta M_i, n_i)$$

where

i = matrix element index from 1 to $j \times k$ for a Markov matrix with j rows and k columns.

M = fatigue load (a force or moment)

ΔM = fatigue load range

n = fatigue load cycles

1.2. The fatigue load factor is 1.0, i.e., fatigue loads are service loads.

2. CAPACITY

2.1. For fatigue DELs, the S-N curve is a single slope curve through the definition point of the fatigue detail category (DC) value at 2E6 cycles. The slope matches the reference m for the DELs. Thereafter, no cutoff (flat slope) is used.

2.2. For fatigue loads in Markov matrices, a two-slope S-N curve is used. Up to 5E6 cycles, $m=3$ is used, and beyond 5E6 cycles, $m=5$ is used. In accordance with the GL Rules (GL, 2010), a cutoff (flat slope) after 1E8 cycles is usually not used, i.e., all fatigue stresses produce damage.

2.2.1. NOTE: For these calculations, the cutoff at 1E8 cycles will be used.

2.3. The S-N curves are adjusted for design values as follows:

2.3.1. Partial safety factor for material:

2.3.1.1. $\gamma_m = 1.10$ (typical value)

2.3.1.2. $\gamma_m = 1.00$ (if component is accessible to approved inspection program)

2.3.2. Partial safety factor for consequence of failure: $\gamma_n = 1.15$

2.3.3. Alternatively, the OEM value of $\gamma_{mf} = 1.25$ may be used.

3. DESIGN CRITERIA

The S-N curve design procedure is taken from Eurocode (EC3-9, 2005) with safety factors overridden by IEC 61400-1 (IEC, 2003) and cutoff prohibitions from the GL Rules (GL, 2010). The results are conservative compared to those that would be obtained from AISC (AISC, 2005, 2010, 2016)—as discussed in RP2011 (AWEA, 2011) Section 7.3.

The following fatigue detail categories (DC) may be used if/where specified:

- Tower internal weldments:DC 80 with no thickness reduction factor (TRF)
- Tower shell circumferential (girth) welds: DC 80 (where specified)
- Tower shell circumferential (girth) welds: DC 90 (where specified)
- Tower shell circumferential (girth) welds: DC 147V (where specified)
- Longitudinal weld seams: DC 112 (typical)
- At welds at hotspots:DC 100 with SCF (unless noted otherwise)
- At welds at hotspots:DC 90 with SCF (where specified)
- At welds at hotspots:DC 112 with SCF (where specified)
- At welds at hotspots: DC 147V with SCF (where specified)
- At shell hotspots in base material (no weld):DC 140 with SCF
- At circular holes in shell:DC 90 with no TRF

FATIGUE

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200
 JOB NO.: 25-031 (GENERIC)

PAGE 5 OF 12
 DATE: 12/5/2025
 FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project									
25-031 = Job No.									
0139-0349 VER 01 (2023.02.13) = Loads Doc.									
VESTAS = Turbine Make									
V163/V166-4.5MW Mk4A = Turbine Model									
S = IEC Site Class									
98.000 = Hub Height (m)									
A024-4468 ver. V01 = Tower Model									
TOWER PROFILE									
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	LOAD STA	ΔM _{DEL}
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN-m)
1			7.218	321.522	98.000				
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715		7308
3		2285	19.9	7.497	305.495	93.115	10.813		7044
4		2285	19.8	7.497	297.999	90.830	10.833		6921
5		2816	17.0	9.239	290.502	88.545	10.845		6878
6		2816	17.4	9.239	281.263	85.729	10.870		6918
7		2816	17.8	9.239	272.024	82.913	10.896		7044
8		2816	17.8	9.239	262.785	80.097	10.923		7241
9		2816	18.2	9.239	253.547	77.281	10.949		7495
10		2816	18.6	9.239	244.308	74.465	10.976		7796
11		2816	19.2	9.239	235.069	71.649	11.003		8134
12		2816	19.7	9.239	225.830	68.833	11.029		8503
13	SPLICE3	3033	20.3	9.951	215.879	65.800	11.057		8929
14		2413	20.9	7.917	207.963	63.387	11.059		9286
15		2298	21.5	7.539	200.423	61.089	11.061		9640
16		2299	22.3	7.543	192.881	58.790	11.064		10007
17		2930	23.8	9.613	183.268	55.860	11.069		10493
18		2930	25.3	9.613	173.655	52.930	11.074		11000
19		2930	26.8	9.613	164.042	50.000	11.079		11530
20		2930	28.2	9.613	154.429	47.070	11.083		12086
21		2930	29.7	9.613	144.816	44.140	11.088		12669
22		2930	31.3	9.613	135.203	41.210	11.094		13284
23	SPLICE2	3130	32.7	10.269	124.934	38.080	11.096		13978
24		3020	32.0	9.908	115.026	35.060	11.311		14688
25		2819	28.7	9.249	105.778	32.241	11.536		15388
26		2819	29.0	9.249	96.529	29.422	11.762		16127
27		2819	28.7	9.249	87.280	26.603	11.988		16905
28		2820	28.9	9.252	78.028	23.783	12.214		17722
29		2818	29.2	9.245	68.783	20.965	12.440		18576
30		2817	29.5	9.242	59.541	18.148	12.667		19466
31	SPLICE1	3028	34.8	9.934	49.606	15.120	12.908		20458
32		2720	34.4	8.924	40.682	12.400	12.908		21374
33		2505	35.3	8.219	32.464	9.895	12.911		22234
34		2505	36.2	8.219	24.245	7.390	12.914		23102
35		1500	52.4	4.921	19.324	5.890	12.967		23623
36		2930	52.4	9.613	9.711	2.960	12.967		24634
37	BOT FLG	2760	52.4	9.055	0.656	0.200	12.967		25566

FATIGUE

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project											FATIGUE CASE 1: DC 80 Internal Brackets										
25-031 = Job No.											80 = DC										
0139-0349 VER 01 (2023.02.13) = Loads Doc.											N = Weld TRF? [Y or N]										
VESTAS = Turbine Make											B = Use which S? [J, A, or B]										
V163/V166-4.5MW Mk4A = Turbine Model											1.250 = γ_{ref}										
S = IEC Site Class											1.030 = Load Factor										
98.000 = Hub Height (m)											1.000 = SCF _{OVERRIDE}										
A024-4468 ver. V01 = Tower Model											4.000 = m										
											1.00E+07 = N _{DEL}										
											2.00E+06 = N _{DC}										
											MAX: DCR 0.994 D 0.977										
TOWER PROFILE																					
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	ELEV (ft)	JOINT ELEV (m)	JOINT ELEV (ft)	OD (ft)	CAN t (in)	S _x , S _y (@D _m) (in ³)	SCF	$\Delta\sigma$ (ksi)	t _{USE} (mm)	Weld TRF	$\Delta\sigma_{ALLOW}$ (ksi)	STRESS DCR	DAMAGE D	STATUS				
1			7.218	321.522	98.000																
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	11096	1.000	6.004	22.0	1.000	6.208	0.967	0.875	OK				
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	10236	1.063	6.669	19.9	1.000	6.208	0.991	0.963	OK				
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	10223	1.000	6.172	19.8	1.000	6.208	0.994	0.977	OK				
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	10262	1.000	6.110	19.8	1.000	6.208	0.984	0.939	OK				
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850													
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008													
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165													
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323													
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559													
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756													
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992													
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228													
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465													
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780													
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370													
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961													
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551													
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102													
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693													
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323													
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874													
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598													
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299													
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417													
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299													
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378													
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496													
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614													
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701													
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543													
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898													
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252													
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	38199	1.000	5.513	52.4	1.000	6.208	0.888	0.622	OK				
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	38199	1.000	5.638	52.4	1.000	6.208	0.908	0.680	OK				
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	38199	1.000	5.879	52.4	1.000	6.208	0.947	0.805	OK				
37	BOT FLG				0.656	0.200	12.967		38199	1.000	6.101	52.4	1.000	6.208	0.983	0.933	OK				

The damage values indicated below in orange cells are calculated by use of the more refined Palmgren-Miner Damage Summation Method (PM-SUM) with S-N curve with (m=3, m=5, cutoff). See the attached supplementary PM-SUM calculations.

FATIGUE

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project							FATIGUE CASE 2: DC 80 Circumferential Welds [NOT USED]									
25-031 = Job No.																
0139-0349 VER 01 (2023.02.13) = Loads Doc.							80 = DC									
VESTAS = Turbine Make							Y = Weld TRF? [Y or N]									
V163/V166-4.5MW Mk4A = Turbine Model							J = Use which S? [J, A, or B]									
S = IEC Site Class							1.250 = γ_{mf}									
98.000 = Hub Height (m)							1.030 = Load Factor									
A024-4468 ver. V01 = Tower Model							1.000 = SCF _{OVERRIDE}									
							4.000 = m									
							1.00E+07 = N_{DEL}									
							2.00E+06 = N_{DC}									
							MAX: DCR N/A D N/A									
TOWER PROFILE																
JOINT	H _{CAN}	t	H _{CAN}	ELEV	ELEV	OD	t	S _x , S _y	SCF	$\Delta\sigma$	t _{USE}	Weld	$\Delta\sigma_{ALLOW}$	STRESS	DAMAGE	STATUS
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(@D _m)		(ksi)	(mm)	TRF	(ksi)	DCR	D	
								(in ³)				(-)		(-)	(-)	
1			7.218	321.522	98.000											
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715									
3		2285	19.9	7.497	305.495	93.115	10.813									
4		2285	19.8	7.497	297.999	90.830	10.833									
5		2816	17.0	9.239	290.502	88.545	10.845									
6		2816	17.4	9.239	281.263	85.729	10.870									
7		2816	17.8	9.239	272.024	82.913	10.896									
8		2816	18.2	9.239	262.785	80.097	10.923									
9		2816	18.6	9.239	253.547	77.281	10.949									
10		2816	19.2	9.239	244.308	74.465	10.976									
11		2816	19.7	9.239	235.069	71.649	11.003									
12		3033	20.3	9.951	225.830	68.833	11.029									
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057									
14		2298	21.5	7.539	207.963	63.387	11.059									
15		2299	22.3	7.543	200.423	61.089	11.061									
16		2930	23.8	9.613	192.881	58.790	11.064									
17		2930	25.3	9.613	183.268	55.860	11.069									
18		2930	26.8	9.613	173.655	52.930	11.074									
19		2930	28.2	9.613	164.042	50.000	11.079									
20		2930	29.7	9.613	154.429	47.070	11.083									
21		2930	31.3	9.613	144.816	44.140	11.088									
22		3130	32.7	10.269	135.203	41.210	11.094									
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096									
24		2819	28.7	9.249	115.026	35.060	11.311									
25		2819	29.0	9.249	105.778	32.241	11.536									
26		2819	28.7	9.249	96.529	29.422	11.762									
27		2820	28.9	9.252	87.280	26.603	11.988									
28		2818	29.2	9.245	78.028	23.783	12.214									
29		2817	29.5	9.242	68.783	20.965	12.440									
30		3028	34.8	9.934	59.541	18.148	12.667									
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908									
32		2505	35.3	8.219	40.682	12.400	12.908									
33		2505	36.2	8.219	32.464	9.895	12.911									
34		1500	52.4	4.921	24.245	7.390	12.914									
35		2930	52.4	9.613	19.324	5.890	12.967									
36		2760	52.4	9.055	9.711	2.960	12.967									
37	BOT_FLG				0.656	0.200	12.967									

FATIGUE

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project							FATIGUE CASE 3: DC 90 Circumferential Welds									
25-031 = Job No.																
0139-0349 VER 01 (2023.02.13) = Loads Doc.							90 = DC									
VESTAS = Turbine Make							Y = Weld TRF? [Y or N]									
V163/V166-4.5MW Mk4A = Turbine Model							J = Use which S? [J, A, or B]									
S = IEC Site Class							1.250 = γ_{mf}									
98.000 = Hub Height (m)							1.030 = Load Factor									
A024-4468 ver. V01 = Tower Model							1.000 = SCF _{OVERRIDE}									
							4.000 = m									
							1.00E+07 = N_{DEL}									
							2.00E+06 = N_{DC}									
							MAX: DCR N/A D N/A									
TOWER PROFILE																
JOINT	H_{CAN}	t	H_{CAN}	ELEV	ELEV	OD	t	S_x, S_y	SCF	$\Delta\sigma$	t_{USE}	Weld	$\Delta\sigma_{ALLOW}$	STRESS	DAMAGE	STATUS
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(@ D_m)		(ksi)	(mm)	TRF	(ksi)	DCR	D	
								(in ²)				(-)		(-)	(-)	
1			7.218	321.522	98.000											
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715									
3		2285	19.9	7.497	305.495	93.115	10.813									
4		2285	19.8	7.497	297.999	90.830	10.833									
5		2816	17.0	9.239	290.502	88.545	10.845									
6		2816	17.4	9.239	281.263	85.729	10.870									
7		2816	17.8	9.239	272.024	82.913	10.896									
8		2816	18.2	9.239	262.785	80.097	10.923									
9		2816	18.6	9.239	253.547	77.281	10.949									
10		2816	19.2	9.239	244.308	74.465	10.976									
11		2816	19.7	9.239	235.069	71.649	11.003									
12		3033	20.3	9.951	225.830	68.833	11.029									
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057									
14		2298	21.5	7.539	207.963	63.387	11.059									
15		2299	22.3	7.543	200.423	61.089	11.061									
16		2930	23.8	9.613	192.881	58.790	11.064									
17		2930	25.3	9.613	183.268	55.860	11.069									
18		2930	26.8	9.613	173.655	52.930	11.074									
19		2930	28.2	9.613	164.042	50.000	11.079									
20		2930	29.7	9.613	154.429	47.070	11.083									
21		2930	31.3	9.613	144.816	44.140	11.088									
22		3130	32.7	10.269	135.203	41.210	11.094									
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096									
24		2819	28.7	9.249	115.026	35.060	11.311									
25		2819	29.0	9.249	105.778	32.241	11.536									
26		2819	28.7	9.249	96.529	29.422	11.762									
27		2820	28.9	9.252	87.280	26.603	11.988									
28		2818	29.2	9.245	78.028	23.783	12.214									
29		2817	29.5	9.242	68.783	20.965	12.440									
30		3028	34.8	9.934	59.541	18.148	12.667									
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908									
32		2505	35.3	8.219	40.682	12.400	12.908									
33		2505	36.2	8.219	32.464	9.895	12.911									
34		1500	52.4	4.921	24.245	7.390	12.914									
35		2930	52.4	9.613	19.324	5.890	12.967									
36		2760	52.4	9.055	9.711	2.960	12.967									
37	BOT_FLG				0.656	0.200	12.967									

FATIGUE

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project							FATIGUE CASE 6: Doorway Max. SCF Estimate (Information Only)										
25-031 = Job No.							147 = DC										
0139-0349 VER 01 (2023.02.13) = Loads Doc.							Y = Weld TRF? [Y or N]										
VESTAS = Turbine Make							J = Use which S? [J, A, or B]										
V163/V166-4.5MW Mk4A = Turbine Model							1.250 = γ_{mf}										
S = IEC Site Class							1.030 = Load Factor										
98.000 = Hub Height (m)							1.44 = SCF OEM value										
A024-4468 ver. V01 = Tower Model							4.000 = m										
							1.00E+07 = N_{DEL}										
							2.00E+06 = N_{DC}										
							MAX: DCR 0.861 D 0.549										
TOWER PROFILE																	
JOINT	H_{CAN}	t	H_{CAN}	ELEV	ELEV	OD	t	S_x, S_y	SCF	$\Delta\sigma$	t_{USE}	Weld	$\Delta\sigma_{ALLOW}$	STRESS	DAMAGE	STATUS	
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(@ D_m)		(ksi)	(mm)	TRF	(ksi)	DCR	D		
								(in ³)				(-)		(-)	(-)		
1			7.218	321.522	98.000												
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715									0.8661	
3		2285	19.9	7.497	305.495	93.115	10.813									0.7835	
4		2285	19.8	7.497	297.999	90.830	10.833									0.7795	
5		2816	17.0	9.239	290.502	88.545	10.845									0.6693	
6		2816	17.4	9.239	281.263	85.729	10.870									0.6850	
7		2816	17.8	9.239	272.024	82.913	10.896									0.7008	
8		2816	18.2	9.239	262.785	80.097	10.923									0.7165	
9		2816	18.6	9.239	253.547	77.281	10.949									0.7323	
10		2816	19.2	9.239	244.308	74.465	10.976									0.7559	
11		2816	19.7	9.239	235.069	71.649	11.003									0.7756	
12		3033	20.3	9.951	225.830	68.833	11.029									0.7992	
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057									0.8228	
14		2298	21.5	7.539	207.963	63.387	11.059									0.8465	
15		2299	22.3	7.543	200.423	61.089	11.061									0.8780	
16		2930	23.8	9.613	192.881	58.790	11.064									0.9370	
17		2930	25.3	9.613	183.268	55.860	11.069									0.9961	
18		2930	26.8	9.613	173.655	52.930	11.074									1.0551	
19		2930	28.2	9.613	164.042	50.000	11.079									1.1102	
20		2930	29.7	9.613	154.429	47.070	11.083									1.1693	
21		2930	31.3	9.613	144.816	44.140	11.088									1.2323	
22		3130	32.7	10.269	135.203	41.210	11.094									1.2874	
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096									1.2598	
24		2819	28.7	9.249	115.026	35.060	11.311									1.1299	
25		2819	29.0	9.249	105.778	32.241	11.536									1.1417	
26		2819	28.7	9.249	96.529	29.422	11.762									1.1299	
27		2820	28.9	9.252	87.280	26.603	11.988									1.1378	
28		2818	29.2	9.245	78.028	23.783	12.214									1.1496	
29		2817	29.5	9.242	68.783	20.965	12.440									1.1614	
30		3028	34.8	9.934	59.541	18.148	12.667									1.3701	
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908									1.3543	
32		2505	35.3	8.219	40.682	12.400	12.908									1.3898	
33		2505	36.2	8.219	32.464	9.895	12.911									1.4252	
34		1500	52.4	4.921	24.245	7.390	12.914									2.0630	
35		2930	52.4	9.613	19.324	5.890	12.967									2.0630	
36		2760	52.4	9.055	9.711	2.960	12.967		38199	1.440	8.466	52.4	0.862	9.837	0.861	0.549	OK
37	BOT_FLG				0.656	0.200	12.967										

FATIGUE

BY: NAA

PAGE 12 OF 12

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/5/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASEL1 = Project										FATIGUE CASE 7: Doorway Max. SCF Estimate (Information Only)							
25-031		= Job No.															
0139-0349 VER 01 (2023.02.13)		= Loads Doc.								140 = DC							
VESTAS		= Turbine Make								N = Weld TRF? [Y or N]							
V163/V166-4.5MW Mk4A		= Turbine Model								J = Use which S? [J, A, or B]							
S		= IEC Site Class								1.250 = γ_{ref}							
98.000		= Hub Height (m)								1.030 = Load Factor							
A024-4468 ver. V01		= Tower Model								2.91 = SCF OEM value							
										4.000 = m							
										1.00E+07 = N_{DEL}							
										2.00E+06 = N_{DC}							
										MAX: DCR 0.971 D 0.888							
TOWER PROFILE																	
JOINT	H_{CAN}	t	H_{CAN}	ELEV	JOINT ELEV	OD	CAN t	S_x, S_y	SCF	$\Delta\sigma$	t_{USE}	Weld TRF	$\Delta\sigma_{ALLOW}$	STRESS DCR	DAMAGE D	STATUS	
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(@ D_m)		(ksi)	(mm)	(-)	(ksi)	(-)	(-)		
1			7.218	321.522	98.000												
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715		2.910								
3		2285	19.9	7.497	305.495	93.115	10.813		2.910								
4		2285	19.8	7.497	297.999	90.830	10.833		2.910								
5		2816	17.0	9.239	290.502	88.545	10.845		2.910								
6		2816	17.4	9.239	281.263	85.729	10.870		2.910								
7		2816	17.8	9.239	272.024	82.913	10.896		2.910								
8		2816	17.8	9.239	262.785	80.097	10.923		2.910								
9		2816	18.2	9.239	253.547	77.281	10.949		2.910								
10		2816	18.6	9.239	244.308	74.465	10.976		2.910								
11		2816	19.2	9.239	235.069	71.649	11.003		2.910								
12		2816	19.7	9.239	225.830	68.833	11.029		2.910								
13	SPLICE3	3033	20.3	9.951	215.879	65.800	11.057		2.910								
14		2413	20.9	7.917	207.963	63.387	11.059		2.910								
15		2298	21.5	7.539	200.423	61.089	11.061		2.910								
16		2299	22.3	7.543	192.881	58.790	11.064		2.910								
17		2930	23.8	9.613	183.268	55.860	11.069		2.910								
18		2930	25.3	9.613	173.655	52.930	11.074		2.910								
19		2930	26.8	9.613	164.042	50.000	11.079		2.910								
20		2930	28.2	9.613	154.429	47.070	11.083		2.910								
21		2930	29.7	9.613	144.816	44.140	11.088		2.910								
22		2930	31.3	9.613	135.203	41.210	11.094		2.910								
23	SPLICE2	3130	32.7	10.269	124.934	38.080	11.096		2.910								
24		3020	32.0	9.908	115.026	35.060	11.311		2.910								
25		2819	28.7	9.249	105.778	32.241	11.536		2.910								
26		2819	29.0	9.249	96.529	29.422	11.762		2.910								
27		2819	28.7	9.249	87.280	26.603	11.988		2.910								
28		2820	28.9	9.252	78.028	23.783	12.214		2.910								
29		2818	29.2	9.245	68.783	20.965	12.440		2.910								
30		2817	29.5	9.242	59.541	18.148	12.667		2.910								
31	SPLICE1	3028	34.8	9.934	49.606	15.120	12.908		2.910								
32		2720	34.4	8.924	40.682	12.400	12.908		2.910								
33		2505	35.3	8.219	32.464	9.895	12.911		2.910								
34		2505	36.2	8.219	24.245	7.390	12.914		2.910								
35		1500	52.4	4.921	19.324	5.890	12.967		2.910								
36		2930	52.4	9.613	9.711	2.960	12.967		2.910	61964	10.547	85.0	1.000	10.863	0.971	0.888	OK
37	BOT_FLG	2760	52.4	9.055	0.656	0.200	12.967		2.910								

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SECTION 4

DATE: December 7, 2025 (Rev. 0)

ASE JOB NO.: 25-031

PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

CONTENTS: **SECTION 4—TOWER SPLICE FLANGES AND BOLTS DESIGN**

General Notes.....	1
Splice Design Loads	2
Splice Strength and Fatigue Design.....	4

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TOWER SPLICE FLANGES AND BOLTS DESIGN

GENERAL NOTES

STRENGTH DESIGN

1. DEMAND

Design by the LRFD method is strength design and uses factored loads that include a design load factor.

1.1. Governing extreme loads are obtained from the turbine OEM's loads document.

1.2. The following load combination provides the maximum moment on the tower flanges:

$$U_{EX1} = 1.2D + W_{u,IEC}$$

where $W_{u,IEC}$ is a factored load that includes the IEC design load factor. Since the $P-\Delta$ moment amplification is maximized, the contribution to bolt tension from overturning moment is maximized.

1.3. The following load combination provides the minimum dead load on the tower flanges:

$$U_{EX2} = 0.9D + W_{u,IEC}$$

where $W_{u,IEC}$ is a factored load that includes the IEC design load factor. Since gravity load is minimized, the resistance to bolt tension from the counteracting dead load is minimized.

2. CAPACITY

The "capacity" values for comparison to or assessment of the demand values are calculated from the following:

2.1. Strength limit states from the Seidel Method, as is cited in RP2011 (AWEA, 2011).

2.2. Design strength from the AISC LRFD provisions (AISC, 2005, 2010, 2016).

3. DESIGN CRITERIA

See Section 1 of this calculation booklet for the description of design criteria.

FATIGUE DESIGN

4. FATIGUE

See the discussion in the tower shell fatigue calculations in Section 3 of this calculation booklet. Stress concentration factors are obtained either from the turbine OEM or by stress analysis. The following fatigue detail category (DC) is used:

Bolts: DC 36*

SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER
 ASE JOB NO.: 25-031 (GENERIC)

PAGE 1 OF 10
 DATE: 12/5/2025
 FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V	
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1	
2	TOWER GEOMETRY:																		
3	Tower top elevation	Htop	(ft)	314.304		314.304		314.304		314.304		314.304		314.304		314.304		314.304	
4	Splice elevation	Hspl	(ft)	314.304		215.879		124.934		49.606		314.304		215.879		124.934		49.606	
5																			
6	Wall thickness at splice	t	(mm)	22.0		20.3		32.0		34.4		22.0		20.3		32.0		34.4	
7	Wall mean diameter	Dwm	(mm)	3244		3350		3350		3900		3244		3350		3350		3900	
8	Wall outside diameter	Dwod	(mm)	3266		3370		3382		3934		3266		3370		3382		3934	
9	Wall inside diameter	Dwid	(mm)	3222		3330		3318		3866		3222		3330		3318		3866	
10	Bolt circle diameter	Dbc	(mm)	3100		3224		3147		3695		3100		3224		3147		3695	
11	Flange inside diameter	Dflg_id	(mm)	3010		3043		2863		3398		3010		3043		2863		3398	
12	Flange outside diameter	Dflg_od	(mm)	3268		3373		3391		3942		3268		3373		3391		3942	
13	Flange width	BF	(mm)	129.0		165.0		264.0		272.0		129.0		165.0		264.0		272.0	
14	Wall thickness at splice	t	(in)	0.866		0.799		1.260		1.354		0.866		0.799		1.260		1.354	
15	Wall mean diameter	Dwm	(in)	127.717		131.890		131.890		153.543		127.717		131.890		131.890		153.543	
16	Wall outside diameter	Dwod	(in)	128.583		132.689		133.150		154.898		128.583		132.689		133.150		154.898	
17	Wall inside diameter	Dwid	(in)	126.850		131.091		130.630		152.189		126.850		131.091		130.630		152.189	
18	Bolt circle diameter	Dbc	(in)	122.047		126.929		123.898		145.472		122.047		126.929		123.898		145.472	
19	Flange inside diameter	Dflg_id	(in)	118.504		119.803		112.717		133.780		118.504		119.803		112.717		133.780	
20	Flange outside diameter	Dflg_od	(in)	128.661		132.795		133.504		155.197		128.661		132.795		133.504		155.197	
21	Tower shell section modulus	S _{twr}	(in ³)	11096.170		10918.787		17211.881		25077.047		11096.170		10918.787		17211.881		25077.047	
22	Tower cross sectional area	A _{twr}	(in ²)	347.525		331.149		522.008		653.289		347.525		331.149		522.008		653.289	
23																			
24	TOWER SPLICE FACTORED LOADS:																		
25	(in GL Coordinate Axes)																		
26	Load Combination	LC		EX2=0.9D+W _u where W _u contains a load factor								EX1=1.2D+W _u where W _u contains a load factor							
27	Factored axial compression, i.e., Pu	Fuz	(kip)	453		551		690		831		608		740		925		1113	
28	Factored shear force, i.e., Vu	Fuxy	(kip-ft)	290		290		290		290		290		290		290		290	
29	Factored moment, i.e., Mu	Muxy	(kip-ft)	11693		35596		63342		87306		11693		35596		63342		87306	
30																			

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SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER
 ASE JOB NO.: 25-031 (GENERIC)

PAGE 2 OF 10
 DATE: 12/5/2025
 FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
31	TOWER TOP FATIGUE LOADS:																	
32	(in GL Coordinate Axes)																	
33	Fx Fatigue Damage Equivalent Load	Fx	(kip)	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000		0.0000		0.0000
34	Fy (Assumed out of phase)	Fy	(kip)	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A
35	Fz (Assumed out of phase)	Fz	(kip)	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A
36	Mx (Assumed out of phase)	Mx	(kip-ft)	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A
37	My Fatigue Damage Equivalent Load	My	(kip-ft)	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000		0.0000		0.0000
38	Mz (Assumed out of phase)	Mz	(kip-ft)	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A
39																		
40	Cycles for damage equivalent loads	n	(cycles)	1.0000E+07		1.0000E+07		1.0000E+07		1.0000E+07		1.0000E+07		1.0000E+07		1.0000E+07		1.0000E+07
41	rho, correlation coeff.	ρ		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000
42	Scaling factor	β		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000
43	Partial safety factor for fatigue strength	γ _{Mf}		1.250		1.250		1.250		1.250		1.250		1.250		1.250		1.250
44	Fatigue load factor	F _s		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000
45																		
46	MATERIAL SAFETY FACTORS:																	
47	Partial safety factor for material (yield)	γ _{My}		1.10		1.10		1.10		1.10		1.10		1.10		1.10		1.10
48	Partial safety factor for material (ultimate)	γ _{Mu}		1.25		1.25		1.25		1.25		1.25		1.25		1.25		1.25
49																		
50	WALL:																	
51	Wall steel yield stress	F _{y wall}	(ksi)	50.039		50.039		50.039		50.039		50.039		50.039		50.039		50.039
52	Wall steel elastic modulus	E _{wall}	(ksi)	29000		29000		29000		29000		29000		29000		29000		29000
53																		
54	FLANGES:																	
55	Flange steel yield stress	F _{y flg}	(ksi)	50.039		42.787		41.336		39.886		50.039		42.787		41.336		39.886
56	Flange steel elastic modulus	E _{flg}	(ksi)	29000		29000		29000		29000		29000		29000		29000		29000
57	Flange total height with weldneck	HT	(mm)	400		115		200		215		400		115		200		215

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SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA

PAGE 3 OF 10

PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
58	Flange thickness	TF	(mm)	200		85		150		165		200		85		150		165
59	Flange weldneck height	HWN	(mm)	200		30		50		50		200		30		50		50
60	Weldneck thickness	TWN	(mm)	24		23		41		42		24		23		41		42
61	Ration HWN/TWN	H/T	(-)	8.333		1.304		1.220		1.190		8.333		1.304		1.220		1.190
62	Flange width	BF	(mm)	129		165		264		272		129		165		264		272
63	Distance - protruding heel from wall	XA	(mm)	1		1		5		4		1		1		5		4
64	Distance - toe to bolt line	XB	(mm)	45		91		142		149		45		91		142		149
65	Distance - wall center to flange toe	XC	(mm)	117		154		244		251		117		154		244		251
66	Distance - wall face to bolt line	XD	(mm)	61.0		52.9		85.5		85.3		61.0		52.9		85.5		85.3
67	Flange Thickness	TF	(in)	7.874		3.346		5.906		6.496		7.874		3.346		5.906		6.496
68	Flange Width	BF	(in)	5.079		6.496		10.394		10.709		5.079		6.496		10.394		10.709
69	Distance - protruding heel from wall	XA	(in)	0.039		0.053		0.177		0.150		0.039		0.053		0.177		0.150
70	Distance - toe to bolt line	XB	(in)	1.772		3.563		5.591		5.846		1.772		3.563		5.591		5.846
71	Distance - wall center to flange toe	XC	(in)	4.606		6.043		9.587		9.882		4.606		6.043		9.587		9.882
72	Distance - wall face to bolt line	XD	(in)	2.402		2.081		3.366		3.358		2.402		2.081		3.366		3.358
73	Same as XB	ai	(in)	1.772		3.563		5.591		5.846		1.772		3.563		5.591		5.846
74	Distance - wall center to bolt line	b	(in)	2.835		2.480		3.996		4.035		2.835		2.480		3.996		4.035
75	Trib. width per bolt @ wall centerline	L _{t_wm}	(in)	3.344		3.572		5.755		5.743		3.344		3.572		5.755		5.743
76	Trib. width per bolt @ inside wall face	L _{t_iwf}	(in)	3.321		3.550		5.700		5.692		3.321		3.550		5.700		5.692
77	Trib. width per bolt @ bolt circle	L _{t_bc}	(in)	3.195		3.438		5.406		5.441		3.195		3.438		5.406		5.441
78	Flange S @ L _{t_iwf}	S _{t_iwf}	(in ³)	34.316		6.626		33.130		40.032		34.316		6.626		33.130		40.032
79	Flange S @ L _{t_bc} minus bolt hole	S _{t_bc}	(in ³)	19.592		3.109		14.260		17.498		19.592		3.109		14.260		17.498
80	Flange Z @ L _{t_bc} minus bolt hole	Z _{t_bc}	(in ³)	29.388		4.664		21.390		26.247		29.388		4.664		21.390		26.247
81	Flange I @ L _{t_wm}	I _{t_wm}	(in ⁴)	136.026		11.155		98.769		131.181		136.026		11.155		98.769		131.181
82	METHOD - VOID/FOR REFERENCE ONLY																	
83	Compression radius	R _{comp}	(in)	8.976		4.882		8.366		8.957		8.976		4.882		8.366		8.957
84	Status: R _{comp} exceeds L _{t_bc} /2 ?			Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes
85	Status: R _{comp} exceeds XB ?			Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes
86	Status: R _{comp} exceeds BF-XB ?			Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes
87	Flange area under compression (Use flange area if R _{comp} exceeds all the above dimensions)	A	(in ²)	16.228		22.331		56.189		58.262		16.228		22.331		56.189		58.262
88	Correction (reduction) to area	A _{Abzug}	(in ²)	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000
89	Reduced flange compression area	A _{ERS}	(in ²)	16.228		22.331		56.189		58.262		16.228		22.331		56.189		58.262
90	Substitution diameter	D _{ERS}	(in)	4.545		5.332		8.458		8.613		4.545		5.332		8.458		8.613
91	Flange substitution area	ADI ₁	(in ²)	10.331		12.247		31.063		32.396		10.331		12.247		31.063		32.396

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SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
92	FLANGES (Continued):																	
93	METHOD PER R.C. JUVINALL - FOR REFERENCE ONLY																	
94	Bolt hole diameter	d_1	(in)	1.299		1.772		2.953		2.953		1.299		1.772		2.953		2.953
95	$1.5*d_{bolt}$ (approximate)	d_2	(in)	1.772		2.480		4.252		4.252		1.772		2.480		4.252		4.252
96	$d_2 + t_f*\tan(30 \text{ deg})$	d_3	(in)	8.054		4.792		14.497		15.947		8.054		4.792		14.497		15.947
97	Flange substitution area	AD_{1_2}	(in ²)	17.631		7.920		62.176		73.263		17.631		7.920		62.176		73.263
98	METHOD PER J.E. SHIGLEY - FOR REFERENCE ONLY																	
99	Select α_{shig} as average of 30-45 deg.	α_{shig}	degrees	37.500		37.500		37.500		37.500		37.500		37.500		37.500		37.500
100	$\tan(\alpha_{shig})$			0.767		0.767		0.767		0.767		0.767		0.767		0.767		0.767
101	$2*TF*\tan(\alpha_{shig}) + d_2$			13.856		7.616		13.315		14.221		13.856		7.616		13.315		14.221
102	Flange substitution area	AD_{1_3}	(in ²)	14.647		10.845		33.310		35.800		14.647		10.845		33.310		35.800
103	METHOD - SIMPLIFIED																	
104	Half-apex Radius	α	(deg)	45.000		45.000		45.000		45.000		45.000		45.000		45.000		45.000
105	Compression Radius	R_{comp}	(in)	8.976		4.882		8.366		8.957		8.976		4.882		8.366		8.957
106	Hole to Heel Corner Distance	r_1	(in)	3.673		3.400		5.511		5.571		3.673		3.400		5.511		5.571
107	Hole to Toe Corner Distance	r_2	(in)	2.386		3.956		6.210		6.448		2.386		3.956		6.210		6.448
108	Hole to Side Distance	r_3	(in)	1.598		1.719		2.703		2.720		1.598		1.719		2.703		2.720
109	Determine width of comp. area	W_{ca}	(in)	3.195		3.438		5.406		5.441		3.195		3.438		5.406		5.441
110	Determine heel dist. of comp. area	L_1	(in)	3.307		2.933		4.803		4.862		3.307		2.933		4.803		4.862
111	Determine toe dist. of comp. area	L_2	(in)	1.772		3.563		5.591		5.846		1.772		3.563		5.591		5.846
112	Length of comp. area	L_{ca}	(in)	5.079		6.496		10.394		10.709		5.079		6.496		10.394		10.709
113	Comp. area not reduced for hole	A	(in ²)	16.228		22.331		56.189		58.262		16.228		22.331		56.189		58.262
114	Effective diameter of comp. area A	D_{eff}	(in)	4.545		5.332		8.458		8.613		4.545		5.332		8.458		8.613
115	Average diameter of comp. cylinder	D_{cyl}	(in)	3.375		4.202		6.690		6.767		3.375		4.202		6.690		6.767
116	Subtraction area of bolt hole	$A_{bolthole}$	(in ²)	1.326		2.465		6.848		6.848		1.326		2.465		6.848		6.848
117	Flange substitution area	AD_{1_4}	(in ²)	7.621		11.399		28.301		29.118		7.621		11.399		28.301		29.118
118																		
119	Area for flange spring stiffness (select from AD ₁ ; above)	$AD_{1_{USE}}$	(in ²)	7.621		11.399		28.301		29.118		7.621		11.399		28.301		29.118
120																		

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SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER
 ASE JOB NO.: 25-031 (GENERIC)

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 DATE: 12/5/2025
 FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
121	BOLTS:			M30		M42		M72		M72		M30		M42		M72		M72
122	Bolt spacing	S	(dbolt)	2.71		2.08		1.91		1.92		2.71		2.08		1.91		1.92
123	Total number of bolts	nbolt		120		116		72		84		120		116		72		84
124	Bolt diameter	dbolt	(in)	1.181		1.654		2.835		2.835		1.181		1.654		2.835		2.835
125	Bolt threads per inch	n		Override		Override		Override		Override		Override		Override		Override		Override
126	Bolt hole diameter	dhole	(in)	1.299		1.772		2.953		2.953		1.299		1.772		2.953		2.953
127	Bolt type			Grade 10.9		Grade 10.9		Grade 10.9		Grade 10.9		Grade 10.9		Grade 10.9		Grade 10.9		Grade 10.9
128	Bolt yield stress	Fyb	(ksi)	130.536		130.536		130.536		130.536		130.536		130.536		130.536		130.536
129	Bolt ultimate stress	Fub	(ksi)	145.040		145.040		145.040		145.040		145.040		145.040		145.040		145.040
130	Bolt pretension	Fpret	(kip)	78.684		159.615		490.086		490.086		78.684		159.615		490.086		490.086
131	Pretension reduction factor	f _{VG}		0.950		0.950		0.950		0.950		0.950		0.950		0.950		0.950
132	Actual bolt pretension = f _{VG} *F _{pret}	F _{pret RED}	(kip)	74.749		151.634		465.582		465.582		74.749		151.634		465.582		465.582
133	Bolt Tensile Strength (LRFD Table J3.2)	Ft	(ksi)	113		113		113		113		113		113		113		113
134	Bolt gross area	Ag	(in ²)	1.096		2.147		6.311		6.311		1.096		2.147		6.311		6.311
135	Bolt tensile stress area	Ats	(in ²)	0.870		1.736		5.363		5.363		0.870		1.736		5.363		5.363
136	Spacing in bolt diameters	S	(dbolt)	2.705		2.079		1.907		1.919		2.705		2.079		1.907		1.919
137	WASHERS:																	
138	Washer outside diameter	Dod_w	(in)	2.205		3.071		4.921		4.921		2.205		3.071		4.921		4.921
139	Washer hole diameter	Did_w	(in)	1.220		1.693		2.913		2.913		1.220		1.693		2.913		2.913
140	Washer thickness	t_w	(in)	0.197		0.315		0.394		0.394		0.197		0.315		0.394		0.394
141	Washer E	E_w	(ksi)	30458		30458		30458		30458		30458		30458		30458		30458
142	Washer area	A_w	(in ²)	2.648		5.156		12.355		12.355		2.648		5.156		12.355		12.355
143																		
144	EFFECTIVE SPRING DATA:																	
145	Stiffness of one washer	km_w	(kip/in)	409687		498571		955843		955843		409687		498571		955843		955843
146	Stiffness of one flange plate	km_f	(kip/in)	28068		98786		138977		129991		28068		98786		138977		129991
147	Stiffness of total members in grip	km	(kip/in)	13134		41225		60668		57214		13134		41225		60668		57214
148	Stiffness of bolt	kb	(kip/in)	1968		8504		14527		13282		1968		8504		14527		13282
149	Total spring stiffness = kb + km	C	(kip/in)	15103		49729		75194		70496		15103		49729		75194		70496
150	Portion taken by bolt = kb/(kb+km)	p		0.130		0.171		0.193		0.188		0.130		0.171		0.193		0.188
151	Part taken by members=km/(kb+km)	q		0.870		0.829		0.807		0.812		0.870		0.829		0.807		0.812
152	Verify that (p+q) = 1.0	p+q		1.0000		1.0000		1.0000		1.0000		1.0000		1.0000		1.0000		1.0000
153																		

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SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER
 ASE JOB NO.: 25-031 (GENERIC)

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 DATE: 12/5/2025
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	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V	
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1	
154	CHECK BOLT FATIGUE:	SEE SEPARATE ATTACHED CALCULATIONS																	
155	Detail Category (for bolt tension)	DC	(N/mm ²)	36		36		36		36		36		36		36		36	
156	S-N curve slope (inverted)	m		4		4		4		4		4		4		4		4	
157	Ref. value of fatigue strength @ 2e6	$\Delta\sigma_C$	(ksi)	5.221		5.221		5.221		5.221		5.221		5.221		5.221		5.221	
158	Reduction for Bolt Diam. > 30 mm	C_{red}		1.000		0.919		0.803		0.803		1.000		0.919		0.803		0.803	
159	$\Delta\sigma_C C_{red}/F_m$ @ 2e6 cycles	$\Delta\sigma_C/F_m$	(ksi)	4.177		3.840		3.356		3.356		4.177		3.840		3.356		3.356	
160	$\Delta\sigma_C C_{red}/F_m$ @ n cycles	$\Delta\sigma/F_m$	(ksi)	2.793		2.568		2.244		2.244		2.793		2.568		2.244		2.244	
161																			
162	Vertical moment arm to tower top	z	(ft)	0.000		98.425		189.370		264.698		0.000		98.425		189.370		264.698	
163	M_Equation(z, Mtx, Fty, p, β)*Fs or from loads document	$M(z)$	(kip-ft)	5533		6764		10636		15504		5533		6764		10636		15504	
164	M_Equation(z, Mtx, Fty, r, b)*Fs or from loads document	$M(z)$	(kip-in)	66399		81168		127631		186043		66399		81168		127631		186043	
165	Wall bending stress = M/S	fb	(ksi)	5.984		7.434		7.415		7.419		5.984		7.434		7.415		7.419	
166	Wall fatigue stress	$\Delta\sigma_{wall}$	(ksi)	5.984		7.434		7.415		7.419		5.984		7.434		7.415		7.419	
167	Wall tributary area	A_{t_w}	(in ²)	2.896		2.855		7.250		7.777		2.896		2.855		7.250		7.777	
168	Wall trib. fatigue force	T_{wall}	(kip)	17.330		21.222		53.762		57.698		17.330		21.222		53.762		57.698	
169	Force Transfer Factor (wall to bolt)	FTF_{fat}		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000	
170	Applied bolt fatigue force	T_{ba}	(kip)	17.330		21.222		53.762		57.698		17.330		21.222		53.762		57.698	
171	Fatigue force seen by bolt = p*T_ba	T_{bolt}	(kip)	2.259		3.629		10.386		10.871		2.259		3.629		10.386		10.871	
172	Fatigue stress in bolt = T_{bolt}/A_{ts}	$\Delta\sigma_{bolt}$	(ksi)	2.598		2.091		1.937		2.027		2.598		2.091		1.937		2.027	
173	N @ $\Delta\sigma_{bolt}$	N	(cycles)	13375935		22771831		18036269		15030491		13375935		22771831		18036269		15030491	
174	Verify Schmidt/Neuper Model C Zone I:																		
175	Geometry factor	λ^*		3.286		1.994		2.021		1.986		3.286		1.994		2.021		1.986	
176	Model C, Zone I limit	Z_I	(kip)	5.750		58.283		174.474		180.390		5.750		58.283		174.474		180.390	
177	Model C, Zone II limit	Z_{II}	(kip)	26.159		91.711		285.516		288.845		26.159		91.711		285.516		288.845	
178	STATUS: $T_{ba} \leq Z_I$			OVER		Zone I: OK		Zone I: OK		Zone I: OK		OVER		Zone I: OK		Zone I: OK		Zone I: OK	
179																			
180	$R = DCR \sigma = (dS_b * Fs) / (dS @ N / F_m)$	R		0.930		0.814		0.863		0.903		0.930		0.814		0.863		0.903	
181	APPROXIMATE D = Damage = n/N	D		0.748		0.439		0.554		0.665		0.748		0.439		0.554		0.665	
182	STATUS: $D \leq 1.0$			≤ 1.0 Okay		≤ 1.0 Okay		≤ 1.0 Okay		≤ 1.0 Okay		≤ 1.0 Okay		≤ 1.0 Okay		≤ 1.0 Okay		≤ 1.0 Okay	
183	NOTE: The fatigue check by damage equivalent load is APPROXIMATE only and FOR REFERENCE ONLY.																		
184	Fatigue check by Miner damage summation shall represent final calculation results.																		
185																			

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

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	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
186	CHECK BOLT AT FACTORED LOAD: (per AISC LRFD standard)																	
187	CHECK SHEAR:																	
188	Resistance factor (bolt in shear)	ϕ_v		0.750		0.750		0.750		0.750		0.750		0.750		0.750		0.750
189	Nom. bolt shear strength = 0.563Fu	Fv	(ksi)	81.658		81.658		81.658		81.658		81.658		81.658		81.658		81.658
190	Bolt factored shear force	V_{u_bolt}	(kip)	2.414		2.497		4.023		3.449		2.414		2.497		4.023		3.449
191	Design shear strength = $\phi F_v A_b$	ϕV_{n_bolt}	(kip)	67.100		131.516		386.496		386.496		67.100		131.516		386.496		386.496
192	STATUS: DCR <= 1.0			0.036		0.019		0.010		0.009		0.036		0.019		0.010		0.009
193	CHECK TENSION:																	
194	Resistance factor (bolt in tension)	ϕ_T		0.750		0.750		0.750		0.750		0.750		0.750		0.750		0.750
195	Factored bolt shear stress = V_{u_bolt}/A_b	f_{uV}	(ksi)	2.203		1.163		0.638		0.546		2.203		1.163		0.638		0.546
196	Nom. bolt tension strength = $f_t A_b$ See LRFD Equation J3-3a	Ft	(ksi)	113.000		113.000		113.000		113.000		113.000		113.000		113.000		113.000
197	-Fuz/A + Muxy/S [(+)=Tension]	f_{tT}	(ksi)	11.344		37.456		42.840		40.505		10.896		36.887		42.390		40.074
198	Wall factored tension force	T_{u_wall}	(kip)	32.851		106.928		310.596		315.019		31.554		105.303		307.336		311.663
199	Force transfer factor = XC/XB	FTF _{ext}		2.600		1.696		1.715		1.690		2.600		1.696		1.715		1.690
200	Bolt factored tension force	T_{u_bolt}	(kip)	85.414		181.364		532.607		532.457		82.041		178.608		527.016		526.783
201	Design tension strength = $\phi F_t A_b$	ϕT_n	(kip)	92.855		181.996		534.844		534.844		92.855		181.996		534.844		534.844
202	STATUS: DCR <= 1.0			0.920		0.997		0.996		0.996		0.884		0.981		0.985		0.985
203	CHECK FLANGE IN BENDING: (per AISC LRFD standard)																	
204	Resistance factor (flexure)	ϕ_b		0.900		0.900		0.900		0.900		0.900		0.900		0.900		0.900
205	Flange yield moment = $F_{y_flg} S_{t_bc}$	My	(kip-in)	980.350		133.041		589.450		697.915		980.350		133.041		589.450		697.915
206	Flange plastic moment = $F_{y_flg} Z_{t_bc}$	Mp	(kip-in)	1470.525		199.562		884.175		1046.873		1470.525		199.562		884.175		1046.873
207	Nom. moment strength = $\min[Mp, 1.5My]$	Mn	(kip-in)	1470.525		199.562		884.175		1046.873		1470.525		199.562		884.175		1046.873
208	Factored moment = $b T_{u_wall}$	Mu1	(kip-in)	93.122		265.216		1241.162		1271.239		89.445		261.185		1228.133		1257.694
209	Factored moment = $D_{arm} T_{u_bolt}$	Mu2	(kip-in)	36.150		107.105		516.356		516.211		34.722		105.477		510.935		510.710
210	Factored moment = $Mu1 - Mu2$	Mu	(kip-in)	56.973		158.111		724.806		755.029		54.723		155.708		717.197		746.984
211	Design moment strength (based on Z minus bolt hole)	ϕMn	(kip-in)	1323.473		179.605		795.757		942.186		1323.473		179.605		795.757		942.186
212	STATUS: DCR $Mu/\phi Mn <= 1.0$			0.043		0.880		0.911		0.801		0.041		0.867		0.901		0.793
213	Flange yield moment = $F_{y_flg} S_{flg}$	My	(kip-in)	1652.132		274.525		1298.904		1526.234		1652.132		274.525		1298.904		1526.234
214	Flange plastic moment = $F_{y_flg} Z_{flg}$	Mp	(kip-in)	2478.198		411.788		1948.355		2289.350		2478.198		411.788		1948.355		2289.350
215	Design moment strength (based on Zgross)	ϕMn	(kip-in)	2230.378		370.609		1753.520		2060.415		2230.378		370.609		1753.520		2060.415
216	Factored moment = $b'_E T_{u_wall}$	Mu	(kip-in)	65.315		138.922		638.923		660.424		62.736		136.811		632.216		653.387
217	STATUS: DCR $Mu/\phi Mn <= 1.0$			0.029		0.375		0.364		0.321		0.028		0.369		0.361		0.317
218																		
219	GOVERNING FLG LRFD DCR			0.043		0.880		0.911		0.801		0.041		0.867		0.901		0.793

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SPLICE STRENGTH-FATIGUE DESIGN

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER
 ASE JOB NO.: 25-031 (GENERIC)

PAGE 8 OF 10
 DATE: 12/5/2025
 FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
220	NOT USED																	
252																		

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SPLICE STRENGTH-FATIGUE DESIGN

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	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
253	NOT USED																	
278																		

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SPLICE STRENGTH-FATIGUE DESIGN

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T	U	V
1	NOMENCLATURE		UNITS	SPLICE TOP		FLG-3		FLG-2		FLG-1		SPLICE TOP		FLG-3		FLG-2		FLG-1
279	DCR SUMMARY:																	
280																		
281	FATIGUE CHECKS:																	
282	FATIGUE DAMAGE by DEL	Ddel		0.748		0.439		0.554		0.665								
283	FATIGUE DAMAGE by Miners Rule	Dsum		0.047		0.731		0.806		0.851								
284	FATIGUE DAMAGE: D <= 1.0			<= 1.0 Okay		<= 1.0 Okay		<= 1.0 Okay		<= 1.0 Okay								
285																		
286	LOAD COMBINATION	LC		EX2=0.9D+Wu where Wu contains a load factor							EX1=1.2D+Wu where Wu contains a load factor							
287																		
288	AISC LRFD CHECKS:																	
289	LRFD BOLT SHEAR: DCR <= 1.0			0.036		0.019		0.010		0.009		0.036		0.019		0.010		0.009
290	LRFD BOLT TENSION: DCR <= 1.0			0.920		0.997		0.996		0.996		0.884		0.981		0.985		0.985
291	LRFD FLANGE: DCR $\frac{M_u}{M_n} \leq 1.0$			0.043		0.880		0.911		0.801		0.041		0.867		0.901		0.793
292	SEIDEL FAILURE MODES:			0.811		0.983		0.941		0.943		0.778		0.968		0.931		0.933
302																		
303																		

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FLG TOP

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	CHECK SPLICE BOLT FATIGUE BY MINER DAMAGE SUMMATION																		
2	0.047 = D = DAMAGE = $\sum n_i/N_i$						120 = nbolts	25.58 = Z1				1.250 = F_M							
3							1622 = rm (mm)	116.36 = Z2				1.0000 = C_{red} for Bolt Size Reduction Factor							
4											116.36 = Z2 OVERRIDE				23.28 = $\Delta\sigma_D$ @ Detail Category 36* @N=1E7				
5							2265 = Fz, Actual Dead (kN)				0.870 = q				with no adjustment factors				
6							(conservative to ignore)				0.130 = p								
7											333 = F_{pret_RED} (kN)								
8											3.29 = λ^*								
9	1.2317 = Extra Load Factor to										561 = Asp Bolt (mm2)								
10	calibrate with Loads Doc DEL																		
11																			
12	Level	MRange	MMean	n _i	MMin	MMax	Zmin	Zmax	Fs,Min	Fs,Max	ΔFs	Zone	Δσs	m	log(a)	Ni	n _i /N _i	$\sum n_i/N_i$	
13	[-]	[kNm]	[kNm]	[-]	[kNm]	[kNm]	[kN]	[kN]	[kN]	[kN]	[kN]		[N/mm2]						
14	1	0	-5868	3.3E-02	-5868	-5868	-79.2	-79.2	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
15	2	0	-5572	3.9E-01	-5572	-5572	-76.1	-76.1	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
16	3	322	-5275	1.2E+01	-5436	-5114	-74.7	-71.4	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
17	4	0	-5275	1.7E+00	-5275	-5275	-73.1	-73.1	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
18	5	0	-4979	6.2E+00	-4979	-4979	-70.0	-70.0	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
19	6	965	-4683	3.9E-01	-5165	-4200	-72.0	-62.0	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
20	7	643	-4683	7.7E+01	-5004	-4361	-70.3	-63.7	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
21	8	0	-4683	5.3E+03	-4683	-4683	-67.0	-67.0	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
22	9	643	-4386	3.9E-01	-4708	-4065	-67.3	-60.6	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
23	10	322	-4386	5.3E+02	-4547	-4226	-65.6	-62.3	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
24	11	0	-4386	7.3E+03	-4386	-4386	-64.0	-64.0	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
25	12	5468	-4090	1.3E+00	-6824	-1356	-89.0	-32.8	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
26	13	4181	-4090	2.7E+00	-6181	-1999	-82.4	-39.4	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
27	14	1287	-4090	2.8E+00	-4733	-3447	-67.5	-54.3	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
28	15	965	-4090	7.4E-01	-4573	-3608	-65.9	-55.9	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
29	16	643	-4090	1.1E+03	-4412	-3768	-64.2	-57.6	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
30	17	322	-4090	4.9E+03	-4251	-3929	-62.6	-59.3	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
31	18	0	-4090	3.2E+04	-4090	-4090	-60.9	-60.9	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
32	19	4181	-3794	1.3E+00	-5885	-1703	-79.3	-36.4	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
33	20	3860	-3794	7.6E+01	-5724	-1864	-77.7	-38.0	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
34	21	2895	-3794	1.1E+03	-5241	-2346	-72.7	-43.0	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
35	22	2573	-3794	7.6E+01	-5080	-2507	-71.1	-44.6	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
36	23	2252	-3794	1.0E+03	-4920	-2668	-69.4	-46.3	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
37	24	1287	-3794	1.0E+03	-4437	-3150	-64.5	-51.3	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
38	25	965	-3794	6.6E-02	-4276	-3311	-62.8	-52.9	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
39	26	643	-3794	3.0E+03	-4115	-3472	-61.2	-54.6	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
40	27	322	-3794	1.9E+04	-3955	-3633	-59.5	-56.2	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
41	28	0	-3794	1.5E+05	-3794	-3794	-57.9	-57.9	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
16401	16388	0	0	0.0E+00	0	0	-18.9	-18.9	333	333	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0467	

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BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER
 ASE JOB NO.: 25-031 (GENERIC)

PAGE 2 OF 4
 DATE: 12/5/2025
 FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	CHECK SPLICE BOLT FATIGUE BY MINER DAMAGE SUMMATION																		
2	0.731	= D = DAMAGE = $\sum n_i/N_i$					116	= nbolts	259.25	= Z1				1.250	= F_M				
3							1675	= rm (mm)	407.95	= Z2				0.9193	= C_{red} for Bolt Size Reduction Factor				
4									407.95	= Z2 OVERRIDE				23.28	= $\Delta\sigma_D$ @ Detail Category 36* @N=1E7				
5					0	= Fz, Actual Dead (kN)			0.829	= q					with no adjustment factors				
6						(conservative to ignore)			0.171	= p									
7									675	= F_{pret_RED} (kN)									
8									1.99	= λ^*									
9		1.2232	= Extra Load Factor to							1120	= Asp Bolt (mm2)								
10			calibrate with Loads Doc DEL																
11																			
12	Level	MRange	MMean	n _i	MMin	MMax	Zmin	Zmax	Fs,Min	Fs,Max	ΔFs	Zone	Δσs	m	log(a)	Ni	n _i /N _i	Σn _i /N _i	
13	[-]	[kNm]	[kNm]	[-]	[kNm]	[kNm]	[kN]	[kN]	[kN]	[kN]	[kN]		[N/mm2]						
14	1	1087	-15630	2.7E+00	-16174	-15086	-166.5	-155.3	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
15	2	0	-13651	5.3E+00	-13651	-13651	-140.5	-140.5	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
16	3	1087	-12662	5.3E+00	-13206	-12118	-135.9	-124.7	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
17	4	0	-12662	4.7E+01	-12662	-12662	-130.3	-130.3	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
18	5	0	-11673	1.0E+01	-11673	-11673	-120.2	-120.2	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
19	6	2174	-10683	2.7E+00	-11770	-9596	-121.2	-98.8	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
20	7	1087	-10683	8.8E+00	-11227	-10139	-115.6	-104.4	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
21	8	0	-10683	1.4E+01	-10683	-10683	-110.0	-110.0	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
22	9	7610	-9694	2.7E+00	-13499	-5889	-138.9	-60.6	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
23	10	1087	-9694	8.8E+00	-10237	-9150	-105.4	-94.2	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
24	11	0	-9694	4.7E+01	-9694	-9694	-99.8	-99.8	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
25	12	22829	-8704	1.3E+00	-20119	2710	-207.1	27.9	675	679	4.8	I	5.8	5	13.835	1.05E+10	0.0000	0.0000	
26	13	18481	-8704	1.3E+00	-17945	536	-184.7	5.5	675	675	0.9	I	1.1	5	13.835	3.47E+13	0.0000	0.0000	
27	14	16307	-8704	1.3E+00	-16858	-551	-173.5	-5.7	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
28	15	15219	-8704	1.3E+00	-16314	-1095	-167.9	-11.3	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
29	16	2174	-8704	7.0E+00	-9791	-7617	-100.8	-78.4	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
30	17	1087	-8704	2.2E+01	-9248	-8161	-95.2	-84.0	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
31	18	0	-8704	4.1E+01	-8704	-8704	-89.6	-89.6	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
32	19	16307	-7715	2.7E+00	-15868	439	-163.3	4.5	675	675	0.8	I	0.9	5	13.835	9.46E+13	0.0000	0.0000	
33	20	7610	-7715	2.7E+00	-11520	-3910	-118.6	-40.2	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
34	21	3261	-7715	2.7E+00	-9346	-6084	-96.2	-62.6	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
35	22	2174	-7715	5.3E+00	-8802	-6628	-90.6	-68.2	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
36	23	1087	-7715	5.8E+01	-8258	-7171	-85.0	-73.8	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
37	24	0	-7715	4.2E+02	-7715	-7715	-79.4	-79.4	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
38	25	15219	-6726	5.3E+00	-14335	884	-147.6	9.1	675	676	1.6	I	1.9	5	13.835	2.84E+12	0.0000	0.0000	
39	26	11958	-6726	3.1E+00	-12705	-746	-130.8	-7.7	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
40	27	7610	-6726	2.7E+00	-10530	-2921	-108.4	-30.1	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
41	28	5435	-6726	2.7E+00	-9443	-4008	-97.2	-41.3	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
16401	16388	0	0	0.0E+00	0	0	0.0	0.0	675	675	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.7311	

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BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/5/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 03_SpliceDesign_2016-03-12.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	CHECK SPLICE BOLT FATIGUE BY MINER DAMAGE SUMMATION																		
2	0.806	= D = DAMAGE = $\sum n_i/N_i$					72	= nbolts	776.09	= Z1			1.250	= F_M					
3							1675	= rm (mm)	1270.03	= Z2			0.8034	= C_{red} for Bolt Size Reduction Factor					
4									1270.03	= Z2 OVERRIDE			23.28	= $\Delta\sigma_D$ @ Detail Category 36* @N=1E7					
5										0.807	= q			with no adjustment factors					
6										0.193	= p								
7										2071	= $F_{pret RED}$ (kN)								
8										2.02	= λ^*								
9		1.2288	= Extra Load Factor to								3460	= Asp Bolt (mm2)							
10			calibrate with Loads Doc DEL																
11																			
12	Level	MRange	MMean	n _i	MMin	MMax	Zmin	Zmax	Fs,Min	Fs,Max	ΔFs	Zone	Δσs	m	log(a)	Ni	n _i /N _i	Σn _i /N _i	
13	[-]	[kNm]	[kNm]	[-]	[kNm]	[kNm]	[kN]	[kN]	[kN]	[kN]	[kN]		[N/mm2]						
14	1	0	-21864	2.7E+00	-21864	-21864	-362.6	-362.6	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
15	2	0	-20128	1.1E+01	-20128	-20128	-333.8	-333.8	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
16	3	0	-18391	3.5E+00	-18391	-18391	-305.0	-305.0	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
17	4	0	-16655	1.1E+01	-16655	-16655	-276.2	-276.2	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
18	5	35221	-14919	1.3E+00	-32530	2692	-539.5	44.6	2071	2080	8.6	I	3.9	5	13.835	7.80E+10	0.0000	0.0000	
19	6	0	-14919	5.6E+01	-14919	-14919	-247.4	-247.4	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
20	7	41091	-13183	1.3E+00	-33728	7362	-559.3	122.1	2071	2095	23.6	I	10.6	5	13.835	5.09E+08	0.0000	0.0000	
21	8	29350	-13183	1.3E+00	-27858	1492	-462.0	24.7	2071	2076	4.8	I	2.1	5	13.835	1.49E+12	0.0000	0.0000	
22	9	27394	-13183	1.3E+00	-26880	514	-445.8	8.5	2071	2073	1.6	I	0.7	5	13.835	3.07E+14	0.0000	0.0000	
23	10	13697	-13183	5.3E+00	-20031	-6335	-332.2	-105.1	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
24	11	5870	-13183	2.7E+00	-16118	-10248	-267.3	-169.9	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
25	12	3913	-13183	3.5E+00	-15140	-11226	-251.1	-186.2	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
26	13	0	-13183	2.8E+01	-13183	-13183	-218.6	-218.6	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
27	14	31307	-11446	2.7E+00	-27100	4208	-449.4	69.8	2071	2084	13.5	I	6.1	5	13.835	8.36E+09	0.0000	0.0000	
28	15	29350	-11446	2.7E+00	-26121	3229	-433.2	53.5	2071	2081	10.3	I	4.7	5	13.835	3.14E+10	0.0000	0.0000	
29	16	27394	-11446	1.3E+00	-25143	2251	-417.0	37.3	2071	2078	7.2	I	3.2	5	13.835	1.91E+11	0.0000	0.0000	
30	17	11740	-11446	2.7E+00	-17316	-5576	-287.2	-92.5	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
31	18	1957	-11446	7.0E+00	-12424	-10468	-206.0	-173.6	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
32	19	0	-11446	3.1E+02	-11446	-11446	-189.8	-189.8	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
33	20	29350	-9710	2.7E+00	-24385	4965	-404.4	82.3	2071	2087	15.9	I	7.2	5	13.835	3.65E+09	0.0000	0.0000	
34	21	23480	-9710	4.4E+00	-21450	2030	-355.7	33.7	2071	2078	6.5	I	2.9	5	13.835	3.20E+11	0.0000	0.0000	
35	22	19567	-9710	1.3E+00	-19494	73	-323.3	1.2	2071	2071	0.2	I	0.1	5	13.835	5.26E+18	0.0000	0.0000	
36	23	11740	-9710	6.2E+00	-15580	-3840	-258.4	-63.7	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
37	24	9783	-9710	8.8E+00	-14602	-4818	-242.2	-79.9	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
38	25	7827	-9710	2.7E+00	-13624	-5797	-225.9	-96.1	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
39	26	5870	-9710	3.5E+00	-12645	-6775	-209.7	-112.4	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
40	27	3913	-9710	2.9E+01	-11667	-7754	-193.5	-128.6	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
41	28	1957	-9710	2.5E+01	-10689	-8732	-177.3	-144.8	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.0000	
16401	16388	0	0	0.0E+00	0	0	0.0	0.0	2071	2071	0.0	I	0.0	5	13.835	1.00E+99	0.0000	0.8059	

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SECTION 5

DATE: December 7, 2025 (Rev. 0)

ASE JOB NO.: 25-031

PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

CONTENTS: **SECTION 5—TOWER BASE FLANGE DESIGN**

General Notes.....	1
Tower Base Design Loads	[See Section 4]
DCR Summary.....	3
Base Plate Design	9

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TOWER BASE FLANGE DESIGN

GENERAL NOTES

SCOPE

The scope of the steel tower design includes the steel tower base flange. All other components including reinforced concrete, items embedded in concrete, and grout are by others and fall within the foundation designer’s scope of work. See the table below.

ITEM	DESIGN SCOPE	
	TOWER	FOUNDATION
Tower base flange	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Anchor Rods (Anchor bolts) embedded in concrete	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Anchor plate embedded in concrete	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Foundation reinforced concrete	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Grout beneath the tower base flange	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Load spreading/distribution (bearing) plate, if any	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Table 5-1. Items and Their Design Scope

However, the tower base flange design effectively sets design limits such as the total number of anchor rods, the size of holes as a limit to the anchor rod diameter that can be accommodated, and the amount of bearing area at the base flange contact surface. For this reason, additional calculations are performed to ensure that the provided tower base flange geometry does have at least one feasible anchorage solution considering the tower base loads and typically available anchor options.



These additional calculations for items in the foundation design scope and not included in the tower design scope are for “information only.” The results most likely are not coordinated with the foundation designer’s results, and need not be. For items under the foundation design scope as indicated in the Table above, the foundation design by others shall govern, and these “information only” calculations may be ignored.

STRENGTH DESIGN

1. DEMAND

Design by the LRFD method is strength design and uses factored loads that include a design load factor.

1.1. Governing extreme loads are obtained from the turbine OEM’s loads document.

1.2. The following load combinations are considered:

1.2.1. For strength design:

$(0.9 \text{ or } 1.2)D + 1.2(PT_{max})$ at initial PT jacking

$(0.9 \text{ or } 1.2)D + W_{u,IEC} + 1.0(PT)$at extreme wind

where

$W_{u,IEC}$ is a factored load that includes the IEC design load factor.

PT_{max} is the larger of (a) the maximum jacking force considering over jacking or (b) the maximum allowable post-tension force developed by the installation procedure.

PT is the post-tension in the anchor in service after all losses.

1.2.2. For service load criteria:

$1.0D + 1.0(PT_{max})$ at initial PT jacking

$1.0D + 1.0(PT) + W_{IEC}$at extreme wind

where

W_{IEC} is the IEC service load (without design load factor).

2. CAPACITY

The “capacity” values for comparison to or assessment of the demand values are calculated from the following:

2.1. The steel base plate capacity is calculated from the ANSI/AISC 360 specification (AISC, 2005, 2010, 2016).

2.2. The concrete bearing capacity is calculated from ACI 318 (ACI, 2014, 2019).

3. DESIGN CRITERIA

The flange plate in bending is assessed according to AISC 360. The concrete-related calculations for “information only” are according to ACI 318.

0.0-DCR SUMMARY

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION					
2						
3	0.0-DCR SUMMARY					
4						
5	DESIGN NOTES:					
6	This is a summary of Demand over Capacity Ratios (DCR), i.e., design utilization, such that: DCR \leq 1.000, PASS. The design is acceptable. DCR > 1.000, FAIL. The design is subject to overload or overstress. 1.000 < DCR \leq 1.100 may be given "Over but ACCEPT" status for practical design tolerance.					
7						
8	1.0-INPUT					
9						
10	2.0-CHECK POST-TENSION VALUE				DCR:	
11	2.0.1-CHECK AGAINST MAX. FATIGUE LOAD:				0.748	PASS
12	2.0.2-CHECK AGAINST MAX. SERVICE LOAD:				0.839	PASS
13						
14	3.0-TOWER BASE PLATE DESIGN				DCR:	
15	3.0.1-CHECK TOWER BASE FLANGE PLATE:				0.511	PASS
16						
17	3.1-TOWER BASE PLATE BEARING				DCR:	
18	3.1.1-CHECK GROUT BEARING AT BASE PLATE:				0.951	PASS
19	3.1.2-CHECK CONCRETE BEARING AT BASE PLATE:				0.951	PASS
20						
21	3.2-TOWER BASE PLATE SERVICEABILITY				DCR:	
22	3.2.1-CHECK GROUT BEARING AT BASE PLATE (at Sustained Service Load):				0.711	PASS
23	3.2.2-CHECK CONCRETE BEARING AT BASE PLATE (at Sustained Service Load):				0.711	PASS
24	3.2.3-CHECK GROUT BEARING AT BASE PLATE (at Transient Service Load):				0.582	PASS
25	3.2.4-CHECK CONCRETE BEARING AT BASE PLATE (at Transient Service Load):				0.582	PASS
26						
27	4.0-EMBEDDED ANCHOR PLATE BEARING				DCR:	
28	4.0.1-CHECK CONCRETE BEARING AT EMBEDDED PLATE:				0.886	PASS
29	4.0.2-CHECK GROUT BEARING AT BASE PLATE:				0.831	PASS
30						
31	4.1-EMBEDDED ANCHOR PLATE DESIGN				DCR:	
32	[BY OTHERS]					
33	4.1.1-CHECK EMBEDDED ANCHOR PLATE @ Cantilever Edge:				0.254	PASS
34	4.1.2-CHECK EMBEDDED ANCHOR PLATE @ Plate Midspan:				0.583	PASS
35						
36	5.0-BEARING PLATE DESIGN				DCR:	
37	[BY OTHERS]					
38	5.0.1-CHECK BEARING PLATE BENDING				0.317	PASS

1.0-INPUT

BY: NAA

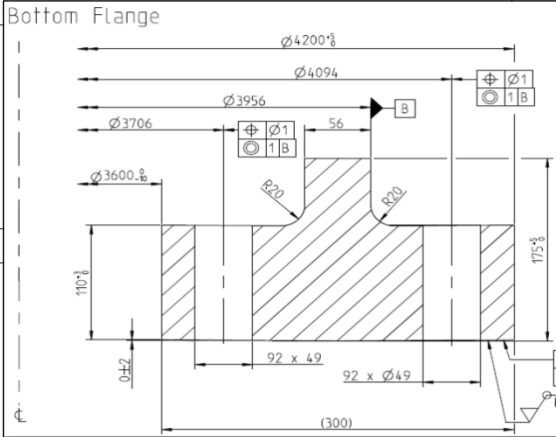
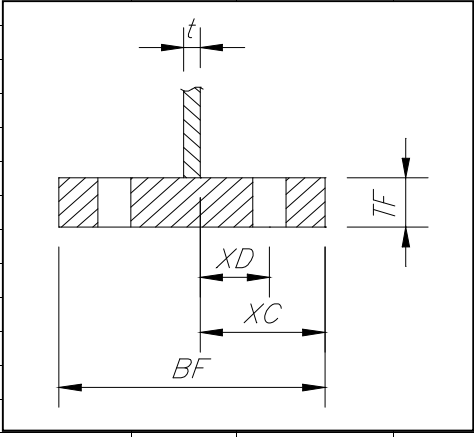
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DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2	1.0-INPUT					
3						
4						
17	TOWER BASE GEOMETRY:					
18	Wall thickness at tower base	t	2.063	(in)	52.400	(mm)
19	Wall outside diameter	D_{OD}	155.606	(in)	3952.400	(mm)
20	Wall inside diameter	D_{ID}	151.480	(in)	3847.600	(mm)
21	Wall mean diameter	D_m	153.543	(in)	3900.000	(mm)
22	Tower cross-sectional area	A	995.127	(in ²)	642016	(mm ²)
23	Tower section modulus at ϕ_m	S	38198.757	(in ³)	625965478	(mm ³)
24						
25	TOWER BASEPLATE:					
26	Base plate thickness	TF	4.331	(in)	110.000	(mm)
27	Base plate width	BF	11.811	(in)	300.000	(mm)
28	Width of grout contact = $MAX[BF, BF_{brg}]$	BF_{USE}	16.142	(in)	410.000	(mm)
29	Base plate edge to face of wall	XC	7.039	(in)	178.800	(mm)
30	Face of wall to bolt hole	XD	2.787	(in)	70.800	(mm)
31	Flange yield stress	F_y	41.336	(ksi)	285.000	(MPa)
32						
33	BEARING PLATE:					
34	Bearing plate thickness	TF_{brg}	2.362	(in)	60.000	(mm)
35	Bearing plate width	BF_{brg}	16.142	(in)	410.000	(mm)
36	Tower base plate width	BF_{twr}	11.811	(in)	300.000	(mm)
37	Bearing plate yield stress	F_y	48.588	(ksi)	335.000	(MPa)
38						
39	EMBEDDED ANCHOR PLATE:					
40	Embedded ring plate min. thickness	TF	2.165	(in)	55.000	(mm)
41	Embedded ring plate width	BF	16.142	(in)	410.000	(mm)
42	Embedded ring plate yield stress	F_y	50.000	(ksi)	344.732	(MPa)
43						
44	PLATE DESIGN PARAMETERS:					
45	Resistance factor (flexure)	ϕ_b	0.900		0.900	

1.0-INPUT

BY: NAA

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FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
46						
47	ANCHOR ROD DATA:					
48	Total number of anchor rods (total at inner and outer bolt circles)	n_{TOTAL}	184	(no.)	184	(no.)
49	Anchor rod designation		R71-11			
50	Anchor rod ultimate tensile strength	T_{ult}	237.000	(kip)	53.280	(kN)
51	Anchor rod diameter	D_{ROD}	1.563	(in)	39.688	(mm)
52	Anchor rod hole diameter in baseplate	D_{HOLE}	1.929	(in)	49.000	(mm)
53	PVC sleeve OD	OD_{SLV}	1.900	(in)	48.260	(mm)
54	Anchor rod nominal post-tension $0.66T_{ult}$	$P_{b_nominal}$	156.420	(kip)	35.165	(kN)
55	Assumed post-tension loss	X_{LOSS}	10%	(%)	10%	(%)
56	Assumed post-tension tolerance	P_{b_tol}	5.000	(kip)	1.124	(kN)
57	Anchor rod max. jacking post-tension	$P_{b_maxjack}$	178.800	(kip)	40.196	(kN)
58	Anchor rod post-tension after losses	P_{b_losses}	145.778	(kip)	32.772	(kN)
59	Anchor rod max. post-tension allowed	P_{b_maxall}	189.600	(kip)	42.624	(kN)
60	PT DESIGN PARAMETERS AT JACKING					
61	Anchor rod post-tension chosen from above and considered in this calculation	P_b	189.600	(kip)	42.624	(kN)
62	Load factor for pretension: $\gamma = 1.2$ at max. jacking (installation) force $\gamma = 1.0$ with other design loads	$\gamma_{BEARING}$	1.200		1.200	
63	PT DESIGN PARAMETERS IN SERVICE					
64	Anchor rod post-tension chosen from above and considered in this calculation	P_b	145.778	(kip)	32.772	(kN)
65	Load factor for pretension: $\gamma = 1.2$ at max. jacking (installation) force $\gamma = 1.0$ with other design loads	$\gamma_{BEARING}$	1.000		1.000	
66	Other data:					
67	Tributary length at shell per anchor pair	L_{TRIB}	5.243	(in)	133.176	(mm)
68	Tributary area at shell per anchor pair	A_{TRIB}	10.817	(in ²)	6978	(mm ²)

1.0-INPUT

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

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FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
69						
70	GROUT:					
71	Grout 28-day strength	f_g	12000	(psi)	82.736	(MPa)
72	Grout early strength at jacking	$f_{g,early}$	9600	(psi)	66.189	(MPa)
73	Time of this required early grout strength		At Jacking		At Jacking	
74	Confinement parameter, 2.0 max.	$\sqrt{(A_2/A_1)}$	1.000		1.000	
	Resistance factor (bearing):					
	$\phi = 0.85$ at PT anchorage zone					
75	$\phi = 0.65$ at surface bearing	ϕ_c	0.850		0.850	
76						
77	CONCRETE:					
78	AT BASE OR BEARING PLATE:					
79	Concrete 28-day strength at base plate	$f'_{c,BPL}$	6000	(psi)	41.368	(MPa)
80	Concrete early strength at base plate	$f'_{c,BPL,early}$	4500	(psi)	31.026	(MPa)
81	Confinement parameter, 2.0 max.	$\sqrt{(A_2/A_1)}$	2.000		2.000	
	Resistance factor (bearing):					
	$\phi = 0.85$ at PT anchorage zone					
82	$\phi = 0.65$ at surface bearing	ϕ_c	0.850		0.850	
83	AT EMBEDDED ANCHOR PLATE:					
84	Concrete 28-day strength at embed. plate	$f'_{c,EPL}$	6000	(psi)	41.368	(MPa)
85	Concrete early strength at embed. plate	$f'_{c,EPL,early}$	4500	(psi)	31.026	(MPa)
86	Confinement parameter, 2.0 max.	$\sqrt{(A_2/A_1)}$	2.000		2.000	
	Resistance factor (bearing):					
	$\phi = 0.85$ at PT anchorage zone					
87	$\phi = 0.65$ at surface bearing	ϕ_c	0.850		0.850	

1.0-INPUT

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

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FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
88						
89	TOWER BASE FACTORED LOADS (for base flange bending):					
90	Note: These loads are chosen to maximize design uplift on the base plate.					
91	Load combination description	LC	$U = (0.9)D + W_u$ (maximize design uplift)			
92	Factored axial load	P_u	954	(kip)	4242	(kN)
93	Factored shear force	V_u	290	(kip)	1289	(kN)
94	Factored moment	M_u	101790	(kip-ft)	138008	(kN-m)
95						
96	TOWER BASE FACTORED LOADS (for base flange compression):					
97	Note: These loads are chosen to maximize design compression on the base plate.					
98	Load combination description	LC	$U = (1.2)D + W_u$ (maximize compression)			
99	Factored axial load	P_u	1276	(kip)	5678	(kN)
100	Factored shear force	V_u	290	(kip)	1289	(kN)
101	Factored moment	M_u	101790	(kip-ft)	138008	(kN-m)
102						
103	TOWER BASE SERVICE SUSTAINED LOADS: (direction to maximize compression)					
104	Note: These loads are chosen to maximize sustained service compression on the base plate.					
105	Load combination description	LC	$SUSTAINED = 1.0D + 1.0PT$			
106	Service axial load = 1.0D	P_{sus}	1075.700	(kip)	4785	(kN)
107	Service shear force	V_{sus}	N/A	(kip)	N/A	(kN)
108	Service moment	M_{sus}	0	(kip-ft)	0	(kN-m)
109						
110	TOWER BASE SERVICE OPERATIONAL LOADS: (direction to maximize compression)					
111	Note: These loads are chosen to maximize operational service compression on the base plate.					
112	Load combination description	LC	$OPER = SUSTAINED + W_{DLC1.x}$			
113	Service axial load (exluding dead load)	$P_{DLC1.x}$	0	(kip)	0.000	(kN)
114	Service shear force	$V_{DLC1.x}$	N/A	(kip)	N/A	(kN)
115	Service moment	$M_{DLC1.x}$	96940	(kip-ft)	131432	(kN-m)
116						
117	TOWER BASE FATIGUE LOAD:					
118	Maximum Fatigue Moment (estimated)	M_{fat}	67586	(kip-ft)	91634	(kN-m)
119						
120	TOWER BASE MAXIMUM SERVICE LOADS: (direction to maximize anchor tension)					
121	Note: These loads are chosen to maximize service tension on the anchors.					
122	Load combination description	LC	$MAX SERVICE$			
123	Service axial load=1.0D	$P_{service}$	1076	(kip)	4784.930	(kN)
124	Service shear force	$V_{service}$	N/A	(kip)	N/A	(kN)
125	Service moment	$M_{service}$	75400	(kip-ft)	102228	(kN-m)

2.0-CHECK POST-TENSION

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2						
3	2.0-CHECK POST-TENSION VALUE					
4						
5	DESIGN NOTES:					
6	For this calculation, the anchor rod post-tension shall not be exceeded by the maximum fatigue tension or the maximum service load tension. This criterion prohibits anchor tension under service loads.					
7	INPUT:					
8	Total number of anchor rods	n_{TOTAL}	184	(no.)	184	(no.)
9	Wall mean diameter	D_m	153.543	(in)	3900	(mm)
10	Anchor rod pretension after losses	P_{b_losses}	145.778	(kip)	648.450	(kN)
11						
12	2.0.1-CHECK AGAINST MAX. FATIGUE LOAD:					
13	Service axial load = 1.0D	$P_{service}$	1076	(kip)	4784.930	(kN)
14	Maximum Fatigue Moment	M_{fat}	67586	(kip-ft)	91634	(kN-m)
15	Maximum Fatigue Tension	$T_{fatigue}$	108.983	(kip)	484.778	(kN)
16	STATUS: DCR $T_{fatigue}/P_{b_losses} \leq 1.0$		0.748		0.748	
17						
18	2.0.2-CHECK AGAINST MAX. SERVICE LOAD:					
19	Service axial load	$P_{service}$	1076	(kip)	4784.930	(kN)
20	Service moment	$M_{service}$	75400	(kip-ft)	102228	(kN-m)
21	Maximum Service Tension	$T_{service}$	122.259	(kip)	543.830	(kN)
22	STATUS: DCR $T_{service}/P_{b_losses} \leq 1.0$		0.839		0.839	

3.0-BASE PLATE DESIGN

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

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ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2						
3	3.0-TOWER BASE PLATE DESIGN					
4						
5	INPUT:					
6	TOWER BASE FACTORED LOADS:					
7	Load combination description	<i>LC</i>	U = (0.9)D+ Wu (maximize design uplift)			
8	Factored axial load	P_u	954	(kip)	4242	(kN)
9	Factored shear force	V_u	290	(kip)	1289	(kN)
10	Factored moment	M_u	101790	(kip-ft)	138008	(kN-m)
11	TOWER BASE GEOMETRY:					
12	Wall thickness at tower base	<i>t</i>	2.063	(in)	52.400	(mm)
13	Wall outside diameter	D_{OD}	155.606	(in)	3952.400	(mm)
14	Wall mean diameter	D_m	153.543	(in)	3900.000	(mm)
15	TOWER BASEPLATE DATA:					
16	Base plate thickness	<i>TF</i>	4.331	(in)	110.000	(mm)
17	Face of wall to bolt hole	<i>XD</i>	2.787	(in)	70.800	(mm)
18	Flange yield stress	F_y	41.336	(ksi)	285.000	(MPa)
19						
20	3.0.1-CHECK TOWER BASE FLANGE PLATE:					
21	Total number of anchor rods (total at inner and	n_{TOTAL}	184	(no.)	184	(no.)
22	Tributary length at shell	L_{TRIB}	5.243	(in)	133.176	(mm)
23	Base plate section modulus	S_{PL}	16.389	(in ³)	268572	(mm ³)
24	Base plate plastic section modulus	Z_{PL}	24.584	(in ³)	402858	(mm ³)
25	Factored Bolt tension	T_u	167.758	(kip)	746.221	(kN)
26	Plate bending moment = $T_u * XD$	M_{uPL}	467.609	(kip-in)	52.832	(kN-m)
27	Resistance factor (flexure)	ϕ_b	0.900		0.900	
28	Yield moment = $F_y * S_{PL}$	M_y	677.473	(kip-in)	76.543	(kN-m)
29	Plastic moment = $F_y * Z_{PL}$	M_p	1016.210	(kip-in)	114.815	(kN-m)
30	$M_n = \min[M_p, 1.5M_y]$	M_n	1016.210	(kip-in)	114.815	(kN-m)
31		$\phi_b M_n$	914.589	(kip-in)	103.334	(kN-m)
32	STATUS: DCR $M_{uPL} / \phi M_n \leq 1.0$	<i>DCR</i>	0.511		0.511	

3.1-BASE PLATE BEARING

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2						
3	3.1-TOWER BASE PLATE BEARING					
4						
5	INPUT:					
6	TOWER BASE FACTORED LOADS: (to maximize compression)					
7	Load combination description	LC	U = (1.2)D+ Wu (maximize compression)			
8	Factored axial load	P_u	1276	(kip)	5678	(kN)
9	Factored shear force	V_u	290	(kip)	1289	(kN)
10	Factored moment	M_u	101790	(kip-ft)	138008	(kN-m)
11	Tower cross-sectional area	A	995.127	(in ²)	642016	(mm ²)
12	Tower section modulus at ϕ_m	S	38198.757	(in ³)	625965478	(mm ³)
13	Tributary length at shell per anchor pair	L_{TRIB}	5.243	(in)	133.176	(mm)
14	Tributary area at shell per anchor pair	A_{TRIB}	10.817	(in ²)	6978	(mm ²)
15	Tower shell compression = $P_u/A+M_u/S$	$f_{u,Comp}$	33.260	(ksi)	229.314	(MPa)
16	Tower shell compression force per anchor	C_u	179.879	(kip)	800	(kN)
17	TOWER BASE PLATE LOADS:					
18	Anchor rod designation		R71-11		R71-11	
19	Anchor rod ultimate tensile strength	T_{ult}	237.000	(kip)	1054	(kN)
20	Anchor rod nominal post-tension	$P_{b_nominal}$	156.420	(kip)	696	(kN)
21	Assumed post-tension loss	X_{LOSS}	10%	(%)	10%	(%)
22	Anchor rod max. jacking post-tension	$P_{b_maxjack}$	178.800	(kip)	795	(kN)
23	Anchor rod post-tension after losses	P_{b_losses}	145.778	(kip)	648	(kN)
24	Anchor rod max. post-tension allowed	P_{b_maxall}	189.600	(kip)	843	(kN)
25	Anchor rod post-tension chosen from above and considered in this calculation	P_b	145.778	(kip)	648	(kN)
26	Load factor for pretension: $\gamma = 1.2$ at max. jacking (installation) force $\gamma = 1.0$ with other design loads	$\gamma_{BEARING}$	1.000		1.000	
27	Factored pretension bearing load	P_{bu1}	145.778	(kip)	648	(kN)
28	Factored max. load from load combos	$P_{bu2} = C_u$	179.879	(kip)	800	(kN)
29	Factored bearing load = $P_{bu1} + P_{bu2}$	P_{bu}	325.657	(kip)	1449	(kN)
30	PVC sleeve OD	OD_{SLV}	1.900	(in)	48.260	(mm)
31	Base plate width	BF	16.142	(in)	410.000	(mm)

3.1-BASE PLATE BEARING

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
32						
33	3.1.1-CHECK GROUT BEARING AT BASE PLATE:					
34	Grout 28-day strength	f_g	12000	(psi)	82.736	(MPa)
35	Bearing area per anchor bolt	A_I	39.482	(in ²)	25472	(mm ²)
36	$MAX[\sqrt{(A_2/A_1)}, 2.0]$	$\sqrt{(A_2/A_1)}$	1.000		1.000	
37	Resistance factor (bearing)	ϕ_c	0.850		0.850	
38	Nominal bearing strength	P_p	402.712	(kip)	1791.342	(kN)
39	Design bearing strength	$\phi_c P_p$	342.305	(kip)	1522.641	(kN)
40	Factored bearing load = $P_{bu1} + P_{bu2}$	P_{bu}	325.657	(kip)	1448.586	(kN)
41	STATUS: DCR $P_{bu} / \phi_c P_p \leq 1.0$		0.951		0.951	
42						
43	3.1.2-CHECK CONCRETE BEARING AT BASE PLATE:					
44	Concrete 28-day strength at base plate	$f'_{c,BPL}$	6000	(psi)	41.368	(MPa)
45	Average length between bolts	L_{TRIB}	5.243	(in)	133.176	(mm)
46	Net bearing area per Anchor rod	A_I	39.482	(in ²)	25472	(mm ²)
47	$MAX[\sqrt{(A_2/A_1)}, 2.0]$	$\sqrt{(A_2/A_1)}$	2.000		2.000	
48	Resistance factor (bearing): $\phi = 0.85$ at PT anchorage zone $\phi = 0.65$ at surface bearing	ϕ_c	0.850		0.850	
49	Nominal bearing strength	P_p	402.712	(kip)	1791.342	(kN)
50	Design bearing strength	$\phi_c P_p$	342.305	(kip)	1522.641	(kN)
51	Factored bearing load = $P_{bu1} + P_{bu2}$	P_{bu}	325.657	(kip)	1448.586	(kN)
52	STATUS: DCR $P_{bu} / \phi_c P_p \leq 1.0$		0.951		0.951	

3.2-BASE PL-SERVICEABILITY

BY: NAA

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2						
3	3.2-TOWER BASE PLATE SERVICEABILITY					
4						
5	DESIGN NOTES:					
6	For this calculation, the top of the foundation is interpreted as a flexural member for compliance with ACI 318 Section 18.4 Serviceability Requirements.					
7	INPUT:					
8	TOWER BASE SERVICE SUSTAINED LOADS: (direction to maximize compression)					
9	Load combination description	LC	SUSTAINED = 1.0D+ 1.0PT			
10	Service axial load	P_{sus}	1076	(kip)	4785	(kN)
11	Anchor rod post-tension after losses	P_{b_losses}	145.778	(kip)	648	(kN)
12	Service shear force	V_{sus}	N/A	(kip)	N/A	(kN)
13	Service moment	M_{sus}	0	(kip-ft)	0	(kN-m)
14	Total compression on tributary shell = $(P_{sus} + n_{TOTAL} P_{b_losses})/A + M_{sus}/S$	$f_{sus,Comp}$	28.035	(ksi)	193.295	(MPa)
15	Compression force per anchor	C_{sus}	151.624	(kip)	674	(kN)
16	TOWER BASE SERVICE OPERATIONAL LOADS: (direction to maximize compression)					
17	Load combination description	LC	OPER = SUSTAINED + WDLC1.x			
18	Service axial load (exluding dead load)	$P_{DLCL.x}$	0	(kip)	0	(kN)
19	Service shear force	$V_{DLCL.x}$	N/A	(kip)	N/A	(kN)
20	Service moment	$M_{DLCL.x}$	96940	(kip-ft)	131432	(kN-m)
21	Total compression = $P_{DLCL.x}/A + M_{DLCL.x}/S$	$f_{DLCL.x,Comp}$	2.538	(ksi)	17.497	(MPa)
22	Compression force per anchor	$C_{DLCL.x}$	13.725	(kip)	61	(kN)
23	Total compression force per anchor = $C_{oper} = C_{sus} + C_{DLCL.x}$	C_{oper}	165.349	(kip)	736	(kN)
24						
25	3.2.1-CHECK GROUT BEARING AT BASE PLATE (at Sustained Service Load):					
26	Grout 28-day strength	f_g	12000	(psi)	82.736	(MPa)
27	Bearing area per anchor bolt	A_1	39.482	(in ²)	25472	(mm ²)
28	$MAX[\sqrt{(A_2/A_1)}, 2.0]$	$\sqrt{(A_2/A_1)}$	1.000		1.000	
29	Allowable bearing strength = $0.45f'_{c_grout}$	P_p	213.200	(kip)	948.358	(kN)
30	Compression force per anchor	C_{sus}	151.624	(kip)	674.455	(kN)
31	STATUS: DCR $C_{sus}/P_p \leq 1.0$		0.711		0.711	
32						
33	3.2.2-CHECK CONCRETE BEARING AT BASE PLATE (at Sustained Service Load):					
34	Concrete 28-day strength at base plate	$f'_{c,BPL}$	6000	(psi)	41.368	(MPa)
35	Net bearing area per Anchor rod	A_1	39.482	(in ²)	25472	(mm ²)
36	$MAX[\sqrt{(A_2/A_1)}, 2.0]$	$\sqrt{(A_2/A_1)}$	2.000		2.000	
37	Allowable bearing strength = $0.45f'_c$	P_p	213.200	(kip)	948.358	(kN)
38	Compression force per anchor	C_{sus}	151.624	(kip)	674.455	(kN)
39	STATUS: DCR $C_{sus}/P_p \leq 1.0$		0.711		0.711	

3.2-BASE PL-SERVICEABILITY

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
40						
41	3.2.3-CHECK GROUT BEARING AT BASE PLATE (at Transient Service Load):					
42	Grout 28-day strength	f_g	12000	(psi)	82.736	(MPa)
43	Bearing area per anchor bolt	A_I	39.482	(in ²)	25472	(mm ²)
44	$MAX[\sqrt{(A_2/A_I)}, 2.0]$	$\sqrt{(A_2/A_I)}$	1.000		1.000	
45	Allowable bearing strength = $0.60f'_{c_grout}$	P_p	284.267	(kip)	1264.477	(kN)
46	Total compression force per anchor	C_{oper}	165.349	(kip)	735.507	(kN)
47	STATUS: DCR $C_{oper}/P_p \leq 1.0$		0.582		0.582	
48						
49	3.2.4-CHECK CONCRETE BEARING AT BASE PLATE (at Transient Service Load):					
50	Concrete 28-day strength at base plate	$f'_{c,BPL}$	6000	(psi)	41.368	(MPa)
51	Net bearing area per Anchor rod	A_I	39.482	(in ²)	25472	(mm ²)
52	$MAX[\sqrt{(A_2/A_I)}, 2.0]$	$\sqrt{(A_2/A_I)}$	2.000		2.000	
53	Allowable bearing strength = $0.60f'_c$	P_p	284.267	(kip)	1264.477	(kN)
54	Total compression force per anchor	C_{oper}	165.349	(kip)	735.507	(kN)
55	STATUS: DCR $C_{oper}/P_p \leq 1.0$		0.582		0.582	

4.0-EMBED PLATE BEARING

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2						
3	4.0-EMBEDDED ANCHOR PLATE BEARING					
4						
5	INPUT:					
6	Anchor rod designation		R71-11			
7	Anchor rod ultimate tensile strength	T_{ult}	237.000	(kip)	1054.224	(kN)
8	Anchor rod nominal post-tension	$P_{b_nominal}$	156.420	(kip)	695.788	(kN)
9	Assumed post-tension loss	X_{LOSS}	10%	(%)	10%	(%)
10	Anchor rod max. jacking post-tension	$P_{b_maxjack}$	173.800	(kip)	773.097	(kN)
11	Anchor rod post-tension after losses	P_{b_losses}	156.420	(kip)	695.788	(kN)
12	Anchor rod max. post-tension allowed	P_{b_maxall}	189.600	(kip)	843.379	(kN)
13	Anchor rod post-tension chosen from above and considered in this calculation	P_b	189.600	(kip)	843.379	(kN)
14	Load factor for pretension: $\gamma = 1.2$ at max. jacking (installation) force $\gamma = 1.0$ with other design loads	$\gamma_{BEARING}$	1.200		1.200	
15	Factored pretension bearing load	P_{bu1}	227.520	(kip)	1012.055	(kN)
16	Factored max. load from load combos	$P_{bu2} = T_u$	167.758	(kip)	746.221	(kN)
17	Factored bearing load= $MAX[P_{bu1}, P_{bu2}]$	P_{bu}	227.520	(kip)	1012.055	(kN)
18	Tributary length at shell	L_{TRIB}	5.243	(in)	133.176	(mm)
19	PVC sleeve OD	OD_{SLV}	1.900	(in)	48.260	(mm)
20	Embedded ring plate width	BF	16.142	(in)	410.000	(mm)
21						
22	4.0.1-CHECK CONCRETE BEARING AT EMBEDDED PLATE:					
23	Note: Treat as the upside-down version of a surface bearing plate.					
24	Concrete early strength at embed. plate	$f'_{c,EPL,early}$	4500	(psi)	31.026	(MPa)
25	Average length between bolts	L_{TRIB}	5.243	(in)	133.176	(mm)
26	Net bearing area per Anchor rod	A_1	39.482	(in ²)	25472	(mm ²)
27	$MAX[\sqrt{(A_2/A_1)}, 2.0]$	$\sqrt{(A_2/A_1)}$	2.000		2.000	
28	Resistance factor (bearing)	ϕ_c	0.850		0.850	
29	Nominal bearing strength	P_p	302.034	(kip)	1343.507	(kN)
30	Design bearing strength	$\phi_c P_p$	256.729	(kip)	1141.981	(kN)
31	Factored bearing load= $MAX[P_{bu1}, P_{bu2}]$	P_{bu}	227.520	(kip)	1012.055	(kN)
32	STATUS: $DCR P_{bu} / \phi_c P_p \leq 1.0$		0.886		0.886	

4.0-EMBED PLATE BEARING

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
42						
43	4.0.2-CHECK GROUT BEARING AT BASE PLATE:					
44	Grout early strength at jacking	$f_{g,early}$	9600	(psi)	66.189	(MPa)
45	Time of this required grout strength		At Jacking		At Jacking	
46	Bearing area per anchor bolt	A_1	39.482	(in ²)	25472	(mm ²)
47	$MAX[\sqrt{(A_2/A_1)}, 2.0]$	$\sqrt{(A_2/A_1)}$	1.000		1.000	
48	Resistance factor (bearing)	ϕ_c	0.850		0.850	
49	Nominal bearing strength	P_p	322.169	(kip)	1433.074	(kN)
50	Design bearing strength	$\phi_c P_p$	273.844	(kip)	1218.113	(kN)
51	Factored bearing load= $MAX[P_{bu1}, P_{bu2}]$	P_{bu}	227.520	(kip)	1012.055	(kN)
52	STATUS: $DCR P_{bu} / \phi_c P_p \leq 1.0$		0.831		0.831	

5.0-BEARING PL DESIGN

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PROJECT: VESTAS V163V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_BasePlateLRFD_v02_2013-02-23_Rev01.xlsx

	A	B	C	D	E	F
1	DESCRIPTION		VALUE	UNITS	VALUE	UNITS
2						
3	5.0-BEARING PLATE DESIGN					
4						
5	INPUT:					
6	Bearing plate thickness	TF_{brg}	2.362	(in)	60.000	(mm)
7	Bearing plate width	BF_{brg}	16.142	(in)	410.000	(mm)
8	Tower base plate width	BF_{twr}	11.811	(in)	300.000	(mm)
9	Bearing plate yield stress	F_y	48.588	(ksi)	335.000	(MPa)
10	Tributary length at shell	L_{TRIB}	5.243	(in)	133.176	(mm)
11						
12	5.0.1-CHECK BEARING PLATE BENDING					
13	Factored bearing stress under bearing plate	w_u	8.248	(ksi)	56.869	(MPa)
14	Factored bearing stress under bearing plate	$w_{u,Ltrib}$	43.247	(kip/in)	298.175	(MPa)
15	Bearing plate section modulus	S_{PL}	4.876	(in ³)	79906	(mm ³)
16	Bearing plate plastic section modulus	Z_{PL}	7.314	(in ³)	119859	(mm ³)
17	Bearing plate edge cantilever length	L_{cant}	2.165	(in)	55.000	(mm)
18	Plate bending moment = $w_{u,Ltrib} (L_{cant}^2)/2$	M_{uPL}	101	(kip-in)	11	(kN-m)
19	Resistance factor (flexure)	ϕ_b	0.900		0.900	
20	Yield moment = $F_y * S_{PL}$	M_y	237	(kip-in)	27	(kN-m)
21	Plastic moment = $F_y * Z_{PL}$	M_p	355	(kip-in)	40	(kN-m)
22	$M_n = \min[M_p, 1.5M_y]$	M_n	355	(kip-in)	40	(kN-m)
23	Plate flexural design strength	$\phi_b M_n$	320	(kip-in)	36	(kN-m)
24	STATUS: DCR $M_{uPL}/\phi M_n \leq 1.0$	DCR	0.317		0.317	

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SECTION 6

DATE: December 7, 2025 (Rev. 0)

ASE JOB NO.: 25-031

PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

CONTENTS: SECTION 6—TOWER SHELL PENETRATIONS

TOWER DOOR OPENING:

General Notes.....	1
Stress Concentration Factor (SCF)	3
Door Design Summary	4
Door Reinforcement Compressive Strength	5
Door Fatigue Checks.....	6
Isometric View of Base Opening & Door Stiffener Model	8

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TOWER SHELL PENETRATIONS

GENERAL NOTES

SCOPE

The tower shell penetrations addressed by this section include the following:

- The tower doorway opening in the bottom section.

STRENGTH DESIGN

1. DEMAND

Design by the LRFD method is strength design and uses factored loads that include a design load factor.

- 1.1. Governing extreme loads are obtained from the turbine OEM's loads document.
- 1.2. The following load combinations are considered for strength design:

$$1.2D + W_{u,IEC}$$

where $W_{u,IEC}$ is a factored load that includes the IEC design load factor.

- 1.3. The door frame (or frame plate) is checked for out-of-plane compression buckling.
- 1.4. The plate in the stress hotspot just outside of the doorway opening is checked using the Von Mises stress at the hotspot.

2. CAPACITY

The “capacity” values for comparison to or assessment of the demand values are calculated from the nominal compression strength of the tower shell multiplied by a capacity reduction factor.

3. DESIGN CRITERIA

Design criteria are taken from AISC 360 (AISC, 2005, 2010, 2016). Stress concentration factors (SCF) are obtained from an envelope of stress analysis results, textbook equations, and the turbine OEM's results.

FATIGUE DESIGN

4. DEMAND

See the general discussion in the tower shell fatigue calculations in Section 3 of this calculation report.

5. CAPACITY

See the discussion in the tower shell fatigue calculations in Section 3 of this calculation booklet.

6. DESIGN CRITERIA

See the discussion in the tower shell fatigue calculations in Section 3 of this calculation booklet.

DOOR SCF

BY: NAA

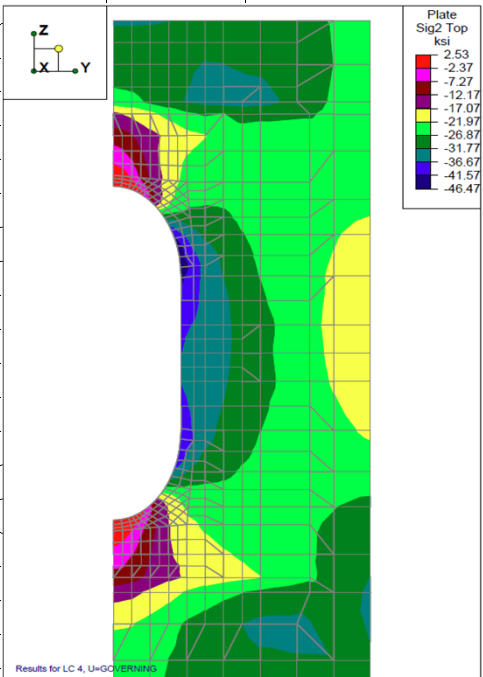
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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/8/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_DOOR_CALCS_v3-2014-02-10.xlsx

ITEM	SYMBOL	UNITS	VALUE	
DOOR STRESS CONCENTRATION FACTOR (SCF):				
Major Axis Length	$2a$	(mm)	2044	
Minor Axis Width	$2b$	(mm)	965	effective; 750 actual
	a	(mm)	1022	
	b	(mm)	482.5	
Stiffener Plate Thickness	t_{PL}	(mm)	85	
Stiffener Plate Width	w_{PL}	(mm)	646	
Wall Thickness	h	(mm)	52.4	
Area of Reinforcement	A_r	(mm ²)	100914.99	
PARAMETERS FOR CHART 4.58a				
REF: Peterson's Stress Concretration Factors, 3rd Ed., by Pilkey and Pilkey				
Parameter $A_r / [(a+b)h]$			0.000	Use zero effective
Parameter a/b			2.118	
Estimated Stress Concentration Factor	$K_{t,est}$		2.76	Within 6% of OEM value
Stress Concentration Factor to Use	K_t		2.91	Therefore use OEM value
RISA PLATE MODEL ESTIMATE				
Normal Stress	σ	(ksi)	19.664	
Hotspot Stress	$\sigma_{hotspot}$	(ksi)	46.470	
Estimated SCF	SCF_{est}		2.363	
SCF increased conservatively	SCF		2.836	+20% conservative
TURBINE OEM's FEA ESTIMATE				
OEM's SCF	SCF_{OEM}		2.91	
Stress Concentration Factor to Use	K_t		2.91	=MAX[K_t , SCF , SCF_{OEM}]
				

DOOR DESIGN SUMMARY

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/8/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_DOOR_CALCS_v3-2014-02-10.xlsx

ITEM	SYMBOL	UNITS	VALUE	
TOWER DOOR STIFFENER PLATE DESIGN SUMMARY				
GENERAL INFORMATION				
Stiffener Plate:				
Stiffener Plate Thickness	t	(mm)	85	
Stiffener Plate Width	b	(mm)	646.01761	
Tower Gross Properties at Hot Spot:				
Tower wall thickness	t_{WALL}	(mm)	52.4	
Tower Mean Diameter	D_m	(mm)	3900	
Tower Area	A	(mm ²)	642016	
	A	(in ²)	995.127	
Tower Section Modulus	S	(mm ³)	6.26E+08	
	S	(in ³)	3.82E+04	
FATIGUE DESIGN CHECK (SUMMARY ONLY--SEE ATTACHED FOR CALCULATIONS)				
WELD at top or bottom of panel:				
Fatigue Stress Concentration Factor: Weld	SCF		1.44	
Fatigue Damage	D		0.549	< 1.0, OKAY
PLATE at top or bottom of doorway:				
Fatigue Stress Concentration Factor: Plate	SCF		2.91	
Fatigue Damage	D		0.888	< 1.0, OKAY
See the attached fatigue damage calculation.				
EXTREME DESIGN CHECK (SUMMARY ONLY--SEE ATTACHED FOR CALCULATIONS)				
Hot Spot Extreme Stress:				
Tower steel yield strength	F_y	(ksi)	45.688	
Hot Spot SCF for Extreme Stress:	SCF		2.910	
Maximum hot spot stress	$f_{HOTSPOT}$	(ksi)	57.222	Approximate Estimate
Maximum hot spot stress from FEA	$f_{HOTSPOT}$	(ksi)	46.470	Use FEA - more accurate
Utilization ratio	DCR		1.017	approx 1.0, OKAY
Stiffener Compression:				
Utilization ratio	DCR		0.835	< 1.0, OKAY
See attached compressive strength calculation for detailed calculation.				

FLAT BAR COMPRESSIVE STRENGTH

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/8/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_DOOR_CALCS_v3-2014-02-10.xlsx

ITEM	SYMBOL	UNITS	VALUE				
TOWER DOOR STIFFENER PLATE							
SOLID RECTANGULAR BARS IN COMPRESSION							
(per AISC 360-10 LRFD)					Flat Bar:		
						646 mm	
Plate Thickness	t	(mm)	646	Reversed			
Plate Width	b	(mm)	85	for			
Plate Thickness	t	(in)	25.434	Vestas		85 mm	
Plate Width	b	(in)	3.346	flat			
Steel type	<i>Steel</i>		EN S355	panel!			
Steel yield stress	F_y	(ksi)	45.69				
Steel elastic modulus	E	(ksi)	29000				
Effective length factor	K		1.00				
Plate column height for compression	L	(in)	43.850	(2/3*Eff. clear opening height)			
Area	A	(in ²)	85.113				
Slenderness param. = $\lambda = (b/t)$	λ		0.132				
Slenderness param. (compact): $\lambda_p = 0.56(E/F_y)^{0.5}$	λ_p		14.109				
Slenderness param. (noncompact): $\lambda_r = 1.03(E/F_y)^{0.5}$	λ_r		25.950				
$Q=Q_s$	Q		1.000				
Radius of gyration (buckle into side wall)	r_y	(in)	7.3421				
Radius of gyration (buckle out of plane of wall)	r_x	(in)	0.9660				
Radius of gyration to use	r_{USE}	(in)	0.9660	Use value consistent with buckling out of the plane of the wall			
Least KL/r	KL/r_{USE}		45.391				
Elastic critical buckling stress	F_e	(ksi)	138.918				
KL/r Limit = $4.71(E/(QF_y))^{0.5}$	$(KL/r)_{limit}$		118.664				
	F_{cr}	(ksi)	39.812				
Nominal strength $P_n = F_{cr}A_g$	P_n	(k)	3388.534				
Resistance factor for compression	ϕ_c		0.900				
Design axial strength in compression	$\phi_c P_n$	(k)	3050				
Required axial strength in compression	P_u	(k)	2546				
Status:	DCR		0.83	<=1.0, OK			
Note:	Bending DCR is estimated to be small, so is ignored.						

DOOR PLATE

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/8/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_DOOR_CALCS_v3-2014-02-10.xlsx

MINER'S RULE CUMULATIVE FATIGUE DAMAGE							
Tower Door Plate		= Item				D = 0.888	
	= Station						
2.960	= Elevation		3.3465	= t_{wall} (in)			
140	= Det. Cat		156.8898	= D_{OD} (in)			
			150.1969	= D_{ID} (in)			
2.91	= SCF		61964	= S (in ³)			
1.03	= F_s (on loads)		16.1481	= $\Delta\sigma$ (ksi) @ 5e6			
1.250	= F_m (on material)		1.0000	= Weld Thickness Factor N/A			
20.00	= Design Life (years)		12.9185	= $\Delta\sigma/F_m$ *(Adjustments)			
LOAD RANGE	LIFETIME CYCLES	LOAD RANGE	STRESS RANGE	m		ALLOW. CYCLES	$D_i =$
ΔM	n_i	ΔM	$\Delta\sigma$	4		N_i	$\Sigma(n_i/N_i)$
(kN-m)	(cycles)	(k-in)	(ksi)				(cycles)
24634	1.00E+07	218032	10.547	1		1.13E+07	0.888
						Damage D=	0.888

TOWER CIRC WELD BELOW-DEL

BY: NAA

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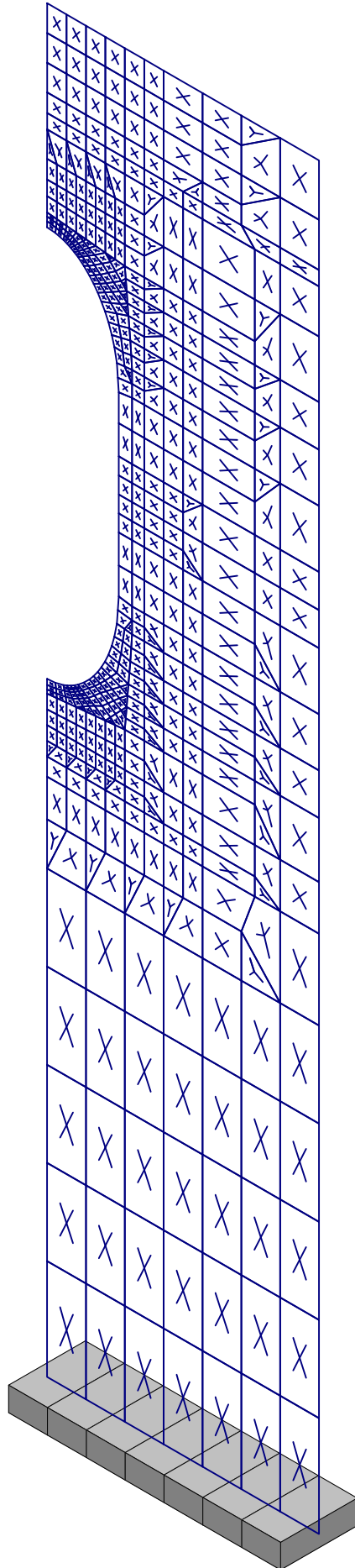
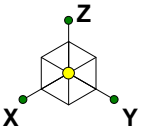
PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/8/2025

ASE JOB NO.: 25-031 (GENERIC)

FILE: 02_DOOR_CALCS_v3-2014-02-10.xlsx

MINER'S RULE CUMULATIVE FATIGUE DAMAGE							
Tower Circ Weld		= Item				D = 0.549	
	= Station						
2.960	= Elevation		2.0630	= t_{wall} (in)			
147	= Det. Cat.		155.6063	= D_{OD} (in)			
			151.4803	= D_{ID} (in)			
1.44	= SCF		38199	= S (in ³)			
1.03	= F_s (on loads)		16.9555	= $\Delta\sigma$ (ksi) @ 5e6			
1.250	= F_m (on material)		0.8624	= Weld Thickness Factor			
20.00	= Design Life (years)		11.6983	= $\Delta\sigma/F_m$ *(Adjustments)			
LOAD RANGE	LIFETIME CYCLES	LOAD RANGE	STRESS RANGE	m		ALLOW. CYCLES	$D_i =$
ΔM	n_i	ΔM	$\Delta\sigma$	4		N_i	$\Sigma(n_i/N_i)$
(kN-m)	(cycles)	(k-in)	(ksi)				(cycles)
24634	1.00E+07	218032	8.466	1		1.82E+07	0.549
						Damage D=	0.549



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SECTION 7

DATE: December 7, 2025 (Rev. 0)
ASE JOB NO.: 25-031
PROJECT: Vestas V163/V166-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower

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EARTHQUAKE DESIGN

GENERAL NOTES

STRENGTH DESIGN

1. DEMAND

1.1. The seismic design utilizes the modal response spectrum analysis (MRSA) procedure in accordance with ASCE 7. These calculations use the following generic parameters:

1.1.1. 2021 International Building Code (IBC)

1.1.2. ASCE 7-16:

1.1.2.1. With Supplements 1, 2, and 3

1.1.2.2. Ground motion hazard analysis (GMHA) assumed not performed

1.1.3. Risk Category II

1.1.4. Site Class $D_{default}$ (not D_{stiff})

1.1.5. Mapped Spectral Parameters:

1.1.5.1. $S_s = 1.500$ g

1.1.5.2. $S_1 = 0.599999$ g < 0.600 g

These generic parameters are chosen such that the design loads from the seismic design load combinations (see below) do not significantly exceed the turbine OEM's governing extreme loads from the OEM loads document. Due to the differences in the general shape of the vertical distribution between wind load and seismic load, the up-tower seismic bending moments may sometimes exceed the wind bending moments despite being approximately equal in value at the tower base. However, since up-tower reserve strength tends to be high, the exceedance of seismic load over wind load usually does not affect design, therefore such an exceedance would be considered to be insignificant.

Although spectral acceleration map values may be slightly different between ASCE 7-05 (ASCE, 2005), ASCE 7-10 (ASCE, 2010), and ASCE 7-16 (ASCE, 2017), the design response spectrum definition and all other related seismic calculations are virtually identical; therefore, other than edition-specific values of spectral map values and variation in soil site coefficients, these earthquake load calculations are also substantially compliant with ASCE 7-05, 7-10, and 7-16.

1.2. The following load combinations are considered for strength design: (the load combination designation, i.e., "EQ#," is referenced throughout the calculations)

1.2.1. Earthquake with turbine at standstill:

$$EQ1 = (1.2+0.2S_{DS})D + 1.0E_{h,1\%}$$

$$EQ2 = (0.9-0.2S_{DS})D + 1.0E_{h,1\%}$$

where:

$1.0E_h$ is a design load that includes a 1.4 design load factor.

$E_h = \rho Q_E$ as defined in ASCE 7.

E_h is based on $R=1.5$.

$E_{h,1\%}$ is E_h based on a design response spectrum adjusted to 1% damping.

1.2.2. Earthquake with turbine during operation:

$$EQ3 = (1.2+0.2S_{DS})D + 0.75(1.0E_{h,5\%} + 1.0M)$$

$$EQ4 = (0.9-0.2S_{DS})D + 0.75(1.0E_{h,5\%} + 1.0M)$$

$$EQ5 = (1.2+0.2S_{DS})D + 0.75(1.0E_{h,1\%} + 1.0M_{IP})$$

$$EQ6 = (0.9-0.2S_{DS})D + 0.75(1.0E_{h,1\%} + 1.0M_{IP})$$

where:

$1.0E_h$ is a design load that includes a 1.4 design load factor.

$E_h = \rho Q_E$ as defined in ASCE 7.

E_h is based on $R=1.5$.

$E_{h,5\%}$ is E_h based on a design response spectrum with standard 5% damping.

$E_{h,1\%}$ is E_h based on a design response spectrum with standard 1% damping.

M is the machinery load (an unfactored service load) (a.k.a. “operational” load) concurrent with earthquake that is taken as the larger of the average operational load or the emergency stop load. For the specific case of IEC requirements (IEC, 2019), M is the larger of:

- Mean loads during normal power production determined at V_r
- Loads during emergency stop at V_r

where V_r is the rated wind speed, which is the minimum wind speed at hub height at which a wind turbine’s rated power is achieved in the case of steady wind without turbulence.

M_{IP} is the machinery load (an unfactored service load) (a.k.a. “operational” load) concurrent with earthquake that for the specific case of IEC requirements (IEC, 2019) is the loads during idling or parked condition at V_{out} , the cut-out wind speed, which is the highest 10 min average wind speed at hub height at which the wind turbine starts to produce power in the case of steady wind without turbulence.

0.75 is a factor that approximates the square root sum of the squares (SRSS) combination of the earthquake load and the concurrent machinery load, i.e.:

$$0.75(1.0E_h + 1.0M) \approx [(1.0E_h)^2 + (1.0M)^2]^{1/2}$$

1.2.3. E contains a vertical component of earthquake load equal to $E_v=0.2S_{Ds}D$ as defined in ASCE 7.

2. CAPACITY

See Section 3 of this calculation booklet for the description of tower shell capacity.

3. DESIGN CRITERIA

The seismic design criteria is taken from RP2011 (AWEA, 2011) for use with ASCE 7 and the IBC (ICC, 2006, 2009, 2012, 2015, 2017, 2020). The RP2011 procedure is also generally compatible with IEC 61400-1 (IEC, 2003, 2019) and the GL Rules (GL, 2010).

EXCERPT: ASCE 7-05 DESIGN RESPONSE SPECTRUM

- δ_{xe} = deflection of Level x at the center of the mass at and above Level x determined by an elastic analysis, Section 12.8-6
- δ_{xm} = modal deflection of Level x at the center of the mass at and above Level x as determined by Section 19.3.2
- $\tilde{\delta}_x, \tilde{\delta}_{x1}$ = deflection of Level x at the center of the mass at and above Level x , Eqs. 19.2-13 and 19.3-3 (in. or mm)
- θ = stability coefficient for P -delta effects as determined in Section 12.8.7
- ρ = a redundancy factor based on the extent of structural redundancy present in a building as defined in Section 12.3.4
- ρ_s = spiral reinforcement ratio for precast, prestressed piles in Sections 14.2.7.1.6 and 14.2.7.2.6
- λ = time effect factor
- Ω_0 = overstrength factor as defined in Tables 12.2-1, 5.4-1, and 15.3-1

11.4 SEISMIC GROUND MOTION VALUES

11.4.1 Mapped Acceleration Parameters. The parameters S_S and S_1 shall be determined from the 0.2 and 1.0 s spectral response accelerations shown on Figs. 22-1 through 22-14, respectively. Where S_1 is less than or equal to 0.04 and S_S is less than or equal to 0.15, the structure is permitted to be assigned to Seismic Design Category A and is only required to comply with Section 11.7.

11.4.2 Site Class. Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Chapter 20. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

11.4.3 Site Coefficients and Adjusted Maximum Considered Earthquake (MCE) Spectral Response Acceleration Parameters. The MCE spectral response acceleration for short periods (S_{MS}) and at 1 s (S_{M1}), adjusted for Site Class effects, shall be determined by Eqs. 11.4-1 and 11.4-2, respectively.

$$S_{MS} = F_a S_S \tag{11.4-1}$$

$$S_{M1} = F_v S_1 \tag{11.4-2}$$

where

S_S = the mapped MCE spectral response acceleration at short periods as determined in accordance with Section 11.4.1, and

S_1 = the mapped MCE spectral response acceleration at a period of 1 s as determined in accordance with Section 11.4.1

where site coefficients F_a and F_v are defined in Tables 11.4-1 and 11.4-2, respectively. Where the simplified design procedure

TABLE 11.4-1 SITE COEFFICIENT, F_a

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_S .

Minimum Design Loads for Buildings and Other Structures

TABLE 11.4-2 SITE COEFFICIENT, F_v

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_1 .

of Section 12.14 is used, the value of F_a shall be determined in accordance with Section 12.14.8.1, and the values for F_v , S_{MS} , and S_{M1} need not be determined.

11.4.4 Design Spectral Acceleration Parameters. Design earthquake spectral response acceleration parameter at short period, S_{DS} , and at 1 s period, S_{D1} , shall be determined from Eqs. 11.4-3 and 11.4-4, respectively. Where the alternate simplified design procedure of Section 12.14 is used, the value of S_{DS} shall be determined in accordance with Section 12.14.8.1, and the value for S_{D1} need not be determined.

$$S_{DS} = \frac{2}{3} S_{MS} \tag{11.4-3}$$

$$S_{D1} = \frac{2}{3} S_{M1} \tag{11.4-4}$$

11.4.5 Design Response Spectrum. Where a design response spectrum is required by this standard and site-specific ground motion procedures are not used, the design response spectrum curve shall be developed as indicated in Fig. 11.4-1 and as follows:

- For periods less than T_0 , the design spectral response acceleration, S_a , shall be taken as given by Eq. 11.4-5:

$$S_a = S_{DS} \left(0.4 + 0.6 \frac{T}{T_0} \right) \tag{11.4-5}$$

- For periods greater than or equal to T_0 and less than or equal to T_S , the design spectral response acceleration, S_a , shall be taken equal to S_{DS} .

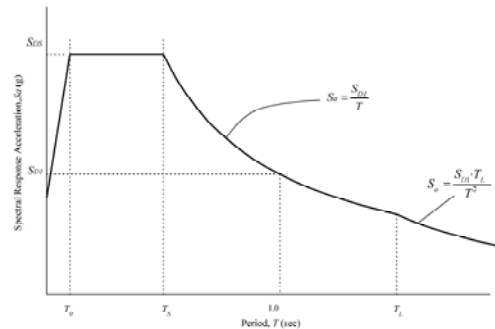


FIGURE 11.4-1 DESIGN RESPONSE SPECTRUM

EXCERPT: ASCE 7-05 DESIGN RESPONSE SPECTRUM (Continued)

3. For periods greater than T_S , and less than or equal to T_L , the design spectral response acceleration, S_a , shall be taken as given by Eq. 11.4-6:

$$S_a = \frac{S_{D1}}{T} \quad (11.4-6)$$

4. For periods greater than T_L , S_a shall be taken as given by Eq. 11.4-7:

$$S_a = \frac{S_{D1} T_L}{T^2} \quad (11.4-7)$$

where

S_{DS} = the design spectral response acceleration parameter at short periods

S_{D1} = the design spectral response acceleration parameter at 1-s period

T = the fundamental period of the structure, s

$$T_0 = 0.2 \frac{S_{D1}}{S_{DS}}$$

$$T_S = \frac{S_{D1}}{S_{DS}} \text{ and}$$

T_L = long-period transition period (s) shown in Fig. 22-15 (Conterminous United States), Fig. 22-16 (Region 1), Fig. 22-17 (Alaska), Fig. 22-18 (Hawaii), Fig. 22-19 (Puerto Rico, Culebra, Vieques, St. Thomas, St. John, and St. Croix), and Fig. 22-20 (Guam and Tutuila).

11.4.6 MCE Response Spectrum. Where a MCE response spectrum is required, it shall be determined by multiplying the design response spectrum by 1.5.

11.4.7 Site-Specific Ground Motion Procedures. The site-specific ground motion procedures set forth in Chapter 21 are permitted to be used to determine ground motions for any structure. A site response analysis shall be performed in accordance with Section 21.1 for structures on Site Class F sites, unless the exception to Section 20.3.1 is applicable. For seismically isolated structures and for structures with damping systems on sites with S_1 greater than or equal to 0.6, a ground motion hazard analysis shall be performed in accordance with Section 21.2.

11.5 IMPORTANCE FACTOR AND OCCUPANCY CATEGORY

11.5.1 Importance Factor. An importance factor, I , shall be assigned to each structure in accordance with Table 11.5-1 based on the Occupancy Category from Table 1-1.

11.5.2 Protected Access for Occupancy Category IV. Where operational access to an Occupancy Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Occupancy Category IV structures. Where operational access is less than 10 ft from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Occupancy Category IV structure.

TABLE 11.5-1 IMPORTANCE FACTORS

Occupancy Category	I
I or II	1.0
III	1.25
IV	1.5

TABLE 11.6-1 SEISMIC DESIGN CATEGORY BASED ON SHORT PERIOD RESPONSE ACCELERATION PARAMETER

Value of S_{DS}	Occupancy Category		
	I or II	III	IV
$S_{DS} < 0.167$	A	A	A
$0.167 \leq S_{DS} < 0.33$	B	B	C
$0.33 \leq S_{DS} < 0.50$	C	C	D
$0.50 \leq S_{DS}$	D	D	D

11.6 SEISMIC DESIGN CATEGORY

Structures shall be assigned a Seismic Design Category in accordance with Section 11.6.1.1.

Occupancy Category I, II, or III structures located where the mapped spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category E. Occupancy Category IV structures located where the mapped spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category F. All other structures shall be assigned to a Seismic Design Category based on their Occupancy Category and the design spectral response acceleration parameters, S_{DS} and S_{D1} , determined in accordance with Section 11.4.4. Each building and structure shall be assigned to the more severe Seismic Design Category in accordance with Table 11.6-1 or 11.6-2, irrespective of the fundamental period of vibration of the structure, T .

Where S_1 is less than 0.75, the Seismic Design Category is permitted to be determined from Table 11.6-1 alone where all of the following apply:

- In each of the two orthogonal directions, the approximate fundamental period of the structure, T_a , determined in accordance with Section 12.8.2.1 is less than $0.8T_S$, where T_S is determined in accordance with Section 11.4.5.
- In each of two orthogonal directions, the fundamental period of the structure used to calculate the story drift is less than T_S .
- Eq. 12.8-2 is used to determine the seismic response coefficient C_s .
- The diaphragms are rigid as defined in Section 12.3.1 or for diaphragms that are flexible, the distance between vertical elements of the seismic force-resisting system does not exceed 40 ft.

Where the alternate simplified design procedure of Section 12.14 is used, the Seismic Design Category is permitted to be determined from Table 11.6-1 alone, using the value of S_{DS} determined in Section 12.14.8.1.

11.7 DESIGN REQUIREMENTS FOR SEISMIC DESIGN CATEGORY A

11.7.1 Applicability of Seismic Requirements for Seismic Design Category A Structures. Structures assigned to Seismic Design Category A need only comply with the requirements of

TABLE 11.6-2 SEISMIC DESIGN CATEGORY BASED ON 1-S PERIOD RESPONSE ACCELERATION PARAMETER

Value of S_{D1}	OCCUPANCY CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067$	A	A	A
$0.067 \leq S_{D1} < 0.133$	B	B	C
$0.133 \leq S_{D1} < 0.20$	C	C	D
$0.20 \leq S_{D1}$	D	D	D

EXCERPT: ASCE 7-10 DESIGN RESPONSE SPECTRUM

CHAPTER 11 SEISMIC DESIGN CRITERIA

Table 11.4-1 Site Coefficient, F_a

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE _R) Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

Note: Use straight-line interpolation for intermediate values of S_S .

Table 11.4-2 Site Coefficient, F_v

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE _R) Spectral Response Acceleration Parameter at 1-s Period				
	$S_I \leq 0.1$	$S_I = 0.2$	$S_I = 0.3$	$S_I = 0.4$	$S_I \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7				

Note: Use straight-line interpolation for intermediate values of S_I .

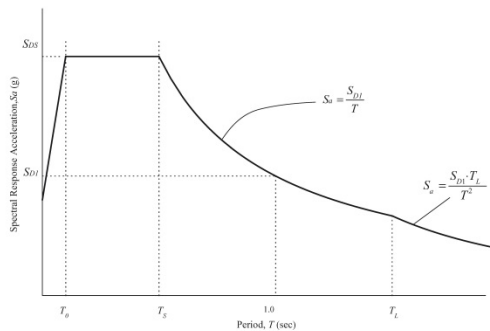


FIGURE 11.4-1 Design Response Spectrum.

11.4.5 Design Response Spectrum

Where a design response spectrum is required by this standard and site-specific ground motion procedures are not used, the design response spectrum curve shall be developed as indicated in Fig. 11.4-1 and as follows:

1. For periods less than T_0 , the design spectral response acceleration, S_a , shall be taken as given by Eq. 11.4-5:

$$S_a = S_{DS} \left(0.4 + 0.6 \frac{T}{T_0} \right) \quad (11.4-5)$$

2. For periods greater than or equal to T_0 and less than or equal to T_S , the design spectral response acceleration, S_a , shall be taken equal to S_{DS} .
3. For periods greater than T_S , and less than or equal to T_L , the design spectral response acceleration, S_a , shall be taken as given by Eq. 11.4-6:

$$S_a = \frac{S_{D1}}{T} \quad (11.4-6)$$

4. For periods greater than T_L , S_a shall be taken as given by Eq. 11.4-7:

$$S_a = \frac{S_{D1} T_L}{T^2} \quad (11.4-7)$$

where

S_{DS} = the design spectral response acceleration parameter at short periods

EXCERPT: ASCE 7-10 DESIGN RESPONSE SPECTRUM (Continued)

MINIMUM DESIGN LOADS

S_{D1} = the design spectral response acceleration parameter at 1-s period
 T = the fundamental period of the structure, s
 $T_0 = 0.2 \frac{S_{D1}}{S_{DS}}$
 $T_S = \frac{S_{D1}}{S_{DS}}$ and
 T_L = long-period transition period (s) shown in Figs. 22-12 through 22-16.

11.4.6 Risk-Targeted Maximum Considered (MCE_R) Response Spectrum

Where an MCE_R response spectrum is required, it shall be determined by multiplying the design response spectrum by 1.5.

11.4.7 Site-Specific Ground Motion Procedures

The site-specific ground motion procedures set forth in Chapter 21 are permitted to be used to determine ground motions for any structure. A site response analysis shall be performed in accordance with Section 21.1 for structures on Site Class F sites, unless the exception to Section 20.3.1 is applicable. For seismically isolated structures and for structures with damping systems on sites with S_1 greater than or equal to 0.6, a ground motion hazard analysis shall be performed in accordance with Section 21.2.

11.5 IMPORTANCE FACTOR AND RISK CATEGORY

11.5.1 Importance Factor

An importance factor, I_C , shall be assigned to each structure in accordance with Table 1.5-2.

11.5.2 Protected Access for Risk Category IV

Where operational access to a Risk Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Risk Category IV structures. Where operational access is less than 10 ft from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Risk Category IV structure.

11.6 SEISMIC DESIGN CATEGORY

Structures shall be assigned a Seismic Design Category in accordance with this section.

Risk Category I, II, or III structures located where the mapped spectral response acceleration

parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category E. Risk Category IV structures located where the mapped spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category F. All other structures shall be assigned to a Seismic Design Category based on their Risk Category and the design spectral response acceleration parameters, S_{DS} and S_{D1} , determined in accordance with Section 11.4.4. Each building and structure shall be assigned to the more severe Seismic Design Category in accordance with Table 11.6-1 or 11.6-2, irrespective of the fundamental period of vibration of the structure, T .

Where S_1 is less than 0.75, the Seismic Design Category is permitted to be determined from Table 11.6-1 alone where all of the following apply:

1. In each of the two orthogonal directions, the approximate fundamental period of the structure, T_a , determined in accordance with Section 12.8.2.1 is less than $0.8T_s$, where T_s is determined in accordance with Section 11.4.5.
2. In each of two orthogonal directions, the fundamental period of the structure used to calculate the story drift is less than T_s .
3. Eq. 12.8-2 is used to determine the seismic response coefficient C_s .

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

Value of S_{DS}	Risk Category	
	I or II or III	IV
$S_{DS} < 0.167$	A	A
$0.167 \leq S_{DS} < 0.33$	B	C
$0.33 \leq S_{DS} < 0.50$	C	D
$0.50 \leq S_{DS}$	D	D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

Value of S_{D1}	Risk Category	
	I or II or III	IV
$S_{D1} < 0.067$	A	A
$0.067 \leq S_{D1} < 0.133$	B	C
$0.133 \leq S_{D1} < 0.20$	C	D
$0.20 \leq S_{D1}$	D	D

EXCERPT:—ASCE 7-16 DESIGN RESPONSE SPECTRUM

0.15, the structure is permitted to be assigned to Seismic Design Category A and is only required to comply with Section 11.7.

User Note: Electronic values of mapped acceleration parameters and other seismic design parameters are provided at the U.S. Geological Survey (USGS) website at <https://doi.org/10.5066/F7NK3C76>.

11.4.3 Site Class. Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Chapter 20. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D, subject to the requirements of Section 11.4.4, shall be used unless the authority having jurisdiction or geotechnical data determine that Site Class E or F soils are present at the site.

For situations in which site investigations, performed in accordance with Chapter 20, reveal rock conditions consistent with Site Class B, but site-specific velocity measurements are not made, the site coefficients F_a , F_v , and F_{PGA} shall be taken as unity (1.0).

11.4.4 Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters. The MCE_R spectral response acceleration parameters for short periods (S_{MS}) and at 1 s (S_{M1}), adjusted for site class effects, shall be determined by Eqs. (11.4-1) and (11.4-2), respectively.

$$S_{MS} = F_a S_5 \quad (11.4-1)$$

$$S_{M1} = F_v S_1 \quad (11.4-2)$$

where

S_5 = the mapped- MCE_R spectral response acceleration parameter at short periods as determined in accordance with Section 11.4.2, and

S_1 = the mapped MCE_R spectral response acceleration parameter at a period of 1 s as determined in accordance with Section 11.4.2

where site coefficients F_a and F_v are defined in Tables 11.4-1 and 11.4-2, respectively. Where Site Class D is selected as the default site class per Section 11.4.3, the value of F_a shall not be less than 1.2. Where the simplified design procedure of Section 12.14 is used, the value of F_a shall be determined in accordance with Section 12.14.8.1, and the values for F_v , S_{MS} , and S_{M1} need not be determined.

Table 11.4-1 Short-Period Site Coefficient, F_a

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at Short Period					
	$S_5 \leq 0.25$	$S_5 = 0.5$	$S_5 = 0.75$	$S_5 = 1.0$	$S_5 = 1.25$	$S_5 \geq 1.5$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	See	See	See
F	See	See	See	Section 11.4.8	Section 11.4.8	Section 11.4.8
	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8

Note: Use straight-line interpolation for intermediate values of S_5 .

Table 11.4-2 Long-Period Site Coefficient, F_v

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-s Period					
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2 ^a	2.0 ^a	1.9 ^a	1.8 ^a	1.7 ^a
E	4.2	See	See	See	See	See
F	See	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8
	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8

Note: Use straight-line interpolation for intermediate values of S_1 .
^aAlso, see requirements for site-specific ground motions in Section 11.4.4.

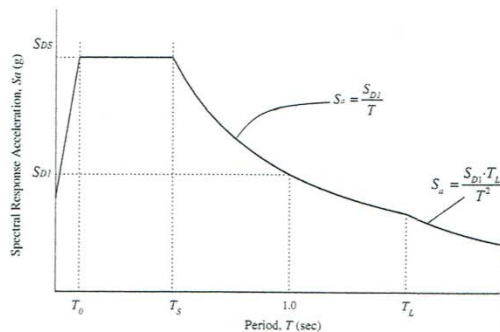


FIGURE 11.4-1 Design Response Spectrum

11.4.5 Design Spectral Acceleration Parameters. Design earthquake spectral response acceleration parameters at short periods, S_{DS} , and at 1-s periods, S_{D1} , shall be determined from Eqs. (11.4-3) and (11.4-4), respectively. Where the alternate simplified design procedure of Section 12.14 is used, the value of S_{DS} shall be determined in accordance with Section 12.14.8.1, and the value for S_{D1} need not be determined.

$$S_{DS} = \frac{2}{3} S_{MS} \quad (11.4-3)$$

$$S_{D1} = \frac{2}{3} S_{M1} \quad (11.4-4)$$

11.4.6 Design Response Spectrum. Where a design response spectrum is required by this standard and site-specific ground motion procedures are not used, the design response spectrum curve shall be developed as indicated in Fig. 11.4-1 and as follows:

1. For periods less than T_0 , the design spectral response acceleration, S_a , shall be taken as given in Eq. (11.4-5):

$$S_a = S_{DS} \left(0.4 + 0.6 \frac{T}{T_0} \right) \quad (11.4-5)$$

EXCERPT:—ASCE 7-16 DESIGN RESPONSE SPECTRUM (Continued)

- For periods greater than or equal to T_0 and less than or equal to T_s , the design spectral response acceleration, S_a , shall be taken as equal to S_{DS} .
- For periods greater than T_s and less than or equal to T_L , the design spectral response acceleration, S_a , shall be taken as given in Eq. (11.4-6):

$$S_a = \frac{S_{D1}}{T} \quad (11.4-6)$$

- For periods greater than T_L , S_a shall be taken as given in Eq. (11.4-7):

$$S_a = \frac{S_{D1}T_L}{T^2} \quad (11.4-7)$$

where

- S_{DS} = the design spectral response acceleration parameter at short periods
- S_{D1} = the design spectral response acceleration parameter at a 1-s period
- T = the fundamental period of the structure, s
- $T_0 = 0.2(S_{D1}/S_{DS})$
- $T_s = S_{D1}/S_{DS}$, and
- T_L = long-period transition period(s) shown in Figs. 22-14 through 22-17.

11.4.7 Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum. Where an MCE_R response spectrum is required, it shall be determined by multiplying the design response spectrum by 1.5.

11.4.8 Site-Specific Ground Motion Procedures. A site response analysis shall be performed in accordance with Section 21.1 for structures on Site Class F sites, unless exempted in accordance with Section 20.3.1. A ground motion hazard analysis shall be performed in accordance with Section 21.2 for the following:

- seismically isolated structures and structures with damping systems on sites with S_1 greater than or equal to 0.6,
- structures on Site Class E sites with S_s greater than or equal to 1.0, and,
- structures on Site Class D and E sites with S_1 greater than or equal to 0.2.

EXCEPTION: A ground motion hazard analysis is not required for structures other than seismically isolated structures and structures with damping systems where:

- Structures on Site Class E sites with S_s greater than or equal to 1.0, provided the site coefficient F_a is taken as equal to that of Site Class C.
- Structures on Site Class D sites with S_1 greater than or equal to 0.2, provided the value of the seismic response coefficient C_s is determined by Eq. (12.8-2) for values of $T \leq 1.5T_s$ and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for $T_L \geq T > 1.5T_s$ or Eq. (12.8-4) for $T > T_L$.
- Structures on Site Class E sites with S_1 greater than or equal to 0.2, provided that T is less than or equal to T_s and the equivalent static force procedure is used for design.

It shall be permitted to perform a site response analysis in accordance with Section 21.1 and/or a ground motion hazard analysis in accordance with Section 21.2 to determine ground motions for any structure.

When the procedures of either Section 21.1 or 21.2 are used, the design response spectrum shall be determined in accordance with Section 21.3, the design acceleration parameters shall be determined in accordance with Section 21.4, and, if required, the MCE_G peak ground acceleration parameter shall be determined in accordance with Section 21.5.

11.5 IMPORTANCE FACTOR AND RISK CATEGORY

11.5.1 Importance Factor. An Importance Factor, I_e , shall be assigned to each structure in accordance with Table 1.5-2.

11.5.2 Protected Access for Risk Category IV. Where operational access to a Risk Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Risk Category IV structures. Where operational access is less than 10 ft (3.048 m) from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Risk Category IV structure.

11.6 SEISMIC DESIGN CATEGORY

Structures shall be assigned a Seismic Design Category in accordance with this section.

Risk Category I, II, or III structures located where the mapped spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category E. Risk Category IV structures located where the mapped spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category F. All other structures shall be assigned to a Seismic Design Category based on their Risk Category and the design spectral response acceleration parameters, S_{DS} and S_{D1} , determined in accordance with Section 11.4.5. Each building and structure shall be assigned to the more severe Seismic Design Category in accordance with Table 11.6-1 or 11.6-2, respectively

TABLE 11.6-1 Seismic Design Category Based on Short-Period Response Acceleration Parameter

Value of S_{DS}	Risk Category	
	I or II or III	IV
$S_{DS} < 0.167$	A	A
$0.167 \leq S_{DS} < 0.33$	B	C
$0.33 \leq S_{DS} < 0.50$	C	D
$0.50 \leq S_{DS}$	D	D

TABLE 11.6-2 Seismic Design Category Based on 1-s Period Response Acceleration Parameter

Value of S_{D1}	Risk Category	
	I or II or III	IV
$S_{D1} < 0.067$	A	A
$0.067 \leq S_{D1} < 0.133$	B	C
$0.133 \leq S_{D1} < 0.20$	C	D
$0.20 \leq S_{D1}$	D	D

ASCE 7-16 EARTHQUAKE LOADS

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PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC) FILE: 03.0_EQ_GENERIC_ASCE 7-16_Supp1-3_VER20220203_B=5%.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS	VALUE	NOTES
2	STANDARD: ASCE 7-16 with Supplements 1-3				
3					
4	LOCATION				
5	Site/Project Name			GENERIC	
6	Latitude	LAT		N/A	
7	Longitude	LON		N/A	
8	Zip Code	Zip		N/A	
9	MAP MCE _R PARAMETERS				
10	0.2-sec Mapped SRA @ 5% damped	S _S	(g)	1.500	
11	1.0-sec Mapped SRA @ 5% damped	S _I	(g)	0.599999	< 0.6 g
12	Long-Period Transition Period	T _L	(sec)	12.0	
13	SITE CLASS MODIFIED MCE _R PARAMETERS @ 5% DAMPED				
14	Soil Parameters				
15	Site Class	SiteClass		Ddefault	
16	Supplement 3:				
17	11.4.8(1) SiteClass D and S _I ≥ 0.2	11.4.8(1)		TRUE	
18	EXCEPTION: GMHA performed?	GMHA		FALSE	
19	Increase Factor (IF) on S _{M1}	IF _{SM1}		1.500	NOTE: [!!! 1.5 ON SM1 !!!]
20	11.4.8(2) SiteClass E and (S _S ≥ 1.0 or S _I ≥ 0.2)	11.4.8(2)		FALSE	
21	EXCEPTION 1: Use ELF with C _s = S _{DS} / (R/I _e)	11.4.8(2)(1)		FALSE	
22	EXCEPTION 2: RE: 15.7	11.4.8(2)(2)		FALSE	
23					
24	Is 11.4.8 GMHA required?	11.4.8 _a		FALSE	
25	Is 11.4.8 site response analysis per 21.1 required?	11.4.8 _b		FALSE	
26					
27	Short-Period Site Coefficient	F _a		1.200	
28	Long-Period Site Coefficient	F _v		1.700	
29	Soil Modified MCE _R = F _a S _S	S _{MS}	(g)	1.800	
30	Soil Modified MCE _R = F _v S _I * IF _{SM1}	S _{M1}	(g)	1.530	NOTE: [!!! 1.5 ON SM1 !!!]
31	DESIGN SRA PARAMETERS @ 5% DAMPED				
32	Design 0.2-sec SRA	S _{DS}	(g)	1.200	
33	Design 1.0-sec SRA	S _{D1}	(g)	1.020	

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DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC) FILE: 03.0_EQ_GENERIC_ASCE 7-16_Supp1-3_VER20220203_B=5%.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS	VALUE	NOTES
34	STRUCTURE PARAMETERS				
35	Total Seismic Weight	W	(kip)	1075.700	
36	Reliability/Redundancy Factor	ρ		1.0	
37	Risk Category	RC		II	
38	Importance Factor	I_e		1.00	
39	Sesimic Design Category @ S_1	SDC_1		N/A	Section 11.6
40	Sesimic Design Category @ S_{DS}	SDC_{DS}		D	Table 11.6-1
41	Sesimic Design Category @ S_{D1}	SDC_{D1}		D	Table 11.6-2
42	Governing $SDC = \text{MAX}[SDC_1, SDC_2]$	SDC		D	Governing SDC
43	Seismic Force-Resisting System	$SFRS$		Steel tubular support structure for WTG	
44	Structural System Ductility Factor	R		1.5	
45	Deflection Amplification Factor	C_d		1.5	
46	Structure Type	ST		All Other	
47	Coefficient	C_t		0.020	
48	Exponent	x		0.75	
49	Structure Height	h_n	(ft)	320.538	
50	Approximate Fundamental Period	T_a	(sec)	1.515	
51	Period "cap" factor	C_u		1.400	
52	Upper Limit on T_B	$C_u T_a$	(sec)	2.121	
53	Analytical Fundamental Period	T_B	(sec)	5.375	
54	Period Selection	PS		Tb only	
55	Structure Fundamental Period	T	(sec)	5.375	

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	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS	VALUE	NOTES
56					
57	DESIGN RESPONSE SPECTRUM AND SEISMIC BASE SHEAR				
58	DESIGN RESPONSE SPECTRUM				
59	Effective Structural Damping	β		5%	Code Default
60	$T_0 = 0.2 T_S$	T_0	(sec)	0.170	
61	$T_S = S_{D1}/S_{DS}$	T_S	(sec)	0.850	
62	Is $T > 3.5 T_S$	$3.5 T_S$	(sec)	2.975	$\leq T$
63	Is the Structural Height > 160 ft	h_n	(ft)	320.538	> 160 ft
64	Dynamic Analysis Required?			YES	
65	R/I_e	R/I_e		1.500	
66	$C_{S@DS} = S_{DS} / (R/I_e)$	$C_{S@DS}$		0.800	
67	$C_{S,MAX1} = S_{D1}/[T(R/I_e)]$	$C_{S,MAX1}$		0.127	
68	$C_{S,MAX2} = S_{D1}T_L/[(R/I_e)T^2]$	$C_{S,MAX2}$		N/A	
69	$C_{S,MAX} = \text{MAX}[C_{S,MAX1}, C_{S,MAX2}]$	$C_{S,MAX}$		0.127	
70	$C_{s@T} = \text{MIN}[C_{s@DS}, C_{S,MAX}]$	$C_{s@T}$		0.127	
71					
72	For Building Structures:				
73	$C_{S,MIN1} = 0.01$	$C_{S,MIN1}$		0.010	
74	$C_{S,MIN1A} = 0.044S_{DS}I_e$	$C_{S,MIN1A}$		0.053	
75	$C_{S,MIN2} = 0.5S_1/(R/I_e)$	$C_{S,MIN2}$		N/A	Applicable @ $S_1 \geq 0.6g$
76	For Nonbuilding Structures:				
77	Is this a Nonbuilding Structure?	NBS		TRUE	Chapter 15 applies
78	$C_{S,MIN3} = 0.03$	$C_{S,MIN3}$		0.030	
79	$C_{S,MIN3A} = 0.044S_{DS}I_e$	$C_{S,MIN3A}$		0.053	
80	$C_{S,MIN4} = 0.8S_1/(R/I_e)$	$C_{S,MIN4}$		N/A	Applicable @ $S_1 \geq 0.6g$
81	Governing $C_{S,MIN}$	$C_{S,MIN}$		0.053	
82					
83	Governing C_S	C_S		0.127	
84					
85	Total Seismic Weight	W	(kip)	1075.700	
86					
87	HORIZONTAL SEISMIC LOAD - BASE SHEAR				
88	Reliability/Redundancy Factor	ρ		1.000	
89	Seismic Base Shear $V = Q_E = C_S W$	$V = Q_E$	(kip)	136.088	
90	Horizontal Earthquake Load $E_h = \rho Q_E$	E_h	(kip)	136.088	
91					
92	VERTICAL SEISMIC LOAD				
93	Vertical Seismic Coefficient on D	$0.2S_{DS}$		0.240	
94	Vertical Seismic Load $E_v = 0.2S_{DS}D$	E_v	(kip)	258.168	
95					
96					
97					

ASCE 7-16 RSA PARAMETERS

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DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC) FILE: 03.0_EQ_GENERIC_ASCE 7-16_Supp1-3_VER20220203_B=5%.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS	VALUE	NOTES
3	STANDARD: ASCE 7-16				
4	DESIGN BASE SHEAR WITH DAMPING ADJUSTMENT				
5	DAMPING ADJUSTMENT				
6	Effective Structural Damping	β	(%)	5.0	Adjust if other than 5%
7	Select Damping Adjustment Method			RP2011	
8	Spectral Damping Adjustment Factor	B_S		1.000	
9	Spectral Damping Adjustment Factor	B_1		1.000	
10	ADJUSTED DESIGN RESPONSE SPECTRUM				
11		R		1.5	
12		I_e		1.00	
13	R/I_e	R/I_e		1.500	
14	Fundamental Period	T	(sec)	5.375	
15					
16	Adjusted 0.2-sec SRA: $S_{DS} B_S$	$S_{DS} B_S$	(g)	1.200	
17	Adjusted 1.0-sec SRA: $S_{D1} B_1$	$S_{D1} B_1$	(g)	1.020	
18	$C_{S@DS} = S_{DS} B_S / (R/I_e)$	$C_{S@SDS}$		0.800	
19	$C_{S,MAX1} = S_{D1} B_1 / [T(R/I_e)]$	$C_{S,MAX1}$		0.127	
20	$C_{S,MAX2} = S_{D1} B_1 T_L / [(R/I_e) T^2]$	$C_{S,MAX2}$		N/A	
21	$C_{S,MAX} = \text{MAX}[C_{S,MAX1}, C_{S,MAX2}]$	$C_{S,MAX}$		0.127	
22	$C_{S@T} = \text{MIN}[C_{S@DS}, C_{S,MAX}]$	$C_{S@T}$		0.127	
23					
24	For Building Structures:				
25	$C_{S,MIN1} = 0.01 B_S$	$C_{S,MIN1}$		0.010	
26	$C_{S,MIN1A} = 0.044 S_{DS} B_S I_e$	$C_{S,MIN1A}$		0.053	
27	$C_{S,MIN2} = 0.5 S_1 B_1 / (R/I_e)$	$C_{S,MIN2}$		N/A	Applicable @ $S_1 \geq 0.6g$
28	For Nonbuilding Structures:				
29	Is this a Nonbuilding Structure?	NBS		TRUE	
30	$C_{S,MIN3} = 0.03 B_S$	$C_{S,MIN3}$		0.030	
31	$C_{S,MIN3A} = 0.044 S_{DS} B_S I_e$	$C_{S,MIN3A}$		0.053	
32	$C_{S,MIN4} = 0.8 S_1 B_1 / (R/I_e)$	$C_{S,MIN4}$		N/A	Applicable @ $S_1 \geq 0.6g$
33	Governing $C_{S,MIN}$	$C_{S,MIN}$		0.053	
34					
35	Governing C_S	C_S		0.127	
36					
37	Total Seismic Weight	W	(kip)	1075.700	
38					
39	Seismic Base Shear $V=Q_E=C_S W$	$V=Q_E$	(kip)	136.088	
40					
41					
42					
43					
44					
45					

ASCE 7-16 RSA PARAMETERS

BY: NAA

PAGE 5 OF 5

PROJECT: VESTAS V163/V166 HH98M-TA36200 TOWER

DATE: 12/7/2025

ASE JOB NO.: 25-031 (GENERIC) FILE: 03.0_EQ_GENERIC_ASCE 7-16_Supp1-3_VER20220203_B=5%.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS	VALUE	NOTES
46	MODAL RESPONSE SPECTRUM ANALYSIS (MRSA) SCALING PARAMETERS				
47	Minimum Modal Mass Participation	$MMMP$	(%)	90%	
48	ELF Base Shear $V=V_{ELF}$	V	(kip)	136.088	
49	Scale Factor on $V=V_{ELF}$	SF_{MRSA}		0.85	
50	$SF_{MRSA} V$	$SF_{MRSA} V$	(kip)	115.675	
51	MRSA Base Shear = V_{MRSA}	V_{MRSA}	(kip)	226.451	
52	MRSA Base Shear divided by R/I_e : $V_t = V_{MRSA} / (R/I_e)$	V_t	(kip)	150.967	$\geq SF_{MRSA} * V$, do not scale
53	MRSA Base Moment	M_{MRSA}	(kip-ft)	43245	
54	MRSA Base Moment divided by R/I_e : $M_t = M_{MRSA} / (R/I_e)$	M_t	(kip-ft)	28830	
55	Scaling Factor for Forces and Moments: $SF_{MRSA} V/V_t$	SF		1.000	
56	Scaled Design Base Shear = $SF * V_t$	$V_{u,base}$	(kip)	150.967	
57	Scaled Design Base Moment at $SF * M_t$	$M_{u,base}$	(kip-ft)	28830	
58					
59	Scaling of Drifts from $S_a / (R/I_e)$ response spectrum:				
60	C_d / I_e	C_d / I_e		1.500	
61	Scale Factor for Drifts	SF_{drift1}		1.500	Section 12.9.1.2
62	$S_1 \geq 0.600$ g ?			NO	
63	$C_s = (0.5 \text{ or } 0.8)(S_1 B_1) / (R/I_e)$	C_s		0.320	
64		$SF_{MRSA} C_s W$	(kip)	292.590	
65	$SF_{MRSA} C_s W \geq V_t$			YES	
66	Scale Factor for Drifts incl. C_d / I_e	SF_{drift2}		N/A	Section 12.9.1.4.2
67					
68	Use $SF_{drift} = \text{MAX}(SF_{drift1}, SF_{drift2})$	SF_{drift}		1.500	
69					
70					
71					
72					
73					
74					
75					
76					
77					
78					
79					
80					
81					
82					
83					
84					

$$EQ1 = 1.2D + 0.75(1.0E5\% + 1.0M)$$

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 2 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project 25-031 = Job No. 0139-0349 VER 01 (2023.02.13) = Loads Doc.		SECTION PROPERTIES AT TOP AND BOTTOM ENDS OF CAN MEMBERS																	
VESTAS = Turbine Make V163/V166-4.5MW Mk4A = Turbine Model S = IEC Site Class 98.000 = Hub Height (m) A024-4468 ver. V01 = Tower Model		Display Convention: Properties at a joint row are for the top of the "member below."																	
TOWER PROFILE							SECTION PROPERTIES												
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	t _{MEMB} (mm)	t _{MEMB} (in)	OD (in)	ID (in)	A (in ²)	I _x , I _y (in ⁴)	r _m (in)	S _x , S _y (@D _m) (in ³)	J/c (@D _m) (in ³)	r gyration (in)	Z _x , Z _y (in ³)	
1			7.218	321.522	98.000														
2	TOP_FLG			314.304	95.800	10.715	0.8661	22	0.866142	128.583	126.850	347.525	7.086E+05	63.858	11096.170	22192.340	45.156	14128.299	
3		2685	22.0	8.809	305.495	93.115	10.813	20	0.783465	129.760	128.193	317.453	6.601E+05	64.488	10235.984	20471.968	45.601	13033.020	
4		2285	19.9	7.497	297.999	90.830	10.833	20	0.779528	130.001	128.442	316.457	6.606E+05	64.611	10223.236	20446.472	45.687	13016.786	
5		2285	19.8	7.497	290.502	88.545	10.845	17	0.669291	130.135	128.797	272.220	5.704E+05	64.733	8810.807	17621.613	45.774	11218.367	
6		2816	17.0	9.239	281.263	85.729	10.870	17	0.685039	130.437	129.098	272.854	5.744E+05	64.884	8851.908	17703.816	45.880	11270.699	
7		2816	17.4	9.239	272.024	82.913	10.896	17	0.685039	130.754	129.384	279.924	5.920E+05	65.035	9102.355	18204.710	45.987	11589.585	
8		2816	17.8	9.239	262.785	80.097	10.923	18	0.700787	130.770	129.368	286.359	6.056E+05	65.035	9311.604	18623.209	45.987	11856.018	
9		2816	18.2	9.239	253.547	77.281	10.949	18	0.700787	131.072	129.670	287.023	6.098E+05	65.185	9354.840	18709.681	46.094	11911.067	
10		2816	18.6	9.239	244.308	74.465	10.976	19	0.732283	131.087	129.654	293.473	6.235E+05	65.185	9565.062	19130.123	46.094	12178.737	
11		2816	19.2	9.239	235.069	71.649	11.003	19	0.755906	131.389	129.956	294.152	6.279E+05	65.336	9609.371	19218.743	46.200	12235.154	
12		3033	20.3	9.951	225.830	68.833	11.029	19	0.732283	131.405	129.940	300.617	6.417E+05	65.336	9820.566	19641.133	46.200	12504.064	
13	SPLICE3			215.879	65.800	11.057	0.7992	20	0.755906	131.706	130.242	301.310	6.461E+05	65.487	9865.955	19731.910	46.307	12561.855	
14		2413	20.9	7.917	207.963	63.387	11.059	20	0.799213	131.732	130.278	303.364	7.150E+05	65.789	10867.098	21734.197	46.631	13836.590	
15		2298	21.5	7.539	200.423	61.089	11.061	21	0.822835	132.689	131.091	331.149	7.201E+05	65.945	10918.787	21837.573	46.631	13902.401	
16		2299	22.3	7.543	192.881	58.790	11.064	21	0.822835	132.713	131.067	340.937	7.413E+05	65.945	11241.509	22483.019	46.631	14313.320	
17		2930	23.8	9.613	183.268	55.860	11.069	21	0.846457	132.736	131.043	350.724	7.626E+05	65.945	11564.232	23128.465	46.631	14724.240	
18		2930	25.3	9.613	173.655	52.930	11.074	22	0.877953	132.736	131.043	350.724	7.626E+05	65.945	11564.232	23128.465	46.631	14724.240	
19		2930	26.8	9.613	164.042	50.000	11.079	22	0.877953	132.768	131.012	363.774	7.910E+05	65.945	11994.529	23989.059	46.631	15272.135	
20		2930	28.2	9.613	154.429	47.070	11.083	22	0.877953	132.768	131.012	363.774	7.910E+05	65.945	11994.529	23989.059	46.631	15272.135	
21		2930	29.7	9.613	144.816	44.140	11.088	24	0.937008	132.827	130.953	388.244	8.442E+05	65.945	12801.336	25602.672	46.631	16299.442	
22		3130	32.7	10.269	135.203	41.210	11.094	24	0.937008	132.827	130.953	388.244	8.442E+05	65.945	12801.336	25602.672	46.631	16299.442	
23	SPLICE2			124.934	38.080	11.096	1.2598	25	0.996063	132.886	130.894	412.713	8.974E+05	65.945	13608.143	27216.286	46.631	17326.755	
24		3020	32.0	9.908	115.026	35.060	11.311	25	0.996063	132.886	130.894	412.713	8.974E+05	65.945	13608.143	27216.286	46.631	17326.755	
25		2819	28.7	9.249	105.778	32.241	11.536	27	1.055118	132.945	130.835	437.182	9.507E+05	65.945	14414.950	28829.900	46.632	18354.076	
26		2819	29.0	9.249	96.529	29.422	11.762	27	1.055118	132.945	130.835	437.182	9.507E+05	65.945	14414.950	28829.900	46.632	18354.076	
27		2819	28.7	9.249	87.280	26.603	11.988	28	1.102366	133.000	130.780	460.020	1.000E+06	65.945	15167.970	30335.940	46.632	19312.915	
28		2820	28.9	9.252	78.028	23.783	12.214	28	1.102366	133.000	130.780	460.020	1.000E+06	65.945	15167.970	30335.940	46.632	19312.915	
29		2817	29.5	9.242	68.783	20.965	12.440	30	1.169291	133.059	130.720	484.489	1.054E+06	65.945	15974.777	31949.553	46.632	20340.250	
30		3028	34.8	9.934	59.541	18.148	12.667	30	1.169291	133.059	130.720	484.489	1.054E+06	65.945	15974.777	31949.553	46.632	20340.250	
31	SPLICE1			49.606	15.120	12.908	1.3543	31	1.232283	133.122	130.657	510.589	1.110E+06	65.945	16835.371	33670.741	46.632	21436.083	
32		2720	34.4	8.924	40.682	12.400	12.908	31	1.232283	133.122	130.657	510.589	1.110E+06	65.945	16835.371	33670.741	46.632	21436.083	
33		2505	35.3	8.219	32.464	9.895	12.911	33	1.287402	133.177	130.602	533.427	1.160E+06	65.945	17588.390	35176.781	46.632	22394.946	
34		2505	36.2	8.219	24.245	7.390	12.914	33	1.287402	133.177	130.602	533.427	1.160E+06	65.945	17588.390	35176.781	46.632	22394.946	
35		1500	52.4	4.921	19.324	5.890	12.967	32	1.259843	133.150	130.630	522.008	1.135E+06	65.945	17211.881	34423.761	46.632	21915.514	
36		2930	52.4	9.613	9.711	2.960	12.967	32	1.259843	133.150	130.630	522.008	1.135E+06	65.945	17211.881	34423.761	46.632	21915.514	
37	BOT_FLG			0.656	0.200	12.967	2.0630	32	1.259843	133.150	130.630	522.008	1.135E+06	65.945	17211.881	34423.761	46.632	21915.514	

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EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN							MEMBER AVERAGE PROPERTIES												
25-031																			
0139-0349 VER 01 (2023.02.13)																			
VESTAS																			
V163/V166-4.5MW Mk4A																			
S																			
98.000 = Hub Height (m)																			
A024-4468 ver. V01																			
TOWER PROFILE							MEMBER SECTION PROPERTIES												
JOINT	H_CAN	t	H_CAN	JOINT ELEV	JOINT ELEV	CAN t	I_MEMB	D_MAVG	OD	ID	A_MEMB	I_MEMB	J_MEMB	A_MEMB	I_MEMB	J_MEMB			
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(mm)	(mm)	(mm)	(mm)	(mm ²)	(mm ⁴)	(mm ⁴)	(in ²)	(in ⁴)	(in ⁴)			
1			7.218	321.522	98.000														
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	22	3260	3282	3238	225315	2.993E+11	5.987E+11	349.239	719151	1438303	
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	20	3279	3299	3259	205002	2.755E+11	5.511E+11	317.754	662005	1324010	
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	20	3285	3305	3266	204359	2.757E+11	5.514E+11	316.757	662431	1324863	
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	17	3292	3309	3275	175830	2.382E+11	4.765E+11	272.537	572360	1144720	
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	17	3300	3317	3283	180386	2.455E+11	4.911E+11	279.599	589927	1179855	
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	18	3308	3325	3290	184961	2.529E+11	5.059E+11	286.691	607703	1215405	
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	18	3315	3333	3297	189556	2.604E+11	5.209E+11	293.812	625687	1251374	
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	19	3323	3342	3304	194170	2.680E+11	5.360E+11	300.963	643883	1287765	
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	19	3331	3350	3311	200895	2.786E+11	5.571E+11	311.388	669262	1338524	
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	20	3338	3358	3319	206601	2.878E+11	5.756E+11	320.232	691441	1382883	
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	20	3346	3366	3326	213391	2.986E+11	5.973E+11	330.757	717508	1435016	
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	21	3350	3371	3329	219959	3.086E+11	6.171E+11	340.937	741349	1482698	
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	22	3350	3372	3329	226273	3.174E+11	6.349E+11	350.724	762633	1525267	
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	22	3350	3372	3328	234693	3.292E+11	6.585E+11	363.774	791013	1582026	
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	24	3350	3374	3326	250479	3.514E+11	7.028E+11	388.244	844225	1688450	
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	25	3350	3375	3325	266266	3.735E+11	7.471E+11	412.713	897439	1794877	
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	27	3350	3377	3323	282052	3.957E+11	7.914E+11	437.182	950653	1901306	
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	28	3350	3378	3322	296786	4.164E+11	8.327E+11	460.020	1000321	2000642	
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	30	3350	3380	3320	312573	4.385E+11	8.770E+11	484.489	1053538	2107075	
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	31	3350	3381	3319	329412	4.621E+11	9.243E+11	510.589	1110303	2220607	
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	33	3350	3383	3317	344146	4.828E+11	9.656E+11	533.427	1159975	2319950	
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	32	3384	3416	3352	340237	4.872E+11	9.744E+11	527.368	1170464	2340928	
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	29	3453	3482	3424	311352	4.641E+11	9.282E+11	482.596	1115052	2230104	
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	29	3522	3551	3493	320872	4.976E+11	9.951E+11	497.352	1195372	2390744	
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	29	3591	3619	3562	323753	5.218E+11	1.044E+12	501.818	1253663	2507326	
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	29	3660	3688	3631	332254	5.562E+11	1.112E+12	514.995	1336343	2672686	
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	29	3728	3757	3699	342012	5.943E+11	1.189E+12	530.119	1427775	2855550	
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	30	3797	3827	3768	351896	6.342E+11	1.268E+12	545.440	1523701	3047402	
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	35	3866	3900	3831	422626	7.895E+11	1.579E+12	655.071	1896792	3793584	
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	34	3900	3934	3866	421476	8.014E+11	1.603E+12	653.289	1925356	3850712	
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	35	3900	3935	3865	432503	8.224E+11	1.645E+12	670.381	1975737	3951474	
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	36	3900	3936	3864	443530	8.433E+11	1.687E+12	687.473	2026118	4052237	
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222	
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222	
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222	
37	BOT_FLG				0.656	0.200	12.967												

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EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200
 JOB NO.: 25-031 (GENERIC)

PAGE 5 OF 15
 DATE: 12/7/2025
 FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project										MATERIAL PROPERTIES									
25-031 = Job No.										ID	NAME	F _y	F _w	E	v	G	P _{STEEL}	t _{MIN}	t _{MAXINCL}
0139-0349 VER 01 (2023.02.13) = Loads Doc.										(no)	(-)	(ksi)	(ksi)	(ksi)	(-)	(ksi)	(pcf)	(mm)	(mm)
VESTAS = Turbine Make										15	RIGIDMASSLESS	50	65	2.90E+07	0	1.12E+07	0	0	10000
V163/V166-4.5MW Mk4A = Turbine Model										4	S355-355-00-16	51	68	2.90E+04	0	1.12E+04	490	0	16
S = IEC Site Class										5	S355-345-16-40	50	68	2.90E+04	0	1.12E+04	490	16	40
98.000 = Hub Height (m)										6	S355-335-40-63	49	68	2.90E+04	0	1.12E+04	490	40	63
A024-4468 ver. V01 = Tower Model										14	S420-400-16-40	58	75	2.90E+04	0	1.12E+04	490	16	40

TOWER PROFILE									MEMBER MATERIAL PROPERTIES									
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t		ID	NAME	F _y	F _w	E	v	G	P _{STEEL}	t _{MIN}	t _{MAXINCL}
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)		(no)	(-)	(ksi)	(ksi)	(ksi)	(-)	(ksi)	(pcf)	(mm)	(mm)
1			7.218	321.522	98.000				15	RIGIDMASSLESS	50.000	65.000	2.90E+07	0.300	1.12E+07	0	0	10000
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63
37	BOT FLG				0.656	0.200	12.967											

EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN							BASIC LOAD CASE 1 OF 3 (MAX.)											
25-031												BASIC LOAD CASE						
0139-0349 VER 01 (2023.02.13)												D+E _v /1.4						
VESTAS							1.200 = S _{DS} @ 5% = β					LOAD FACTORS:						
V163/V166-4.5MW Mk4A							1.200 = S _{DS} @ 5% = β					LF _{Fz} 1.440 = 1.2+0.2S _{DS}						
S							3.806 = x _{CG} (ft)					LF _{Mz} 1.440						
98.000 = Hub Height (m)												LF _{Fxy} 1.440						
A024-4468 ver. V01												LF _{Mxy} 1.440						
TOWER PROFILE							SERVICE LOADS					FACTORED LOADS						
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN OD	t	LOAD STA	F _Z	M _Z	F _{XY}	M _{XY}	F _Z	M _Z	F _{XY}	M _{XY,0.1}	LF _{FR}	M _{XY,0.2}
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)
1			7.218	321.522	98.000			98.000	2265	0.000	0.000	803	3262	0	0	1156	1.000	1156
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	2308	0.000	0.000	803	3324	0	0	1156	1.000	1156
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	2350	0.000	0.000	803	3384	0	0	1156	1.000	1156
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	2387	0.000	0.000	803	3437	0	0	1156	1.000	1156
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	2425	0.000	0.000	803	3492	0	0	1156	1.000	1156
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	2465	0.000	0.000	803	3549	0	0	1156	1.000	1156
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	2505	0.000	0.000	803	3607	0	0	1156	1.000	1156
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	2547	0.000	0.000	803	3667	0	0	1156	1.000	1156
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	2589	0.000	0.000	803	3729	0	0	1156	1.000	1156
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	2633	0.000	0.000	803	3792	0	0	1156	1.000	1156
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	2678	0.000	0.000	803	3857	0	0	1156	1.000	1156
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	2727	0.000	0.000	803	3926	0	0	1156	1.000	1156
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	2795	0.000	0.000	803	4024	0	0	1156	1.000	1156
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	2836	0.000	0.000	803	4084	0	0	1156	1.000	1156
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	2878	0.000	0.000	803	4144	0	0	1156	1.000	1156
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	2928	0.000	0.000	803	4216	0	0	1156	1.000	1156
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	2987	0.000	0.000	803	4301	0	0	1156	1.000	1156
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	3050	0.000	0.000	803	4392	0	0	1156	1.000	1156
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	3116	0.000	0.000	803	4487	0	0	1156	1.000	1156
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	3186	0.000	0.000	803	4588	0	0	1156	1.000	1156
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	3259	0.000	0.000	803	4693	0	0	1156	1.000	1156
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	3339	0.000	0.000	803	4808	0	0	1156	1.000	1156
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	3481	0.000	0.000	803	5012	0	0	1156	1.000	1156
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	3555	0.000	0.000	803	5119	0	0	1156	1.000	1156
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	3625	0.000	0.000	803	5220	0	0	1156	1.000	1156
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	3696	0.000	0.000	803	5322	0	0	1156	1.000	1156
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	3768	0.000	0.000	803	5426	0	0	1156	1.000	1156
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	3842	0.000	0.000	803	5533	0	0	1156	1.000	1156
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	3918	0.000	0.000	803	5642	0	0	1156	1.000	1156
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	4007	0.000	0.000	803	5770	0	0	1156	1.000	1156
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	4181	0.000	0.000	803	6020	0	0	1156	1.000	1156
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	4267	0.000	0.000	803	6145	0	0	1156	1.000	1156
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	4353	0.000	0.000	803	6268	0	0	1156	1.000	1156
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	4433	0.000	0.000	803	6384	0	0	1156	1.000	1156
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	4544	0.000	0.000	803	6543	0	0	1156	1.000	1156
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	4685	0.000	0.000	803	6747	0	0	1156	1.000	1156
37	BOT_FLG				0.656	0.200	12.967	0.200	4785	0.000	0.000	803	6890	0	0	1156	1.000	1156

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Bakersfield, CA 93301

EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project								BASIC LOAD CASE 2 OF 3 (MAX.)										
25-031 = Job No.								BASIC LOAD CASE										
0139-0349 VER 01 (2023.02.13) = Loads Doc.								[E _{50/1.4}] ... at R=1.5, 5% damping										
VESTAS = Turbine Make								LOAD FACTORS:										
V163/V166-4.5MW Mk4A = Turbine Model								LF _{Fz} 1.050 = (0.75)(1.4)										
S = IEC Site Class								LF _{Mz} 1.050										
98.000 = Hub Height (m)								LF _{Fxy} 1.050										
A024-4468 ver. V01 = Tower Model								LF _{Mxy} 1.050										
3.806 = x _{CG} (ft)																		
TOWER PROFILE								SERVICE LOADS				FACTORED LOADS						
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	LOAD STA (m)	F _Z (kN)	M _Z (kN-m)	F _{XY} (kN)	M _{XY} (kN-m)	1.050 F _Z (kN)	1.050 M _Z (kN-m)	1.050 F _{XY} (kN)	1.050 M _{XY,0.1} (kN-m)	LF _{Fz}	M _{XY,0.2} (kN-m)
1			7.218	321.522	98.000			98.000	0	306	264	8284	0.000	322	277	8698	1.000	8698
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	0	306	270	8141	0.000	322	283	8548	1.000	8548
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	0	306	275	7983	0.000	322	289	8382	1.000	8382
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	0	306	280	7892	0.000	322	294	8286	1.000	8286
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	0	306	284	7842	0.000	322	298	8234	1.000	8234
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	0	306	288	7841	0.000	322	302	8234	1.000	8234
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	0	306	291	7911	0.000	322	305	8306	1.000	8306
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	0	306	293	8049	0.000	322	308	8451	1.000	8451
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	0	306	295	8252	0.000	322	309	8665	1.000	8665
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	0	306	296	8518	0.000	322	311	8943	1.000	8943
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	0	306	298	8838	0.000	322	313	9280	1.000	9280
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	0	306	299	9209	0.000	322	314	9669	1.000	9669
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	0	306	302	9656	0.000	322	318	10139	1.000	10139
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	0	306	305	10039	0.000	322	320	10541	1.000	10541
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	0	306	307	10427	0.000	322	323	10948	1.000	10948
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	0	306	311	10837	0.000	322	327	11379	1.000	11379
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	0	306	316	11388	0.000	322	332	11957	1.000	11957
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	0	306	322	11968	0.000	322	338	12567	1.000	12567
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	0	306	329	12576	0.000	322	346	13205	1.000	13205
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	0	306	337	13211	0.000	322	354	13872	1.000	13872
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	0	306	346	13873	0.000	322	364	14567	1.000	14567
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	0	306	357	14562	0.000	322	375	15291	1.000	15291
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	0	306	379	15331	0.000	322	398	16098	1.000	16098
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	0	306	391	16103	0.000	322	410	16908	1.000	16908
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	0	306	402	16859	0.000	322	422	17702	1.000	17702
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	0	306	412	17652	0.000	322	433	18534	1.000	18534
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	0	306	422	18481	0.000	322	444	19405	1.000	19405
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	0	306	432	19348	0.000	322	454	20315	1.000	20315
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	0	306	441	20250	0.000	322	463	21263	1.000	21263
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	0	306	449	21188	0.000	322	472	22247	1.000	22247
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	0	306	464	22234	0.000	322	487	23346	1.000	23346
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	0	306	470	23210	0.000	322	493	24370	1.000	24370
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	0	306	474	24135	0.000	322	497	25342	1.000	25342
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	0	306	476	25084	0.000	322	500	26338	1.000	26338
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	0	306	478	25663	0.000	322	502	26946	1.000	26946
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	0	306	480	26814	0.000	322	504	28154	1.000	28154
37	BOT_FLG				0.656	0.200	12.967	0.200	0	306	480	27920	0.000	322	504	29316	1.000	29316

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EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 9 OF 15
DATE: 12/7/2025
FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

Table with columns: TOWER PROFILE, SERVICE LOADS, FACTORED LOADS. Rows include JOINT, H_CAN, t, H_CAN, JOINT ELEV, JOINT ELEV, OD, CAN t, LOAD STA, F_Z, M_Z, F_XY, M_XY, F_Z, M_Z, F_XY, M_XY, L_F_P, M_XY, L_2. Includes project info and load factors.

EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project		LOAD COMBINATION																
25-031 = Job No.		Load Summary at Flange Elevations:																
0139-0349 VER 01 (2023.02.13) = Loads Doc.		F_z	F_{xy} $M_{xy,0.1}$															
VESTAS = Turbine Make		TOP_FLG	3290.237 874.463 14888.751															
V163/V166-4.5MW Mk4A = Turbine Model		SPLICE3	3991.128 907.571 37865.348															
S = IEC Site Class		SPLICE2	4979.010 986.374 62763.046															
98.000 = Hub Height (m)		SPLICE1	5986.785 1074.843 84580.994															
A024-4468 ver. V01 = Tower Model		BOT_FLG	6856.988 1090.752 99407.539															
LOAD COMBINATION: $U_{EQ1} = (1.2+0.2S_{DB})D + 0.75(1.0E_{55}+1.0M)$																		
FLAG SETTINGS: P_A Flag=[The Override Value or 1=Use Analysis]																		
INPUT : Δ_{USE} Flag=[CALCulated or INPUT]																		
SRSS : $\Delta_{Input,TOT}$ Flag=[ABSSUM or SRSS] with Input Δ_i																		
SRSS : Δ_{TOTAL} Flag=[ABSSUM or SRSS] with Δ_{TOO}																		
TOWER PROFILE																		
SERVICE LOADS								FACTORED LOADS										
JOINT	H_{CAN}	t	H_{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	LOAD STA	F_z	M_z	F_{xy}	M_{xy}	F_z	M_z	F_{xy}	$M_{xy,0.1}$	LF_{FA}	$M_{xy,0.2}$
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)
1			7.218	321.522	98.000			98.000	2221	4564	1053	13982	3229	3515	869	13526	1.000	13526
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	2264	4564	1058	15467	3290	3515	874	14597	1.020	14889
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	2306	4564	1063	17301	3351	3515	880	15924	1.045	16635
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	2343	4564	1068	18906	3404	3515	885	17101	1.063	18171
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	2381	4564	1072	20555	3459	3515	889	18323	1.078	19755
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	2420	4564	1076	22651	3516	3515	893	19895	1.094	21774
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	2461	4564	1078	24817	3574	3515	896	21540	1.108	23865
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	2502	4564	1081	27052	3634	3515	898	23258	1.119	26026
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	2545	4564	1082	29353	3695	3515	900	25045	1.128	28253
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	2589	4564	1084	31715	3758	3515	902	26896	1.135	30538
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	2634	4564	1085	34132	3824	3515	903	28805	1.141	32876
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	2682	4564	1086	36598	3893	3515	905	30765	1.146	35258
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	2750	4564	1089	39302	3991	3515	908	32927	1.150	37865
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	2792	4564	1091	41478	4051	3515	910	34674	1.152	39961
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	2833	4564	1094	43574	4110	3515	913	36363	1.154	41975
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	2883	4564	1097	45692	4182	3515	916	38074	1.156	44005
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	2942	4564	1102	48420	4268	3515	921	40285	1.157	46611
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	3005	4564	1108	51177	4358	3515	928	42527	1.158	49234
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	3072	4564	1115	53962	4454	3515	935	44798	1.158	51873
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	3141	4564	1123	56774	4554	3515	943	47098	1.158	54527
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	3215	4564	1132	59614	4660	3515	953	49426	1.157	57196
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	3295	4564	1142	62483	4775	3515	964	51785	1.156	59879
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	3436	4564	1164	65582	4979	3515	986	54340	1.155	62763
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	3511	4564	1176	68605	5086	3515	999	56839	1.154	65565
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	3580	4564	1186	71465	5186	3515	1010	59210	1.152	68199
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	3651	4564	1197	74364	5288	3515	1021	61622	1.150	70851
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	3723	4564	1207	77302	5392	3515	1032	64075	1.147	73522
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	3798	4564	1216	80281	5499	3515	1042	66569	1.145	76211
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	3874	4564	1225	83297	5609	3515	1051	69102	1.142	78916
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	3962	4564	1233	86351	5736	3515	1060	71673	1.139	81637
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	4136	4564	1248	89674	5987	3515	1075	74480	1.136	84581
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	4223	4564	1253	92698	6112	3515	1081	77040	1.133	87249
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	4308	4564	1257	95511	6235	3515	1085	79428	1.130	89719
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	4389	4564	1259	98349	6351	3515	1087	81841	1.127	92202
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	4499	4564	1262	100059	6509	3515	1090	83297	1.125	93695
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	4641	4564	1263	103421	6713	3515	1091	86164	1.121	96627
37	BOT_FLG				0.656	0.200	12.967	0.200	4741	4564	1262	106609	6857	3515	1091	88886	1.118	99408

EQ1=1.2D+0.75(1.0E5%+1.0M)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project										CHECK INTERACTION				
25-031 = Job No.										AISC = Interaction Flag: "AISC": Use AISC interaction criteria "RP2011": Use RP2011 interaction criteria 1.000 = Direct Shear Flag: max. shear and max. flexure do not occur at the same cross section location "0.000": Use 0.000 x Direct Shear "1.000": Use 1.000 x Direct Shear "0.###": Use intermediate value to reduce Direct Shear MAX: 0.958				
0139-0349 VER 01 (2023.02.13) = Loads Doc.														
VESTAS = Turbine Make														
V163/V166-4.5MW Mk4A = Turbine Model														
S = IEC Site Class														
98.000 = Hub Height (m)														
A024-4468 ver. V01 = Tower Model														
TOWER PROFILE										CALC: INTERACTION DCR				
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	DCR _e	1.000 DCR _e	DCR _e	AISC DCR _i	By Member DCR _i	By Joint DCR _i	
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)							
1			7.218	321.522	98.000									
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	0.069 <= 0.2	0.044	0.382	0.382	0.414	0.382
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	0.068 <= 0.2	0.043	0.414	0.414	0.502	0.465
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	0.085 <= 0.2	0.054	0.465	0.465	0.542	0.505
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	0.085 <= 0.2	0.054	0.502	0.502	0.703	0.646
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	0.120 <= 0.2	0.077	0.646	0.646	0.740	0.703
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	0.120 <= 0.2	0.077	0.703	0.703	0.778	0.740
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	0.114 <= 0.2	0.073	0.684	0.684	0.814	0.778
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	0.108 <= 0.2	0.070	0.721	0.721	0.850	0.814
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	0.108 <= 0.2	0.070	0.778	0.778	0.874	0.850
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	0.102 <= 0.2	0.067	0.758	0.758	0.902	0.874
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	0.102 <= 0.2	0.067	0.814	0.814	0.928	0.874
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	0.097 <= 0.2	0.063	0.794	0.794	0.944	0.928
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	0.097 <= 0.2	0.064	0.850	0.850	0.956	0.944
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	0.090 <= 0.2	0.059	0.819	0.819	0.958	0.956
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	0.090 <= 0.2	0.059	0.874	0.874	0.937	0.958
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	0.090 <= 0.2	0.059	0.874	0.874	0.918	0.937
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	0.046 <= 0.2	0.039	0.871	0.871	0.901	0.918
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	0.041 <= 0.2	0.037	0.857	0.857	0.889	0.901
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	0.039 <= 0.2	0.035	0.847	0.847	0.874	0.889
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	0.039 <= 0.2	0.035	0.889	0.889	0.874	0.889
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	0.037 <= 0.2	0.034	0.834	0.834	0.857	0.874
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	0.037 <= 0.2	0.034	0.874	0.874	0.850	0.857
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	0.034 <= 0.2	0.031	0.812	0.812	0.850	0.850
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	0.030 <= 0.2	0.031	0.850	0.850	0.784	0.850
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	0.032 <= 0.2	0.031	0.894	0.894	0.897	0.894
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	0.031 <= 0.2	0.031	0.897	0.897	0.888	0.897
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	0.029 <= 0.2	0.030	0.888	0.888	0.888	0.888
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	0.030 <= 0.2	0.030	0.899	0.899	0.901	0.899
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	0.029 <= 0.2	0.030	0.901	0.901	0.901	0.901
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	0.028 <= 0.2	0.029	0.894	0.894	0.896	0.896
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	0.028 <= 0.2	0.029	0.894	0.894	0.886	0.886
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	0.028 <= 0.2	0.029	0.894	0.894	0.886	0.886
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	0.028 <= 0.2	0.029	0.894	0.894	0.886	0.886
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	0.016 <= 0.2	0.019	0.539	0.539	0.548	0.548
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	0.016 <= 0.2	0.020	0.548	0.548	0.565	0.565
37	BOT_FLG				0.656	0.200	12.967		0.016 <= 0.2	0.020	0.581	0.581		0.581

EQ3=1.2D+1.0E1%

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 1 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN										TOWER GEOMETRY									
25-031					= Project					7.218					= Hub Voffset (ft)				
0139-0349 VER 01 (2023.02.13)					= Job No.					313.648					= Tower Length (ft)				
VESTAS					= Loads Doc.					0.656					= Pedestal Voffset (ft)				
V163/V166-4.5MW Mk4A					= Turbine Make					321.522					= Hub Height (ft)				
S					= Turbine Model					98.000					= Hub Height (m)				
98.000					= IEC Site Class					3244					= Top Width (mm)				
A024-4468 ver. V01					= Tower Model					3900					= Base Width (mm)				
TOWER PROFILE										TOWER LAYOUT									
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	D _m	H _{FLG-NECK}	H _{SHELL-ONLY}	OD	D _m	ID						
(mm)	(mm)	(ft)	(ft)	(m)	(m)	(ft)	(in)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)						
1			7.218	321.522	98.000														
2	TOP_FLG			314.304	95.800	10.715	0.8661	3244		29485	3266	3244	3222						
		2685	22.0	8.809					400		3298	3276	3254						
3				305.495	93.115	10.813	0.7835	3276		27200	3296	3276	3256						
	2285	19.9	7.497						0		3302	3282	3262						
4				297.999	90.830	10.833	0.7795	3282			3302	3282	3262						
	2285	19.8	7.497								3308	3288	3269						
5				290.502	88.545	10.845	0.6693	3288			3305	3288	3271						
	2816	17.0	9.239								3313	3296	3279						
6				281.263	85.729	10.870	0.6850	3296			3313	3296	3279						
	2816	17.4	9.239								3321	3304	3286						
7				272.024	82.913	10.896	0.7008	3304			3322	3304	3286						
	2816	17.8	9.239								3329	3311	3294						
8				262.785	80.097	10.923	0.7165	3311			3330	3311	3293						
	2816	18.2	9.239								3337	3319	3301						
9				253.547	77.281	10.949	0.7323	3319			3338	3319	3300						
	2816	18.6	9.239								3345	3327	3308						
10				244.308	74.465	10.976	0.7559	3327			3346	3327	3308						
	2816	19.2	9.239								3354	3334	3315						
11				235.069	71.649	11.003	0.7756	3334			3354	3334	3315						
	2816	19.7	9.239								3362	3342	3322						
		3033	20.3	9.951			0.7992		115		3362	3342	3322						
13	SPLICE3			215.879	65.800	11.057	0.8228	3350		27405	3370	3350	3330						
		2413	20.9	7.917					115		3371	3350	3329						
14				207.963	63.387	11.059	0.8465	3350			3372	3350	3329						
	2298	21.5	7.539								3372	3350	3329						
15				200.423	61.089	11.061	0.8780	3350			3372	3350	3328						
	2299	22.3	7.543								3372	3350	3328						
16				192.881	58.790	11.064	0.9370	3350			3374	3350	3326						
	2930	23.8	9.613								3374	3350	3326						
17				183.268	55.860	11.069	0.9961	3350			3375	3350	3325						
	2930	25.3	9.613								3375	3350	3325						
18				173.655	52.930	11.074	1.0551	3350			3377	3350	3323						
	2930	26.8	9.613								3377	3350	3323						
19				164.042	50.000	11.079	1.1102	3350			3378	3350	3322						
	2930	28.2	9.613								3378	3350	3322						
20				154.429	47.070	11.083	1.1693	3350			3380	3350	3320						
	2930	29.7	9.613								3380	3350	3320						
21				144.816	44.140	11.088	1.2323	3350			3381	3350	3319						
	2930	31.3	9.613								3381	3350	3319						
22				135.203	41.210	11.094	1.2874	3350			3383	3350	3317						
	3130	32.7	10.269						200		3383	3350	3317						
23	SPLICE2			124.934	38.080	11.096	1.2598	3350		22545	3382	3350	3318						
		3020	32.0	9.908					200		3451	3419	3387						
24				115.026	35.060	11.311	1.1299	3419			3447	3419	3390						
	2819	28.7	9.249								3516	3488	3459						
25				105.778	32.241	11.536	1.1417	3488			3517	3488	3459						
	2819	29.0	9.249								3585	3556	3527						
26				96.529	29.422	11.762	1.1299	3556			3585	3556	3528						
	2819	28.7	9.249								3654	3625	3596						
27				87.280	26.603	11.988	1.1378	3625			3654	3625	3596						
	2820	28.9	9.252								3723	3694	3665						
28				78.028	23.783	12.214	1.1496	3694			3723	3694	3665						
	2818	29.2	9.245								3792	3763	3733						
29				68.783	20.965	12.440	1.1614	3763			3792	3763	3733						
	2817	29.5	9.242								3861	3831	3802						
30				59.541	18.148	12.667	1.3701	3831			3866	3831	3797						
	3028	34.8	9.934						215		3935	3900	3865						
31	SPLICE1			49.606	15.120	12.908	1.3543	3900		14530	3934	3900	3866						
		2720	34.4	8.924					215		3934	3900	3866						
32				40.682	12.400	12.908	1.3898	3900			3935	3900	3865						
	2505	35.3	8.219								3935	3900	3865						
33				32.464	9.895	12.911	1.4252	3900			3936	3900	3864						
	2505	36.2	8.219								3936	3900	3864						
34				24.245	7.390	12.914	2.0630	3900			3952	3900	3848						
	1500	52.4	4.921								3952	3900	3848						
35				19.324	5.890	12.967	2.0630	3900			3952	3900	3848						
	2930	52.4	9.613								3952	3900	3848						
36				9.711	2.960	12.967	2.0630	3900			3952	3900	3848						
	2760	52.4	9.055						175		3952	3900	3848						
37	BOT_FLG			0.656	0.200	12.967		3900			3952	3900	3848						

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EQ3=1.2D+1.0E1%

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 3 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN 25-031 0139-0349 VER 01 (2023.02.13) VESTAS V163/V166-4.5MW Mk4A S 98.000 = Hub Height (m) A024-4468 ver. V01							= Project = Job No. = Loads Doc. = Turbine Make = Turbine Model = IEC Site Class = Tower Model															MINIMUM SECTION PROPERTIES AT TOWER JOINTS														
TOWER PROFILE							SECTION PROPERTIES																													
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN t	t _{MIN}	t _{MIN}	OD (@ _{MIN})	ID (@ _{MIN})	A (@ _{MIN})	I _x , I _y	r _m	S _x , S _y (@ _{D_m})	J/c (@ _{D_m})	r gyration	Z _x , Z _y (in3)																			
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(mm)	(in)	(in)	(in)	(in)	(in ⁴)	(in)	(in ³)	(in ³)	(in)	(in3)																			
1			7.218	321.522	98.000																															
2	TOP FLG			314.304	95.800	10.715	22	0.8661	128.583	126.850	347.525	7.086E+05	63.858	11096.170	22192.340	45.156	14128.299																			
3		2685	22.0	8.809	305.495	93.115	10.813	0.8661	20	0.7835	129.760	128.193	317.453	6.601E+05	64.488	10235.984	20471.968	45.601	13033.020																	
4		2285	19.9	7.497	297.999	90.830	10.833	0.7835	20	0.7795	130.001	128.442	316.457	6.606E+05	64.611	10223.236	20446.472	45.687	13016.786																	
5		2285	19.8	7.497	290.502	88.545	10.845	0.7795	17	0.6693	130.135	128.797	272.220	5.704E+05	64.733	8810.807	17621.613	45.774	11218.367																	
6		2816	17.0	9.239	281.263	85.729	10.870	0.6693	17	0.6693	130.437	129.098	272.854	5.744E+05	64.884	8851.908	17703.816	45.880	11270.699																	
7		2816	17.4	9.239	272.024	82.913	10.896	0.6850	17	0.6850	130.754	129.384	279.924	5.920E+05	65.035	9102.355	18204.710	45.987	11589.585																	
8		2816	17.8	9.239	262.785	80.097	10.923	0.7008	18	0.7008	131.072	129.670	287.023	6.098E+05	65.185	9354.840	18709.681	46.094	11911.067																	
9		2816	18.2	9.239	253.547	77.281	10.949	0.7165	18	0.7165	131.389	129.956	294.152	6.279E+05	65.336	9609.371	19218.743	46.200	12235.154																	
10		2816	18.6	9.239	244.308	74.465	10.976	0.7323	19	0.7323	131.706	130.242	301.310	6.461E+05	65.487	9865.955	19731.910	46.307	12561.855																	
11		2816	19.2	9.239	235.069	71.649	11.003	0.7559	19	0.7559	132.032	130.520	311.746	6.716E+05	65.638	10231.172	20462.344	46.414	13026.877																	
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	20	0.7992	132.353	130.802	320.600	6.938E+05	65.789	10545.903	21091.807	46.520	13427.617																	
13	SPLICE3			215.879	65.800	11.057	20	0.7992	132.689	131.091	331.149	7.201E+05	65.945	10918.787	21837.573	46.631	13902.401																			
14		2413	20.9	7.917	207.963	63.387	11.059	0.8228	21	0.8228	132.713	131.067	340.937	7.413E+05	65.945	11241.509	22483.019	46.631	14313.320																	
15		2298	21.5	7.539	200.423	61.089	11.061	0.8465	22	0.8465	132.736	131.043	350.724	7.626E+05	65.945	11564.232	23128.465	46.631	14724.240																	
16		2299	22.3	7.543	192.881	58.790	11.064	0.8780	22	0.8780	132.768	131.012	363.774	7.910E+05	65.945	11994.529	23989.059	46.631	15272.135																	
17		2930	23.8	9.613	183.268	55.860	11.069	0.9370	24	0.9370	132.827	130.953	388.244	8.442E+05	65.945	12801.336	25602.672	46.631	16299.442																	
18		2930	25.3	9.613	173.655	52.930	11.074	0.9961	25	0.9961	132.886	130.894	412.713	8.974E+05	65.945	13608.143	27216.286	46.631	17326.755																	
19		2930	26.8	9.613	164.042	50.000	11.079	1.0551	27	1.0551	132.945	130.835	437.182	9.507E+05	65.945	14414.950	28829.900	46.632	18354.076																	
20		2930	28.2	9.613	154.429	47.070	11.083	1.1102	28	1.1102	133.000	130.780	460.020	1.000E+06	65.945	15167.970	30335.940	46.632	19312.915																	
21		2930	29.7	9.613	144.816	44.140	11.088	1.1693	30	1.1693	133.059	130.720	484.489	1.054E+06	65.945	15974.777	31949.553	46.632	20340.250																	
22		3130	32.7	10.269	135.203	41.210	11.094	1.2323	31	1.2323	133.122	130.657	510.589	1.110E+06	65.945	16835.371	33670.741	46.632	21436.083																	
23	SPLICE2			124.934	38.080	11.096	32	1.2598	133.150	130.630	522.008	1.135E+06	65.945	17211.881	34423.761	46.632	21915.514																			
24		3020	32.0	9.908	115.026	35.060	11.311	1.2598	29	1.1299	135.728	133.468	477.790	1.082E+06	67.299	16077.441	32154.883	47.589	20470.915																	
25		2819	28.7	9.249	105.778	32.241	11.536	1.1299	29	1.1299	138.436	136.176	487.402	1.149E+06	68.653	16730.764	33461.528	48.547	21302.751																	
26		2819	29.0	9.249	96.529	29.422	11.762	1.1417	29	1.1299	141.143	138.883	497.013	1.218E+06	70.007	17397.097	34794.195	49.504	22151.153																	
27		2819	28.7	9.249	87.280	26.603	11.988	1.1299	29	1.1299	143.851	141.591	506.624	1.290E+06	71.360	18076.442	36152.884	50.461	23016.122																	
28		2820	28.9	9.252	78.028	23.783	12.214	1.1378	29	1.1378	146.567	144.292	519.836	1.374E+06	72.715	18899.841	37799.681	51.419	24064.515																	
29		2818	29.2	9.245	68.783	20.965	12.440	1.1496	29	1.1496	149.286	146.986	535.007	1.468E+06	74.068	19813.436	39626.872	52.376	25227.757																	
30		2817	29.5	9.242	59.541	18.148	12.667	1.1614	30	1.1614	152.003	149.680	550.376	1.565E+06	75.421	20754.873	41509.746	53.332	26426.447																	
31	SPLICE1			49.606	15.120	12.908	34	1.3543	154.898	152.189	653.289	1.925E+06	76.772	25077.047	50154.093	54.288	31929.916																			
32		2720	34.4	8.924	40.682	12.400	12.908	1.3543	34	1.3543	154.898	152.189	653.289	1.925E+06	76.772	25077.047	50154.093	54.288	31929.916																	
33		2505	35.3	8.219	32.464	9.895	12.911	1.3898	35	1.3898	154.933	152.154	670.381	1.976E+06	76.772	25733.132	51466.264	54.288	32765.336																	
34		2505	36.2	8.219	24.245	7.390	12.914	1.4252	36	1.4252	154.969	152.118	687.473	2.026E+06	76.772	26389.218	52778.435	54.288	33600.760																	
35		1500	52.4	4.921	19.324	5.890	12.967	2.0630	52	2.0630	155.606	151.480	995.127	2.933E+06	76.772	38198.757	76397.514	54.291	48639.095																	
36		2930	52.4	9.613	9.711	2.960	12.967	2.0630	52	2.0630	155.606	151.480	995.127	2.933E+06	76.772	38198.757	76397.514	54.291	48639.095																	
37	BOT FLG			0.656	0.200	12.967	52	2.0630	155.606	151.480	995.127	2.933E+06	76.772	38198.757	76397.514	54.291	48639.095																			

EQ3=1.2D+1.0E1%

BY: NAA

PAGE 4 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN								MEMBER AVERAGE PROPERTIES										
25-031																		
0139-0349 VER 01 (2023.02.13)																		
VESTAS																		
V163/V166-4.5MW Mk4A																		
S																		
98.000																		
A024-4468 ver. V01																		
TOWER PROFILE								MEMBER SECTION PROPERTIES										
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	I _{MEMB}	D _{MAVG}	OD	ID	A _{MEMB}	I _{MEMB}	J _{MEMB}	A _{MEMB}	I _{MEMB}	J _{MEMB}	
																		(mm)
1			7.218	321.522	98.000													1.0E+08 1.0E+08 1.0E+08
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	22	3260	3282	3238	225315	2.993E+11	5.987E+11	349.239	719151	1438303
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	20	3279	3299	3259	205002	2.755E+11	5.511E+11	317.754	662005	1324010
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	20	3285	3305	3266	204359	2.757E+11	5.514E+11	316.757	662431	1324863
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	17	3292	3309	3275	175830	2.382E+11	4.765E+11	272.537	572360	1144720
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	17	3300	3317	3283	180386	2.455E+11	4.911E+11	279.599	589927	1179855
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	18	3308	3325	3290	184961	2.529E+11	5.059E+11	286.691	607703	1215405
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	18	3315	3333	3297	189556	2.604E+11	5.209E+11	293.812	625687	1251374
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	19	3323	3342	3304	194170	2.680E+11	5.360E+11	300.963	643883	1287765
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	19	3331	3350	3311	200895	2.786E+11	5.571E+11	311.388	669262	1338524
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	20	3338	3358	3319	206601	2.878E+11	5.756E+11	320.232	691441	1382883
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	20	3346	3366	3326	213391	2.986E+11	5.973E+11	330.757	717508	1435016
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	21	3350	3371	3329	219959	3.086E+11	6.171E+11	340.937	741349	1482698
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	22	3350	3372	3329	226273	3.174E+11	6.349E+11	350.724	762633	1525267
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	22	3350	3372	3328	234693	3.292E+11	6.585E+11	363.774	791013	1582026
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	24	3350	3374	3326	250479	3.514E+11	7.028E+11	388.244	844225	1688450
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	25	3350	3375	3325	266266	3.735E+11	7.471E+11	412.713	897439	1794877
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	27	3350	3377	3323	282052	3.957E+11	7.914E+11	437.182	950653	1901306
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	28	3350	3378	3322	296786	4.164E+11	8.327E+11	460.020	1000321	2000642
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	30	3350	3380	3320	312573	4.385E+11	8.770E+11	484.489	1053538	2107075
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	31	3350	3381	3319	329412	4.621E+11	9.243E+11	510.589	1110303	2220607
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	33	3350	3383	3317	344146	4.828E+11	9.656E+11	533.427	1159975	2319950
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	32	3384	3416	3352	340237	4.872E+11	9.744E+11	527.368	1170464	2340928
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	29	3453	3482	3424	311352	4.641E+11	9.282E+11	482.596	1115052	2230104
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	29	3522	3551	3493	320872	4.976E+11	9.951E+11	497.352	1195372	2390744
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	29	3591	3619	3562	323753	5.218E+11	1.044E+12	501.818	1253663	2507326
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	29	3660	3688	3631	332254	5.562E+11	1.112E+12	514.995	1336343	2672686
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	29	3728	3757	3699	342012	5.943E+11	1.189E+12	530.119	1427775	2855550
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	30	3797	3827	3768	351896	6.342E+11	1.268E+12	545.440	1523701	3047402
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	35	3866	3900	3831	422626	7.895E+11	1.579E+12	655.071	1896792	3793584
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	34	3900	3934	3866	421476	8.014E+11	1.603E+12	653.289	1925356	3850712
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	35	3900	3935	3865	432503	8.224E+11	1.645E+12	670.381	1975737	3951474
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	36	3900	3936	3864	443530	8.433E+11	1.687E+12	687.473	2026118	4052237
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222
37	BOT_FLG				0.656	0.200	12.967											

EQ3=1.2D+1.0E1%

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN								= Project									MATERIAL PROPERTIES											
25-031								= Job No.									ID	NAME	F_y	F_u	E	v	G	P _{STEEL}	t_{MIN}	$t_{MAXINCL}$		
0139-0349 VER 01 (2023.02.13)								= Loads Doc.									(no)	(-)	(ksi)	(ksi)	(ksi)	(-)	(ksi)	(pcf)	(mm)	(mm)		
VESTAS								= Turbine Make									15	RIGIDMASSLESS	50	65	2.90E+07	0	1.12E+07	0	0	10000		
V163/V166-4.5MW Mk4A								= Turbine Model									4	S355-355-00-16	51	68	2.90E+04	0	1.12E+04	490	0	16		
S								= IEC Site Class									5	S355-345-16-40	50	68	2.90E+04	0	1.12E+04	490	16	40		
98.000								= Hub Height (m)									6	S355-335-40-63	49	68	2.90E+04	0	1.12E+04	490	40	63		
A024-4468 ver. V01								= Tower Model									14	S420-400-16-40	58	75	2.90E+04	0	1.12E+04	490	16	40		
TOWER PROFILE										MEMBER MATERIAL PROPERTIES																		
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	ID	NAME	F_y	F_u	E	v	G	P _{STEEL}	t_{MIN}	$t_{MAXINCL}$											
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(no)	(-)	(ksi)	(ksi)	(ksi)	(-)	(ksi)	(pcf)	(mm)	(mm)											
1			7.218	321.522	98.000			15	RIGIDMASSLESS	50.000	65.000	2.90E+07	0.300	1.12E+07	0	0	10000											
2	TOP_FLG			314.304	95.800	10.715		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
	2685	22.0	8.809				0.8661																					
3		2285	19.9	7.497	305.495	93.115	10.813	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
4		2285	19.8	7.497	297.999	90.830	10.833	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
5		2816	17.0	9.239	290.502	88.545	10.845	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
6		2816	17.4	9.239	281.263	85.729	10.870	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
7		2816	17.8	9.239	272.024	82.913	10.896	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
8		2816	18.2	9.239	262.785	80.097	10.923	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
9		2816	18.6	9.239	253.547	77.281	10.949	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
10		2816	19.2	9.239	244.308	74.465	10.976	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
11		2816	19.7	9.239	235.069	71.649	11.003	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
12		3033	20.3	9.951	225.830	68.833	11.029	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
13	SPLICE3			215.879	65.800	11.057		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
	2413	20.9	7.917				0.8228																					
14		2298	21.5	7.539	207.963	63.387	11.059	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
15		2299	22.3	7.543	200.423	61.089	11.061	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
16		2930	23.8	9.613	192.881	58.790	11.064	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
17		2930	25.3	9.613	183.268	55.860	11.069	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
18		2930	26.8	9.613	173.655	52.930	11.074	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
19		2930	28.2	9.613	164.042	50.000	11.079	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
20		2930	29.7	9.613	154.429	47.070	11.083	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
21		2930	31.3	9.613	144.816	44.140	11.088	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
22		3130	32.7	10.269	135.203	41.210	11.094	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
23	SPLICE2			124.934	38.080	11.096		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
	3020	32.0	9.908				1.2598																					
24		2819	28.7	9.249	115.026	35.060	11.311	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
25		2819	29.0	9.249	105.778	32.241	11.536	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
26		2819	28.7	9.249	96.529	29.422	11.762	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
27		2820	28.9	9.252	87.280	26.603	11.988	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
28		2818	29.2	9.245	78.028	23.783	12.214	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
29		2817	29.5	9.242	68.783	20.965	12.440	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
30		3028	34.8	9.934	59.541	18.148	12.667	14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40											
31	SPLICE1			49.606	15.120	12.908		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
	2720	34.4	8.924				1.3543																					
32		2505	35.3	8.219	40.682	12.400	12.908	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
33		2505	36.2	8.219	32.464	9.895	12.911	5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40											
34		1500	52.4	9.211	24.245	7.390	12.914	6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63											
35		2930	52.4	9.613	19.324	5.890	12.967	6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63											
36		2760	52.4	9.055	9.711	2.960	12.967	6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63											
37	BOT_FLG			0.656	0.200	12.967																						

EQ3=1.2D+1.0E1%

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 6 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN				DEAD LOADS														
25-031	= Project			509.288 = W _{TURBINE} (kips)				FLANGES AND STIFFENING RINGS: W _{TMD,SC,RC} (kips) = 0.000										
0139-0349 VER 01 (2023.02.13)	= Job No.			490	= ρ _{STEEL} (pcf)			<i>I</i> _{FLG} (in)	<i>b</i> _{FLG} (in)	<i>OD</i> (in)	<i>XA</i> (in)	<i>OD</i> _{FLG} (in)	<i>ID</i> _{FLG} (in)	<i>W</i> _{FLG} (kip)				
VESTAS	= Loads Doc.			0.015	= W _{MISC} /W _{SHELL}			7.874	4.882	128.583	0.000	128.583	118.819	4.236				
V163/V166-4.5MW Mk4A	= Turbine Make			511.326	= W _{SHELL} (kips)			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
S	= Turbine Model			7.670	= W _{MISC} (kips)			3.346	6.496	132.689	0.000	132.689	119.697	2.444				
98.000	= IEC Site Class			0.0245	= w _{MISC} (klf)			5.906	10.394	133.150	0.000	133.150	112.362	6.712				
A024-4468	= Hub Height (m)			0.000				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
ver. V01	= Tower Model			6.496				10.709	154.898	0.000	0.000	154.898	133.480	8.936				
				0.000				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
				4.331				11.811	155.606	4.874	165.354	141.732	6.996					
TOWER PROFILE				DEAD LOADS														
JOINT	<i>H</i> _{CAN} (mm)	<i>t</i> (mm)	<i>H</i> _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN <i>t</i> (in)	CAN DL (kips)	Nodal Wt shell only (kips)	Flange Misc DL (kips)	Internal Nodal DL (kips)	Nodal Wt MIN (kips)	Nodal Wt MAX (kips)	Nodal Mass MIN (kips/32.2)	Nodal Mass MAX (kips/32.2)	Cum. Twr. DL (kips)	Cum. Tot. DL (kips)	
1				321.522	98.000					509.288	0.000	509.288	509.288	15.816	15.816	0.000	509.288	
2	TOP_FLG 2685	22.0	8.809	314.304	95.800	10.715	0.8661	10.469	5.234	4.236	0.108	9.470	9.578	0.294	0.297	9.578	518.866	
3	2285	19.9	7.497	305.495	93.115	10.813	0.7835	8.106	9.287	0.000	0.199	9.287	9.487	0.288	0.295	19.065	528.352	
4	2285	19.8	7.497	297.999	90.830	10.833	0.7795	8.080	8.093	0.000	0.183	8.093	8.276	0.251	0.257	27.341	536.629	
5	2816	17.0	9.239	290.502	88.545	10.845	0.6693	8.568	8.324	0.000	0.205	8.324	8.529	0.259	0.265	35.870	545.158	
6	2816	17.4	9.239	281.263	85.729	10.870	0.6850	8.790	8.679	0.000	0.226	8.679	8.905	0.270	0.277	44.775	554.063	
7	2816	17.8	9.239	272.024	82.913	10.896	0.7008	9.013	8.901	0.000	0.226	8.901	9.127	0.276	0.283	53.902	563.190	
8	2816	18.2	9.239	262.785	80.097	10.923	0.7165	9.237	9.125	0.000	0.226	9.125	9.351	0.283	0.290	63.253	572.541	
9	2816	18.6	9.239	253.547	77.281	10.949	0.7323	9.462	9.349	0.000	0.226	9.349	9.575	0.290	0.297	72.828	582.116	
10	2816	19.2	9.239	244.308	74.465	10.976	0.7559	9.789	9.625	0.000	0.226	9.625	9.851	0.299	0.306	82.679	591.967	
11	2816	19.7	9.239	235.069	71.649	11.003	0.7756	10.067	9.928	0.000	0.226	9.928	10.154	0.308	0.315	92.834	602.121	
12	3033	20.3	9.951	225.830	68.833	11.029	0.7992	11.200	10.633	0.000	0.235	10.633	10.868	0.330	0.338	103.702	612.990	
13	SPICE3 2413	20.9	7.917	215.879	65.800	11.057	0.8228	9.184	10.192	4.888	0.218	15.080	15.298	0.468	0.475	119.000	628.288	
14	2298	21.5	7.539	207.963	63.387	11.059	0.8465	8.998	9.091	0.000	0.189	9.091	9.280	0.282	0.288	128.280	637.568	
15	2299	22.3	7.543	200.423	61.089	11.061	0.8780	9.337	9.167	0.000	0.184	9.167	9.352	0.285	0.290	137.631	646.919	
16	2930	23.8	9.613	192.881	58.790	11.064	0.9370	12.700	11.018	0.000	0.210	11.018	11.228	0.342	0.349	148.859	658.147	
17	2930	25.3	9.613	183.268	55.860	11.069	0.9961	13.500	13.100	0.000	0.235	13.100	13.335	0.407	0.414	162.194	671.482	
18	2930	26.8	9.613	173.655	52.930	11.074	1.0551	14.300	13.900	0.000	0.235	13.900	14.135	0.432	0.439	176.329	685.617	
19	2930	28.2	9.613	164.042	50.000	11.079	1.1102	15.047	14.674	0.000	0.235	14.674	14.909	0.456	0.463	191.238	700.526	
20	2930	29.7	9.613	154.429	47.070	11.083	1.1693	15.848	15.448	0.000	0.235	15.448	15.683	0.480	0.487	206.921	716.209	
21	2930	31.3	9.613	144.816	44.140	11.088	1.2323	16.702	16.275	0.000	0.235	16.275	16.510	0.505	0.513	223.431	732.719	
22	3130	32.7	10.269	135.203	41.210	11.094	1.2874	18.640	17.671	0.000	0.243	17.671	17.914	0.549	0.556	241.345	750.633	
23	SPICE2 3020	32.0	9.908	124.934	38.080	11.096	1.2598	17.780	18.210	13.425	0.247	31.635	31.881	0.982	0.990	273.226	782.514	
24	2819	28.7	9.249	115.026	35.060	11.311	1.1299	15.188	16.484	0.000	0.234	16.484	16.718	0.512	0.519	289.944	799.232	
25	2819	29.0	9.249	105.778	32.241	11.536	1.1417	15.652	15.420	0.000	0.226	15.420	15.646	0.479	0.486	305.590	814.878	
26	2819	28.7	9.249	96.529	29.422	11.762	1.1299	15.793	15.723	0.000	0.226	15.723	15.949	0.488	0.495	321.539	830.827	
27	2820	28.9	9.252	87.280	26.603	11.988	1.1378	16.213	16.003	0.000	0.226	16.003	16.229	0.497	0.504	337.768	847.056	
28	2818	29.2	9.245	78.028	23.783	12.214	1.1496	16.678	16.445	0.000	0.226	16.445	16.672	0.511	0.518	354.440	863.728	
29	2817	29.5	9.242	68.783	20.965	12.440	1.1614	17.153	16.916	0.000	0.226	16.916	17.142	0.525	0.532	371.582	880.870	
30	3028	34.8	9.934	59.541	18.148	12.667	1.3701	22.144	19.649	0.000	0.234	19.649	19.883	0.610	0.617	391.465	900.753	
31	SPICE1 2720	34.4	8.924	49.606	15.120	12.908	1.3543	19.838	20.991	17.871	0.231	38.862	39.093	1.207	1.214	430.558	939.846	
32	2505	35.3	8.219	40.682	12.400	12.908	1.3898	18.748	19.293	0.000	0.210	19.293	19.502	0.599	0.606	450.060	959.348	
33	2505	36.2	8.219	32.464	9.895	12.911	1.4252	19.226	18.987	0.000	0.201	18.987	19.188	0.590	0.596	469.248	978.536	
34	1500	52.4	4.921	24.245	7.390	12.914	2.0630	16.664	17.945	0.000	0.161	17.945	18.106	0.557	0.562	487.353	996.641	
35	2930	52.4	9.613	19.324	5.890	12.967	2.0630	32.551	24.608	0.000	0.178	24.608	24.785	0.764	0.770	512.139	1021.427	
36	2760	52.4	9.055	9.711	2.960	12.967	2.0630	30.662	31.607	0.000	0.228	31.607	31.835	0.982	0.989	543.974	1053.262	
37	BOT_FLG			0.656	0.200	12.967			15.331	6.996	0.111	22.328	22.438	0.693	0.697	566.412	1075.700	

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EQ3=1.2D+1.0E1%

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 7 OF 15
DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN									BASIC LOAD CASE 1 OF 3 (MAX.)																	
25-031			= Project									BASIC LOAD CASE														
0139-0349 VER 01 (2023.02.13)			= Job No.									D+E _{1.4}														
VESTAS			= Loads Doc.			1.200 = S _{DS} @ 5% = β						LOAD FACTORS: LF _{Fz} 1.536 LF _{Mz} 1.536 = 1.2+0.2S _{DS} LF _{Fxy} 1.536 LF _{Mxy} 1.536														
V163/V166-4.5MW Mk4A			= Turbine Make			1.680 = S _{DS} @ 1% = β																				
S			= Turbine Model			3.806 = x _{CG} (ft)																				
98.000			= Hub Height (m)																							
A024-4468 ver. V01			= Tower Model																							
TOWER PROFILE									SERVICE LOADS									FACTORED LOADS								
JOINT	H _{CAN}	t	H _{CAN}	JOINT	JOINT	CAN	LOAD	F _Z	M _Z	F _{XY}	M _{XY}	F _Z	M _Z	F _{XY}	M _{XY,0.1}	LF _{Fz}	M _{XY,0.2}									
(ft)	(mm)	(mm)	(ft)	ELEV	ELEV	t	STA	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)									
1			7.218	321.522	98.000		98.000	2265	0.000	0.000	2628	3480	0	0	4036	1.000	4036									
2	TOP_FLG			314.304	95.800	10.715	95.800	2308	0.000	0.000	2628	3545	0	0	4036	1.000	4036									
	2685	22.0	8.809																							
3				305.495	93.115	10.813	93.115	2350	0.000	0.000	2628	3610	0	0	4036	1.000	4036									
	2285	19.9	7.497																							
4				297.999	90.830	10.833	90.830	2387	0.000	0.000	2628	3666	0	0	4036	1.000	4036									
	2285	19.8	7.497																							
5				290.502	88.545	10.845	88.545	2425	0.000	0.000	2628	3725	0	0	4036	1.000	4036									
	2816	17.0	9.239																							
6				281.263	85.729	10.870	85.729	2465	0.000	0.000	2628	3786	0	0	4036	1.000	4036									
	2816	17.4	9.239																							
7				272.024	82.913	10.896	82.913	2505	0.000	0.000	2628	3848	0	0	4036	1.000	4036									
	2816	17.8	9.239																							
8				262.785	80.097	10.923	80.097	2547	0.000	0.000	2628	3912	0	0	4036	1.000	4036									
	2816	18.2	9.239																							
9				253.547	77.281	10.949	77.281	2589	0.000	0.000	2628	3977	0	0	4036	1.000	4036									
	2816	18.6	9.239																							
10				244.308	74.465	10.976	74.465	2633	0.000	0.000	2628	4045	0	0	4036	1.000	4036									
	2816	19.2	9.239																							
11				235.069	71.649	11.003	71.649	2678	0.000	0.000	2628	4114	0	0	4036	1.000	4036									
	2816	19.7	9.239																							
12				225.830	68.833	11.029	68.833	2727	0.000	0.000	2628	4188	0	0	4036	1.000	4036									
	3033	20.3	9.951																							
13	SP-LICE3			215.879	65.800	11.057	65.800	2795	0.000	0.000	2628	4293	0	0	4036	1.000	4036									
	2413	20.9	7.917																							
14				207.963	63.387	11.059	63.387	2836	0.000	0.000	2628	4356	0	0	4036	1.000	4036									
	2298	21.5	7.539																							
15				200.423	61.089	11.061	61.089	2878	0.000	0.000	2628	4420	0	0	4036	1.000	4036									
	2299	22.3	7.543																							
16				192.881	58.790	11.064	58.790	2928	0.000	0.000	2628	4497	0	0	4036	1.000	4036									
	2930	23.8	9.613																							
17				183.268	55.860	11.069	55.860	2987	0.000	0.000	2628	4588	0	0	4036	1.000	4036									
	2930	25.3	9.613																							
18				173.655	52.930	11.074	52.930	3050	0.000	0.000	2628	4684	0	0	4036	1.000	4036									
	2930	26.8	9.613																							
19				164.042	50.000	11.079	50.000	3116	0.000	0.000	2628	4786	0	0	4036	1.000	4036									
	2930	28.2	9.613																							
20				154.429	47.070	11.083	47.070	3186	0.000	0.000	2628	4893	0	0	4036	1.000	4036									
	2930	29.7	9.613																							
21				144.816	44.140	11.088	44.140	3259	0.000	0.000	2628	5006	0	0	4036	1.000	4036									
	2930	31.3	9.613																							
22				135.203	41.210	11.094	41.210	3339	0.000	0.000	2628	5129	0	0	4036	1.000	4036									
	3130	32.7	10.269																							
23	SP-LICE2			124.934	38.080	11.096	38.080	3481	0.000	0.000	2628	5346	0	0	4036	1.000	4036									
	3020	32.0	9.908																							
24				115.026	35.060	11.311	35.060	3555	0.000	0.000	2628	5461	0	0	4036	1.000	4036									
	2819	28.7	9.249																							
25				105.778	32.241	11.536	32.241	3625	0.000	0.000	2628	5568	0	0	4036	1.000	4036									
	2819	29.0	9.249																							
26				96.529	29.422	11.762	29.422	3696	0.000	0.000	2628	5677	0	0	4036	1.000	4036									
	2819	28.7	9.249																							
27				87.280	26.603	11.988	26.603	3768	0.000	0.000	2628	5787	0	0	4036	1.000	4036									
	2820	28.9	9.252																							
28				78.028	23.783	12.214	23.783	3842	0.000	0.000	2628	5901	0	0	4036	1.000	4036									
	2818	29.2	9.245																							
29				68.783	20.965	12.440	20.965	3918	0.000	0.000	2628	6018	0	0	4036	1.000	4036									
	2817	29.5	9.242																							
30				59.541	18.148	12.667	18.148	4007	0.000	0.000	2628	6154	0	0	4036	1.000	4036									
	3028	34.8	9.934																							
31	SP-LICE1			49.606	15.120	12.908	15.120	4181	0.000	0.000	2628	6421	0	0	4036	1.000	4036									
	2720	34.4	8.924																							
32				40.682	12.400	12.908	12.400	4267	0.000	0.000	2628	6555	0	0	4036	1.000	4036									
	2505	35.3	8.219																							
33				32.464	9.895	12.911	9.895	4353	0.000	0.000	2628	6686	0	0	4036	1.000	4036									
	2505	36.2	8.219																							
34				24.245	7.390	12.914	7.390	4433	0.000	0.000	2628	6809	0	0	4036	1.000	4036									
	1500	52.4	4.921																							
35				19.324	5.890	12.967	5.890	4544	0.000	0.000	2628	6979	0	0	4036	1.000	4036									
	2930	52.4	9.613																							
36				9.711	2.960	12.967	2.960	4685	0.000	0.000	2628	7196	0	0	4036	1.000	4036									
	2760	52.4	9.055																							
37	BOT_FLG			0.656	0.200	12.967	0.200	4785	0.000	0.000	2628	7350	0	0	4036	1.000	4036									

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EQ3=1.2D+1.0E1%

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 8 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project							BASIC LOAD CASE 2 OF 3 (MAX.)											
25-031 = Job No.				0139-0349 VER 01 (2023.02.13) = Loads Doc.			BASIC LOAD CASE (E ₁₅₀ /1.4) ... at R=1.5, 1% damping											
VESTAS = Turbine Make				V163/V166-4.5MW Mk4A = Turbine Model			LOAD FACTORS: LF _{Fz} 1.400 LF _{Mz} 1.400 LF _{Fxy} 1.400 LF _{Mxy} 1.400											
S = IEC Site Class				98.000 = Hub Height (m)			3.806 = x _{CG} (ft)											
A024-4468 ver. V01 = Tower Model																		
TOWER PROFILE							SERVICE LOADS				FACTORED LOADS							
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN OD (ft)	t (in)	LOAD STA (m)	F _Z (kN)	M _Z (kN-m)	F _{XY} (kN)	M _{XY} (kN-m)	1.400 F _Z (kN)	1.400 M _Z (kN-m)	1.400 F _{XY} (kN)	1.400 M _{XY,0.1} (kN-m)	LF _{Fa}	M _{XY,0.2} (kN-m)
1			7.218	321.522	98.000			98.000	0	429	370	11598	0.000	601	518	16237	1.000	16237
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	0	429	377	11398	0.000	601	528	15957	1.000	15957
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	0	429	385	11177	0.000	601	539	15647	1.000	15647
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	0	429	392	11048	0.000	601	548	15467	1.000	15467
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	0	429	398	10978	0.000	601	557	15370	1.000	15370
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	0	429	403	10978	0.000	601	564	15369	1.000	15369
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	0	429	407	11075	0.000	601	570	15505	1.000	15505
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	0	429	410	11268	0.000	601	574	15775	1.000	15775
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	0	429	413	11553	0.000	601	578	16175	1.000	16175
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	0	429	415	11925	0.000	601	581	16694	1.000	16694
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	0	429	417	12374	0.000	601	584	17323	1.000	17323
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	0	429	419	12892	0.000	601	587	18049	1.000	18049
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	0	429	423	13519	0.000	601	593	18927	1.000	18927
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	0	429	427	14054	0.000	601	597	19676	1.000	19676
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	0	429	430	14598	0.000	601	602	20437	1.000	20437
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	0	429	435	15172	0.000	601	610	21240	1.000	21240
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	0	429	442	15943	0.000	601	619	22320	1.000	22320
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	0	429	451	16756	0.000	601	631	23458	1.000	23458
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	0	429	461	17607	0.000	601	645	24649	1.000	24649
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	0	429	472	18496	0.000	601	661	25894	1.000	25894
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	0	429	485	19422	0.000	601	679	27191	1.000	27191
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	0	429	500	20387	0.000	601	700	28542	1.000	28542
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	0	429	530	21463	0.000	601	742	30049	1.000	30049
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	0	429	547	22544	0.000	601	766	31561	1.000	31561
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	0	429	562	23603	0.000	601	787	33044	1.000	33044
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	0	429	577	24712	0.000	601	808	34597	1.000	34597
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	0	429	591	25874	0.000	601	828	36223	1.000	36223
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	0	429	605	27087	0.000	601	847	37922	1.000	37922
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	0	429	617	28351	0.000	601	864	39691	1.000	39691
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	0	429	629	29663	0.000	601	881	41528	1.000	41528
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	0	429	649	31128	0.000	601	909	43579	1.000	43579
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	0	429	657	32494	0.000	601	920	45491	1.000	45491
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	0	429	663	33789	0.000	601	928	47305	1.000	47305
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	0	429	666	35118	0.000	601	933	49165	1.000	49165
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	0	429	670	35928	0.000	601	938	50299	1.000	50299
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	0	429	671	37539	0.000	601	940	52554	1.000	52554
37	BOT_FLG				0.656	0.200	12.967	0.200	0	429	672	39087	0.000	601	940	54722	1.000	54722

EQ3=1.2D+1.0E1%

BY: NAA

PAGE 9 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN										BASIC LOAD CASE 3 OF 3 (MAX.)									
25-031										= Project									
0139-0349 VER 01 (2023.02.13)										= Job No.									
VESTAS										= Loads Doc.									
V163/V166-4.5MW Mk4A										= Turbine Make									
S										= Turbine Model									
98.000										= IEC Site Class									
A024-4468 ver. V01										= Hub Height (m)									
										= Tower Model									
										BASIC LOAD CASE									
										Not used.									
										LOAD FACTORS:									
										$-2265 = F_z$ (kN) $-2265 = W_{TURBINE}$ (kN) $0 = \text{Net } F_z$ (kN) (-)Uplift									
										$LF_{Fz} = 0.000$ $LF_{Mz} = 0.000$ $LF_{Fxy} = 0.000$ $LF_{Mxy} = 0.000$									
TOWER PROFILE								SERVICE LOADS							FACTORED LOADS				
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	LOAD STA	F _Z	M _Z	F _{XY}	M _{XY}	F _Z	M _Z	F _{XY}	M _{XY,0.1}	LF _{Fz}	M _{XY,0.2}	
(mm)	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)	
1			7.218	321.522	98.000			98.000	0.000	0	0	0	0	0	0	0	1.000	0	
2	TOP_FLG			314.304	95.800	10.715		95.800	0.000	0	0	0	0	0	0	0	1.000	0	
3	2685	22.0	8.809	305.495	93.115	10.813		93.115	0.000	0	0	0	0	0	0	0	1.000	0	
4	2285	19.9	7.497	297.999	90.830	10.833		90.830	0.000	0	0	0	0	0	0	0	1.000	0	
5	2285	19.8	7.497	290.502	88.545	10.845		88.545	0.000	0	0	0	0	0	0	0	1.000	0	
6	2816	17.0	9.239	281.263	85.729	10.870		85.729	0.000	0	0	0	0	0	0	0	1.000	0	
7	2816	17.4	9.239	272.024	82.913	10.896		82.913	0.000	0	0	0	0	0	0	0	1.000	0	
8	2816	17.8	9.239	262.785	80.097	10.923		80.097	0.000	0	0	0	0	0	0	0	1.000	0	
9	2816	18.2	9.239	253.547	77.281	10.949		77.281	0.000	0	0	0	0	0	0	0	1.000	0	
10	2816	18.6	9.239	244.308	74.465	10.976		74.465	0.000	0	0	0	0	0	0	0	1.000	0	
11	2816	19.2	9.239	235.069	71.649	11.003		71.649	0.000	0	0	0	0	0	0	0	1.000	0	
12	2816	19.7	9.239	225.830	68.833	11.029		68.833	0.000	0	0	0	0	0	0	0	1.000	0	
13	SPLICE3	3033	20.3	9.951	215.879	65.800	11.057	65.800	0.000	0	0	0	0	0	0	0	1.000	0	
14	2413	20.9	7.917	207.963	63.387	11.059		63.387	0.000	0	0	0	0	0	0	0	1.000	0	
15	2298	21.5	7.539	200.423	61.089	11.061		61.089	0.000	0	0	0	0	0	0	0	1.000	0	
16	2299	22.3	7.543	192.881	58.790	11.064		58.790	0.000	0	0	0	0	0	0	0	1.000	0	
17	2930	23.8	9.613	183.268	55.860	11.069		55.860	0.000	0	0	0	0	0	0	0	1.000	0	
18	2930	25.3	9.613	173.655	52.930	11.074		52.930	0.000	0	0	0	0	0	0	0	1.000	0	
19	2930	26.8	9.613	164.042	50.000	11.079		50.000	0.000	0	0	0	0	0	0	0	1.000	0	
20	2930	28.2	9.613	154.429	47.070	11.083		47.070	0.000	0	0	0	0	0	0	0	1.000	0	
21	2930	29.7	9.613	144.816	44.140	11.088		44.140	0.000	0	0	0	0	0	0	0	1.000	0	
22	2930	31.3	9.613	135.203	41.210	11.094		41.210	0.000	0	0	0	0	0	0	0	1.000	0	
23	SPLICE2	3130	32.7	10.269	124.934	38.080	11.096	38.080	0.000	0	0	0	0	0	0	0	1.000	0	
24	3020	32.0	9.908	115.026	35.060	11.311		35.060	0.000	0	0	0	0	0	0	0	1.000	0	
25	2819	28.7	9.249	105.778	32.241	11.536		32.241	0.000	0	0	0	0	0	0	0	1.000	0	
26	2819	29.0	9.249	96.529	29.422	11.762		29.422	0.000	0	0	0	0	0	0	0	1.000	0	
27	2819	28.7	9.249	87.280	26.603	11.988		26.603	0.000	0	0	0	0	0	0	0	1.000	0	
28	2820	28.9	9.252	78.028	23.783	12.214		23.783	0.000	0	0	0	0	0	0	0	1.000	0	
29	2818	29.2	9.245	68.783	20.965	12.440		20.965	0.000	0	0	0	0	0	0	0	1.000	0	
30	2817	29.5	9.242	59.541	18.148	12.667		18.148	0.000	0	0	0	0	0	0	0	1.000	0	
31	SPLICE1	3028	34.8	9.934	49.606	15.120	12.908	15.120	0.000	0	0	0	0	0	0	0	1.000	0	
32	2720	34.4	8.924	40.682	12.400	12.908		12.400	0.000	0	0	0	0	0	0	0	1.000	0	
33	2505	35.3	8.219	32.464	9.895	12.911		9.895	0.000	0	0	0	0	0	0	0	1.000	0	
34	2505	36.2	8.219	24.245	7.390	12.914		7.390	0.000	0	0	0	0	0	0	0	1.000	0	
35	1500	52.4	4.921	19.324	5.890	12.967		5.890	0.000	0	0	0	0	0	0	0	1.000	0	
36	2930	52.4	9.613	9.711	2.960	12.967		2.960	0.000	0	0	0	0	0	0	0	1.000	0	
37	BOT_FLG	2760	52.4	9.055	0.656	0.200	12.967	0.200	0.000	0	0	0	0	0	0	0	1.000	0	

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EQ3=1.2D+1.0E1%

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200
 JOB NO.: 25-031 (GENERIC)

PAGE 10 OF 15
 DATE: 12/7/2025
 FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN						LOAD COMBINATION											
25-031 = Project						Load Summary at Flange Elevations:											
0139-0349 VER 01 (2023.02.13) = Job No.						LOAD COMBINATION: $U_{EQ3} = (1.2+0.2S_{D6})D + 1.0E_{1\%}$											
VESTAS = Turbine Make						FLAG SETTINGS:						INPUT : Δ_{USE} Flag = [The Override Value or 1=Use Analysis] SRSS : $\Delta_{Input,TOT}$ Flag = [ABSSUM or SRSS] with Input Δ_i SRSS : Δ_{TOTAL} Flag = [ABSSUM or SRSS] with $\Delta_{TOOVmm/m}$					
V163/V166-4.5MW Mk4A = Turbine Model						1.000 ; P A Flag = [CALCulated or INPUT]											
S = IEC Site Class																	
98.000 = Hub Height (m)																	
A024-4468 ver. V01 = Tower Model						TOP_FLG 3545.118 528.333 20230.498 SPLICE3 4292.735 592.669 26967.198 SPLICE2 5346.476 742.110 40981.087											
						SPLICE1 6421.435 909.194 55964.399 BOT_FLG 7349.652 940.150 67518.721											
TOWER PROFILE							SERVICE LOADS					FACTORED LOADS					
JOINT	H_{CAN} (mm)	t (mm)	H_{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN t (in)	LOAD STA (m)	F_Z (kN)	M_Z (kN-m)	F_{XY} (kN)	M_{XY} (kN-m)	F_Z (kN)	M_Z (kN-m)	F_{XY} (kN)	$M_{XY,0.1}$ (kN-m)	LF_{FA}	$M_{XY,0.2}$ (kN-m)
1			7.218	321.522	98.000		98.000	2265	429	370	14225	3480	601	518	20273	1.000	20273
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	95.800	2308	429	377	14025	3545	601	528	19993	1.012	20230
3		2285	19.9	7.497	305.495	93.115	93.115	2350	429	385	13804	3610	601	539	19684	1.029	20261
4		2285	19.8	7.497	297.999	90.830	90.830	2387	429	392	13676	3666	601	548	19504	1.045	20372
5		2816	17.0	9.239	290.502	88.545	88.545	2425	429	398	13606	3725	601	557	19406	1.060	20567
6		2816	17.4	9.239	281.263	85.729	85.729	2465	429	403	13606	3786	601	564	19406	1.078	20928
7		2816	17.8	9.239	272.024	82.913	82.913	2505	429	407	13703	3848	601	570	19541	1.096	21424
8		2816	18.2	9.239	262.785	80.097	80.097	2547	429	410	13896	3912	601	574	19812	1.113	22053
9		2816	18.6	9.239	253.547	77.281	77.281	2589	429	413	14181	3977	601	578	20211	1.129	22809
10		2816	19.2	9.239	244.308	74.465	74.465	2633	429	415	14552	4045	601	581	20731	1.142	23681
11		2816	19.7	9.239	235.069	71.649	71.649	2678	429	417	15001	4114	601	584	21359	1.154	24657
12		3033	20.3	9.951	225.830	68.833	68.833	2727	429	419	15520	4188	601	587	22085	1.165	25726
13	SPLICE3	2413	20.9	7.917	215.879	65.800	65.800	2795	429	423	16147	4293	601	593	22963	1.174	26967
14		2298	21.5	7.539	207.963	63.387	63.387	2836	429	427	16682	4356	601	597	23712	1.181	28002
15		2299	22.3	7.543	200.423	61.089	61.089	2878	429	430	17226	4420	601	602	24473	1.186	29029
16		2930	23.8	9.613	192.881	58.790	58.790	2928	429	435	17799	4497	601	610	25277	1.191	30095
17		2930	25.3	9.613	183.268	55.860	183.268	2987	429	442	18571	4588	601	619	26357	1.195	31500
18		2930	26.8	9.613	173.655	52.930	173.655	3050	429	451	19383	4684	601	631	27494	1.199	32953
19		2930	28.2	9.613	164.042	50.000	164.042	3116	429	461	20235	4786	601	645	28686	1.201	34451
20		2930	29.7	9.613	154.429	47.070	154.429	3186	429	472	21123	4893	601	661	29930	1.202	35991
21		2930	31.3	9.613	144.816	44.140	144.816	3259	429	485	22050	5006	601	679	31227	1.203	37573
22		3130	32.7	10.269	135.203	41.210	135.203	3339	429	500	23015	5129	601	700	32579	1.203	39197
23	SPLICE2	3020	32.0	9.908	124.934	38.080	124.934	3481	429	530	24091	5346	601	742	34085	1.202	40981
24		2819	28.7	9.249	115.026	35.060	115.026	3555	429	547	25172	5461	601	766	35598	1.201	42751
25		2819	29.0	9.249	105.778	32.241	105.778	3625	429	562	26231	5568	601	787	37080	1.199	44457
26		2819	28.7	9.249	96.529	29.422	96.529	3696	429	577	27340	5677	601	808	38634	1.196	46217
27		2820	28.9	9.252	87.280	26.603	87.280	3768	429	591	28502	5787	601	828	40260	1.193	48031
28		2818	29.2	9.245	78.028	23.783	78.028	3842	429	605	29715	5901	601	847	41958	1.189	49900
29		2817	29.5	9.242	68.783	20.965	68.783	3918	429	617	30978	6018	601	864	43727	1.185	51820
30		3028	34.8	9.934	59.541	18.148	59.541	4007	429	629	32291	6154	601	881	45565	1.181	53790
31	SPLICE1	2720	34.4	8.924	49.606	15.120	49.606	4181	429	649	33756	6421	601	909	47615	1.175	55964
32		2505	35.3	8.219	40.682	12.400	40.682	4267	429	657	35122	6555	601	920	49528	1.171	57975
33		2505	36.2	8.219	32.464	9.895	32.464	4353	429	663	36417	6686	601	928	51341	1.166	59867
34		1500	52.4	4.921	24.245	7.390	24.245	4433	429	666	37745	6809	601	933	53201	1.162	61795
35		2930	52.4	9.613	19.324	5.890	19.324	4544	429	670	38555	6979	601	938	54335	1.159	62966
36		2760	52.4	9.055	9.711	2.960	9.711	4685	429	671	40167	7196	601	940	56591	1.154	65290
37	BOT_FLG				0.656	0.200	0.656	4785	429	672	41715	7350	601	940	58759	1.149	67519

EQ3=1.2D+1.0E1%

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 11 OF 15
DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

TOWER PROFILE							DESIGN STRESSES							
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN t (in)	f _a =σ _{Tacc} (ksi)	f _b =σ _{Maxy} (ksi)	f _c =f _a +f _b (ksi)	f _v =σ _{Vaxy} (ksi)	f _e =σ _{Maxc} (ksi)	f _r =f _v +f _e (ksi)		
1			7.218	321.522	98.000									
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	2.293	16.137	18.430	0.684	0.240	0.923
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	2.312	15.847	18.159	0.691	0.235	0.926
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	2.556	17.519	20.075	0.764	0.260	1.023
5		2816	17.0	9.239	292.999	88.845	10.845	0.6693	2.592	17.549	20.140	0.775	0.259	1.034
6		2816	17.4	9.239	290.502	88.545	10.845	0.6850	2.605	17.637	20.242	0.779	0.260	1.039
7		2816	17.8	9.239	264.024	82.913	10.896	0.7008	2.641	17.739	20.380	0.789	0.259	1.048
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	3.076	20.661	23.737	0.919	0.302	1.221
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	3.119	20.926	24.045	0.929	0.300	1.230
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	3.047	20.445	23.492	0.908	0.293	1.201
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	3.090	20.832	23.923	0.915	0.292	1.207
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	3.021	20.364	23.385	0.894	0.285	1.180
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	3.064	20.865	23.929	0.899	0.284	1.184
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	2.997	20.407	23.403	0.880	0.278	1.158
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	3.040	21.008	24.048	0.883	0.277	1.160
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	2.974	20.556	23.531	0.864	0.271	1.135
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	3.018	21.244	24.262	0.867	0.269	1.136
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	2.923	20.580	23.504	0.840	0.261	1.101
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	2.967	21.331	24.297	0.842	0.260	1.102
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	2.891	20.789	23.681	0.820	0.253	1.074
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	2.937	21.591	24.528	0.823	0.252	1.075
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	2.850	20.953	23.803	0.799	0.245	1.043
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	2.914	21.860	24.774	0.805	0.243	1.048
24		2819	28.7	9.249	115.026	35.060	11.311	1.2598	2.831	21.232	24.063	0.782	0.236	1.018
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	2.872	22.047	24.919	0.788	0.236	1.024
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	2.792	21.432	24.224	0.766	0.230	0.996
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	2.833	22.218	25.051	0.772	0.230	1.002
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	2.732	21.421	24.153	0.745	0.222	0.966
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	2.779	22.207	24.986	0.754	0.222	0.975
30		2760	52.4	9.055	59.541	18.148	12.667	1.3701	2.604	20.807	23.411	0.706	0.208	0.914
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	2.657	21.779	24.436	0.717	0.208	0.925
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	2.499	20.488	22.987	0.675	0.195	0.870
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	2.552	21.433	23.985	0.688	0.195	0.883
34		1500	52.4	9.219	24.245	7.390	12.914	2.0630	2.409	20.233	22.642	0.649	0.184	0.833
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	2.461	21.153	23.614	0.663	0.184	0.848
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	2.339	20.103	22.442	0.630	0.175	0.806
37	BOT FLG				0.656	0.200	12.967		2.391	21.001	23.393	0.646	0.175	0.821
									2.271	19.941	22.211	0.613	0.166	0.780
									2.323	20.817	23.140	0.630	0.166	0.797
									2.204	19.753	21.957	0.598	0.158	0.756
									2.258	20.607	22.865	0.616	0.158	0.774
									2.161	19.725	21.886	0.590	0.151	0.741
									2.253	20.623	22.876	0.626	0.151	0.777
									2.303	21.074	23.376	0.639	0.154	0.794
									2.304	21.108	23.412	0.646	0.148	0.795
									2.569	23.535	26.104	0.721	0.165	0.886
									2.568	23.519	26.087	0.726	0.159	0.885
									2.541	23.275	25.817	0.719	0.157	0.876
									2.541	23.270	25.811	0.724	0.151	0.875
									2.568	23.513	26.081	0.731	0.153	0.884
									2.568	23.518	26.086	0.735	0.147	0.882
									2.550	23.355	25.905	0.730	0.146	0.876
									2.552	23.368	25.920	0.732	0.141	0.873
									2.526	23.128	25.654	0.725	0.139	0.864
									2.529	23.148	25.677	0.726	0.134	0.860
									2.503	22.913	25.416	0.718	0.133	0.851
									2.514	22.939	25.452	0.720	0.128	0.848
									2.131	19.445	21.576	0.610	0.109	0.719
									2.184	19.525	21.710	0.619	0.105	0.723
									2.210	19.752	21.962	0.626	0.106	0.732
									2.256	20.462	22.718	0.633	0.106	0.739
									2.198	19.940	22.139	0.617	0.103	0.721
									2.242	20.591	22.833	0.623	0.103	0.726
									2.186	20.079	22.266	0.607	0.101	0.708
									2.227	20.726	22.953	0.610	0.101	0.711
									1.538	14.318	15.857	0.422	0.070	0.491
									1.577	14.590	16.166	0.424	0.070	0.493
									1.577	14.590	16.166	0.424	0.070	0.493
									1.626	15.128	16.754	0.425	0.070	0.494
									1.626	15.128	16.754	0.425	0.070	0.494
									1.660	15.644	17.305	0.425	0.070	0.494

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EQ3=1.2D+1.0E1%

BY: NAA

PAGE 12 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project							DESIGN STRENGTH PER ASCE/AWEA RP2011											
25-031 = Job No.							CHECK LOCAL BUCKLING STRENGTH											
0139-0349 VER 01 (2023.02.13) = Loads Doc.							<div style="border: 1px solid black; padding: 5px; display: inline-block;">370</div> = (D/t) _{MAX}											
VESTAS = Turbine Make																		
V163/V166-4.5MW Mk4A = Turbine Model																		
S = IEC Site Class																		
98.000 = Hub Height (m)																		
A024-4468 ver. V01 = Tower Model																		
TOWER PROFILE							CALC: LOCAL BUCKLING DCR											
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN t (in)	D _{OD} /t=D/t	λ _{0.11E}	λ _{0.357E}	λ _{MAX}	Q	F _{cr1} (ksi)	F _{cr2} (ksi)	F _{cr} (ksi)	ϕ _s F _{cr} (ksi)	DCR _c		
1			7.218	321.522	98.000													
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	148.455	63.751	206.740	370.000	0.815	40.782	53.889	40.782	36.704	0.502
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	149.909	63.751	206.740	370.000	0.814	40.710	53.366	40.710	36.639	0.496
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	165.623	63.751	206.740	370.000	0.800	40.013	48.302	40.013	36.012	0.557
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	166.769	63.751	206.740	370.000	0.799	39.967	47.971	39.967	35.970	0.563
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	167.082	63.751	206.740	370.000	0.798	39.955	47.881	39.955	35.959	0.567
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	194.888	63.751	206.740	370.000	0.780	39.027	41.144	39.027	35.124	0.676
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	194.888	63.751	206.740	370.000	0.780	39.014	41.049	39.014	35.112	0.685
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	190.431	63.751	206.740	370.000	0.782	39.146	42.010	39.146	35.231	0.667
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	190.871	63.751	206.740	370.000	0.782	39.133	41.913	39.133	35.219	0.679
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	186.604	63.751	206.740	370.000	0.785	39.265	42.871	39.265	35.338	0.662
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	187.035	63.751	206.740	370.000	0.784	39.251	42.773	39.251	35.326	0.677
13	SPICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	182.946	63.751	206.740	370.000	0.787	39.383	43.729	39.383	35.445	0.660
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	183.367	63.751	206.740	370.000	0.787	39.369	43.628	39.369	35.432	0.679
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	179.857	63.751	206.740	370.000	0.789	39.500	44.582	39.500	35.550	0.662
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	174.268	63.751	206.740	370.000	0.793	39.486	44.480	39.486	35.538	0.683
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	174.667	63.751	206.740	370.000	0.793	39.683	45.906	39.683	35.715	0.658
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	170.259	63.751	206.740	370.000	0.796	39.668	45.802	39.668	35.702	0.681
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	170.259	63.751	206.740	370.000	0.796	39.832	46.987	39.832	35.849	0.661
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	170.648	63.751	206.740	370.000	0.796	39.817	46.880	39.817	35.835	0.684
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	165.634	63.751	206.740	370.000	0.800	40.012	48.299	40.012	36.011	0.661
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	166.025	63.751	206.740	370.000	0.799	39.997	48.186	39.997	35.977	0.688
23	SPICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	161.287	63.751	206.740	370.000	0.803	40.192	49.601	40.192	36.173	0.665
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	161.287	63.751	206.740	370.000	0.803	40.192	49.601	40.192	36.173	0.689
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	156.814	63.751	206.740	370.000	0.807	40.387	51.016	40.387	36.348	0.666
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	156.814	63.751	206.740	370.000	0.807	40.387	51.016	40.387	36.348	0.689
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	151.224	63.751	206.740	370.000	0.812	40.646	52.902	40.646	36.582	0.660
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	151.224	63.751	206.740	370.000	0.812	40.646	52.902	40.646	36.582	0.683
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	141.756	63.751	206.740	370.000	0.822	41.133	56.435	41.133	37.020	0.632
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	141.756	63.751	206.740	370.000	0.822	41.133	56.435	41.133	37.020	0.660
31	SPICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	133.411	63.751	206.740	370.000	0.832	41.619	59.965	41.619	37.457	0.614
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	133.411	63.751	206.740	370.000	0.832	41.619	59.965	41.619	37.457	0.640
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	126.000	63.751	206.740	370.000	0.841	42.105	63.492	42.105	37.895	0.598
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	126.000	63.751	206.740	370.000	0.841	42.105	63.492	42.105	37.895	0.623
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	119.794	63.751	206.740	370.000	0.851	42.558	66.781	42.558	38.302	0.586
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	119.794	63.751	206.740	370.000	0.851	42.558	66.781	42.558	38.302	0.611
37	BOT FLG				0.656	0.200	12.967		113.795	63.751	206.740	370.000	0.860	43.043	70.302	43.043	38.739	0.573
									108.029	63.751	206.740	370.000	0.871	43.560	74.054	43.560	39.204	0.560
									103.446	63.751	206.740	370.000	0.880	44.012	77.335	44.012	39.611	0.553
									103.446	63.751	206.740	370.000	0.880	44.012	77.335	44.012	39.611	0.578
									105.688	54.985	178.313	370.000	0.846	49.104	75.695	49.104	44.194	0.529
									107.837	54.985	178.313	370.000	0.843	48.896	74.186	48.896	44.007	0.532
									120.122	54.985	178.313	370.000	0.825	47.851	66.599	47.851	43.066	0.606
									122.518	54.985	178.313	370.000	0.822	47.672	65.297	47.672	42.905	0.608
									121.261	54.985	178.313	370.000	0.823	47.765	65.973	47.765	42.989	0.601
									123.632	54.985	178.313	370.000	0.820	47.591	64.708	47.591	42.832	0.603
									124.914	54.985	178.313	370.000	0.819	47.499	64.044	47.499	42.749	0.610
									127.310	54.985	178.313	370.000	0.816	47.333	62.839	47.333	42.600	0.612
									126.436	54.985	178.313	370.000	0.817	47.393	63.273	47.393	42.654	0.607
									128.817	54.985	178.313	370.000	0.814	47.232	62.104	47.232	42.509	0.610
									127.504	54.985	178.313	370.000	0.816	47.320	62.743	47.320	42.588	0.602
									129.858	54.985	178.313	370.000	0.813	47.164	61.606	47.164	42.447	0.605
									128.548	54.985	178.313	370.000	0.814	47.250	62.234	47.250	42.525	0.598
									130.877	54.985	178.313	370.000	0.812	47.097	61.126	47.097	42.388	0.600
									111.097	54.985	178.313	370.000	0.838	48.597	72.009	48.597	43.737	0.493
									113.069	54.985	178.313	370.000						

EQ3=1.2D+1.0E1%

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project							DESIGN STRENGTH PER ASCE/AWEA RP2011							
25-031 = Job No.							CHECK DIRECT SHEAR STRENGTH							
0139-0349 VER 01 (2023.02.13) = Loads Doc.														
VESTAS = Turbine Make														
V163/V166-4.5MW Mk4A = Turbine Model														
S = IEC Site Class														
98,000 = Hub Height (m)														
A024-4468 ver. V01 = Tower Model														
TOWER PROFILE							CALC: DIRECT SHEAR DCR							
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN OD (ft)	t (in)	L _{SECTION} (in)	F _{cr1} (ksi)	F _{cr2} (ksi)	F _{cr,MAX} (ksi)	F _{cr} (ksi)	ϕ _s F _{cr} (ksi)	DCR _v
1			7.218	321.522	98.000									
2	TOP_FLG			314.304	95.800	10.715	0.8661	1181.102	29.544	12.506	28.890	28.890	26.001	0.026
3	2685	22.0	8.809	305.495	93.115	10.813	0.7835	1181.102	29.329	12.324	28.890	28.890	26.001	0.027
4	2285	19.9	7.497	297.999	90.830	10.833	0.7795	1181.102	25.885	10.612	28.890	25.885	23.296	0.033
5	2285	19.8	7.497	290.502	88.545	10.845	0.6693	1181.102	25.848	10.582	28.890	25.848	23.263	0.033
6	2816	17.0	9.239	281.263	85.729	10.870	0.6850	1181.102	25.686	10.503	28.890	25.686	23.118	0.034
7	2816	17.4	9.239	272.024	82.913	10.896	0.7008	1181.102	25.650	10.474	28.890	25.650	23.085	0.034
8	2816	17.8	9.239	262.785	80.097	10.923	0.7165	1181.102	21.213	8.343	28.890	21.213	19.091	0.048
9	2816	18.2	9.239	253.547	77.281	10.949	0.7323	1181.102	21.176	8.314	28.890	21.176	19.058	0.049
10	2816	18.6	9.239	244.308	74.465	10.976	0.7559	1181.102	21.799	8.608	28.890	21.799	19.619	0.046
11	2816	19.2	9.239	235.069	71.649	11.003	0.7756	1181.102	21.761	8.578	28.890	21.761	19.585	0.047
12	3033	20.3	9.951	225.830	68.833	11.029	0.7992	1181.102	22.386	8.874	28.890	22.386	20.147	0.044
13	2413	20.9	7.917	215.879	65.800	11.057	0.8228	1181.102	22.347	8.843	28.890	22.347	20.113	0.045
14	2298	21.5	7.539	207.963	63.387	11.059	0.8465	1181.102	22.975	9.141	28.890	22.975	20.677	0.043
15	2299	22.3	7.543	200.423	61.089	11.061	0.8780	1181.102	22.935	9.110	28.890	22.935	20.642	0.043
16	2930	23.8	9.613	192.881	58.790	11.064	0.9370	1181.102	23.565	9.410	28.890	23.565	21.208	0.041
17	2930	25.3	9.613	183.268	55.860	11.069	0.9961	1181.102	23.524	9.378	28.890	23.524	21.172	0.041
18	2930	26.8	9.613	173.655	52.930	11.074	1.0551	1181.102	24.473	9.833	28.890	24.473	22.026	0.038
19	2930	28.2	9.613	164.042	50.000	11.079	1.1102	1181.102	24.432	9.799	28.890	24.432	21.988	0.038
20	2930	29.7	9.613	154.429	47.070	11.083	1.1693	1181.102	25.227	10.182	28.890	25.227	22.704	0.036
21	2930	31.3	9.613	144.816	44.140	11.088	1.2323	1181.102	25.183	10.147	28.890	25.183	22.665	0.036
22	3130	32.7	10.269	135.203	41.210	11.094	1.2874	1181.102	26.142	10.611	28.890	26.142	23.528	0.034
23	3020	32.0	9.908	124.934	38.080	11.096	1.2598	562.874	26.096	10.574	28.890	26.096	23.487	0.034
24	2819	28.7	9.249	115.026	35.060	11.311	1.1299	562.874	28.151	11.043	28.890	28.151	25.336	0.031
25	2819	29.0	9.249	105.778	32.241	11.536	1.1417	562.874	28.151	11.043	28.890	28.151	25.336	0.031
26	2819	28.7	9.249	96.529	29.422	11.762	1.1299	562.874	29.161	11.519	28.890	29.161	26.001	0.029
27	2820	28.9	9.252	87.280	26.603	11.988	1.1378	562.874	29.161	11.519	28.890	29.161	26.001	0.029
28	2818	29.2	9.245	78.028	23.783	12.214	1.1496	562.874	30.518	12.164	28.890	30.518	26.001	0.029
29	2817	29.5	9.242	68.783	20.965	12.440	1.1614	562.874	33.094	13.402	28.890	33.094	26.001	0.027
30	3028	34.8	9.934	59.541	18.148	12.667	1.3701	562.874	33.094	13.402	28.890	33.094	26.001	0.028
31	2720	34.4	9.924	49.606	15.120	12.908	1.3543	562.874	35.710	14.679	28.890	35.710	26.001	0.026
32	2505	35.3	8.219	40.682	12.400	12.908	1.3898	562.874	35.710	14.679	28.890	35.710	26.001	0.026
33	2505	36.2	8.219	32.464	9.895	12.911	1.4252	562.874	38.363	15.993	28.890	38.363	26.001	0.025
34	1500	52.4	9.921	24.245	7.390	12.914	2.0630	562.874	38.363	15.993	28.890	38.363	26.001	0.025
35	2930	52.4	9.613	19.324	5.890	12.967	2.0630	562.874	38.363	15.993	28.890	38.363	26.001	0.025
36	2760	52.4	9.055	9.711	2.960	12.967	2.0630	562.874	55.327	15.911	33.496	55.327	33.496	30.146
37	BOT_FLG			0.656	0.200	12.967		587.402	55.327	15.911	33.496	55.327	33.496	30.146

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BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

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DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project								CHECK TORSIONAL SHEAR STRENGTH								
25-031 = Job No.																
0139-0349 VER 01 (2023.02.13) = Loads Doc.																
VESTAS = Turbine Make																
V163/V166-4.5MW Mk4A = Turbine Model																
S = IEC Site Class																
98.000 = Hub Height (m)																
A024-4468 ver. V01 = Tower Model																
TOWER PROFILE								CALC: TORSIONAL SHEAR DCR					CALC: TOTAL SHEAR DCR			
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	F _{cr1} (ksi)	F _{cr2} (ksi)	F _{crMAX} (ksi)	F _{cr} (ksi)	ϕ _r F _{cr} (ksi)	DCR _r	DCR _ϕ	DCR _{r+ϕ}	
1			7.218	321.522	98.000											
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	22.547	9.480	28.890	22.547	20.292	0.027	0.012	0.038
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	19.899	8.163	28.890	19.899	17.909	0.033	0.015	0.047
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	19.871	8.140	28.890	19.871	17.884	0.033	0.014	0.048
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	19.746	8.079	28.890	19.746	17.772	0.034	0.015	0.048
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	19.719	8.057	28.890	19.719	17.747	0.034	0.015	0.049
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	16.307	6.418	28.890	16.307	14.677	0.021	0.048	0.021
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	16.279	6.395	28.890	16.279	14.651	0.020	0.049	0.020
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	16.758	6.621	28.890	16.758	15.082	0.019	0.046	0.019
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	16.729	6.598	28.890	16.729	15.056	0.019	0.047	0.019
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	17.209	6.826	28.890	17.209	15.488	0.018	0.044	0.018
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	17.180	6.802	28.890	17.180	15.462	0.018	0.045	0.018
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	17.662	7.032	28.890	17.662	15.896	0.017	0.043	0.017
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	17.631	7.008	28.890	17.631	15.868	0.017	0.043	0.017
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	18.116	7.239	28.890	18.116	16.304	0.017	0.041	0.017
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	18.084	7.214	28.890	18.084	16.276	0.017	0.041	0.017
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	18.814	7.564	28.890	18.814	16.933	0.015	0.038	0.015
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	18.782	7.538	28.890	18.782	16.904	0.015	0.038	0.015
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	19.393	7.832	28.890	19.393	17.454	0.015	0.036	0.015
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	19.360	7.805	28.890	19.360	17.424	0.014	0.036	0.014
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	20.097	8.163	28.890	20.097	18.087	0.014	0.034	0.014
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	20.061	8.134	28.890	20.061	18.055	0.013	0.034	0.013
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	21.641	8.495	28.890	21.641	19.477	0.012	0.031	0.012
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	22.418	8.861	28.890	22.418	20.176	0.011	0.029	0.011
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	22.418	8.861	28.890	22.418	20.176	0.011	0.030	0.011
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	23.461	9.357	28.890	23.461	21.115	0.010	0.029	0.010
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	23.461	9.357	28.890	23.461	21.115	0.010	0.029	0.010
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	25.441	10.309	28.890	25.441	22.897	0.009	0.027	0.009
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	25.441	10.309	28.890	25.441	22.897	0.009	0.028	0.009
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	27.452	11.292	28.890	27.452	24.707	0.008	0.026	0.008
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	27.452	11.292	28.890	27.452	24.707	0.008	0.026	0.008
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	29.491	12.303	28.890	29.491	26.001	0.007	0.025	0.007
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	31.420	13.271	28.890	31.420	26.001	0.007	0.024	0.007
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	33.511	14.334	28.890	33.511	26.001	0.006	0.024	0.006
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	33.511	14.334	28.890	33.511	26.001	0.006	0.024	0.006
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	35.770	15.497	28.890	35.770	26.001	0.006	0.023	0.006
37	BOT_FLG				0.656	0.200	12.967		37.770	16.538	28.890	37.770	26.001	0.006	0.023	0.006
									51.196	16.015	33.496	51.196	30.146	0.005	0.021	0.005
									50.429	15.538	33.496	50.429	30.146	0.005	0.021	0.005
									44.046	13.217	33.496	44.046	30.146	0.005	0.024	0.005
									43.398	12.831	33.496	43.398	30.146	0.005	0.024	0.005
									43.963	13.031	33.496	43.963	30.146	0.005	0.024	0.005
									43.329	12.658	33.496	43.329	30.146	0.005	0.024	0.005
									42.772	12.463	33.496	42.772	30.146	0.005	0.024	0.005
									42.167	12.113	33.496	42.167	30.146	0.005	0.024	0.005
									42.533	12.239	33.496	42.533	30.146	0.005	0.024	0.005
									41.942	11.901	33.496	41.942	30.146	0.005	0.024	0.005
									42.484	12.086	33.496	42.484	30.146	0.005	0.024	0.005
									41.905	11.758	33.496	41.905	30.146	0.004	0.024	0.004
									42.442	11.939	33.496	42.442	30.146	0.004	0.024	0.004
									41.874	11.621	33.496	41.874	30.146	0.004	0.024	0.004
									51.427	14.859	33.496	51.427	30.146	0.004	0.020	0.004
									50.753	14.472	33.496	50.753	30.146	0.003	0.021	0.003
									48.973	14.226	28.890	48.973	26.001	0.004	0.024	0.004
									48.973	14.226	28.890	48.973	26.001	0.004	0.024	0.004
									50.571	14.782	28.890	50.571	26.001	0.004	0.024	0.004
									50.571	14.782	28.890	50.571	26.001	0.004	0.024	0.004
									52.179	15.346	28.890	52.179	26.001	0.004	0.023	0.004
									52.179	15.346	28.890	52.179	26.001	0.004	0.023	0.004
									82.592	26.562	28.053	82.592	25.247	0.003	0.017	0.003
									82.592	26.562	28.053	82.592	25.247	0.003	0.017	0.003
									82.592	26.562	28.053	82.592	25.247	0.003	0.017	0.003
									82.592	26.562	28.053	82.592	25.247	0.003	0.017	0.003

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PAGE 15 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

TOWER PROFILE							CALC: INTERACTION DCR				By Member	By Joint	
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN OD (ft)	t (in)	DCR _e	1.000 DCR _v	DCR _c	AISC DCR _i	DCR _i	DCR _i
1			7.218	321.522	98.000								
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	0.012 <=0.2	0.026	0.502	0.502	0.502
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	0.015 <=0.2	0.033	0.557	0.557	0.559
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	0.015 <=0.2	0.033	0.559	0.559	0.559
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	0.021 <=0.2	0.048	0.676	0.676	0.685
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	0.020 <=0.2	0.049	0.685	0.685	0.679
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	0.019 <=0.2	0.046	0.667	0.667	0.679
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	0.018 <=0.2	0.044	0.662	0.662	0.677
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	0.018 <=0.2	0.045	0.677	0.677	0.679
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	0.017 <=0.2	0.043	0.660	0.660	0.683
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	0.017 <=0.2	0.043	0.679	0.679	0.681
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	0.017 <=0.2	0.041	0.662	0.662	0.681
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	0.015 <=0.2	0.038	0.658	0.658	0.688
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	0.015 <=0.2	0.038	0.658	0.658	0.688
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	0.010 <=0.2	0.029	0.660	0.660	0.689
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	0.010 <=0.2	0.029	0.660	0.660	0.683
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	0.009 <=0.2	0.027	0.632	0.632	0.660
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	0.009 <=0.2	0.028	0.660	0.660	0.640
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	0.008 <=0.2	0.026	0.614	0.614	0.640
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	0.008 <=0.2	0.026	0.640	0.640	0.623
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	0.007 <=0.2	0.025	0.598	0.598	0.611
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	0.007 <=0.2	0.024	0.586	0.586	0.611
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	0.006 <=0.2	0.024	0.573	0.573	0.597
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	0.006 <=0.2	0.024	0.597	0.597	0.578
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	0.005 <=0.2	0.024	0.578	0.578	0.583
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	0.005 <=0.2	0.023	0.553	0.553	0.578
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	0.005 <=0.2	0.024	0.578	0.578	0.583
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	0.005 <=0.2	0.024	0.553	0.553	0.578
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	0.004 <=0.2	0.024	0.578	0.578	0.578
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	0.004 <=0.2	0.024	0.600	0.600	0.498
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	0.003 <=0.2	0.021	0.493	0.493	0.498
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	0.004 <=0.2	0.024	0.568	0.568	0.498
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	0.004 <=0.2	0.024	0.568	0.568	0.587
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	0.004 <=0.2	0.023	0.569	0.569	0.587
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	0.003 <=0.2	0.017	0.375	0.375	0.586
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	0.003 <=0.2	0.017	0.382	0.382	0.382
37	BOT_FLG				0.656	0.200	12.967		0.003 <=0.2	0.017	0.396	0.396	0.396
													0.409

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PAGE 1 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN							TOWER GEOMETRY									
25-031							7.218 = Hub Voffset (ft)									
0139-0349 VER 01 (2023.02.13)							313.648 = Tower Length (ft)									
VESTAS							0.656 = Pedestal Voffset (ft)									
V163/V166-4.5MW Mk4A							321.522 = Hub Height (ft)									
S							98.000 = Hub Height (m)									
98.000 = Hub Height (m)																
A024-4468 ver. V01							3244 = Top Width (mm)									
							3900 = Base Width (mm)									
TOWER PROFILE							TOWER LAYOUT									
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	D _m (mm)	H _{FLG-NECK} (mm)	H _{SHELL ONLY} (mm)	OD (mm)	D _m (mm)	ID (mm)			
1			7.218	321.522	98.000											
2	TOP_FLG	2685	22.0	314.304	95.800	10.715	0.8661	3244	400	29485	3266	3244	3222			
3	2285	19.9	7.497	305.495	93.115	10.813	0.7835	3276	0	27200	3296	3276	3256			
4	2285	19.8	7.497	297.999	90.830	10.833	0.7795	3282			3302	3282	3262			
5	2816	17.0	9.239	290.502	88.545	10.845	0.6693	3288			3302	3288	3271			
6	2816	17.4	9.239	281.263	85.729	10.870	0.6850	3296			3308	3288	3269			
7	2816	17.8	9.239	272.024	82.913	10.896	0.7008	3304			3305	3288	3271			
8	2816	18.2	9.239	262.785	80.097	10.923	0.7165	3311			3313	3296	3279			
9	2816	18.6	9.239	253.547	77.281	10.949	0.7323	3319			3313	3296	3279			
10	2816	19.2	9.239	244.308	74.465	10.976	0.7559	3327			3313	3296	3279			
11	2816	19.7	9.239	235.069	71.649	11.003	0.7756	3334			3321	3304	3286			
12	3033	20.3	9.951	225.830	68.833	11.029	0.7992	3342	115		3322	3304	3286			
13	SPLICE3	2413	20.9	215.879	65.800	11.057	0.8228	3350	115	27405	3329	3311	3293			
14	2298	21.5	7.539	207.963	63.387	11.059	0.8465	3350			3332	3311	3292			
15	2299	22.3	7.543	200.423	61.089	11.061	0.8780	3350			3371	3350	3329			
16	2930	23.8	9.613	192.881	58.790	11.064	0.9370	3350			3372	3350	3329			
17	2930	25.3	9.613	183.268	55.860	11.069	0.9961	3350			3372	3350	3328			
18	2930	26.8	9.613	173.655	52.930	11.074	1.0551	3350			3372	3350	3328			
19	2930	28.2	9.613	164.042	50.000	11.079	1.1102	3350			3374	3350	3326			
20	2930	29.7	9.613	154.429	47.070	11.083	1.1693	3350			3374	3350	3326			
21	2930	31.3	9.613	144.816	44.140	11.088	1.2323	3350			3375	3350	3325			
22	3130	32.7	10.269	135.203	41.210	11.094	1.2874	3350	200		3375	3350	3325			
23	SPLICE2	3020	32.0	124.934	38.080	11.096	1.2598	3350	200	22545	3377	3350	3323			
24	2819	28.7	9.249	115.026	35.060	11.311	1.1299	3419			3377	3350	3323			
25	2819	29.0	9.249	105.778	32.241	11.536	1.1417	3488			3378	3350	3322			
26	2819	28.7	9.249	96.529	29.422	11.762	1.1299	3556			3380	3350	3320			
27	2820	28.9	9.252	87.280	26.603	11.988	1.1378	3625			3380	3350	3320			
28	2818	29.2	9.245	78.028	23.783	12.214	1.1496	3694			3381	3350	3319			
29	2817	29.5	9.242	68.783	20.965	12.440	1.1614	3763			3381	3350	3319			
30	3028	34.8	9.934	59.541	18.148	12.667	1.3701	3831	215		3383	3350	3317			
31	SPLICE1	2720	34.4	49.606	15.120	12.908	1.3543	3900	215	14530	3383	3350	3317			
32	2505	35.3	8.219	40.682	12.400	12.908	1.3898	3900			3382	3350	3318			
33	2505	36.2	8.219	32.464	9.895	12.911	1.4252	3900			3451	3419	3387			
34	1500	52.4	4.921	24.245	7.390	12.914	2.0630	3900			3447	3419	3390			
35	2930	52.4	9.613	19.324	5.890	12.967	2.0630	3900			3516	3488	3459			
36	2760	52.4	9.055	9.711	2.960	12.967	2.0630	3900	175		3517	3488	3459			
37	BOT_FLG			0.656	0.200	12.967		3900			3585	3556	3527			

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 2 OF 15
DATE: 12/7/2025
FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN			= Project			SECTION PROPERTIES AT TOP AND BOTTOM ENDS OF CAN MEMBERS													
25-031			= Job No.			Display Convention: Properties at a joint row are for the top of the "member below."													
0139-0349 VER 01 (2023.02.13)			= Loads Doc.																
VESTAS			= Turbine Make																
V163/V166-4.5MW Mk4A			= Turbine Model																
S			= IEC Site Class																
98.000 = Hub Height (m)																			
A024-4468 ver. V01			= Tower Model																
TOWER PROFILE						SECTION PROPERTIES													
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	t	t _{MEMB}	t _{MEMB}	OD	ID	A	I _x , I _y	r _m	S _x , S _y	J/c	r	Z _x , Z _y	
(mm)	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(mm)	(in)	(in)	(in)	(in ²)	(in ⁴)	(in)	(in ³)	(in ³)	(in)	(in ³)	
1			7.218	321.522	98.000														
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715												
3		2285	19.9	7.497	305.495	93.115	10.813												
4		2285	19.8	7.497	297.999	90.830	10.833												
5		2816	17.0	9.239	290.502	88.545	10.845												
6		2816	17.4	9.239	281.263	85.729	10.870												
7		2816	17.8	9.239	272.024	82.913	10.896												
8		2816	18.2	9.239	262.785	80.097	10.923												
9		2816	18.6	9.239	253.547	77.281	10.949												
10		2816	19.2	9.239	244.308	74.465	10.976												
11		2816	19.7	9.239	235.069	71.649	11.003												
12		3033	20.3	9.951	225.830	68.833	11.029												
13	SPICE3	2413	20.9	7.917	215.879	65.800	11.057												
14		2298	21.5	7.539	207.963	63.387	11.059												
15		2299	22.3	7.543	200.423	61.089	11.061												
16		2930	23.8	9.613	192.881	58.790	11.064												
17		2930	25.3	9.613	183.268	55.860	11.069												
18		2930	26.8	9.613	173.655	52.930	11.074												
19		2930	28.2	9.613	164.042	50.000	11.079												
20		2930	29.7	9.613	154.429	47.070	11.083												
21		2930	31.3	9.613	144.816	44.140	11.088												
22		3130	32.7	10.269	135.203	41.210	11.094												
23	SPICE2	3020	32.0	9.908	124.934	38.080	11.096												
24		2819	28.7	9.249	115.026	35.060	11.111												
25		2819	29.0	9.249	105.778	32.241	11.536												
26		2819	28.7	9.249	96.529	29.422	11.762												
27		2820	28.9	9.252	87.280	26.603	11.988												
28		2818	29.2	9.245	78.028	23.783	12.214												
29		2817	29.5	9.242	68.783	20.965	12.440												
30		3028	34.8	9.934	59.541	18.148	12.667												
31	SPICE1	2720	34.4	8.924	49.606	15.120	12.908												
32		2505	35.3	8.219	40.682	12.400	12.908												
33		2505	36.2	8.219	32.464	9.895	12.911												
34		1500	52.4	4.921	24.245	7.390	12.914												
35		2930	52.4	9.613	19.324	5.890	12.967												
36		2760	52.4	9.055	9.711	2.960	12.967												
37	BOT_FLG				0.656	0.200	12.967												

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 3 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN 25-031 0139-0349 VER 01 (2023.02.13)							= Project = Job No.		MINIMUM SECTION PROPERTIES AT TOWER JOINTS												
VESTAS V163/V166-4.5MW Mk4A							= Turbine Make = Turbine Model														
S							= IEC Site Class														
98.000							= Hub Height (m)														
A024-4468 ver. V01							= Tower Model														
TOWER PROFILE							SECTION PROPERTIES														
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	CAN t	t _{MIN}	t _{MIN}	OD (@ _{MIN})	ID (@ _{MIN})	A (@ _{MIN})	I _x I _y	r _m	S _x S _y	J _c	r	Z _x Z _y				
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(mm)	(in)	(in)	(in)	(in ²)	(in ⁴)	(in)	(in ³)	(in ³)	(in)	(in3)				
1			7.218	321.522	98.000																
2	TOP FLG	2685	22.0	314.304	95.800	10.715	0.8661	0.8661	128.583	126.850	347.525	7.086E+05	63.858	11096.170	22192.340	45.156	14128.299				
3		2285	19.9	305.495	93.115	10.813	0.7835	0.7835	129.760	128.193	317.453	6.601E+05	64.488	10235.984	20471.968	45.601	13033.020				
4		2285	19.8	297.999	90.830	10.833	0.7795	0.7795	130.001	128.442	316.457	6.606E+05	64.611	10223.236	20446.472	45.687	13016.786				
5		2816	17.0	290.502	88.545	10.845	0.6693	0.6693	130.135	128.797	272.220	5.704E+05	64.733	8810.807	17621.613	45.774	11218.367				
6		2816	17.4	281.263	85.729	10.870	0.6850	0.6850	130.437	129.098	272.854	5.744E+05	64.884	8851.908	17703.816	45.880	11270.699				
7		2816	17.8	272.024	82.913	10.896	0.7008	0.7008	130.754	129.384	279.924	5.920E+05	65.035	9102.355	18204.710	45.987	11589.585				
8		2816	18.2	262.785	80.097	10.923	0.7165	0.7165	131.072	129.670	287.023	6.098E+05	65.185	9354.840	18709.681	46.094	11911.067				
9		2816	18.6	253.547	77.281	10.949	0.7323	0.7323	131.389	129.956	294.152	6.279E+05	65.336	9609.371	19218.743	46.200	12235.154				
10		2816	19.2	244.308	74.465	10.976	0.7559	0.7559	131.706	130.242	301.310	6.461E+05	65.487	9865.955	19731.910	46.307	12561.855				
11		2816	19.7	235.069	71.649	11.003	0.7756	0.7756	132.032	130.520	311.746	6.716E+05	65.638	10231.172	20462.344	46.414	13026.877				
12		3033	20.3	225.830	68.833	11.029	0.7992	0.7992	132.353	130.802	320.600	6.938E+05	65.789	10545.903	21091.807	46.520	13427.617				
13	SPLICE3	2413	20.9	215.879	65.800	11.057	0.8228	0.8228	132.689	131.091	331.149	7.201E+05	65.945	10918.787	21837.573	46.631	13902.401				
14		2298	21.5	207.963	63.387	11.059	0.8465	0.8465	132.713	131.067	340.937	7.413E+05	65.945	11241.509	22483.019	46.631	14313.320				
15		2299	22.3	200.423	61.089	11.061	0.8780	0.8780	132.736	131.043	350.724	7.626E+05	65.945	11564.232	23128.465	46.631	14724.240				
16		2930	23.8	192.881	58.790	11.064	0.9370	0.9370	132.768	131.012	363.774	7.910E+05	65.945	11994.529	23989.059	46.631	15272.135				
17		2930	25.3	183.268	55.860	11.069	0.9961	0.9961	132.827	130.953	388.244	8.442E+05	65.945	12801.336	25602.672	46.631	16299.442				
18		2930	26.8	173.655	52.930	11.074	1.0551	1.0551	132.886	130.894	412.713	8.974E+05	65.945	13608.143	27216.286	46.631	17326.755				
19		2930	28.2	164.042	50.000	11.079	1.1102	1.1102	132.945	130.835	437.182	9.507E+05	65.945	14414.950	28829.900	46.632	18354.076				
20		2930	29.7	154.429	47.070	11.083	1.1693	1.1693	133.000	130.780	460.020	1.000E+06	65.945	15167.970	30335.940	46.632	19312.915				
21		2930	31.3	144.816	44.140	11.088	1.2323	1.2323	133.059	130.720	484.489	1.054E+06	65.945	15974.777	31949.553	46.632	20340.250				
22		3130	32.7	135.203	41.210	11.094	1.2874	1.2874	133.122	130.657	510.589	1.110E+06	65.945	16835.371	33670.741	46.632	21436.083				
23	SPLICE2	3020	32.0	124.934	38.080	11.096	1.2598	1.2598	133.150	130.630	522.008	1.135E+06	65.945	17211.881	34423.761	46.632	21915.514				
24		2819	28.7	115.026	35.060	11.311	1.1299	1.1299	135.728	133.468	477.790	1.082E+06	67.299	16077.441	32154.883	47.589	20470.915				
25		2819	29.0	105.778	32.241	11.536	1.1417	1.1417	138.436	136.176	487.402	1.149E+06	68.653	16730.764	33461.528	48.547	21302.751				
26		2819	28.7	96.529	29.422	11.762	1.1299	1.1299	141.143	138.883	497.013	1.218E+06	70.007	17397.097	34794.195	49.504	22151.153				
27		2820	28.9	87.280	26.603	11.988	1.1378	1.1378	143.851	141.591	506.624	1.290E+06	71.360	18076.442	36152.884	50.461	23016.122				
28		2818	29.2	78.028	23.783	12.214	1.1496	1.1496	146.567	144.292	519.836	1.374E+06	72.715	18899.841	37799.681	51.419	24064.515				
29		2817	29.5	68.783	20.965	12.440	1.1614	1.1614	149.286	146.986	535.007	1.468E+06	74.068	19813.436	39626.872	52.376	25227.757				
30		3028	34.8	59.541	18.148	12.667	1.3701	1.3701	152.003	149.680	550.376	1.565E+06	75.421	20754.873	41509.746	53.332	26426.447				
31	SPLICE1	2720	34.4	49.606	15.120	12.908	1.3543	1.3543	154.898	152.189	653.289	1.925E+06	76.772	25077.047	50154.093	54.288	31929.916				
32		2505	35.3	40.682	12.400	12.908	1.3898	1.3898	154.898	152.189	653.289	1.925E+06	76.772	25077.047	50154.093	54.288	31929.916				
33		2505	36.2	32.464	9.895	12.911	1.4252	1.4252	154.933	152.154	670.381	1.976E+06	76.772	25733.132	51466.264	54.288	32765.336				
34		1500	52.4	24.245	7.390	12.914	2.0630	2.0630	154.969	152.118	687.473	2.026E+06	76.772	26389.218	52778.435	54.288	33600.760				
35		2930	52.4	19.324	5.890	12.967	2.0630	2.0630	155.606	151.480	995.127	2.933E+06	76.772	38198.757	76397.514	54.291	48639.095				
36		2760	52.4	9.711	2.960	12.967	2.0630	2.0630	155.606	151.480	995.127	2.933E+06	76.772	38198.757	76397.514	54.291	48639.095				
37	BOT FLG			0.656	0.200	12.967			155.606	151.480	995.127	2.933E+06	76.772	38198.757	76397.514	54.291	48639.095				

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

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DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN= Project																									
25-031			= Job No.		MEMBER AVERAGE PROPERTIES																				
0139-0349 VER 01 (2023.02.13)			= Loads Doc.																						
VESTAS			= Turbine Make																						
V163/V166-4.5MW Mk4A			= Turbine Model																						
S			= IEC Site Class																						
98.000			= Hub Height (m)																						
A024-4468 ver. V01			= Tower Model																						
TOWER PROFILE													MEMBER SECTION PROPERTIES												
JOINT	H_CAN	t	H_CAN	JOINT ELEV	JOINT ELEV	OD	CAN t	I_MEMB	D_MAVG	OD	ID	A_MEMB	I_MEMB	J_MEMB	A_MEMB	I_MEMB	J_MEMB								
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(mm)	(mm)	(mm)	(mm)	(mm ²)	(mm ⁴)	(mm ⁴)	(in ²)	(in ⁴)	(in ⁴)								
1			7.218	321.522	98.000										1.0E+08	1.0E+08	1.0E+08								
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	22	3260	3282	3238	225315	2.993E+11	5.987E+11	349.239	719151	1438303							
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	20	3279	3299	3259	205002	2.755E+11	5.511E+11	317.754	662005	1324010							
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	20	3285	3305	3266	204359	2.757E+11	5.514E+11	316.757	662431	1324863							
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	17	3292	3309	3275	175830	2.382E+11	4.765E+11	272.537	572360	1144720							
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	17	3300	3317	3283	180386	2.455E+11	4.911E+11	279.599	589927	1179855							
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	18	3308	3325	3290	184961	2.529E+11	5.059E+11	286.691	607703	1215405							
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	18	3315	3333	3297	189556	2.604E+11	5.209E+11	293.812	625687	1251374							
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	19	3323	3342	3304	194170	2.680E+11	5.360E+11	300.963	643883	1287765							
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	19	3331	3350	3311	200895	2.786E+11	5.571E+11	311.388	669262	1338524							
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	20	3338	3358	3319	206601	2.878E+11	5.756E+11	320.232	691441	1382883							
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	20	3346	3366	3326	213391	2.986E+11	5.973E+11	330.757	717508	1435016							
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	21	3350	3371	3329	219959	3.086E+11	6.171E+11	340.937	741349	1482698							
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	22	3350	3372	3329	226273	3.174E+11	6.349E+11	350.724	762633	1525267							
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	22	3350	3372	3328	234693	3.292E+11	6.585E+11	363.774	791013	1582026							
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	24	3350	3374	3326	250479	3.514E+11	7.028E+11	388.244	844225	1688450							
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	25	3350	3375	3325	266266	3.735E+11	7.471E+11	412.713	897439	1794877							
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	27	3350	3377	3323	282052	3.957E+11	7.914E+11	437.182	950653	1901306							
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	28	3350	3378	3322	296786	4.164E+11	8.327E+11	460.020	1000321	2000642							
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	30	3350	3380	3320	312573	4.385E+11	8.770E+11	484.489	1053538	2107075							
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	31	3350	3381	3319	329412	4.621E+11	9.243E+11	510.589	1110303	2220607							
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	33	3350	3383	3317	344146	4.828E+11	9.656E+11	533.427	1159975	2319950							
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	32	3384	3416	3352	340237	4.872E+11	9.744E+11	527.368	1170464	2340928							
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	29	3453	3482	3424	311352	4.641E+11	9.282E+11	482.596	1115052	2230104							
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	29	3522	3551	3493	320872	4.976E+11	9.951E+11	497.352	1195372	2390744							
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	29	3591	3619	3562	323753	5.218E+11	1.044E+12	501.818	1253663	2507326							
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	29	3660	3688	3631	332254	5.562E+11	1.112E+12	514.995	1336343	2672686							
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	29	3728	3757	3699	342012	5.943E+11	1.189E+12	530.119	1427775	2855550							
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	30	3797	3827	3768	351896	6.342E+11	1.268E+12	545.440	1523701	3047402							
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	35	3866	3900	3831	422626	7.895E+11	1.579E+12	655.071	1896792	3793584							
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	34	3900	3934	3866	421476	8.014E+11	1.603E+12	653.289	1925356	3850712							
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	35	3900	3935	3865	432503	8.224E+11	1.645E+12	670.381	1975737	3951474							
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	36	3900	3936	3864	443530	8.433E+11	1.687E+12	687.473	2026118	4052237							
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222							
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222							
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	52	3900	3952	3848	642016	1.221E+12	2.442E+12	995.127	2933111	5866222							
37	BOT_FLG				0.656	0.200	12.967																		

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200
 JOB NO.: 25-031 (GENERIC)

PAGE 5 OF 15
 DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN				MATERIAL PROPERTIES													
25-031				ID	NAME	F _y	F _w	E	v	G	P _{STEEL}	t _{MIN}	t _{MAXINCL}				
0139-0349 VER 01 (2023.02.13)				(no)	(-)	(ksi)	(ksi)	(ksi)	(-)	(ksi)	(pcf)	(mm)	(mm)				
VESTAS				15	RIGIDMASSLESS	50	65	2.90E+07	0	1.12E+07	0	0	10000				
V163/V166-4.5MW Mk4A				4	S355-355-00-16	51	68	2.90E+04	0	1.12E+04	490	0	16				
S				5	S355-345-16-40	50	68	2.90E+04	0	1.12E+04	490	16	40				
98.000 = Hub Height (m)				6	S355-335-40-63	49	68	2.90E+04	0	1.12E+04	490	40	63				
A024-4468 ver. V01 = Tower Model				14	S420-400-16-40	58	75	2.90E+04	0	1.12E+04	490	16	40				

TOWER PROFILE								MEMBER MATERIAL PROPERTIES													
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	ID	NAME	F _y	F _w	E	v	G	P _{STEEL}	t _{MIN}	t _{MAXINCL}				
(mm)	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(no)	(-)	(ksi)	(ksi)	(ksi)	(-)	(ksi)	(pcf)	(mm)	(mm)				
1			7.218	321.522	98.000			15	RIGIDMASSLESS	50.000	65.000	2.90E+07	0.300	1.12E+07	0	0	10000				
2	TOP FLG			314.304	95.800	10.715		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2685	22.0	8.809				0.8661														
3				305.495	93.115	10.813		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2285	19.9	7.497				0.7835														
4				297.999	90.830	10.833		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2285	19.8	7.497				0.7795														
5				290.502	88.545	10.845		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	17.0	9.239				0.6693														
6				281.263	85.729	10.870		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	17.4	9.239				0.6850														
7				272.024	82.913	10.896		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	17.8	9.239				0.7008														
8				262.785	80.097	10.923		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	18.2	9.239				0.7165														
9				253.547	77.281	10.949		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	18.6	9.239				0.7323														
10				244.308	74.465	10.976		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	19.2	9.239				0.7559														
11				235.069	71.649	11.003		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2816	19.7	9.239				0.7756														
12				225.830	68.833	11.029		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	3033	20.3	9.951				0.7992														
13	SPLICE3			215.879	65.800	11.057		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2413	20.9	7.917				0.8228														
14				207.963	63.387	11.059		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2298	21.5	7.539				0.8465														
15				200.423	61.089	11.061		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2299	22.3	7.543				0.8780														
16				192.881	58.790	11.064		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2930	23.8	9.613				0.9370														
17				183.268	55.860	11.069		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2930	25.3	9.613				0.9961														
18				173.655	52.930	11.074		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2930	26.8	9.613				1.0551														
19				164.042	50.000	11.079		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2930	28.2	9.613				1.1102														
20				154.429	47.070	11.083		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2930	29.7	9.613				1.1693														
21				144.816	44.140	11.088		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2930	31.3	9.613				1.2323														
22				135.203	41.210	11.094		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	3130	32.7	10.269				1.2874														
23	SPLICE2			124.934	38.080	11.096		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	3020	32.0	9.908				1.2598														
24				115.026	35.060	11.311		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	2819	28.7	9.249				1.1299														
25				105.778	32.241	11.536		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	2819	29.0	9.249				1.1417														
26				96.529	29.422	11.762		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	2819	28.7	9.249				1.1299														
27				87.280	26.603	11.988		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	2820	28.9	9.252				1.1378														
28				78.028	23.783	12.214		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	2818	29.2	9.245				1.1496														
29				68.783	20.965	12.440		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	2817	29.5	9.242				1.1614														
30				59.541	18.148	12.667		14	S420-400-16-40	58.016	75.421	2.90E+04	0.300	1.12E+04	490	16	40				
	3028	34.8	9.934				1.3701														
31	SPLICE1			49.606	15.120	12.908		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2720	34.4	8.924				1.3543														
32				40.682	12.400	12.908		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2505	35.3	8.219				1.3898														
33				32.464	9.895	12.911		5	S355-345-16-40	50.039	68.169	2.90E+04	0.300	1.12E+04	490	16	40				
	2505	36.2	8.219				1.4252														
34				24.245	7.390	12.914		6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63				
	1500	52.4	9.921				2.0630														
35				19.324	5.890	12.967		6	S355-335-40-63	48.588	68.169	2.90E+04	0.300	1.12E+04	490	40	63				
	2930	52.4	9.613				2.0630														
36				9.711	2.960	12.967		6	S355-335-40-63	48.588											

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

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DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project		DEAD LOADS		FLANGES AND STIFFENING RINGS: W _{TMD,SC,cc} (kips) = 0.000						
25-031 = Job No.		509.288 = W _{TURBINE} (kips)		I _{FLG} (in)	b _{FLG} (in)	OD (in)	XA (in)	OD _{FLG} (in)	ID _{FLG} (in)	W _{FLG} (kip)
0139-0349 VER 01 (2023.02.13) = Loads Doc.		490 = ρ _{STEEL} (pcf)								
VESTAS = Turbine Make		0.015 = W _{MISC} /W _{SHELL}		7.874	4.882	128.583	0.000	128.583	118.819	4.236
V163/V166-4.5MW Mk4A = Turbine Model		511.326 = W _{SHELL} (kips)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
S = IEC Site Class		7.670 = W _{MISC} (kips)		3.346	6.496	132.689	0.000	132.689	119.697	2.444
98.000 = Hub Height (m)		0.0245 = W _{MISC} (klf)		5.906	10.394	133.150	0.000	133.150	112.362	6.712
A024-4468 ver. V01 = Tower Model				0.000	0.000	0.000	0.000	0.000	0.000	0.000
				6.496	10.709	154.898	0.000	154.898	133.480	8.936
				0.000	0.000	0.000	0.000	0.000	0.000	0.000
				4.331	11.811	155.606	4.874	165.354	141.732	6.996

TOWER PROFILE							DEAD LOADS											
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN OD (ft)	CAN t (in)	CAN DL (kips)	Nodal Wt shell only (kips)	Flange Misc DL (kips)	Internal Nodal DL (kips)	Nodal Wt MIN (kips)	Nodal Wt MAX (kips)	Nodal Mass MIN (kips/32.2)	Nodal Mass MAX (kips/32.2)	Cum. Twr. DL (kips)	Cum. Tot. DL (kips)	
1				321.522	98.000				509.288	0.000	0.000	509.288	509.288	15.816	15.816	0.000	509.288	
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	10.469	5.234	4.236	0.108	9.470	9.578	0.294	0.297	9.578	518.866
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	8.106	9.287	0.000	0.199	9.287	9.487	0.288	0.295	19.065	528.352
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	8.080	8.093	0.000	0.183	8.093	8.276	0.251	0.257	27.341	536.629
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	8.568	8.324	0.000	0.205	8.324	8.529	0.259	0.265	35.870	545.158
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	8.790	8.679	0.000	0.226	8.679	8.905	0.270	0.277	44.775	554.063
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	9.013	8.901	0.000	0.226	8.901	9.127	0.276	0.283	53.902	563.190
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	9.237	9.125	0.000	0.226	9.125	9.351	0.283	0.290	63.253	572.541
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	9.462	9.349	0.000	0.226	9.349	9.575	0.290	0.297	72.828	582.116
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	9.789	9.625	0.000	0.226	9.625	9.851	0.299	0.306	82.679	591.967
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	10.067	9.928	0.000	0.226	9.928	10.154	0.308	0.315	92.834	602.121
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	11.200	10.633	0.000	0.235	10.633	10.868	0.330	0.338	103.702	612.990
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	9.184	10.192	4.888	0.218	15.080	15.298	0.468	0.475	119.000	628.288
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	8.998	9.091	0.000	0.189	9.091	9.280	0.282	0.288	128.280	637.568
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	9.337	9.167	0.000	0.184	9.167	9.352	0.285	0.290	137.631	646.919
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	12.700	11.018	0.000	0.210	11.018	11.228	0.342	0.349	148.859	658.147
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	13.500	13.100	0.000	0.235	13.100	13.335	0.407	0.414	162.194	671.482
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	14.300	13.900	0.000	0.235	13.900	14.135	0.432	0.439	176.329	685.617
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	15.047	14.674	0.000	0.235	14.674	14.909	0.456	0.463	191.238	700.526
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	15.848	15.448	0.000	0.235	15.448	15.683	0.480	0.487	206.921	716.209
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	16.702	16.275	0.000	0.235	16.275	16.510	0.505	0.513	223.431	732.719
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	18.640	17.671	0.000	0.243	17.671	17.914	0.549	0.556	241.345	750.633
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	17.780	18.210	13.425	0.247	31.635	31.881	0.982	0.990	273.226	782.514
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	15.188	16.484	0.000	0.234	16.484	16.718	0.512	0.519	289.944	799.232
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	15.652	15.420	0.000	0.226	15.420	15.646	0.479	0.486	305.590	814.878
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	15.793	15.723	0.000	0.226	15.723	15.949	0.488	0.495	321.539	830.827
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	16.213	16.003	0.000	0.226	16.003	16.229	0.497	0.504	337.768	847.056
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	16.678	16.445	0.000	0.226	16.445	16.672	0.511	0.518	354.440	863.728
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	17.153	16.916	0.000	0.226	16.916	17.142	0.525	0.532	371.582	880.870
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	22.144	19.649	0.000	0.234	19.649	19.883	0.610	0.617	391.465	900.753
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	19.838	20.991	17.871	0.231	38.862	39.093	1.207	1.214	430.558	939.846
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	18.748	19.293	0.000	0.210	19.293	19.502	0.599	0.606	450.060	959.348
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	19.226	18.987	0.000	0.201	18.987	19.188	0.590	0.596	469.248	978.536
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	16.664	17.945	0.000	0.161	17.945	18.106	0.557	0.562	487.353	996.641
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	32.551	24.608	0.000	0.178	24.608	24.785	0.764	0.770	512.139	1021.427
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	30.662	31.607	0.000	0.228	31.607	31.835	0.982	0.989	543.974	1053.262
37	BOT FLG				0.656	0.200	12.967		511.326	15.331	6.996	0.111	22.328	22.438	0.693	0.697	566.412	1075.700
									47.416	7.670								
													558.742	566.412				
									Tower =	1068.030	1075.700							
									Tower+Turbine =									

TEL: 661-742-1327

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 7 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project 25-031 = Job No. 0139-0349 VER 01 (2023.02.13) = Loads Doc.								BASIC LOAD CASE 1 OF 3 (MAX.)										
VESTAS = Turbine Make V163/V166-4.5MW Mk4A = Turbine Model S = IEC Site Class 98.000 = Hub Height (m) A024-4468 ver. V01 = Tower Model								BASIC LOAD CASE										
								LOAD FACTORS: $D+E_{1.4}$ $1.200 = S_{DS} @ 5\% = \beta$ $1.680 = S_{DS} @ 1\% = \beta$ $3.806 = x_{CG} (ft)$ $LF_{Fz} = 1.536$ $LF_{Mz} = 1.536$ $LF_{Fxy} = 1.536$ $LF_{Mxy} = 1.536$ $= 1.2+0.2S_{DS}$										
TOWER PROFILE								SERVICE LOADS				FACTORED LOADS						
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	LOAD STA (m)	F _Z (kN)	M _Z (kN-m)	F _{xy} (kN)	M _{xy} (kN-m)	1.536 F _Z (kN)	1.536 M _Z (kN-m)	1.536 F _{xy} (kN)	1.536 M _{xy,0.1} (kN-m)	LF _{Fz}	M _{xy,0.2} (kN-m)
1			7.218	321.522	98.000			98.000	2265	0.000	0.000	917	3480	0	0	1409	1.000	1409
2	TOP_FLG 2685	22.0	8.809	314.304	95.800	10.715		95.800	2308	0.000	0.000	917	3545	0	0	1409	1.000	1409
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	2350	0.000	0.000	917	3610	0	0	1409	1.000	1409
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	2387	0.000	0.000	917	3666	0	0	1409	1.000	1409
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	2425	0.000	0.000	917	3725	0	0	1409	1.000	1409
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	2465	0.000	0.000	917	3786	0	0	1409	1.000	1409
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	2505	0.000	0.000	917	3848	0	0	1409	1.000	1409
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	2547	0.000	0.000	917	3912	0	0	1409	1.000	1409
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	2589	0.000	0.000	917	3977	0	0	1409	1.000	1409
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	2633	0.000	0.000	917	4045	0	0	1409	1.000	1409
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	2678	0.000	0.000	917	4114	0	0	1409	1.000	1409
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	2727	0.000	0.000	917	4188	0	0	1409	1.000	1409
13	SPLICE3 2413	20.9	7.917	215.879	65.800	11.057	0.8228	65.800	2795	0.000	0.000	917	4293	0	0	1409	1.000	1409
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	2836	0.000	0.000	917	4356	0	0	1409	1.000	1409
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	2878	0.000	0.000	917	4420	0	0	1409	1.000	1409
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	2928	0.000	0.000	917	4497	0	0	1409	1.000	1409
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	2987	0.000	0.000	917	4588	0	0	1409	1.000	1409
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	3050	0.000	0.000	917	4684	0	0	1409	1.000	1409
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	3116	0.000	0.000	917	4786	0	0	1409	1.000	1409
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	3186	0.000	0.000	917	4893	0	0	1409	1.000	1409
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	3259	0.000	0.000	917	5006	0	0	1409	1.000	1409
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	3339	0.000	0.000	917	5129	0	0	1409	1.000	1409
23	SPLICE2 3020	32.0	9.908	124.934	38.080	11.096	1.2598	38.080	3481	0.000	0.000	917	5346	0	0	1409	1.000	1409
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	3555	0.000	0.000	917	5461	0	0	1409	1.000	1409
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	3625	0.000	0.000	917	5568	0	0	1409	1.000	1409
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	3696	0.000	0.000	917	5677	0	0	1409	1.000	1409
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	3768	0.000	0.000	917	5787	0	0	1409	1.000	1409
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	3842	0.000	0.000	917	5901	0	0	1409	1.000	1409
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	3918	0.000	0.000	917	6018	0	0	1409	1.000	1409
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	4007	0.000	0.000	917	6154	0	0	1409	1.000	1409
31	SPLICE1 2720	34.4	8.924	49.606	15.120	12.908	1.3543	15.120	4181	0.000	0.000	917	6421	0	0	1409	1.000	1409
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	4267	0.000	0.000	917	6555	0	0	1409	1.000	1409
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	4353	0.000	0.000	917	6686	0	0	1409	1.000	1409
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	4433	0.000	0.000	917	6809	0	0	1409	1.000	1409
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	4544	0.000	0.000	917	6979	0	0	1409	1.000	1409
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	4685	0.000	0.000	917	7196	0	0	1409	1.000	1409
37	BOT_FLG			0.656	0.200	12.967		0.200	4785	0.000	0.000	917	7350	0	0	1409	1.000	1409

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 8 OF 15
DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN										= Project	BASIC LOAD CASE 2 OF 3 (MAX.)							
25-031										= Job No.	BASIC LOAD CASE							
0139-0349 VER 01 (2023.02.13)										= Loads Doc.	(E _{1st} /1.4) ... at R=1.5, 1% damping							
VESTAS										= Turbine Make	LOAD FACTORS:							
V163/V166-4.5MW Mk4A										= Turbine Model	LF _{Fz} 1.050 = (0.75)(1.4)							
S										= IEC Site Class	LF _{Mz} 1.050							
98.000 = Hub Height (m)											LF _{Fxy} 1.050							
A024-4468 ver. V01										= Tower Model	LF _{Mxy} 1.050							
											3.806 = x _{CG} (ft)							

TOWER PROFILE								SERVICE LOADS						FACTORED LOADS					
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	LOAD STA	F _Z	M _Z	F _{XY}	M _{XY}	F _Z	M _Z	F _{XY}	M _{XY,0.1}	LF _{Fz}	M _{XY,0.2}	
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)	(m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)	
1			7.218	321.522	98.000			98.000	0	429	370	11598	0.000	450	388	12177	1.000	12177	
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	0	429	377	11398	0.000	450	396	11967	1.000	11967	
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	0	429	385	11177	0.000	450	404	11735	1.000	11735	
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	0	429	392	11048	0.000	450	411	11601	1.000	11601	
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	0	429	398	10978	0.000	450	417	11527	1.000	11527	
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	0	429	403	10978	0.000	450	423	11527	1.000	11527	
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	0	429	407	11075	0.000	450	427	11629	1.000	11629	
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	0	429	410	11268	0.000	450	431	11832	1.000	11832	
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	0	429	413	11553	0.000	450	433	12131	1.000	12131	
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	0	429	415	11925	0.000	450	436	12521	1.000	12521	
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	0	429	417	12374	0.000	450	438	12992	1.000	12992	
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	0	429	419	12892	0.000	450	440	13537	1.000	13537	
13	SPICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	0	429	423	13519	0.000	450	445	14195	1.000	14195	
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	0	429	427	14054	0.000	450	448	14757	1.000	14757	
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	0	429	430	14598	0.000	450	452	15328	1.000	15328	
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	0	429	435	15172	0.000	450	457	15930	1.000	15930	
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	0	429	442	15943	0.000	450	465	16740	1.000	16740	
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	0	429	451	16756	0.000	450	473	17593	1.000	17593	
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	0	429	461	17607	0.000	450	484	18487	1.000	18487	
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	0	429	472	18496	0.000	450	496	19420	1.000	19420	
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	0	429	485	19422	0.000	450	509	20393	1.000	20393	
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	0	429	500	20387	0.000	450	525	21407	1.000	21407	
23	SPICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	0	429	530	21463	0.000	450	557	22537	1.000	22537	
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	0	429	547	22544	0.000	450	574	23671	1.000	23671	
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	0	429	562	23603	0.000	450	590	24783	1.000	24783	
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	0	429	577	24712	0.000	450	606	25948	1.000	25948	
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	0	429	591	25874	0.000	450	621	27167	1.000	27167	
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	0	429	605	27087	0.000	450	635	28441	1.000	28441	
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	0	429	617	28351	0.000	450	648	29768	1.000	29768	
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	0	429	629	29663	0.000	450	661	31146	1.000	31146	
31	SPICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	0	429	649	31128	0.000	450	682	32684	1.000	32684	
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	0	429	657	32494	0.000	450	690	34118	1.000	34118	
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	0	429	663	33789	0.000	450	696	35479	1.000	35479	
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	0	429	666	35118	0.000	450	700	36873	1.000	36873	
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	0	429	670	35928	0.000	450	703	37724	1.000	37724	
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	0	429	671	37539	0.000	450	705	39416	1.000	39416	
37	BOT_FLG				0.656	0.200	12.967	0.200	0	429	672	39087	0.000	450	705	41042	1.000	41042	

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

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PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN		= Project		BASIC LOAD CASE 3 OF 3 (MAX.)														
25-031		= Job No.		BASIC LOAD CASE														
0139-0349 VER 01 (2023.02.13)		= Loads Doc.		1.0M _{op} ... (Idle/Parkeed Operational Load)														
VESTAS		= Turbine Make		LOAD FACTORS:														
V163/V166-4.5MW Mk4A		= Turbine Model		LF _{Fz} 0.750														
S		= IEC Site Class		LF _{Mz} 0.750														
98.000		= Hub Height (m)		LF _{Fxy} 0.750														
A024-4468 ver. V01		= Tower Model		LF _{Mxy} 0.750														
				-2112 = F _z (kN)														
				-2265 = W _{TURBINE} (kN)														
				-153 = Net F _z (kN) (-)Uplift														
TOWER PROFILE				SERVICE LOADS				FACTORED LOADS										
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	LOAD STA (m)	F _Z (kN)	M _Z (kN-m)	F _{XY} (kN)	M _{XY} (kN-m)	0.750 F _Z (kN)	0.750 M _Z (kN-m)	0.750 F _{XY} (kN)	0.750 M _{XY,0.1} (kN-m)	LF _{Fz}	M _{XY,0.2} (kN-m)
1			7.218	321.522	98.000			98.000	-153.475	0	162	3093	-115	0	122	2320	1.000	2320
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	-153.475	0	164	3466	-115	0	123	2600	1.000	2600
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	-153.475	0	166	3921	-115	0	124	2941	1.000	2941
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	-153.475	0	167	4309	-115	0	126	3232	1.000	3232
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	-153.475	0	169	4696	-115	0	127	3522	1.000	3522
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	-153.475	0	171	5174	-115	0	128	3880	1.000	3880
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	-153.475	0	173	5651	-115	0	130	4238	1.000	4238
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	-153.475	0	175	6128	-115	0	132	4596	1.000	4596
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	-153.475	0	177	6606	-115	0	133	4954	1.000	4954
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	-153.475	0	180	7083	-115	0	135	5312	1.000	5312
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	-153.475	0	182	7560	-115	0	136	5670	1.000	5670
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	-153.475	0	184	8038	-115	0	138	6028	1.000	6028
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	-153.475	0	186	8552	-115	0	139	6414	1.000	6414
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	-153.475	0	188	8961	-115	0	141	6721	1.000	6721
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	-153.475	0	189	9351	-115	0	142	7013	1.000	7013
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	-153.475	0	191	9740	-115	0	143	7305	1.000	7305
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	-153.475	0	193	10237	-115	0	145	7678	1.000	7678
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	-153.475	0	195	10734	-115	0	147	8050	1.000	8050
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	-153.475	0	198	11230	-115	0	148	8423	1.000	8423
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	-153.475	0	200	11727	-115	0	150	8795	1.000	8795
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	-153.475	0	202	12224	-115	0	151	9168	1.000	9168
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	-153.475	0	204	12720	-115	0	153	9540	1.000	9540
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	-153.475	0	206	13251	-115	0	155	9938	1.000	9938
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	-153.475	0	209	13763	-115	0	157	10322	1.000	10322
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	-153.475	0	211	14241	-115	0	158	10681	1.000	10681
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	-153.475	0	213	14719	-115	0	160	11039	1.000	11039
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	-153.475	0	215	15197	-115	0	161	11397	1.000	11397
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	-153.475	0	217	15675	-115	0	163	11756	1.000	11756
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	-153.475	0	219	16152	-115	0	164	12114	1.000	12114
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	-153.475	0	221	16630	-115	0	166	12472	1.000	12472
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	-153.475	0	223	17143	-115	0	168	12857	1.000	12857
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	-153.475	0	225	17604	-115	0	169	13203	1.000	13203
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	-153.475	0	227	18029	-115	0	170	13522	1.000	13522
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	-153.475	0	229	18454	-115	0	172	13840	1.000	13840
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	-153.475	0	230	18708	-115	0	173	14031	1.000	14031
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	-153.475	0	232	19205	-115	0	174	14403	1.000	14403
37	BOT_FLG				0.656	0.200	12.967	0.200	-153.475	0	234	19673	-115	0	176	14754	1.000	14754

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 10 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN								LOAD COMBINATION										
25-031								Load Summary at Flange Elevations:					LOAD COMBINATION:					
0139-0349 VER 01 (2023.02.13)								F_z	F_{xy}	$M_{xy,0.1}$			$U_{EQ5} = (1.2+0.2S_{Dk})D + 0.75(1.0E_{1\%}+1.0M_{ip})$					
VESTAS								TOP_FLG	3430.012	519.062	16216.681			FLAG SETTINGS:				
V163/V166-4.5MW Mk4A								SPLICE3	4177.629	583.964	26083.060			1.000; PA Flag=[The Override Value or 1=Use Analysis]				
S								SPLICE2	5231.370	711.428	40881.001			INPUT : Δ_{USE} Flag = [CALculated or INPUT]				
98.000 = Hub Height (m)								SPLICE1	6306.329	849.483	55418.142			SRSS : $\Delta_{Input,TOT}$ Flag = [ABSSUM or SRSS] with Input Δ_i				
A024-4468 ver. V01 = Tower Model								BOT_FLG	7234.546	880.980	66081.963			SRSS : Δ_{TOTAL} Flag = [ABSSUM or SRSS] with $\Delta_{TOOmm/mm}$				
TOWER PROFILE								SERVICE LOADS					FACTORED LOADS					
JOINT	H_{CAN}	t	H_{CAN}	JOINT	JOINT	CAN	LOAD	F_z	M_z	F_{xy}	M_{xy}	F_z	M_z	F_{xy}	$M_{xy,0.1}$	LF_{PA}	$M_{xy,0.2}$	
	(mm)	(mm)	(ft)	ELEV	ELEV	OD	STA	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)	(kN)	(kN-m)		(kN-m)	
1			7.218	321.522	98.000		98.000	2112	429	532	15608	3365	450	510	15906	1.000	15906	
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	95.800	2155	429	541	15781	3430	450	519	15976	1.015	16217
3		2285	19.9	7.497	305.495	93.115	10.813	93.115	2197	429	551	16015	3495	450	529	16085	1.036	16671
4		2285	19.8	7.497	297.999	90.830	10.833	90.830	2234	429	559	16274	3551	450	537	16241	1.054	17122
5		2816	17.0	9.239	290.502	88.545	10.845	88.545	2271	429	567	16592	3610	450	544	16458	1.072	17637
6		2816	17.4	9.239	281.263	85.729	10.870	85.729	2311	429	574	17069	3670	450	551	16816	1.092	18362
7		2816	17.8	9.239	272.024	82.913	10.896	82.913	2352	429	580	17643	3733	450	557	17275	1.111	19188
8		2816	18.2	9.239	262.785	80.097	10.923	80.097	2393	429	585	18313	3797	450	562	17836	1.128	20113
9		2816	18.6	9.239	253.547	77.281	10.949	77.281	2436	429	590	19076	3862	450	566	18494	1.143	21132
10		2816	19.2	9.239	244.308	74.465	10.976	74.465	2480	429	594	19925	3929	450	570	19242	1.156	22237
11		2816	19.7	9.239	235.069	71.649	11.003	71.649	2525	429	599	20851	3999	450	574	20071	1.167	23420
12		3033	20.3	9.951	225.830	68.833	11.029	68.833	2573	429	603	21847	4073	450	578	20974	1.176	24671
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	65.800	2641	429	609	22988	4178	450	584	22017	1.185	26083
14		2298	21.5	7.539	207.963	63.387	11.059	63.387	2683	429	614	23932	4241	450	589	22886	1.190	27241
15		2299	22.3	7.543	200.423	61.089	11.061	61.089	2724	429	620	24865	4305	450	594	23749	1.195	28375
16		2930	23.8	9.613	192.881	58.790	11.064	58.790	2774	429	627	25829	4382	450	601	24644	1.198	29535
17		2930	25.3	9.613	183.268	55.860	11.069	55.860	2833	429	636	27097	4473	450	610	25826	1.202	31047
18		2930	26.8	9.613	173.655	52.930	11.074	52.930	2896	429	646	28406	4569	450	620	27052	1.205	32593
19		2930	28.2	9.613	164.042	50.000	11.079	50.000	2963	429	658	29754	4671	450	632	28318	1.207	34170
20		2930	29.7	9.613	154.429	47.070	11.083	47.070	3032	429	672	31140	4778	450	646	29624	1.208	35775
21		2930	31.3	9.613	144.816	44.140	11.088	44.140	3106	429	687	32563	4891	450	661	30970	1.208	37409
22		3130	32.7	10.269	135.203	41.210	11.094	41.210	3185	429	704	34025	5014	450	678	32356	1.208	39072
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	38.080	3327	429	737	35632	5231	450	711	33883	1.207	40881
24		2819	28.7	9.249	115.026	35.060	11.311	35.060	3402	429	756	37224	5346	450	731	35402	1.205	42660
25		2819	29.0	9.249	105.778	32.241	11.536	32.241	3471	429	773	38761	5452	450	749	36872	1.203	44357
26		2819	28.7	9.249	96.529	29.422	11.762	29.422	3542	429	790	40348	5561	450	766	38396	1.200	46090
27		2820	28.9	9.252	87.280	26.603	11.988	26.603	3614	429	806	41987	5672	450	782	39973	1.197	47858
28		2818	29.2	9.245	78.028	23.783	12.214	23.783	3689	429	822	43679	5786	450	798	41606	1.194	49663
29		2817	29.5	9.242	68.783	20.965	12.440	20.965	3765	429	836	45420	5903	450	812	43291	1.190	51500
30		3028	34.8	9.934	59.541	18.148	12.667	18.148	3853	429	850	47210	6039	450	827	45027	1.185	53370
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	15.120	4027	429	873	49188	6306	450	849	46950	1.180	55418
32		2505	35.3	8.219	40.682	12.400	12.908	12.400	4114	429	883	51015	6440	450	859	48730	1.176	57297
33		2505	36.2	8.219	32.464	9.895	12.911	9.895	4199	429	890	52735	6571	450	867	50409	1.172	59054
34		1500	52.4	4.921	24.245	7.390	12.914	7.390	4280	429	896	54488	6694	450	872	52122	1.167	60835
35		2930	52.4	9.613	19.324	5.890	12.967	5.890	4390	429	900	55553	6864	450	876	53163	1.165	61913
36		2760	52.4	9.055	9.711	2.960	12.967	2.960	4532	429	904	57661	7081	450	879	55228	1.160	64045
37	BOT_FLG				0.656	0.200	12.967	0.200	4631	429	906	59677	7235	450	881	57205	1.155	66082

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PROJECT: VESTAS V163/V166 HH98M-TA36200

JOB NO.: 25-031 (GENERIC)

PAGE 11 OF 15

DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project												
25-031 = Job No.												
0139-0349 VER 01 (2023.02.13) = Loads Doc.						Capacity Reduction Factors:						
VESTAS = Turbine Make						0.90 = ϕ_c						
V163/V166-4.5MW Mk4A = Turbine Model						0.90 = ϕ_s						
S = IEC Site Class						0.90 = ϕ_t						
98.000 = Hub Height (m)												
A024-4468 ver. V01 = Tower Model												
DESIGN STRESSES												
TOWER PROFILE												
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN t (in)	f _a = σ_{TAC} (ksi)	f _b = σ_{MAX} (ksi)	f _c =f _a +f _b (ksi)	f _v = σ_{VXY} (ksi)	f _e = σ_{MEC} (ksi)	f _r =f _v +f _e (ksi)
1			7.218	321.522	98.000							
2	TOP_FLG	2685	22.0	314.304	95.800	10.715	2.219	12.935	15.154	0.672	0.180	0.851
3		2285	19.9	305.495	93.115	10.813	2.239	13.039	15.278	0.677	0.176	0.853
4		2285	19.8	297.999	90.830	10.833	2.475	14.415	16.890	0.749	0.195	0.944
5		2816	17.0	290.502	88.545	10.845	2.510	14.749	17.260	0.759	0.194	0.953
6		2816	17.4	281.263	85.729	10.870	2.523	14.824	17.347	0.763	0.195	0.958
7		2816	17.8	272.024	82.913	10.896	2.559	15.212	17.771	0.772	0.194	0.966
8		2816	18.2	262.785	80.097	10.923	2.981	17.717	20.698	0.899	0.226	1.125
9		2816	18.6	253.547	77.281	10.949	3.024	18.360	21.384	0.909	0.225	1.134
10		2816	19.2	244.308	74.465	10.976	2.955	17.938	20.892	0.888	0.220	1.108
11		2816	19.7	235.069	71.649	11.003	2.998	18.658	21.655	0.895	0.219	1.114
12		2816	20.3	225.830	68.833	11.029	2.931	18.238	21.169	0.875	0.214	1.089
13	SPLICE3	3033	20.3	215.879	65.800	11.057	2.974	19.029	22.003	0.881	0.213	1.094
14		2413	20.9	207.963	63.387	11.059	2.908	18.611	21.519	0.861	0.208	1.070
15		2298	21.5	200.423	61.089	11.061	2.952	19.464	22.415	0.866	0.207	1.073
16		2299	22.3	192.881	58.790	11.064	2.888	19.045	21.933	0.847	0.203	1.050
17		2930	23.8	183.268	55.860	11.069	2.932	19.949	22.881	0.851	0.202	1.053
18		2930	25.3	173.655	52.930	11.074	2.840	19.326	22.166	0.824	0.196	1.020
19		2930	26.8	164.042	50.000	11.079	2.884	20.260	23.144	0.828	0.195	1.023
20		2930	28.2	154.429	47.070	11.083	2.811	19.746	22.557	0.807	0.190	0.997
21		2930	29.7	144.816	44.140	11.088	2.856	20.705	23.562	0.811	0.189	1.000
22		3130	32.7	135.203	41.210	11.094	2.772	20.093	22.865	0.787	0.183	0.970
23	SPLICE2	3020	32.0	124.934	38.080	11.096	2.836	21.143	23.979	0.793	0.183	0.975
24		2819	28.7	115.026	35.060	11.111	2.755	20.536	23.291	0.770	0.177	0.947
25		2819	29.0	105.778	32.241	11.136	2.796	21.448	24.245	0.776	0.177	0.954
26		2819	28.7	96.529	29.422	11.162	2.718	20.850	23.568	0.755	0.172	0.927
27		2820	28.9	87.280	26.603	11.188	2.759	21.717	24.476	0.761	0.172	0.934
28		2818	29.2	78.028	23.783	11.214	2.660	20.938	23.598	0.734	0.166	0.900
29		2818	29.5	68.783	20.965	11.240	2.708	21.794	24.502	0.742	0.166	0.909
30		3028	34.8	59.541	18.148	11.267	2.537	20.421	22.958	0.696	0.156	0.851
31	SPLICE1	2720	34.4	49.606	15.120	12.908	2.590	21.466	24.056	0.706	0.156	0.862
32		2505	35.3	40.682	12.400	12.908	2.436	20.193	22.630	0.664	0.147	0.811
33		2505	36.2	32.464	9.895	12.911	2.489	21.199	23.688	0.675	0.147	0.822
34		1500	52.4	24.245	7.390	12.914	2.350	20.012	22.362	0.638	0.138	0.776
35		2930	52.4	19.324	5.890	12.967	2.402	20.980	23.382	0.650	0.138	0.788
36		2760	52.4	9.711	2.960	12.967	2.283	19.939	22.222	0.618	0.131	0.749
37	BOT_FLG			0.656	0.200	12.967	2.335	20.876	23.211	0.631	0.131	0.762
							2.217	19.821	22.039	0.599	0.125	0.724
							2.270	20.727	22.996	0.613	0.125	0.738
							2.154	19.667	21.821	0.582	0.118	0.700
							2.207	20.541	22.749	0.597	0.118	0.716
							2.113	19.662	21.775	0.572	0.113	0.685
							2.205	20.572	22.777	0.600	0.113	0.713
							2.253	21.022	23.275	0.613	0.116	0.729
							2.256	21.063	23.319	0.617	0.111	0.728
							2.515	23.485	26.000	0.688	0.124	0.812
							2.515	23.466	25.981	0.690	0.119	0.810
							2.489	23.223	25.712	0.683	0.118	0.801
							2.490	23.206	25.695	0.686	0.113	0.799
							2.516	23.448	25.964	0.693	0.115	0.807
							2.517	23.433	25.950	0.694	0.110	0.804
							2.500	23.271	25.771	0.689	0.110	0.799
							2.502	23.257	25.759	0.690	0.105	0.795
							2.477	23.018	25.495	0.683	0.104	0.787
							2.481	23.006	25.486	0.683	0.101	0.783
							2.455	22.772	25.227	0.676	0.100	0.775
							2.467	22.760	25.226	0.675	0.096	0.771
							2.091	19.293	21.385	0.572	0.081	0.654
							2.145	19.335	21.480	0.578	0.079	0.657
							2.170	19.560	21.730	0.585	0.079	0.664
							2.216	20.223	22.439	0.591	0.079	0.671
							2.159	19.707	21.867	0.576	0.077	0.654
							2.203	20.312	22.515	0.581	0.077	0.659
							2.149	19.807	21.955	0.567	0.076	0.642
							2.189	20.404	22.593	0.570	0.076	0.646
							1.512	14.096	15.608	0.394	0.052	0.446
							1.551	14.346	15.896	0.396	0.052	0.448
							1.551	14.346	15.896	0.396	0.052	0.448
							1.600	14.840	16.439	0.397	0.052	0.449
							1.600	14.840	16.439	0.397	0.052	0.449
							1.634	15.312	16.946	0.398	0.052	0.450

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA
PROJECT: VESTAS V163/V166 HH98M-TA36200
JOB NO.: 25-031 (GENERIC)

PAGE 12 OF 15
DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project 25-031 = Job No. 0139-0349 VER 01 (2023.02.13) = Loads Doc. VESTAS = Turbine Make V163/V166-4.5MW Mk4A = Turbine Model S = IEC Site Class 98.000 = Hub Height (m) A024-4468 ver. V01 = Tower Model							DESIGN STRENGTH PER ASCE/AWEA RP2011 CHECK LOCAL BUCKLING STRENGTH 370 = (D/t)_{MAX}												
TOWER PROFILE							CALC: LOCAL BUCKLING DCR												
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	CAN OD (ft)	t (in)	D _{OD} /t=D/t	λ _{0.11E}	λ _{0.357E}	λ _{MAX}	Q	F _{cr1} (ksi)	F _{cr2} (ksi)	F _{cr} (ksi)	φ _p F _{cr} (ksi)	DCR _c		
1			7.218	321.522	98.000														
2	TOP FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	148.455	63.751	206.740	370.000	0.815	40.782	53.889	40.782	36.704	0.413	
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	149.909	63.751	206.740	370.000	0.814	40.710	53.366	40.710	36.639	0.417	
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	165.623	63.751	206.740	370.000	0.800	40.013	48.302	40.013	36.012	0.469	
5		2816	17.0	9.239	166.769	63.751	206.740	0.799	167.082	63.751	206.740	370.000	0.799	39.967	47.971	39.967	35.970	0.482	
6		2816	17.4	9.239	167.082	63.751	206.740	0.798	194.888	63.751	206.740	370.000	0.780	39.027	41.144	39.027	35.124	0.589	
7		2816	17.8	9.239	194.888	63.751	206.740	0.780	190.431	63.751	206.740	370.000	0.782	39.014	41.049	39.014	35.112	0.609	
8		2816	18.2	9.239	190.431	63.751	206.740	0.782	190.871	63.751	206.740	370.000	0.782	39.146	42.010	39.146	35.231	0.593	
9		2816	18.6	9.239	190.871	63.751	206.740	0.782	186.604	63.751	206.740	370.000	0.785	39.265	42.871	39.265	35.338	0.599	
10		2816	19.2	9.239	187.035	63.751	206.740	0.784	182.946	63.751	206.740	370.000	0.787	39.251	42.773	39.251	35.326	0.623	
11		2816	19.7	9.239	182.946	63.751	206.740	0.787	183.367	63.751	206.740	370.000	0.787	39.383	43.729	39.383	35.445	0.607	
12		3033	20.3	9.951	183.367	63.751	206.740	0.787	179.445	63.751	206.740	370.000	0.789	39.369	43.628	39.369	35.432	0.633	
13	SPLICE3	2413	20.9	7.917	179.857	63.751	206.740	0.789	174.667	63.751	206.740	370.000	0.793	39.500	44.582	39.500	35.550	0.617	
14		2298	21.5	7.539	174.667	63.751	206.740	0.793	179.857	63.751	206.740	370.000	0.789	39.486	44.480	39.486	35.538	0.644	
15		2299	22.3	7.543	174.268	63.751	206.740	0.793	174.268	63.751	206.740	370.000	0.793	39.683	45.906	39.683	35.715	0.621	
16		2930	23.8	9.613	174.667	63.751	206.740	0.793	174.667	63.751	206.740	370.000	0.793	39.668	45.802	39.668	35.702	0.648	
17		2930	25.3	9.613	170.259	63.751	206.740	0.796	170.259	63.751	206.740	370.000	0.796	39.832	46.987	39.832	35.849	0.629	
18		2930	26.8	9.613	170.648	63.751	206.740	0.796	170.648	63.751	206.740	370.000	0.796	39.817	46.880	39.817	35.835	0.657	
19		2930	28.2	9.613	165.634	63.751	206.740	0.800	165.634	63.751	206.740	370.000	0.800	40.012	48.299	40.012	36.011	0.635	
20		2930	29.7	9.613	166.025	63.751	206.740	0.799	166.025	63.751	206.740	370.000	0.799	39.997	48.186	39.997	35.997	0.666	
21		3130	32.7	10.269	161.287	63.751	206.740	0.803	161.287	63.751	206.740	370.000	0.803	40.192	49.601	40.192	36.173	0.644	
22		3020	32.0	9.908	156.814	63.751	206.740	0.807	156.814	63.751	206.740	370.000	0.807	40.387	51.016	40.387	36.348	0.670	
23	SPLICE2	2819	28.7	9.249	151.224	63.751	206.740	0.812	151.224	63.751	206.740	370.000	0.812	40.646	52.902	40.646	36.582	0.645	
24		2819	29.0	9.249	151.224	63.751	206.740	0.812	141.756	63.751	206.740	370.000	0.822	41.133	56.435	41.133	37.020	0.620	
25		2819	28.7	9.249	141.756	63.751	206.740	0.822	141.756	63.751	206.740	370.000	0.822	41.133	56.435	41.133	37.020	0.650	
26		2819	28.9	9.252	133.411	63.751	206.740	0.832	133.411	63.751	206.740	370.000	0.832	41.619	59.965	41.619	37.457	0.604	
27		2820	28.9	9.252	133.411	63.751	206.740	0.832	126.000	63.751	206.740	370.000	0.841	42.105	63.492	42.105	37.895	0.590	
28		2818	29.2	9.245	126.000	63.751	206.740	0.841	119.794	63.751	206.740	370.000	0.851	42.558	66.781	42.558	38.302	0.580	
29		2817	29.5	9.242	119.794	63.751	206.740	0.851	119.794	63.751	206.740	370.000	0.851	42.558	66.781	42.558	38.302	0.606	
30		3028	34.8	9.934	113.795	63.751	206.740	0.860	113.795	63.751	206.740	370.000	0.860	43.043	70.302	43.043	38.739	0.569	
31	SPLICE1	2720	34.4	9.924	113.795	63.751	206.740	0.860	108.029	63.751	206.740	370.000	0.871	43.560	74.054	43.560	39.204	0.557	
32		2505	35.3	8.219	108.029	63.751	206.740	0.871	108.029	63.751	206.740	370.000	0.871	43.560	74.054	43.560	39.204	0.580	
33		2505	36.2	8.219	103.446	63.751	206.740	0.880	103.446	63.751	206.740	370.000	0.880	44.012	77.335	44.012	39.611	0.550	
34		1500	52.4	4.921	103.446	63.751	206.740	0.880	103.446	63.751	206.740	370.000	0.880	44.012	77.335	44.012	39.611	0.575	
35		2930	52.4	9.613	105.688	54.985	178.313	0.846	105.688	54.985	178.313	370.000	0.846	49.104	75.695	49.104	44.194	0.527	
36		2760	52.4	9.055	107.837	54.985	178.313	0.843	120.122	54.985	178.313	370.000	0.825	47.851	66.599	47.851	43.066	0.530	
37	BOT FLG				120.122	54.985	178.313	0.825	122.518	54.985	178.313	370.000	0.822	47.672	65.297	47.672	42.905	0.606	
					121.261	54.985	178.313	0.823	121.261	54.985	178.313	370.000	0.823	47.765	65.973	47.765	42.989	0.598	
					123.632	54.985	178.313	0.820	123.632	54.985	178.313	370.000	0.820	47.591	64.708	47.591	42.832	0.600	
					124.914	54.985	178.313	0.819	124.914	54.985	178.313	370.000	0.819	47.499	64.044	47.499	42.749	0.607	
					127.310	54.985	178.313	0.816	127.310	54.985	178.313	370.000	0.816	47.333	62.839	47.333	42.600	0.609	
					126.436	54.985	178.313	0.817	126.436	54.985	178.313	370.000	0.817	47.393	63.273	47.393	42.654	0.604	
					128.817	54.985	178.313	0.814	128.817	54.985	178.313	370.000	0.814	47.232	62.104	47.232	42.509	0.606	
					127.504	54.985	178.313	0.816	127.504	54.985	178.313	370.000	0.816	47.320	62.743	47.320	42.588	0.599	
					129.858	54.985	178.313	0.813	129.858	54.985	178.313	370.000	0.813	47.164	61.606	47.164	42.447	0.600	
					128.548	54.985	178.313	0.814	128.548	54.985	178.313	370.000	0.814	47.250	62.234	47.250	42.525	0.593	
					130.877	54.985	178.313	0.812	130.877	54.985	178.313	370.000	0.812	47.097	61.126	47.097	42.388	0.595	
					111.097	54.985	178.313	0.838	111.097	54.985	178.313	370.000	0.838	48.597	72.009	48.597	43.737	0.489	
					113.069	54.985	178.313	0.835	113.069	54.985	178.313	370.000	0.835	48.424	70.753	48.424	43.581	0.493	
					114.372	63.751	206.740	0.859	114.372	63.751	206.740	370.000	0.859	42.994	69.947	42.994	38.695	0.562	
					111.482	63.751	206.740	0.864	111.482	63.751	206.740	370.000	0.864	43.244	71.761	43.244	38.920	0.580	
					111.482	63.751	206.740	0.864	111.482	63.751	206.740	370.000	0.864	43.244	71.761	43.244	38.920	0.578	
					108.735	63.751	206.740	0.869	108.735	63.751	206.740	370.000	0.869	43.494	73.573	43.494	39.145	0.561	
					108.735	63.751	206.740	0.869	108.735	63.751	206.740	370.000	0.869	43.494	73.573	43.494	39.145	0.577	
					75.427	65.654	212.911	0.967	75.427	65.654	212.911	370.000	0.967	47.002	106.062	47.002	42.302	0.369	
					75.427	65.654	212.911	0.967	75.427	65.654	212.911	370.000	0.967	47.002	106.062	47.002	42.302	0.376	
					75.427	65.654	212.911	0.967	75.427	65.654	212.911	370.000	0.967	47.002	106.062	47.002	42.302	0.376	
					75.427	65.654	212.911	0.967	75.427	65.654	212.911	370.000	0.967	47.002	106.062	47.002	42.302	0.389	
					75.427	65.654	212.911	0.967	75.427	65.654	212.911	370.000	0.967	47.002	106.062	47.002	42.302	0.389	
					75.427	65.654	212.911	0.967	75.427	65.654	212.911	370.000	0.967	47.002	106.062	47.002	42.302	0.401	

TEL: 661-742-1327

FAX: 661-369-7214

AGBAYANI STRUCTURAL ENGINEERING
1201 24th Street, Suite B110-

EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PAGE 13 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELINE = Project						DESIGN STRENGTH PER ASCE/AWEA RP2011									
25-031 = Job No.						CHECK DIRECT SHEAR STRENGTH									
0139-0349 VER 01 (2023.02.13) = Loads Doc.															
VESTAS = Turbine Make															
V163/V166-4.5MW Mk4A = Turbine Model															
S = IEC Site Class															
98.000 = Hub Height (m)															
A024-4468 ver. V01 = Tower Model															
TOWER PROFILE						CALC: DIRECT SHEAR DCR									
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	L _{SECTION} (in)	F _{cr1} (ksi)	F _{cr2} (ksi)	F _{cr,MAX} (ksi)	F _{cr} (ksi)	φ _v F _{cr} (ksi)	DCR _v	
1			7.218	321.522	98.000										
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	1181.102	29.544	12.324	28.890	28.890	26.001	0.026
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	1181.102	25.885	10.612	28.890	25.885	23.296	0.032
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	1181.102	25.848	10.582	28.890	25.848	23.263	0.033
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	1181.102	25.686	10.503	28.890	25.686	23.118	0.033
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	1181.102	25.650	10.474	28.890	25.650	23.085	0.033
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	1181.102	21.761	8.578	28.890	21.761	19.585	0.046
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	1181.102	22.386	8.874	28.890	22.386	20.147	0.043
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	1181.102	22.347	8.843	28.890	22.347	20.113	0.044
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	1181.102	22.975	9.141	28.890	22.975	20.677	0.042
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	1181.102	22.935	9.110	28.890	22.935	20.642	0.042
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	1181.102	23.565	9.410	28.890	23.565	21.208	0.040
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	1181.102	23.524	9.378	28.890	23.524	21.172	0.040
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	1091.339	24.473	9.833	28.890	24.473	22.026	0.037
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	1091.339	24.432	9.799	28.890	24.432	21.988	0.038
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	1091.339	25.227	10.182	28.890	25.227	22.704	0.036
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	1091.339	25.183	10.147	28.890	25.183	22.665	0.036
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	1091.339	26.142	10.611	28.890	26.142	23.528	0.033
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	1091.339	26.096	10.574	28.890	26.096	23.487	0.034
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	1091.339	28.151	11.043	28.890	28.151	25.336	0.030
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	1091.339	28.151	11.043	28.890	28.151	25.336	0.031
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	1091.339	29.161	11.519	28.890	29.161	26.001	0.029
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	1091.339	29.161	11.519	28.890	29.161	26.001	0.029
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	1091.339	30.518	12.164	28.890	30.518	26.001	0.028
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	1091.339	30.518	12.164	28.890	30.518	26.001	0.029
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	1091.339	33.094	13.402	28.890	33.094	26.001	0.027
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	1091.339	33.094	13.402	28.890	33.094	26.001	0.027
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	1091.339	35.710	14.679	28.890	35.710	26.001	0.026
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	1091.339	35.710	14.679	28.890	35.710	26.001	0.026
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	1091.339	38.363	15.993	28.890	38.363	26.001	0.025
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	1091.339	38.363	15.993	28.890	38.363	26.001	0.025
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	1091.339	40.871	17.252	28.890	40.871	26.001	0.024
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	1091.339	40.871	17.252	28.890	40.871	26.001	0.024
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	1091.339	43.592	18.634	28.890	43.592	26.001	0.023
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	1091.339	43.592	18.634	28.890	43.592	26.001	0.023
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	1091.339	46.531	20.146	28.890	46.531	26.001	0.022
37	BOT_FLG				0.656	0.200	12.967		1091.339	46.531	20.146	28.890	46.531	26.001	0.022

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA

PAGE 14 OF 15

PROJECT: VESTAS V163/V166 HH98M-TA36200

DATE: 12/7/2025

JOB NO.: 25-031 (GENERIC)

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

TOWER PROFILE								CALC: TORSIONAL SHEAR DCR					CALC: TOTAL SHEAR DCR			
JOINT	H _{CAN} (mm)	t (mm)	H _{CAN} (ft)	JOINT ELEV (ft)	JOINT ELEV (m)	OD (ft)	CAN t (in)	F _{cr1} (ksi)	F _{cr2} (ksi)	F _{crMAX} (ksi)	F _{cr} (ksi)	φ _c F _{cr} (ksi)	DCR _τ	DCR _v	DCR _τ	DCR _{v+τ}
1			7.218	321.522	98.000											
2	TOP_FLG	2685	22.0	314.304	95.800	10.715	0.8661	22.712	9.620	28.890	22.712	20.441	0.009	0.026	0.009	0.035
3		2285	19.9	305.495	93.115	10.813	0.7835	19.899	8.163	28.890	19.899	17.909	0.011	0.032	0.011	0.043
4		2285	19.8	297.999	90.830	10.833	0.7795	19.871	8.140	28.890	19.871	17.884	0.011	0.033	0.011	0.043
5		2816	17.0	290.502	88.545	10.845	0.6693	19.719	8.057	28.890	19.719	17.747	0.011	0.033	0.011	0.044
6		2816	17.4	281.263	85.729	10.870	0.6850	16.307	6.418	28.890	16.307	14.677	0.015	0.047	0.015	0.063
7		2816	17.8	272.024	82.913	10.896	0.7008	16.279	6.395	28.890	16.279	14.651	0.015	0.048	0.015	0.063
8		2816	18.2	262.785	80.097	10.923	0.7165	16.758	6.621	28.890	16.758	15.082	0.015	0.045	0.015	0.060
9		2816	18.6	253.547	77.281	10.949	0.7323	16.729	6.598	28.890	16.729	15.056	0.015	0.046	0.015	0.060
10		2816	19.2	244.308	74.465	10.976	0.7559	17.209	6.826	28.890	17.209	15.488	0.014	0.043	0.014	0.057
11		2816	19.7	235.069	71.649	11.003	0.7756	17.180	6.802	28.890	17.180	15.462	0.014	0.044	0.014	0.058
12		3033	20.3	225.830	68.833	11.029	0.7992	17.662	7.032	28.890	17.662	15.896	0.013	0.042	0.013	0.055
13	SPLICE3	2413	20.9	215.879	65.800	11.057	0.8228	17.631	7.008	28.890	17.631	15.868	0.013	0.042	0.013	0.055
14		2298	21.5	207.963	63.387	11.059	0.8465	18.116	7.239	28.890	18.116	16.304	0.012	0.040	0.012	0.052
15		2299	22.3	200.423	61.089	11.061	0.8780	18.084	7.214	28.890	18.084	16.276	0.012	0.040	0.012	0.053
16		2930	23.8	192.881	58.790	11.064	0.9370	18.814	7.564	28.890	18.814	16.933	0.012	0.037	0.012	0.049
17		2930	25.3	183.268	55.860	11.069	0.9961	18.782	7.538	28.890	18.782	16.904	0.012	0.038	0.012	0.049
18		2930	26.8	173.655	52.930	11.074	1.0551	19.393	7.832	28.890	19.393	17.454	0.011	0.036	0.011	0.046
19		2930	28.2	164.042	50.000	11.079	1.1102	20.097	8.163	28.890	20.097	18.087	0.010	0.036	0.011	0.047
20		2930	29.7	154.429	47.070	11.083	1.1693	20.061	8.134	28.890	20.061	18.055	0.010	0.033	0.010	0.044
21		2930	31.3	144.816	44.140	11.088	1.2323	21.641	8.495	28.890	21.641	19.477	0.009	0.034	0.010	0.044
22		3130	32.7	135.203	41.210	11.094	1.2874	22.418	8.861	28.890	22.418	20.176	0.009	0.030	0.009	0.040
23	SPLICE2	3020	32.0	124.934	38.080	11.096	1.2598	23.461	9.357	28.890	23.461	21.115	0.008	0.029	0.009	0.038
24		2819	28.7	115.026	35.060	11.311	1.1299	23.461	9.357	28.890	23.461	21.115	0.008	0.029	0.009	0.038
25		2819	29.0	105.778	32.241	11.536	1.1417	25.441	10.309	28.890	25.441	22.897	0.007	0.028	0.008	0.036
26		2819	28.7	96.529	29.422	11.762	1.1299	25.441	10.309	28.890	25.441	22.897	0.007	0.027	0.007	0.034
27		2820	28.9	87.280	26.603	11.988	1.1378	27.452	11.292	28.890	27.452	24.707	0.006	0.026	0.006	0.031
28		2818	29.2	78.028	23.783	12.214	1.1496	27.452	11.292	28.890	27.452	24.707	0.006	0.026	0.006	0.032
29		2817	29.5	68.783	20.965	12.440	1.1614	29.491	12.303	28.890	29.491	26.001	0.005	0.025	0.005	0.030
30		3028	34.8	59.541	18.148	12.667	1.3701	29.491	12.303	28.890	29.491	26.001	0.005	0.025	0.005	0.030
31	SPLICE1	2720	34.4	49.606	15.120	12.908	1.3543	31.420	13.271	28.890	31.420	26.001	0.005	0.024	0.005	0.029
32		2505	35.3	40.682	12.400	12.908	1.3898	31.420	13.271	28.890	31.420	26.001	0.005	0.024	0.005	0.029
33		2505	36.2	32.464	9.895	12.911	1.4252	33.511	14.334	28.890	33.511	26.001	0.005	0.023	0.005	0.028
34		1500	52.4	24.245	7.390	12.914	2.0630	33.511	14.334	28.890	33.511	26.001	0.005	0.024	0.005	0.028
35		2930	52.4	19.324	5.890	12.967	2.0630	35.770	15.497	28.890	35.770	26.001	0.005	0.022	0.005	0.027
36		2760	52.4	9.711	2.960	12.967	2.0630	35.770	15.497	28.890	35.770	26.001	0.005	0.023	0.005	0.028
37	BOT_FLG			0.656	0.200	12.967		37.770	16.538	28.890	37.770	26.001	0.004	0.022	0.004	0.026
								37.770	16.538	28.890	37.770	26.001	0.004	0.023	0.004	0.027
								51.196	16.015	33.496	51.196	30.146	0.004	0.020	0.004	0.024
								50.429	15.538	33.496	50.429	30.146	0.004	0.020	0.004	0.024
								44.046	13.217	33.496	44.046	30.146	0.004	0.023	0.004	0.027
								43.398	12.831	33.496	43.398	30.146	0.004	0.023	0.004	0.027
								43.963	13.031	33.496	43.963	30.146	0.004	0.023	0.004	0.027
								43.329	12.658	33.496	43.329	30.146	0.004	0.023	0.004	0.027
								42.772	12.463	33.496	42.772	30.146	0.004	0.023	0.004	0.027
								42.167	12.113	33.496	42.167	30.146	0.004	0.023	0.004	0.027
								42.533	12.239	33.496	42.533	30.146	0.004	0.023	0.004	0.027
								41.942	11.901	33.496	41.942	30.146	0.003	0.023	0.003	0.026
								42.484	12.086	33.496	42.484	30.146	0.003	0.023	0.003	0.026
								41.905	11.758	33.496	41.905	30.146	0.003	0.023	0.003	0.026
								42.442	11.939	33.496	42.442	30.146	0.003	0.022	0.003	0.026
								41.874	11.621	33.496	41.874	30.146	0.003	0.022	0.003	0.026
								51.427	14.859	33.496	51.427	30.146	0.003	0.019	0.003	0.022
								50.753	14.472	33.496	50.753	30.146	0.003	0.019	0.003	0.022
								48.973	14.226	28.890	48.973	26.001	0.003	0.022	0.003	0.026
								48.973	14.226	28.890	48.973	26.001	0.003	0.023	0.003	0.026
								50.571	14.782	28.890	50.571	26.001	0.003	0.022	0.003	0.025
								50.571	14.782	28.890	50.571	26.001	0.003	0.022	0.003	0.025
								52.179	15.346	28.890	52.179	26.001	0.003	0.022	0.003	0.025
								52.179	15.346	28.890	52.179	26.001	0.003	0.022	0.003	0.025
								82.592	26.562	28.053	82.592	25.247	0.002	0.016	0.002	0.018
								82.592	26.562	28.053	82.592	25.247	0.002	0.016	0.002	0.018
								82.592	26.562	28.053	82.592	25.247	0.002	0.016	0.002	0.018
								82.592	26.562	28.053	82.592	25.247	0.002	0.016	0.002	0.018

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EQ5=1.2D+0.75(1.0E1%+1.0Mip)

BY: NAA
 PROJECT: VESTAS V163/V166 HH98M-TA36200
 JOB NO.: 25-031 (GENERIC)

PAGE 15 OF 15
 DATE: 12/7/2025

FILE: V163 HH98M-TA36200_FAT-EXT-EQ.xlsx

VESTAS V163/V166 HH98M-TA36200 BASELIN = Project										CHECK INTERACTION			
25-031 = Job No.										AISC = Interaction Flag:			
0139-0349 VER 01 (2023.02.13) = Loads Doc.										"AISC": Use AISC interaction criteria			
VESTAS = Turbine Make										"RP2011": Use RP2011 interaction criteria			
V163/V166-4.5MW Mk4A = Turbine Model										1.000 = Direct Shear Flag: max. shear and max. flexure do not occur at the same cross section location			
S = IEC Site Class										"0.000": Use 0.000 x Direct Shear			
98.000 = Hub Height (m)										"1.000": Use 1.000 x Direct Shear			
A024-4468 ver. V01 = Tower Model										"0.###": Use intermediate value to reduce Direct Shear			
										MAX: 0.673			
TOWER PROFILE										CALC: INTERACTION DCR			
JOINT	H _{CAN}	t	H _{CAN}	JOINT ELEV	JOINT ELEV	OD	CAN t	DCR _e	1.000 DCR _e	DCR _e	AISC DCR _i	By Member DCR _i	By Joint DCR _i
	(mm)	(mm)	(ft)	(ft)	(m)	(ft)	(in)						
1			7.218	321.522	98.000								
2	TOP_FLG	2685	22.0	8.809	314.304	95.800	10.715	0.8661	0.009 <=0.2	0.026	0.413	0.413	0.417
3		2285	19.9	7.497	305.495	93.115	10.813	0.7835	0.011 <=0.2	0.032	0.469	0.469	0.479
4		2285	19.8	7.497	297.999	90.830	10.833	0.7795	0.011 <=0.2	0.033	0.482	0.482	0.494
5		2816	17.0	9.239	290.502	88.545	10.845	0.6693	0.015 <=0.2	0.047	0.589	0.589	0.609
6		2816	17.4	9.239	281.263	85.729	10.870	0.6850	0.015 <=0.2	0.048	0.609	0.609	0.615
7		2816	17.8	9.239	272.024	82.913	10.896	0.7008	0.015 <=0.2	0.046	0.615	0.615	0.623
8		2816	18.2	9.239	262.785	80.097	10.923	0.7165	0.014 <=0.2	0.043	0.599	0.599	0.623
9		2816	18.6	9.239	253.547	77.281	10.949	0.7323	0.014 <=0.2	0.044	0.623	0.623	0.633
10		2816	19.2	9.239	244.308	74.465	10.976	0.7559	0.013 <=0.2	0.042	0.607	0.607	0.633
11		2816	19.7	9.239	235.069	71.649	11.003	0.7756	0.012 <=0.2	0.042	0.633	0.633	0.644
12		3033	20.3	9.951	225.830	68.833	11.029	0.7992	0.012 <=0.2	0.040	0.617	0.617	0.644
13	SPLICE3	2413	20.9	7.917	215.879	65.800	11.057	0.8228	0.012 <=0.2	0.040	0.644	0.644	0.648
14		2298	21.5	7.539	207.963	63.387	11.059	0.8465	0.010 <=0.2	0.037	0.621	0.621	0.670
15		2299	22.3	7.543	200.423	61.089	11.061	0.8780	0.010 <=0.2	0.038	0.648	0.648	0.673
16		2930	23.8	9.613	192.881	58.790	11.064	0.9370	0.008 <=0.2	0.029	0.673	0.673	0.673
17		2930	25.3	9.613	183.268	55.860	11.069	0.9961	0.008 <=0.2	0.028	0.645	0.645	0.670
18		2930	26.8	9.613	173.655	52.930	11.074	1.0551	0.007 <=0.2	0.029	0.670	0.670	0.650
19		2930	28.2	9.613	164.042	50.000	11.079	1.1102	0.007 <=0.2	0.027	0.620	0.620	0.650
20		2930	29.7	9.613	154.429	47.070	11.083	1.1693	0.006 <=0.2	0.027	0.650	0.650	0.632
21		2930	31.3	9.613	144.816	44.140	11.088	1.2323	0.006 <=0.2	0.026	0.604	0.604	0.617
22		3130	32.7	10.269	135.203	41.210	11.094	1.2874	0.006 <=0.2	0.026	0.632	0.632	0.617
23	SPLICE2	3020	32.0	9.908	124.934	38.080	11.096	1.2598	0.005 <=0.2	0.025	0.590	0.590	0.580
24		2819	28.7	9.249	115.026	35.060	11.311	1.1299	0.005 <=0.2	0.025	0.617	0.617	0.580
25		2819	29.0	9.249	105.778	32.241	11.536	1.1417	0.005 <=0.2	0.024	0.580	0.580	0.606
26		2819	28.7	9.249	96.529	29.422	11.762	1.1299	0.005 <=0.2	0.024	0.606	0.606	0.594
27		2820	28.9	9.252	87.280	26.603	11.988	1.1378	0.005 <=0.2	0.023	0.569	0.569	0.580
28		2818	29.2	9.245	78.028	23.783	12.214	1.1496	0.005 <=0.2	0.023	0.580	0.580	0.575
29		2817	29.5	9.242	68.783	20.965	12.440	1.1614	0.004 <=0.2	0.022	0.550	0.550	0.575
30		3028	34.8	9.934	59.541	18.148	12.667	1.3701	0.004 <=0.2	0.023	0.575	0.575	0.580
31	SPLICE1	2720	34.4	8.924	49.606	15.120	12.908	1.3543	0.004 <=0.2	0.023	0.527	0.527	0.530
32		2505	35.3	8.219	40.682	12.400	12.908	1.3898	0.004 <=0.2	0.020	0.530	0.530	0.606
33		2505	36.2	8.219	32.464	9.895	12.911	1.4252	0.004 <=0.2	0.023	0.604	0.604	0.606
34		1500	52.4	4.921	24.245	7.390	12.914	2.0630	0.004 <=0.2	0.023	0.598	0.598	0.600
35		2930	52.4	9.613	19.324	5.890	12.967	2.0630	0.004 <=0.2	0.023	0.600	0.600	0.607
36		2760	52.4	9.055	9.711	2.960	12.967	2.0630	0.004 <=0.2	0.023	0.607	0.607	0.606
37	BOT_FLG				0.656	0.200	12.967		0.003 <=0.2	0.023	0.606	0.606	0.606
									0.003 <=0.2	0.023	0.599	0.599	0.600
									0.003 <=0.2	0.022	0.595	0.595	0.595
									0.003 <=0.2	0.019	0.489	0.489	0.493
									0.003 <=0.2	0.019	0.493	0.493	0.493
									0.003 <=0.2	0.022	0.562	0.562	0.580
									0.003 <=0.2	0.023	0.580	0.580	0.580
									0.003 <=0.2	0.022	0.562	0.562	0.578
									0.003 <=0.2	0.022	0.578	0.578	0.577
									0.003 <=0.2	0.022	0.561	0.561	0.577
									0.002 <=0.2	0.016	0.369	0.369	0.376
									0.002 <=0.2	0.016	0.376	0.376	0.376
									0.002 <=0.2	0.016	0.376	0.376	0.389
									0.002 <=0.2	0.016	0.389	0.389	0.401
									0.002 <=0.2	0.016	0.389	0.389	0.401
									0.002 <=0.2	0.016	0.401	0.401	0.401

COMPUTER MODEL

GENERAL NOTES

1. The following pages are from the structural analysis program RISA-3D and represent the model used for the modal response spectrum analysis.
2. The model is a lumped mass parameter model with nodes at tower can joints and beam elements between nodes. The beam elements are based on the average cross section dimensions. Since some tower cans may be tapered (having a smaller end and larger end), the average properties at can mid-height are used.
3. The model coordinate axes are as follow:
 - Axes follow the right-hand rule.
 - Z-axis is vertical, positive upward, and negative downward.
 - X-axis and Y-axis are in the horizontal plane.
4. This model does “double duty.” It serves as the dynamic analysis model for MRSA, and it also serves as the model for calculating the system natural frequencies:
 - 4.1. To estimate the upper bound of system natural frequency: minimum mass is applied in the lateral Y-direction; mass moment of inertia is applied about the X-axis; and base rotation is fixed (rigid) about the X-axis.
 - 4.2. To estimate the lower bound of system natural frequencies: maximum mass is applied in the lateral X-direction; mass moment of inertia is applied about the Y-axis; and a base rotational stiffness value is applied about the Y-axis.
5. For the MRSA, the analysis is performed for maximum mass in the lateral X-direction.
6. The foundation below the tower base is modeled as a rigid-massless member extending down for a distance of 2.0 m. Boundary conditions are applied to the bottom end node including the foundation rotational stiffness.



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation?	Yes
Include Warping?	Yes
Trans Load Btwn Intersecting Wood Wall?	Yes
Increase Nailing Capacity for Wind?	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.01%
Include P-Delta for Walls?	Yes
Automatically Iterate Stiffness for Walls?	No
Maximum Iteration Number for Wall Stiffness	3
Gravity Acceleration (ft/sec^2)	32.2
Wall Mesh Size (in)	12
Eigensolution Convergence Tol. (1.E-)	4
Vertical Axis	Z
Global Member Orientation Plane	XY
Static Solver	Standard Skyline
Dynamic Solver	Standard Solver

Hot Rolled Steel Code	AISC 9th: ASD
RISAConnection Code	AISC 14th(360-10): ASD
Cold Formed Steel Code	AISI 1999: ASD
Wood Code	AF&PA NDS-97: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-99
Masonry Code	ACI 530-11: ASD
Aluminum Code	AA ADM1-10: ASD - Building

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	PCA Load Contour
Parame Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections?	Yes
Use Cracked Sections Slab?	Yes
Bad Framing Warnings?	No
Unused Force Warnings?	Yes
Min 1 Bar Diam. Spacing?	No
Concrete Rebar Set	REBAR SET ASTMA615
Min % Steel for Column	1
Max % Steel for Column	8

Seismic Code	ASCE 7-10
Seismic Base Elevation (ft)	Not Entered
Add Base Weight?	Yes
Ct Z	.02
Ct X	.02
T Z (sec)	Not Entered
T X (sec)	Not Entered
R Z	3
R X	3
Ct Exp. Z	.75
Ct Exp. X	.75
SD1	1.02
SDS	1.2
S1	1
TL (sec)	12
Risk Cat	I or II
Om Z	1
Om X	1
Rho Z	1
Rho X	1



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

General Material Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (1/E5 F)	Density[k/ft^3]
1	GEN_STL	29000	11154	.3	.65	.49
2	GEN_RIGIDMASSLESS	3e+8	1.154e+8	.3	.65	0

General Section Sets

	Label	Shape	Type	Material	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	S1		Beam	GEN_RIGIDM...	1e+8	1e+8	1e+8	1e+8
2	S2		Beam	GEN_STL	349.239	7.192e+5	7.192e+5	1.438e+6
3	S3		Beam	GEN_STL	317.754	6.62e+5	6.62e+5	1.324e+6
4	S4		Beam	GEN_STL	316.757	6.624e+5	6.624e+5	1.325e+6
5	S5		Beam	GEN_STL	272.537	5.724e+5	5.724e+5	1.145e+6
6	S6		Beam	GEN_STL	279.599	5.899e+5	5.899e+5	1.18e+6
7	S7		Beam	GEN_STL	286.691	6.077e+5	6.077e+5	1.215e+6
8	S8		Beam	GEN_STL	293.812	6.257e+5	6.257e+5	1.251e+6
9	S9		Beam	GEN_STL	300.963	6.439e+5	6.439e+5	1.288e+6
10	S10		Beam	GEN_STL	311.388	6.693e+5	6.693e+5	1.339e+6
11	S11		Beam	GEN_STL	320.232	6.914e+5	6.914e+5	1.383e+6
12	S12		Beam	GEN_STL	330.757	7.175e+5	7.175e+5	1.435e+6
13	S13		Beam	GEN_STL	340.937	7.413e+5	7.413e+5	1.483e+6
14	S14		Beam	GEN_STL	350.724	7.626e+5	7.626e+5	1.525e+6
15	S15		Beam	GEN_STL	363.774	7.91e+5	7.91e+5	1.582e+6
16	S16		Beam	GEN_STL	388.244	8.442e+5	8.442e+5	1.688e+6
17	S17		Beam	GEN_STL	412.713	8.974e+5	8.974e+5	1.795e+6
18	S18		Beam	GEN_STL	437.182	9.507e+5	9.507e+5	1.901e+6
19	S19		Beam	GEN_STL	460.02	1e+6	1e+6	2.001e+6
20	S20		Beam	GEN_STL	484.489	1.054e+6	1.054e+6	2.107e+6
21	S21		Beam	GEN_STL	510.589	1.11e+6	1.11e+6	2.221e+6
22	S22		Beam	GEN_STL	533.427	1.16e+6	1.16e+6	2.32e+6
23	S23		Beam	GEN_STL	527.368	1.17e+6	1.17e+6	2.341e+6
24	S24		Beam	GEN_STL	482.596	1.115e+6	1.115e+6	2.23e+6
25	S25		Beam	GEN_STL	497.352	1.195e+6	1.195e+6	2.391e+6
26	S26		Beam	GEN_STL	501.818	1.254e+6	1.254e+6	2.507e+6
27	S27		Beam	GEN_STL	514.995	1.336e+6	1.336e+6	2.673e+6
28	S28		Beam	GEN_STL	530.119	1.428e+6	1.428e+6	2.856e+6
29	S29		Beam	GEN_STL	545.44	1.524e+6	1.524e+6	3.047e+6
30	S30		Beam	GEN_STL	655.071	1.897e+6	1.897e+6	3.794e+6
31	S31		Beam	GEN_STL	653.289	1.925e+6	1.925e+6	3.851e+6
32	S32		Beam	GEN_STL	670.381	1.976e+6	1.976e+6	3.951e+6
33	S33		Beam	GEN_STL	687.473	2.026e+6	2.026e+6	4.052e+6
34	S34		Beam	GEN_STL	995.127	2.933e+6	2.933e+6	5.866e+6
35	S35		Beam	GEN_STL	995.127	2.933e+6	2.933e+6	5.866e+6
36	S36		Beam	GEN_STL	995.127	2.933e+6	2.933e+6	5.866e+6
37	S37		Beam	GEN_RIGIDM...	1e+8	1e+8	1e+8	1e+8

Member Primary Data

	Label	I Joint	J Joint	K Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2			S1	Beam	None	GEN_RIGI...	DR1_18
2	M2	N2	N3			S2	Beam	None	GEN_STL	DR1_18
3	M3	N3	N4			S3	Beam	None	GEN_STL	DR1_18
4	M4	N4	N5			S4	Beam	None	GEN_STL	DR1_18
5	M5	N5	N6			S5	Beam	None	GEN_STL	DR1_18
6	M6	N6	N7			S6	Beam	None	GEN_STL	DR1_18
7	M7	N7	N8			S7	Beam	None	GEN_STL	DR1_18
8	M8	N8	N9			S8	Beam	None	GEN_STL	DR1_18
9	M9	N9	N10			S9	Beam	None	GEN_STL	DR1_18
10	M10	N10	N11			S10	Beam	None	GEN_STL	DR1_18
11	M11	N11	N12			S11	Beam	None	GEN_STL	DR1_18
12	M12	N12	N13			S12	Beam	None	GEN_STL	DR1_18
13	M13	N13	N14			S13	Beam	None	GEN_STL	DR1_18
14	M14	N14	N15			S14	Beam	None	GEN_STL	DR1_18
15	M15	N15	N16			S15	Beam	None	GEN_STL	DR1_18
16	M16	N16	N17			S16	Beam	None	GEN_STL	DR1_18
17	M17	N17	N18			S17	Beam	None	GEN_STL	DR1_18
18	M18	N18	N19			S18	Beam	None	GEN_STL	DR1_18
19	M19	N19	N20			S19	Beam	None	GEN_STL	DR1_18
20	M20	N20	N21			S20	Beam	None	GEN_STL	DR1_18



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 Designer : NAA
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Member Primary Data (Continued)

	Label	I Joint	J Joint	K Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
21	M21	N21	N22			S21	Beam	None	GEN_STL	DR1_18
22	M22	N22	N23			S22	Beam	None	GEN_STL	DR1_18
23	M23	N23	N24			S23	Beam	None	GEN_STL	DR1_18
24	M24	N24	N25			S24	Beam	None	GEN_STL	DR1_18
25	M25	N25	N26			S25	Beam	None	GEN_STL	DR1_18
26	M26	N26	N27			S26	Beam	None	GEN_STL	DR1_18
27	M27	N27	N28			S27	Beam	None	GEN_STL	DR1_18
28	M28	N28	N29			S28	Beam	None	GEN_STL	DR1_18
29	M29	N29	N30			S29	Beam	None	GEN_STL	DR1_18
30	M30	N30	N31			S30	Beam	None	GEN_STL	DR1_18
31	M31	N31	N32			S31	Beam	None	GEN_STL	DR1_18
32	M32	N32	N33			S32	Beam	None	GEN_STL	DR1_18
33	M33	N33	N34			S33	Beam	None	GEN_STL	DR1_18
34	M34	N34	N35			S34	Beam	None	GEN_STL	DR1_18
35	M35	N35	N36			S35	Beam	None	GEN_STL	DR1_18
36	M36	N36	N37			S36	Beam	None	GEN_STL	DR1_18
37	M37	N37	N38			S37	Beam	None	GEN_RIGI...	DR1_18

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
1	N1	0	0	320.538058	0	
2	N2	0	0	314.304462	0	
3	N3	0	0	305.495407	0	
4	N4	0	0	297.998688	0	
5	N5	0	0	290.501969	0	
6	N6	0	0	281.263123	0	
7	N7	0	0	272.024278	0	
8	N8	0	0	262.785433	0	
9	N9	0	0	253.546588	0	
10	N10	0	0	244.307743	0	
11	N11	0	0	235.068898	0	
12	N12	0	0	225.830052	0	
13	N13	0	0	215.879265	0	
14	N14	0	0	207.962598	0	
15	N15	0	0	200.423228	0	
16	N16	0	0	192.880577	0	
17	N17	0	0	183.267717	0	
18	N18	0	0	173.654856	0	
19	N19	0	0	164.041995	0	
20	N20	0	0	154.429134	0	
21	N21	0	0	144.816273	0	
22	N22	0	0	135.203412	0	
23	N23	0	0	124.934383	0	
24	N24	0	0	115.026247	0	
25	N25	0	0	105.777559	0	
26	N26	0	0	96.528871	0	
27	N27	0	0	87.280184	0	
28	N28	0	0	78.028215	0	
29	N29	0	0	68.782808	0	
30	N30	0	0	59.540682	0	
31	N31	0	0	49.606299	0	
32	N32	0	0	40.682415	0	
33	N33	0	0	32.463911	0	
34	N34	0	0	24.245407	0	
35	N35	0	0	19.324147	0	
36	N36	0	0	9.711286	0	
37	N37	0	0	0.656168	0	
38	N38	0	0	-6.56168	0	

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N38	Reaction	Reaction	Reaction	Reaction	S3.688e+8	Fixed	



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Joint Loads and Enforced Displacements (BLC 2 : D (Tower Flanges Only))

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...)]
1	N2	L	Z	-4.236
2	N13	L	Z	-4.888
3	N23	L	Z	-13.425
4	N31	L	Z	-17.871
5	N37	L	Z	-6.996

Joint Loads and Enforced Displacements (BLC 3 : D (Misc))

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...)]
1	N1	L	Z	0
2	N2	L	Z	-.108
3	N3	L	Z	-.199
4	N4	L	Z	-.183
5	N5	L	Z	-.205
6	N6	L	Z	-.226
7	N7	L	Z	-.226
8	N8	L	Z	-.226
9	N9	L	Z	-.226
10	N10	L	Z	-.226
11	N11	L	Z	-.226
12	N12	L	Z	-.235
13	N13	L	Z	-.219
14	N14	L	Z	-.189
15	N15	L	Z	-.184
16	N16	L	Z	-.21
17	N17	L	Z	-.235
18	N18	L	Z	-.235
19	N19	L	Z	-.235
20	N20	L	Z	-.235
21	N21	L	Z	-.235
22	N22	L	Z	-.243
23	N23	L	Z	-.247
24	N24	L	Z	-.234
25	N25	L	Z	-.226
26	N26	L	Z	-.226
27	N27	L	Z	-.226
28	N28	L	Z	-.226
29	N29	L	Z	-.226
30	N30	L	Z	-.234
31	N31	L	Z	-.231
32	N32	L	Z	-.21
33	N33	L	Z	-.201
34	N34	L	Z	-.161
35	N35	L	Z	-.178
36	N36	L	Z	-.228
37	N37	L	Z	-.111

Joint Loads and Enforced Displacements (BLC 4 : D(Turbine Only))

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...)]
1	N1	L	Z	-509.288

Joint Loads and Enforced Displacements (BLC 5 : D(MMI))

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...)]
1	N1	M	My	40192

Joint Loads and Enforced Displacements (BLC 6 : Lateral Mass (MIN))

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...)]
1	N1	M	Mx	40192
2	N1	M	Y	15.816
3	N2	M	Y	.294
4	N3	M	Y	.288
5	N4	M	Y	.251
6	N5	M	Y	.259
7	N6	M	Y	.27
8	N7	M	Y	.276
9	N8	M	Y	.283



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Joint Loads and Enforced Displacements (BLC 6 : Lateral Mass (MIN)) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...
10	N9	M	Y	.29
11	N10	M	Y	.299
12	N11	M	Y	.308
13	N12	M	Y	.33
14	N13	M	Y	.468
15	N14	M	Y	.282
16	N15	M	Y	.285
17	N16	M	Y	.342
18	N17	M	Y	.407
19	N18	M	Y	.432
20	N19	M	Y	.456
21	N20	M	Y	.48
22	N21	M	Y	.505
23	N22	M	Y	.549
24	N23	M	Y	.982
25	N24	M	Y	.512
26	N25	M	Y	.479
27	N26	M	Y	.488
28	N27	M	Y	.497
29	N28	M	Y	.511
30	N29	M	Y	.525
31	N30	M	Y	.61
32	N31	M	Y	1.207
33	N32	M	Y	.599
34	N33	M	Y	.59
35	N34	M	Y	.557
36	N35	M	Y	.764
37	N36	M	Y	.982
38	N37	M	Y	.693

Joint Loads and Enforced Displacements (BLC 7 : Lateral Mass (MAX))

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...
1	N1	M	M _y	40192
2	N1	M	X	15.816
3	N2	M	X	.297
4	N3	M	X	.295
5	N4	M	X	.257
6	N5	M	X	.265
7	N6	M	X	.277
8	N7	M	X	.283
9	N8	M	X	.29
10	N9	M	X	.297
11	N10	M	X	.306
12	N11	M	X	.315
13	N12	M	X	.338
14	N13	M	X	.475
15	N14	M	X	.288
16	N15	M	X	.29
17	N16	M	X	.349
18	N17	M	X	.414
19	N18	M	X	.439
20	N19	M	X	.463
21	N20	M	X	.487
22	N21	M	X	.513
23	N22	M	X	.556
24	N23	M	X	.99
25	N24	M	X	.519
26	N25	M	X	.486
27	N26	M	X	.495
28	N27	M	X	.504
29	N28	M	X	.518
30	N29	M	X	.532
31	N30	M	X	.617
32	N31	M	X	1.214
33	N32	M	X	.606
34	N33	M	X	.596
35	N34	M	X	.562



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Joint Loads and Enforced Displacements (BLC 7 : Lateral Mass (MAX)) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...
36	N35	M	X	.77
37	N36	M	X	.989
38	N37	M	X	.697

Joint Loads and Enforced Displacements (BLC 10 : Operational Load: Max[NPP,Estop])

	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...
1	N2	L	My	3610.539
2	N2	L	X	171.643

Joint Loads and Enforced Displacements (BLC 11 : Operational Load: Idling/Parked)

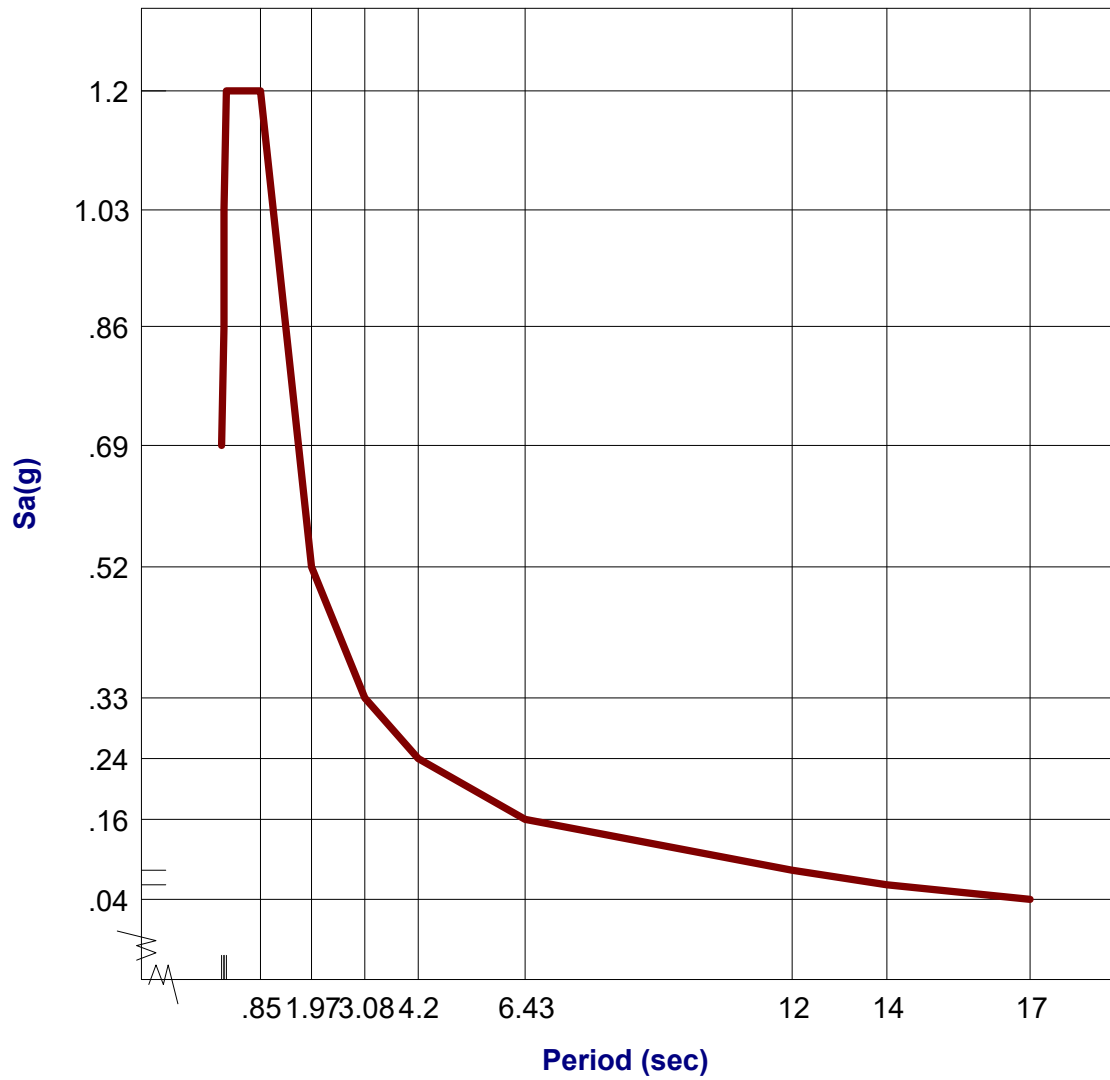
	Joint Label	L,D,M	Direction	Magnitude[(k.k-ft), (in.rad), (k*s^2/f...
1	N2	L	Mv	2281.55
2	N2	L	X	38.987

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribu...	Area(M...	Surface...
1	D (Tower Shell Only)	DL			-1					
2	D (Tower Flanges Only)	DL				5				
3	D (Misc)	DL				37				
4	D(Turbine Only)	DL				1				
5	D(MMI)	DL				1				
6	Lateral Mass (MIN)	DL				38				
7	Lateral Mass (MAX)	DL				38				
10	Operational Load: Max[NPP,Estop]	None				2				
11	Operational Load: Idling/Parked	None				2				

Load Combinations

	Description	Solve PD...S...	BLC	Factor	BLC	Factor	BLC	F...	BLC	Fa...	BLC	Fa...	B...	Fa...	B...	Fa...	B...	Fa...
1	D (Tower Shell Only)		1	1														
2	D(Tower Flanges Only)		2	1														
3	D(Misc)		3	1														
4	D(Tower Only Min)		1	1	2	1												
5	D(Tower Only Max)		1	1	2	1	3	1										
6	D(Turbine Only)		4	1	5	1												
7	D(System Min)		L4	1	L6	1												
8	D(System Max)		L5	1	L6	1												
9																		
10	Lateral Mass (MIN)		6	1														
11	Lateral Mass (MAX)		7	1														
12																		
13	RSA (@B=1%)				SX	1.4												
14	RSA (@B=5%)				SX	1												
15	RSA(R/I) where R=1.5; B=1%; ...				SX	.933												
16	RSA(R/I) where R=1.5; B=5%; ...				SX	.667												
17																		
18	E@STANDSTILL				L15	1												
19	E@CONCURRENT M				L16	1												
20																		
21	DISP@STANDSTILL Cd=1.5				L15	1.5												
22	DISP@CONCURRENT Cd=1.5				L16	1.5												
23																		
24	Operational Load Displacement...		10	1														
25	Operational Load Displacement...		11	1														



ASCE 2010, Parametric Design Spectra

Compatible with ASCE 7-16 design spectra.



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Dynamics Input

Number of Modes	6
Load Combination Number	11 - Lateral Mass (MAX)
Acceleration of Gravity	32.2 (ft/sec^2)
Convergence Tolerance	0.0001

Response Spectra Data

X Direction Spectra	ASCE 2010, Parametric Design Spectra
Modes Used	All 6 modes
Mode No. for Signs	
Modal Combination Method	SRSS
Damping Ratio	5 Percent

Frequencies / Participation

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation		
			X Spectra	Y Spectra	Z Spectra
1	.186	5.375	61.232		
2	1.013	.988	12.202		
3	2.789	.359	8.854		
4	6.737	.148	4.688		
5	12.676	.079	3.403		
6	19.689	.051	1.924		
Totals :			92.302		

Mode Shape 1

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N1	.788	0.000	0.000	0.000	0	0.000
N2	.761	0.000	0.000	0.000	0	0.000
N3	.722	0.000	0.000	0.000	0	0.000
N4	.69	0.000	0.000	0.000	0	0.000
N5	.657	0.000	0.000	0.000	0	0.000
N6	.618	0.000	0.000	0.000	0	0.000
N7	.579	0.000	0.000	0.000	0	0.000
N8	.541	0.000	0.000	0.000	0	0.000
N9	.504	0.000	0.000	0.000	0	0.000
N10	.468	0.000	0.000	0.000	0	0.000
N11	.433	0.000	0.000	0.000	0	0.000
N12	.399	0.000	0.000	0.000	0	0.000
N13	.363	0.000	0.000	0.000	0	0.000
N14	.336	0.000	0.000	0.000	0	0.000
N15	.312	0.000	0.000	0.000	0	0.000
N16	.288	0.000	0.000	0.000	0	0.000
N17	.258	0.000	0.000	0.000	0	0.000
N18	.231	0.000	0.000	0.000	0	0.000
N19	.205	0.000	0.000	0.000	0	0.000
N20	.18	0.000	0.000	0.000	0	0.000
N21	.157	0.000	0.000	0.000	0	0.000
N22	.135	0.000	0.000	0.000	0	0.000
N23	.114	0.000	0.000	0.000	0	0.000
N24	.095	0.000	0.000	0.000	0	0.000
N25	.079	0.000	0.000	0.000	0	0.000
N26	.064	0.000	0.000	0.000	0	0.000
N27	.052	0.000	0.000	0.000	0	0.000
N28	.041	0.000	0.000	0.000	0	0.000
N29	.031	0.000	0.000	0.000	0	0.000
N30	.023	0.000	0.000	0.000	0	0.000
N31	.016	0.000	0.000	0.000	0	0.000
N32	.01	0.000	0.000	0.000	0	0.000
N33	.006	0.000	0.000	0.000	0	0.000
N34	.004	0.000	0.000	0.000	0	0.000
N35	.002	0.000	0.000	0.000	0	0.000
N36	0	0.000	0.000	0.000	0	0.000
N37	0	0.000	0.000	0.000	0	0.000
N38	0.000	0.000	0.000	0.000	0	0.000



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

Mode Shape 2

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N1	.067	0.000	0.000	0.000	-.001	0.000
N2	.158	0.000	0.000	0.000	-.001	0.000
N3	.28	0.000	0.000	0.000	-.001	0.000
N4	.374	0.000	0.000	0.000	0	0.000
N5	.458	0.000	0.000	0.000	0	0.000
N6	.548	0.000	0.000	0.000	0	0.000
N7	.622	0.000	0.000	0.000	0	0.000
N8	.681	0.000	0.000	0.000	0	0.000
N9	.725	0.000	0.000	0.000	0	0.000
N10	.757	0.000	0.000	0.000	0	0.000
N11	.776	0.000	0.000	0.000	0	0.000
N12	.783	0.000	0.000	0.000	0	0.000
N13	.78	0.000	0.000	0.000	0	0.000
N14	.77	0.000	0.000	0.000	0	0.000
N15	.754	0.000	0.000	0.000	0	0.000
N16	.733	0.000	0.000	0.000	0	0.000
N17	.7	0.000	0.000	0.000	0	0.000
N18	.661	0.000	0.000	0.000	0	0.000
N19	.618	0.000	0.000	0.000	0	0.000
N20	.57	0.000	0.000	0.000	0	0.000
N21	.52	0.000	0.000	0.000	0	0.000
N22	.469	0.000	0.000	0.000	0	0.000
N23	.413	0.000	0.000	0.000	0	0.000
N24	.359	0.000	0.000	0.000	0	0.000
N25	.309	0.000	0.000	0.000	0	0.000
N26	.262	0.000	0.000	0.000	0	0.000
N27	.217	0.000	0.000	0.000	0	0.000
N28	.175	0.000	0.000	0.000	0	0.000
N29	.138	0.000	0.000	0.000	0	0.000
N30	.104	0.000	0.000	0.000	0	0.000
N31	.073	0.000	0.000	0.000	0	0.000
N32	.05	0.000	0.000	0.000	0	0.000
N33	.032	0.000	0.000	0.000	0	0.000
N34	.019	0.000	0.000	0.000	0	0.000
N35	.013	0.000	0.000	0.000	0	0.000
N36	.004	0.000	0.000	0.000	0	0.000
N37	0	0.000	0.000	0.000	0	0.000
N38	0.000	0.000	0.000	0.000	0	0.000

Mode Shape 3

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N1	-.209	0.000	0.000	0.000	0	0.000
N2	-.254	0.000	0.000	0.000	0	0.000
N3	-.293	0.000	0.000	0.000	0	0.000
N4	-.295	0.000	0.000	0.000	0	0.000
N5	-.269	0.000	0.000	0.000	0	0.000
N6	-.201	0.000	0.000	0.000	0	0.000
N7	-.099	0.000	0.000	0.000	-.001	0.000
N8	.028	0.000	0.000	0.000	-.001	0.000
N9	.173	0.000	0.000	0.000	-.001	0.000
N10	.328	0.000	0.000	0.000	-.001	0.000
N11	.486	0.000	0.000	0.000	-.001	0.000
N12	.64	0.000	0.000	0.000	-.001	0.000
N13	.796	0.000	0.000	0.000	-.001	0.000
N14	.908	0.000	0.000	0.000	-.001	0.000
N15	1.003	0.000	0.000	0.000	0	0.000
N16	1.084	0.000	0.000	0.000	0	0.000
N17	1.166	0.000	0.000	0.000	0	0.000
N18	1.222	0.000	0.000	0.000	0	0.000
N19	1.252	0.000	0.000	0.000	0	0.000
N20	1.256	0.000	0.000	0.000	0	0.000
N21	1.236	0.000	0.000	0.000	0	0.000
N22	1.192	0.000	0.000	0.000	0	0.000
N23	1.122	0.000	0.000	0.000	0	0.000
N24	1.035	0.000	0.000	0.000	0	0.000
N25	.938	0.000	0.000	0.000	0	0.000
N26	.831	0.000	0.000	0.000	0	0.000
N27	.718	0.000	0.000	0.000	.001	0.000



Company : Agbayani Structural Engineering
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Mode Shape 3. (continued)

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N28	.602	0.000	0.000	0.000	.001	0.000
N29	.489	0.000	0.000	0.000	0	0.000
N30	.381	0.000	0.000	0.000	0	0.000
N31	.276	0.000	0.000	0.000	0	0.000
N32	.192	0.000	0.000	0.000	0	0.000
N33	.127	0.000	0.000	0.000	0	0.000
N34	.075	0.000	0.000	0.000	0	0.000
N35	.051	0.000	0.000	0.000	0	0.000
N36	.017	0.000	0.000	0.000	0	0.000
N37	.003	0.000	0.000	0.000	0	0.000
N38	0.000	0.000	0.000	0.000	0	0.000

Mode Shape 4

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N1	.153	0.000	0.000	0.000	0	0.000
N2	.171	0.000	0.000	0.000	0	0.000
N3	.14	0.000	0.000	0.000	0	0.000
N4	.045	0.000	0.000	0.000	.001	0.000
N5	-.1	0.000	0.000	0.000	.002	0.000
N6	-.332	0.000	0.000	0.000	.002	0.000
N7	-.597	0.000	0.000	0.000	.002	0.000
N8	-.863	0.000	0.000	0.000	.002	0.000
N9	-1.106	0.000	0.000	0.000	.002	0.000
N10	-1.304	0.000	0.000	0.000	.001	0.000
N11	-1.441	0.000	0.000	0.000	0	0.000
N12	-1.506	0.000	0.000	0.000	0	0.000
N13	-1.49	0.000	0.000	0.000	0	0.000
N14	-1.411	0.000	0.000	0.000	-.001	0.000
N15	-1.286	0.000	0.000	0.000	-.002	0.000
N16	-1.119	0.000	0.000	0.000	-.002	0.000
N17	-.857	0.000	0.000	0.000	-.002	0.000
N18	-.557	0.000	0.000	0.000	-.003	0.000
N19	-.238	0.000	0.000	0.000	-.003	0.000
N20	.08	0.000	0.000	0.000	-.003	0.000
N21	.381	0.000	0.000	0.000	-.002	0.000
N22	.647	0.000	0.000	0.000	-.002	0.000
N23	.88	0.000	0.000	0.000	-.002	0.000
N24	1.041	0.000	0.000	0.000	-.001	0.000
N25	1.128	0.000	0.000	0.000	0	0.000
N26	1.154	0.000	0.000	0.000	0	0.000
N27	1.122	0.000	0.000	0.000	0	0.000
N28	1.041	0.000	0.000	0.000	0	0.000
N29	.921	0.000	0.000	0.000	.001	0.000
N30	.773	0.000	0.000	0.000	.001	0.000
N31	.599	0.000	0.000	0.000	.001	0.000
N32	.441	0.000	0.000	0.000	.001	0.000
N33	.306	0.000	0.000	0.000	.001	0.000
N34	.189	0.000	0.000	0.000	0	0.000
N35	.132	0.000	0.000	0.000	0	0.000
N36	.048	0.000	0.000	0.000	0	0.000
N37	.008	0.000	0.000	0.000	0	0.000
N38	0.000	0.000	0.000	0.000	0	0.000

Mode Shape 5

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N1	-.107	0.000	0.000	0.000	0	0.000
N2	-.117	0.000	0.000	0.000	0	0.000
N3	-.025	0.000	0.000	0.000	-.001	0.000
N4	.161	0.000	0.000	0.000	-.002	0.000
N5	.412	0.000	0.000	0.000	-.003	0.000
N6	.765	0.000	0.000	0.000	-.003	0.000
N7	1.102	0.000	0.000	0.000	-.003	0.000
N8	1.363	0.000	0.000	0.000	-.002	0.000
N9	1.508	0.000	0.000	0.000	0	0.000
N10	1.513	0.000	0.000	0.000	0	0.000
N11	1.374	0.000	0.000	0.000	.002	0.000
N12	1.106	0.000	0.000	0.000	.003	0.000
N13	.705	0.000	0.000	0.000	.004	0.000



Company : Agbayani Structural Engineering
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Mode Shape 5, (continued)

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N14	.336	0.000	0.000	0.000	.004	0.000
N15	-.028	0.000	0.000	0.000	.004	0.000
N16	-.374	0.000	0.000	0.000	.003	0.000
N17	-.752	0.000	0.000	0.000	.003	0.000
N18	-1.023	0.000	0.000	0.000	.002	0.000
N19	-1.161	0.000	0.000	0.000	0	0.000
N20	-1.156	0.000	0.000	0.000	0	0.000
N21	-1.014	0.000	0.000	0.000	-.002	0.000
N22	-.756	0.000	0.000	0.000	-.003	0.000
N23	-.388	0.000	0.000	0.000	-.003	0.000
N24	.017	0.000	0.000	0.000	-.003	0.000
N25	.393	0.000	0.000	0.000	-.003	0.000
N26	.725	0.000	0.000	0.000	-.003	0.000
N27	.981	0.000	0.000	0.000	-.002	0.000
N28	1.139	0.000	0.000	0.000	0	0.000
N29	1.189	0.000	0.000	0.000	0	0.000
N30	1.136	0.000	0.000	0.000	0	0.000
N31	.986	0.000	0.000	0.000	.001	0.000
N32	.788	0.000	0.000	0.000	.002	0.000
N33	.582	0.000	0.000	0.000	.002	0.000
N34	.38	0.000	0.000	0.000	.002	0.000
N35	.274	0.000	0.000	0.000	.002	0.000
N36	.104	0.000	0.000	0.000	0	0.000
N37	.018	0.000	0.000	0.000	0	0.000
N38	0.000	0.000	0.000	0.000	0	0.000

Mode Shape 6

Joint Label	X Translation	Y Translation	Z Translation	X Rotation	Y Rotation	Z Rotation
N1	.095	0.000	0.000	0.000	0	0.000
N2	.102	0.000	0.000	0.000	0	0.000
N3	-.071	0.000	0.000	0.000	.002	0.000
N4	-.378	0.000	0.000	0.000	.003	0.000
N5	-.756	0.000	0.000	0.000	.004	0.000
N6	-1.224	0.000	0.000	0.000	.003	0.000
N7	-1.566	0.000	0.000	0.000	.002	0.000
N8	-1.696	0.000	0.000	0.000	0	0.000
N9	-1.577	0.000	0.000	0.000	-.002	0.000
N10	-1.225	0.000	0.000	0.000	-.004	0.000
N11	-.697	0.000	0.000	0.000	-.005	0.000
N12	-.085	0.000	0.000	0.000	-.005	0.000
N13	.55	0.000	0.000	0.000	-.004	0.000
N14	.954	0.000	0.000	0.000	-.003	0.000
N15	1.211	0.000	0.000	0.000	-.002	0.000
N16	1.319	0.000	0.000	0.000	0	0.000
N17	1.236	0.000	0.000	0.000	.002	0.000
N18	.937	0.000	0.000	0.000	.003	0.000
N19	.488	0.000	0.000	0.000	.004	0.000
N20	-.022	0.000	0.000	0.000	.004	0.000
N21	-.497	0.000	0.000	0.000	.003	0.000
N22	-.854	0.000	0.000	0.000	.002	0.000
N23	-1.034	0.000	0.000	0.000	0	0.000
N24	-.972	0.000	0.000	0.000	-.001	0.000
N25	-.727	0.000	0.000	0.000	-.003	0.000
N26	-.357	0.000	0.000	0.000	-.003	0.000
N27	.067	0.000	0.000	0.000	-.003	0.000
N28	.47	0.000	0.000	0.000	-.003	0.000
N29	.787	0.000	0.000	0.000	-.002	0.000
N30	.972	0.000	0.000	0.000	0	0.000
N31	1.01	0.000	0.000	0.000	0	0.000
N32	.904	0.000	0.000	0.000	.001	0.000
N33	.723	0.000	0.000	0.000	.002	0.000
N34	.501	0.000	0.000	0.000	.002	0.000
N35	.373	0.000	0.000	0.000	.002	0.000
N36	.151	0.000	0.000	0.000	.001	0.000
N37	.025	0.000	0.000	0.000	0	0.000
N38	0.000	0.000	0.000	0.000	0	0.000



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	14	N38	-226.451	0	0	0	-44630.721	NC
2	14	Totals:	-226.451	0	0			
3	14	COG (ft):	NC	NC	NC			

Member Section Forces

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mome...	z-z Moment[k-ft]
1	14	M1	1	0	0	124.722	0	12831.008	0
5			5	0	0	124.722	0	12609.763	0
6	14	M2	1	0	0	127.258	0	12609.761	0
10			5	0	0	127.258	0	12365.194	0
11	14	M3	1	0	0	129.862	0	12365.194	0
15			5	0	0	129.862	0	12223.116	0
16	14	M4	1	0	0	132.04	0	12223.116	0
20			5	0	0	132.04	0	12145.957	0
21	14	M5	1	0	0	134.077	0	12145.957	0
25			5	0	0	134.077	0	12145.576	0
26	14	M6	1	0	0	135.827	0	12145.576	0
30			5	0	0	135.827	0	12252.857	0
31	14	M7	1	0	0	137.22	0	12252.857	0
35			5	0	0	137.22	0	12466.54	0
36	14	M8	1	0	0	138.299	0	12466.54	0
40			5	0	0	138.299	0	12782.166	0
41	14	M9	1	0	0	139.154	0	12782.166	0
45			5	0	0	139.154	0	13192.728	0
46	14	M10	1	0	0	139.886	0	13192.728	0
50			5	0	0	139.886	0	13689.532	0
51	14	M11	1	0	0	140.585	0	13689.532	0
55			5	0	0	140.585	0	14263.259	0
56	14	M12	1	0	0	141.367	0	14263.259	0
60			5	0	0	141.367	0	14956.874	0
61	14	M13	1	0	0	142.755	0	14956.874	0
65			5	0	0	142.755	0	15548.853	0
66	14	M14	1	0	0	143.864	0	15548.853	0
70			5	0	0	143.864	0	16150.169	0
71	14	M15	1	0	0	145.118	0	16150.169	0
75			5	0	0	145.118	0	16785.199	0
76	14	M16	1	0	0	146.855	0	16785.199	0
80			5	0	0	146.855	0	17638.658	0
81	14	M17	1	0	0	149.187	0	17638.658	0
85			5	0	0	149.187	0	18537.563	0
86	14	M18	1	0	0	152.013	0	18537.563	0
90			5	0	0	152.013	0	19479.248	0
91	14	M19	1	0	0	155.346	0	19479.248	0
95			5	0	0	155.346	0	20462.584	0
96	14	M20	1	0	0	159.189	0	20462.584	0
100			5	0	0	159.189	0	21487.689	0
101	14	M21	1	0	0	163.555	0	21487.689	0
105			5	0	0	163.555	0	22555.659	0
106	14	M22	1	0	0	168.625	0	22555.659	0
110			5	0	0	168.625	0	23746.182	0
111	14	M23	1	0	0	178.75	0	23746.182	0
115			5	0	0	178.75	0	24941.295	0
116	14	M24	1	0	0	184.433	0	24941.295	0
120			5	0	0	184.433	0	26112.908	0
121	14	M25	1	0	0	189.623	0	26112.908	0
125			5	0	0	189.623	0	27340.69	0
126	14	M26	1	0	0	194.658	0	27340.69	0
130			5	0	0	194.658	0	28625.495	0
131	14	M27	1	0	0	199.439	0	28625.495	0
135			5	0	0	199.439	0	29967.891	0
136	14	M28	1	0	0	203.929	0	29967.891	0
140			5	0	0	203.929	0	31365.725	0
141	14	M29	1	0	0	208.045	0	31365.725	0
145			5	0	0	208.045	0	32817.956	0
146	14	M30	1	0	0	212.18	0	32817.956	0



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

Checked By: _____

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mome...	z-z Moment[k-ft]
150			5	0	0	212.18	0	34438.311	0
151	14	M31	1	0	0	218.995	0	34438.311	0
155			5	0	0	218.995	0	35949.646	0
156	14	M32	1	0	0	221.699	0	35949.646	0
160			5	0	0	221.699	0	37382.848	0
161	14	M33	1	0	0	223.607	0	37382.848	0
165			5	0	0	223.607	0	38852.505	0
166	14	M34	1	0	0	224.749	0	38852.505	0
170			5	0	0	224.749	0	39748.634	0
171	14	M35	1	0	0	225.866	0	39748.634	0
175			5	0	0	225.866	0	41531.35	0
176	14	M36	1	0	0	226.389	0	41531.35	0
180			5	0	0	226.389	0	43244.597	0
181	14	M37	1	0	0	226.451	0	43244.597	0
185			5	0	0	226.451	0	44630.721	0

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
1	14	N1	55.242	0	0	0	2.66e-2	0
2	14	N2	53.329	0	0	0	2.66e-2	0
3	14	N3	50.639	0	0	0	2.628e-2	0
4	14	N4	48.371	0	0	0	2.596e-2	0
5	14	N5	46.127	0	0	0	2.561e-2	0
6	14	N6	43.401	0	0	0	2.507e-2	0
7	14	N7	40.727	0	0	0	2.449e-2	0
8	14	N8	38.108	0	0	0	2.388e-2	0
9	14	N9	35.552	0	0	0	2.324e-2	0
10	14	N10	33.061	0	0	0	2.255e-2	0
11	14	N11	30.641	0	0	0	2.184e-2	0
12	14	N12	28.297	0	0	0	2.11e-2	0
13	14	N13	25.86	0	0	0	2.026e-2	0
14	14	N14	23.99	0	0	0	1.957e-2	0
15	14	N15	22.268	0	0	0	1.89e-2	0
16	14	N16	20.604	0	0	0	1.821e-2	0
17	14	N17	18.57	0	0	0	1.734e-2	0
18	14	N18	16.634	0	0	0	1.646e-2	0
19	14	N19	14.796	0	0	0	1.558e-2	0
20	14	N20	13.058	0	0	0	1.469e-2	0
21	14	N21	11.421	0	0	0	1.38e-2	0
22	14	N22	9.886	0	0	0	1.29e-2	0
23	14	N23	8.361	0	0	0	1.192e-2	0
24	14	N24	7.004	0	0	0	1.093e-2	0
25	14	N25	5.848	0	0	0	9.905e-3	0
26	14	N26	4.804	0	0	0	8.899e-3	0
27	14	N27	3.871	0	0	0	7.891e-3	0
28	14	N28	3.048	0	0	0	6.896e-3	0
29	14	N29	2.334	0	0	0	5.919e-3	0
30	14	N30	1.728	0	0	0	4.959e-3	0
31	14	N31	1.186	0	0	0	4.089e-3	0
32	14	N32	.788	0	0	0	3.282e-3	0
33	14	N33	.499	0	0	0	2.526e-3	0
34	14	N34	.286	0	0	0	1.759e-3	0
35	14	N35	.19	0	0	0	1.432e-3	0
36	14	N36	.061	0	0	0	7.707e-4	0
37	14	N37	.01	0	0	0	1.21e-4	0
38	14	N38	0	0	0	0	1.21e-4	0

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
1	N1	0	0	320.538058	0	
2	N2	0	0	314.304462	0	
3	N3	0	0	305.495407	0	
4	N4	0	0	297.998688	0	
5	N5	0	0	290.501969	0	
6	N6	0	0	281.263123	0	



Company : Agbayani Structural Engineering
 Designer : NAA
 Job Number : 25-031
 Model Name : VESTAS V163/V166 HH98M-TA38200

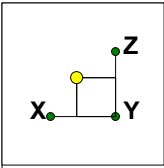
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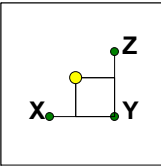
Joint Coordinates and Temperatures (Continued)

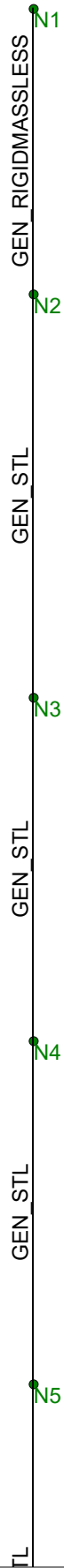
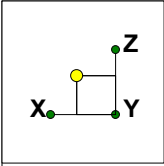
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7	N7	0	0	272.024278	0	
8	N8	0	0	262.785433	0	
9	N9	0	0	253.546588	0	
10	N10	0	0	244.307743	0	
11	N11	0	0	235.068898	0	
12	N12	0	0	225.830052	0	
13	N13	0	0	215.879265	0	
14	N14	0	0	207.962598	0	
15	N15	0	0	200.423228	0	
16	N16	0	0	192.880577	0	
17	N17	0	0	183.267717	0	
18	N18	0	0	173.654856	0	
19	N19	0	0	164.041995	0	
20	N20	0	0	154.429134	0	
21	N21	0	0	144.816273	0	
22	N22	0	0	135.203412	0	
23	N23	0	0	124.934383	0	
24	N24	0	0	115.026247	0	
25	N25	0	0	105.777559	0	
26	N26	0	0	96.528871	0	
27	N27	0	0	87.280184	0	
28	N28	0	0	78.028215	0	
29	N29	0	0	68.782808	0	
30	N30	0	0	59.540682	0	
31	N31	0	0	49.606299	0	
32	N32	0	0	40.682415	0	
33	N33	0	0	32.463911	0	
34	N34	0	0	24.245407	0	
35	N35	0	0	19.324147	0	
36	N36	0	0	9.711286	0	
37	N37	0	0	0.656168	0	
38	N38	0	0	-6.56168	0	

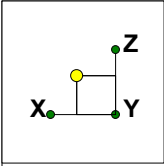
Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N38	Reaction	Reaction	Reaction	Reaction	S3.688e+8	Fixed	









N34

GEN STL

N35

GEN STL

N36

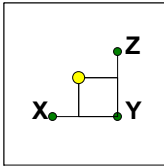
GEN STL

N37

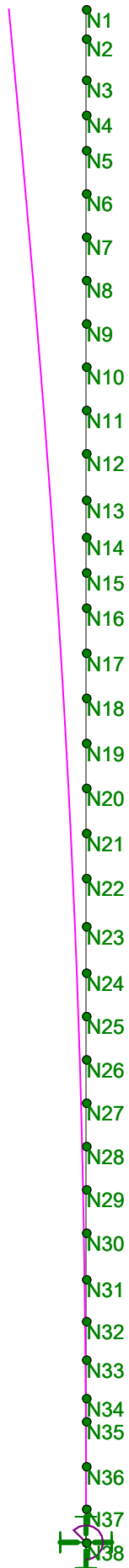
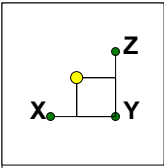
GEN RIGIDMASSLESS

N38



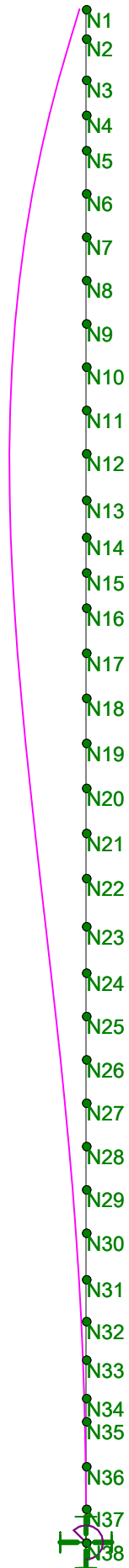
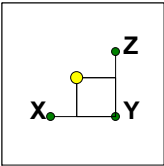


Loads: LC 8, D(System Max)
 Results for LC 8, D(System Max)
 Z-moment Reaction Units are k and k-ft

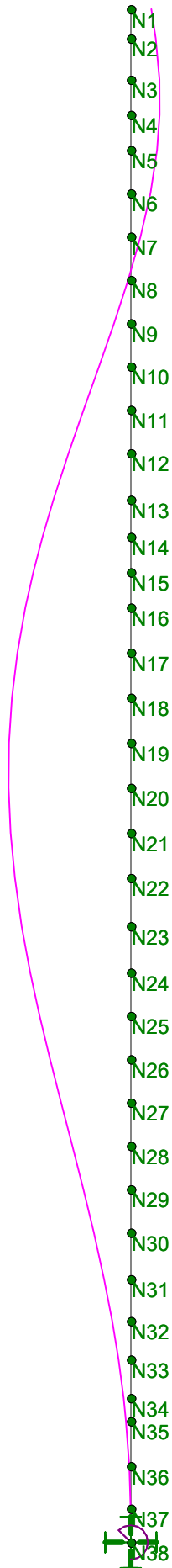
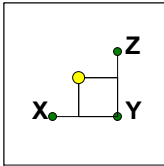


Mode Shape 1 (5.375 Sec)

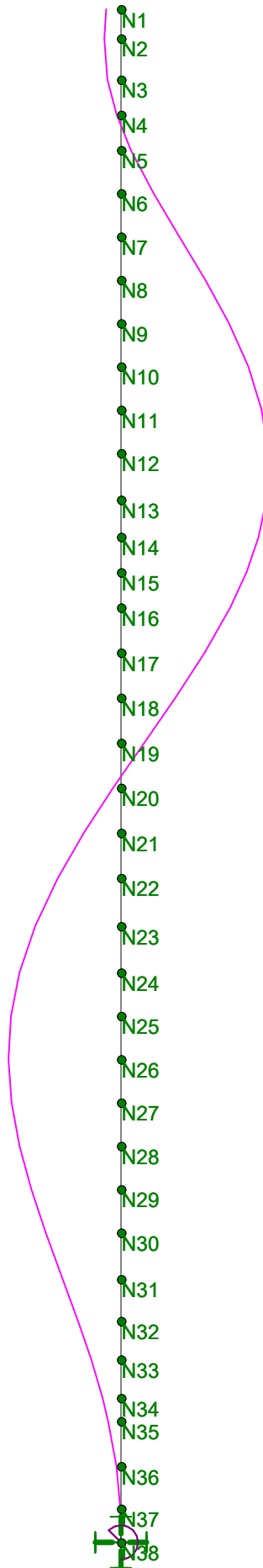
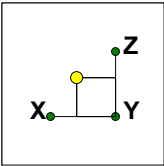




Mode Shape 2 (.988 Sec)

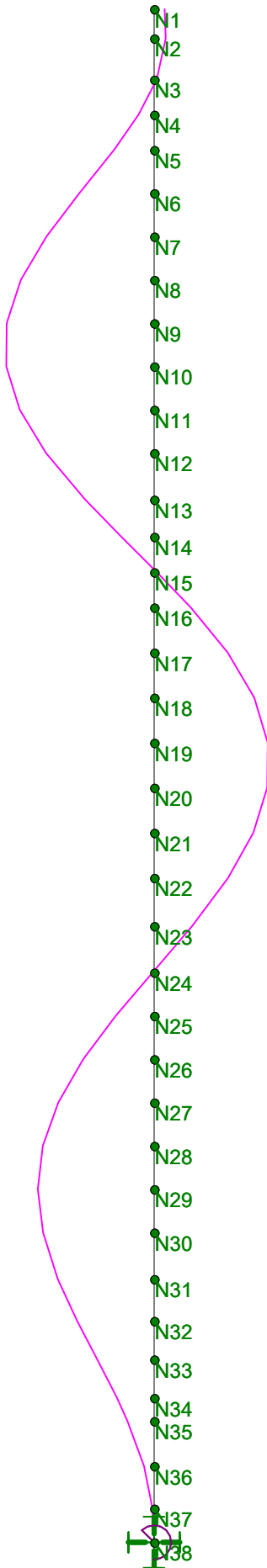
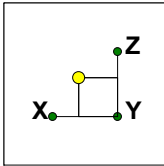


Mode Shape 3 (.359 Sec)

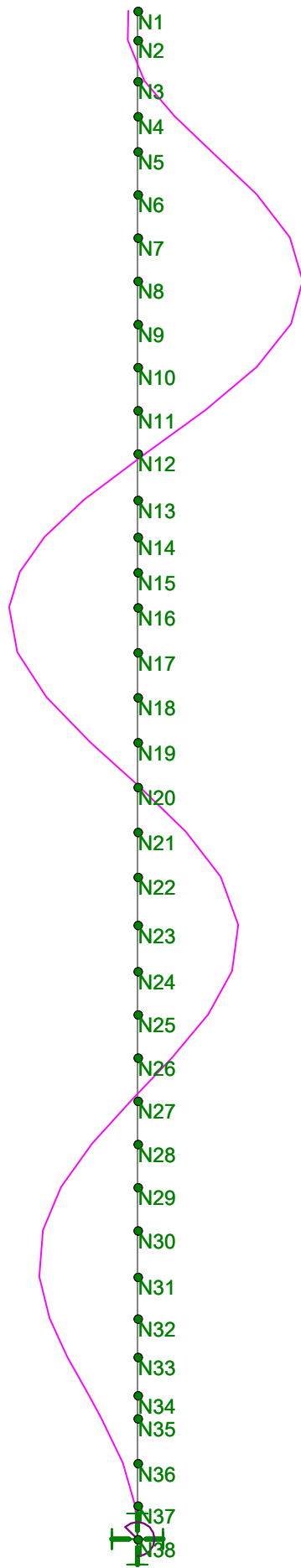
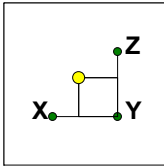


Mode Shape 4 (.148 Sec)





Mode Shape 5 (.079 Sec)



Mode Shape 6 (.051 Sec)

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SECTION 8

DATE: December 18, 2025 (Rev. 1)

ASE JOB NO.: 25-033

PROJECT: Vestas V163-4.5MW MK4 (IEC S) Wind Turbine
HH98M-TA36200-A024-4468_V01 Tubular Tower
SEVEN STARS WIND ENERGY PROJECT
Fifty (50) Towers
Near Weyburn, Saskatchewan, Canada

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Excerpts—2020 NBCC Table C-2.....	8
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IEC and 2020 NBCC Generic Wind Equivalence	11
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EARTHQUAKE DESIGN PARAMETERS:	
General Notes—Earthquake Force	13
Seismic 2020 NBCC—Earthquake Loads	14

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PROJECT SITE PARAMETERS

GENERAL NOTES

1. PROJECT DATA

- 1.1. Name:..... Seven Stars Wind Energy Project
- 1.2. Location: Near Weyburn, Saskatchewan, Canada
See Project Site Layout for location coordinates.
- 1.3. Model Building Code: The 2020 National Building Code of Canada (NBCC)
- 1.4. Local Building Code: Saskatchewan Regulations 124/2021, *The Building Code Regulations*
- 1.5. The project site parameters are summarized below and source data are compiled later in this section.

2. SITE WIND PARAMETERS. See the information in the pages that follow.

3. SITE EARTHQUAKE PARAMETERS. See the information in the pages that follow.

4. COMPARISON OF GENERIC PARAMETERS VERSUS SITE PARAMETERS

See the tables below for a comparison of wind design parameters and seismic design parameters. The generic parameters clearly govern over the site parameters. It may be concluded that the design is acceptable for use at the project site.

Compliance with the 2020 NBCC:

Project site wind pressures derived from nearby locations listed in attached excerpt from 2020 NBCC Table C-2:

- Weyburn.....0.48 kPa 1/50 year

Therefore, given the proximity to Weyburn, use the value $q_{REF}=0.48$ kPa @ 1.2929 kg/m³ standard air density with a reference wind speed at 10m of $V_{ref}=27.25$ m/s.

The WTGS configuration is based on IEC Class S design extreme wind with:

- Reference height: hub height, 98 m
- 3-sec, 50-year wind: $V_{e50}=52.5$ m/s
- Air density: $\rho = 1.225$ kg/m³

The attached wind speed comparisons show that the IEC tower design is equivalent to the following design extreme wind with:

- Static procedure
- Reference height: 10 m
- Exposure: “Open”
- Site air density: 1.173 kg/m³

- Topographic factor:¹ $C_t=1.0$
- Reference velocity: $V_{ref}=29.651$ m/s @ +10 m height
- Reference pressure: $q_{NBCC}=0.516$ kPa

Therefore:

$$q_{NBCC}=0.516 \text{ kPa (design)} > q_{REF}=0.48 \text{ kPa (site), Conservative.}$$

Based on these comparisons, it is concluded that the existing IEC Class S design for wind exceeds the wind design requirement at the new project site with NBCC $q_{ref}=0.48$ kPa. See Code Load Comparison on the following page.

5. SPECIAL CONDITIONS

None.

DESIGN PARAMETER			DESIGN VALUE [Note 1]	SITE VALUE [Note 2]	2020 NBCC ADJUSTED DESIGN VALUE	2020 NBCC VALUE
3-sec, 50-year Wind Speed at Hub Height	V_{e50}	(m/s)	52.5	50.7	52.7 [Note 3]	46.1 [Note 4]
2020 NBCC 50-yr MRI Wind Speed at reference height of +10m	V_{NBCC}	(m/s)	-	-	29.7	28.6
Air Density	ρ	(kg/m ³)	1.225	1.173	1.173	1.173

Note 1. Provided by the Turbine OEM. These parameters are the basis for the “generic” tower design.

Note 2. Provided by the Turbine OEM. These parameters are project site-specific values.

Note 3. This is the design V_{e50} design value adjusted with the site-specific air density.

Note 4. This is the **2020 NBCC** value expressed as an equivalent V_{e50} value adjusted to the site-specific air density and adjusted to hub height.

Table 8.4-1. Summary and Comparison of V_{e50} Parameters

¹ The site V_{e50} value based on site-measured data contains inherent topographic speed up, therefore, $C_t=1.0$ is taken so as not to double count the site speed up inherent in the site wind speed measurements.

Code Load Comparison 2020 NBCC

BY: NAA

Page 1 of 1

VESTAS V163 HH98M-TA36200 SEVEN STARS WIND PROJECT, SK

DATE: 12/15/2025

ASE JOB NO.: 25-033 (PROJECT SITE)

FILE: 01.1_Code_Param_Comparison_2020 NBCC.xlsx

CODE LOAD COMPARISON					
DESIGN PARAMETER			EXISTING DESIGN	NEW RE-USE	COMMENT
DESCRIPTION	SYMBOL	UNITS			
Design Code or Standard			IEC S (Wind) ASCE 7-16 (Seismic)	2020 NBCC	
Site Air Density	ρ_{AIR}	(kg/m ³)	1.225	1.173	
Reference Wind Speed (at 10m)	V_{ref}	(m/s)	N/A	29.651	> 27.249 m/s, PASS
Reference Wind Pressure (at 10m)	q	(Pa)	N/A	516	> 405, PASS
Hub Height	H_{HUB}	(m)	98	Same	
Wind Importance Factor	I		1.0	Same	
Exposure	$Exposure$		N/A	Open	
Exposure Coefficient (maximum)	C_e		N/A	1.579	
Topographic Factor (maximum)	C_t		1.00	1.000	
Reference Wind Speed (at Hub)	$V_{ref,hub}$	(m/s)	52.5	N/A	
Reference Wind Pressure (at Hub)	q	(Pa)	1688	813.9	Design is okay (see hub-height design wind pressure).
Wind Load Factor	LF		1.35	1.40	
Dynamic Factor (Gust Effect)-Baseline	C_g		1.00	2.000	
Design Wind Pressure (at Hub Height) with design wind load factor	$q_u G_f$	(Pa)	2279	2279	IEC Hub Height design pressure equivalence condition with respect to NBCC.
Seismic Importance Factor	I		N/A	1.0	
0.2-sec Mapped Spectral Response Acceleration (SRA) @ 5% damped	S_S	(g's)	1.500	N/A	
1.0-sec Mapped Spectral Response Acceleration (SRA) @ 5% damped	S_I	(g's)	0.599999 < 0.6	N/A	
Site Class	$SiteClass$		$Ddefault$	XD	
Design 0.2-sec SRA @ 5% = S_{DS} / B_S	S_{DS} / B_S	(g's)	1.200	0.290	= NBCC $S(0.2, XD) / B_S$ Design is Conservative
Design 1.0-sec SRA @ 5% = S_{D1} / B_I	S_{D1} / B_I	(g's)	1.020	0.116	= NBCC $S(1.0, XD) / B_S$ Design is Conservative
Seismic Design Category	SDC		D	SC2	
Structural System Ductility Factor	R		1.5	1.0	$R_o R_d$ per NBCC
Analytical Fundamental Period	T_B	(sec)	5.375	Same	
Seismic Response Coefficient (at 5% damping)	C_S	(g's)	0.127	0.069	
Seismic Base Shear	V	(kip)	137	74	NBCC V is much lower than the ASCE 7-16 base shear, and $R_o R_d = 1.0$ is conservative.

SITE LAYOUT

GENERAL NOTES

1. SITE LAYOUT

1.1. PROJECT SITE PLAN(S):



Saskatchewan, CAN¹



RM of Weyburn No. 67, SK²



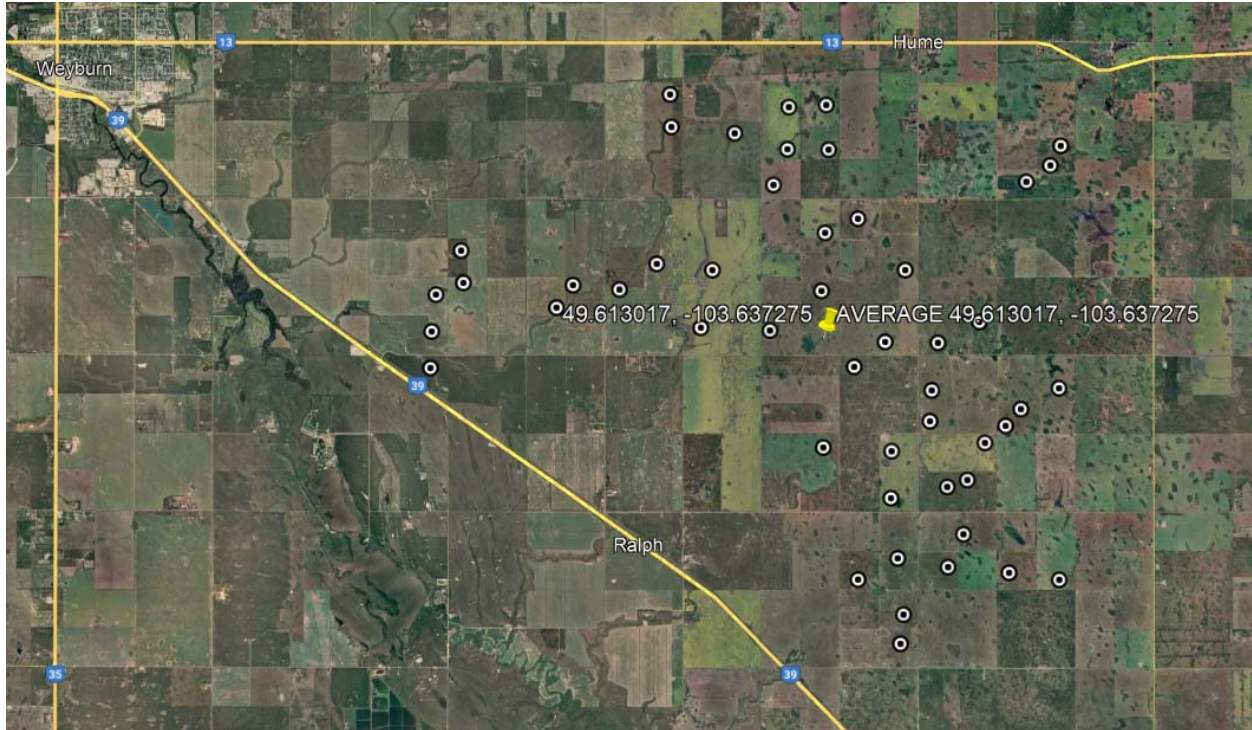
RM of Griffin No. 66, SK³

¹ By MapGrid - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=98178882>

² By awmcphoe - Own work, CC0, <https://commons.wikimedia.org/w/index.php?curid=79289574>

³ By awmcphoe - Own work, CC0, <https://commons.wikimedia.org/w/index.php?curid=79289573>

1.1. PROJECT SITE PLAN(S): (Continued)



Project Site Plan⁴

⁴ Screenshot from Google Earth

1.2. LAT-LON COORDINATES:

There are a total of 50 locations considered for the following WTGS:

- 50 x V163-4.5MW Mk4 turbines installed on Vestas HH98M-TA36200 towers

COUNT	WTG	LATITUDE	LONGITUDE	TOWER
1	1	49.614647	-103.749640	TA36200
2	2	49.621537	-103.748423	TA36200
3	3	49.607856	-103.749974	TA36200
4	4	49.623722	-103.740508	TA36200
5	5	49.629739	-103.741169	TA36200
6	6	49.622513	-103.695515	TA36200
7	7	49.651604	-103.662358	TA36200
8	8	49.612761	-103.619019	TA36200
9	9	49.658840	-103.680974	TA36200
10	10	49.652778	-103.680584	TA36200
11	11	49.615402	-103.672072	TA36200
12	12	49.627289	-103.684795	TA36200
13	13	49.593091	-103.636818	TA36200
14	14	49.619121	-103.713669	TA36200
15	15	49.587047	-103.595373	TA36200
16	16	49.635701	-103.626851	TA36200
17	17	49.597992	-103.606117	TA36200
18	18	49.616465	-103.591902	TA36200
19	19	49.568488	-103.626809	TA36200
20	20	49.570807	-103.600909	TA36200
21	21	49.556514	-103.614582	TA36200
22	22	49.572445	-103.615400	TA36200
23	23	49.612592	-103.603813	TA36200
24	24	49.626125	-103.668766	TA36200
25	25	49.569743	-103.583359	TA36200
26	26	49.568433	-103.568912	TA36200
27	27	49.561954	-103.613732	TA36200
28	28	49.600240	-103.579946	TA36200
29	29	49.604120	-103.568970	TA36200
30	30	49.593948	-103.590307	TA36200
31	31	49.614884	-103.652170	TA36200
32	32	49.649239	-103.568428	TA36200
33	33	49.645608	-103.571419	TA36200
34	34	49.642558	-103.578344	TA36200
35	35	49.623323	-103.708911	TA36200
36	36	49.608116	-103.627933	TA36200
37	37	49.656474	-103.646736	TA36200
38	38	49.656882	-103.635972	TA36200
39	39	49.633078	-103.636305	TA36200
40	40	49.648552	-103.635295	TA36200
41	41	49.648636	-103.647139	TA36200
42	42	49.641985	-103.651179	TA36200
43	43	49.583650	-103.617348	TA36200
44	44	49.597129	-103.584345	TA36200
45	45	49.622265	-103.637340	TA36200
46	46	49.626131	-103.613241	TA36200

COUNT	WTG	LATITUDE	LONGITUDE	TOWER
47	ALT1	49.603733	-103.605603	TA36200
48	ALT2	49.576928	-103.596479	TA36200
49	ALT3	49.585750	-103.601151	TA36200
50	ALT4	49.592406	-103.617153	TA36200
	AVERAGE	49.613017	-103.637275	ALL

Table C-2 (Continued)

Province and Location	Elev., m	Design Temperature				Degree-Days Below 18°C	15 Min. Rain, mm	One Day Rain, 1/50, mm	Ann. Rain, mm	Moist. Index	Ann. Tot. Ppn., mm	Driving Rain Wind Pressures, Pa, 1/5	Snow Load, kPa, 1/50		Hourly Wind Pressures, kPa	
		January		July 2.5%									S _s	S _r	1/10	1/50
		2.5% °C	1% °C	Dry °C	Wet °C											
Vermilion	580	-35	-38	29	19	5740	18	86	310	0.5	410	100	1.7	0.1	0.29	0.36
Wagner	585	-35	-38	26	19	5850	15	81	380	0.6	500	80	1.9	0.1	0.28	0.37
Wainwright	675	-33	-36	29	19	5700	20	81	310	0.5	425	120	2.0	0.1	0.29	0.36
Wetaskiwin	760	-33	-35	29	19	5500	23	86	400	0.6	500	160	2.0	0.1	0.31	0.39
Whitecourt	690	-33	-36	27	19	5650	20	97	440	0.6	550	80	1.9	0.1	0.28	0.37
Wimborne	975	-31	-34	29	18	5310	23	92	325	0.5	450	200	1.6	0.1	0.32	0.40
Saskatchewan																
Assiniboia	740	-32	-34	31	21	5180	25	81	290	0.3	375	240	1.6	0.1	0.39	0.49
Batrum	700	-32	-34	32	20	5080	23	81	270	0.4	350	260	1.2	0.1	0.43	0.54
Biggar	645	-34	-36	30	20	5720	23	81	270	0.4	350	180	2.1	0.1	0.36	0.45
Broadview	600	-34	-35	30	21	5760	25	103	320	0.5	420	160	1.7	0.1	0.36	0.46
Dafne	530	-35	-37	29	21	5860	20	92	300	0.5	380	140	1.7	0.1	0.29	0.37
Dundurn	525	-35	-37	30	21	5600	23	86	275	0.4	380	180	1.5	0.1	0.36	0.46
Estevan	565	-32	-34	32	22	5340	28	92	330	0.4	420	200	1.6	0.1	0.41	0.52
Hudson Bay	370	-36	-38	29	21	6280	20	81	340	0.6	450	80	2.0	0.1	0.29	0.37
Humboldt	565	-36	-38	28	21	6000	20	86	320	0.5	375	140	2.1	0.1	0.31	0.39
Island Falls	305	-39	-41	27	20	7100	18	76	370	0.6	510	80	2.1	0.1	0.26	0.35
Kamsack	455	-34	-37	29	22	6040	20	97	360	0.6	450	120	2.1	0.2	0.32	0.40
Kindersley	685	-33	-35	31	20	5550	23	81	260	0.4	325	200	1.4	0.1	0.36	0.46
Lloydminster	645	-34	-37	28	20	5880	18	81	310	0.5	430	120	2.0	0.1	0.32	0.40
Maple Creek	765	-31	-34	31	20	4780	25	81	275	0.3	380	220	1.2	0.1	0.36	0.45
Meadow Lake	480	-38	-40	28	20	6280	18	81	320	0.5	450	120	1.7	0.1	0.30	0.40
Melfort	455	-36	-38	28	21	6050	20	81	310	0.5	410	120	2.1	0.1	0.28	0.36
Melville	550	-34	-36	29	21	5880	23	97	340	0.5	410	160	1.7	0.1	0.32	0.40
Moose Jaw	545	-32	-34	31	21	5270	25	86	270	0.3	360	200	1.4	0.1	0.41	0.52
Nipawin	365	-37	-39	28	21	6300	20	76	340	0.6	450	100	2.0	0.1	0.30	0.38
North Battleford	545	-34	-36	29	20	5900	20	81	280	0.5	370	120	1.7	0.1	0.36	0.46
Prince Albert	435	-37	-40	28	21	6100	20	81	320	0.5	410	140	1.9	0.1	0.30	0.38

Appendix C

Table C-2 (Continued)

Province and Location	Elev., m	Design Temperature				Degree-Days Below 18°C	15 Min. Rain, mm	One Day Rain, 1/50, mm	Ann. Rain, mm	Moist. Index	Ann. Tot. Ppn., mm	Driv-ing Rain Wind Pres-sures, Pa, 1/5	Snow Load, kPa, 1/50		Hourly Wind Pressures, kPa	
		January		July 2.5%									S _s	S _r	1/10	1/50
		2.5% °C	1% °C	Dry °C	Wet °C											
Qu'Appelle	645	-34	-36	30	22	5620	25	97	340	0.5	430	160	1.7	0.1	0.33	0.42
Regina	575	-34	-36	31	21	5600	28	103	300	0.4	365	200	1.4	0.1	0.39	0.49
Rosetown	595	-34	-36	31	20	5620	23	81	260	0.4	330	200	1.7	0.1	0.39	0.49
Saskatoon	500	-35	-37	30	21	5700	23	86	265	0.4	350	160	1.7	0.1	0.36	0.46
Scott	645	-34	-36	30	20	5960	20	81	270	0.4	360	140	1.9	0.1	0.36	0.45
Strasbourg	545	-34	-36	30	22	5600	25	92	300	0.4	390	180	1.5	0.1	0.33	0.42
Swift Current	750	-31	-34	31	20	5150	25	81	260	0.3	350	240	1.4	0.1	0.43	0.54
Uranium City	265	-42	-44	26	19	7500	12	54	300	0.6	360	100	2.0	0.1	0.27	0.36
Weyburn	575	-33	-35	31	23	5400	28	97	320	0.4	400	200	1.8	0.1	0.38	0.48
Yorkton	510	-34	-37	29	21	6000	23	97	350	0.5	440	140	1.9	0.1	0.32	0.40
Manitoba																
Beausejour	245	-33	-35	29	23	5680	28	103	430	0.6	530	180	2.0	0.2	0.32	0.41
Boissevain	510	-32	-34	30	23	5500	28	119	390	0.5	510	180	2.2	0.2	0.41	0.52
Brandon	395	-33	-35	30	22	5760	28	108	375	0.6	460	180	2.1	0.2	0.39	0.49
Churchill	10	-38	-40	25	18	8950	12	76	265	0.8	410	260	3.0	0.2	0.43	0.55
Dauphin	295	-33	-35	30	22	5900	28	103	400	0.6	490	160	1.9	0.2	0.32	0.40
Flin Flon	300	-38	-40	27	20	6440	18	81	340	0.6	475	80	2.2	0.2	0.28	0.35
Gimli	220	-34	-36	29	23	5800	28	108	410	0.7	530	180	1.9	0.2	0.32	0.40
Island Lake	240	-36	-38	27	20	6900	18	86	380	0.7	550	80	2.6	0.2	0.29	0.37
Lac du Bonnet	260	-34	-36	29	23	5730	28	103	445	0.7	560	180	1.9	0.2	0.29	0.37
Lynn Lake	350	-40	-42	27	19	7770	18	86	310	0.6	490	100	2.4	0.2	0.29	0.37
Morden	300	-31	-33	30	24	5400	28	119	420	0.6	520	180	2.2	0.2	0.41	0.52
Neepawa	365	-32	-34	29	23	5760	28	108	410	0.6	470	180	2.2	0.2	0.35	0.44
Pine Falls	220	-34	-36	28	23	5900	25	97	440	0.7	420	180	1.9	0.2	0.31	0.39
Portage la Prairie	260	-31	-33	30	23	5600	28	108	390	0.5	525	180	2.1	0.2	0.36	0.46
Rivers	465	-34	-36	29	23	5840	28	108	370	0.6	460	180	2.1	0.2	0.36	0.46
Sandilands	365	-32	-34	29	23	5650	28	113	460	0.6	550	180	2.2	0.2	0.32	0.40
Selkirk	225	-33	-35	29	23	5700	28	108	420	0.6	500	180	1.9	0.2	0.32	0.41

TOPOGRAPHIC FACTOR

GENERAL NOTES

The 2020 NBCC topographic factor C_t is taken as 1.0 at hub height for this project. The topographic factor is taken as 1.0 in this case, not to imply that there is no wind speed up, but rather so as not to “double count” the effect already accounted for in the site-measured V_{e50} wind speed.

VIEC to V_2020 NBCC (STATIC)

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VESTAS V163 HH98M-TA36200 TOWER

DATE: 12/14/2025

ASE JOB NO.: 25-033 (PROJECT SITEFILE: 07.0_V_IEC_to_NBCC2020-v2022-08-28-rho1.2929-Exp Open.xlsx)

	A	B	C	D	E	F	G
2	CALCULATE 2020 V_{NBCC} FROM V_{IEC} USING FORCE EQUIVALENCE						
3							
4	IEC Parameters:						
5	Hub Height	H_{HUB}	(m)	98			
6	IEC Standard Air Density	ρ_{IEC}	(kg/m ³)	1.225	@ IEC Std. @ tower design		
7	IEC Loads Document Wind Speed	V_{IEC}	(m/s)	52.5	@ IEC @ tower design		
8	Estimated Dynamic Factor	DAF		1.00			
9	Natural frequency increase factor	NIF		1.00			
10	IEC extreme wind pressure	q_{IEC}	(pa)	1688			
11	$q_{IEC} = \frac{1}{2}\rho_{IEC} V_{es0}^2 (DAF)(NIF)$	q_{IEC}	(psf)	35.26			
12							
13	2020 NBCC						
14	Procedure	$Proc$		STATIC			
15	Exposure	$Exposure$		Open			
16	Power Law Exponent	α		0.20			
17	Reference Height (in denominator)	z_{REF}	(m)	10.0			
18	Minimum Limit for Exposure Factor	$C_{e,MIN}$		0.9			
19	Coefficient	$Coeff$		1.0			
20	Exposure Factor	C_e		1.579			
21	Topographic Factor	C_t		1.000			
22							
23	Wind Importance Factor	I_W		1.00			
24	Air Density to use (Site or NBCC)	ρ_{NBCC}	(kg/m ³)	1.2929			
25							
26	CALCULATE V_{NBCC} and C_g						
27	NBCC Wind Speed	V_{NBCC}	(m/s)	28.243			
28	Gust Effect Factor	C_g		2.000			
29	NBCC Reference Velocity Pressure	q_{NBCC}	(pa)	515.65	For use with $C_g=2.0$		
30		q_{NBCC}	(psf)	10.77			
31	NBCC Hub $q_{NBCC} C_e C_t C_g I_W$	P_{HUB}	(pa)	1628			
32		P_{HUB}	(psf)	34.00			
33	NBCC Hub Wind Speed @ ρ_{NBCC}	V_{HUB}	(m/s)	50.18			
34							
35	Force equivalence is based on factored forces and is defined as follows:						
36	Set $(LF_{IEC})F_{XY_{IEC}} = (LF_{NBCC})F_{XY_{NBCC}}$						
37	IEC wind load factor	LF_{IEC}		1.35	@ DLC 6.1		
38	NBCC wind load factor	LF_{NBCC}		1.40			
39	$(LF_{IEC})\frac{1}{2}\rho V_{IEC}^2 (DAF)(NIF)A_{EFF} = (LF_{NBCC})\frac{1}{2}\rho V_{NBCC}^2 C_e C_t C_g I_W A_{EFF}$ (All in consistent units.)						
40	Then solve for (and iterate to find) V_{NBCC} and C_g						
41							
42	BASELINE (RIGID) PARAMETERS						
43	Gust Effect Factor	C_g		2.000			
44	NBCC Reference Wind Speed	V_{NBCC}	(m/s)	28.243	@ C_g		
45	NBCC Reference Velocity Pressure	q_{NBCC}	(pa)	515.650	@ 1.2929 kg/m ³		
46							

VIEC to V_2020 NBCC (STATIC)

BY: NAA

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VESTAS V163 HH98M-TA36200 TOWER

DATE: 12/14/2025

ASE JOB NO.: 25-033 (PROJECT SITE) FILE: 07.1_V_IEC_to_NBCC2020-v2022-08-28-rhoSITE-Exp Open.xlsx

	A	B	C	D	E	F	G
2	CALCULATE 2020 V_{NBCC} FROM V_{IEC} USING FORCE EQUIVALENCE						
3							
4	IEC Parameters:						
5	Hub Height	H_{HUB}	(m)	98			
6	IEC Standard Air Density	ρ_{IEC}	(kg/m ³)	1.225	@ IEC Std. @ tower design		
7	IEC Loads Document Wind Speed	V_{IEC}	(m/s)	52.5	@ IEC @ tower design		
8	Estimated Dynamic Factor	DAF		1.00			
9	Natural frequency increase factor	NIF		1.00			
10	IEC extreme wind pressure	q_{IEC}	(pa)	1688			
11	$q_{IEC} = \frac{1}{2}\rho_{IEC} V_{IEC}^2 (DAF)(NIF)$	q_{IEC}	(psf)	35.26			
12							
13	2020 NBCC						
14	Procedure	$Proc$		STATIC			
15	Exposure	$Exposure$		Open			
16	Power Law Exponent	α		0.20			
17	Reference Height (in denominator)	z_{REF}	(m)	10.0			
18	Minimum Limit for Exposure Factor	$C_{e,MIN}$		0.9			
19	Coefficient	$Coeff$		1.0			
20	Exposure Factor	C_e		1.579			
21	Topographic Factor	C_t		1.000			
22							
23	Wind Importance Factor	I_W		1.00			
24	Air Density to use (Site or NBCC)	ρ_{NBCC}	(kg/m ³)	1.1730			
25							
26	CALCULATE V_{NBCC} and C_g						
27	NBCC Wind Speed	V_{NBCC}	(m/s)	29.651			
28	Gust Effect Factor	C_g		2.000			
29	NBCC Reference Velocity Pressure	q_{NBCC}	(pa)	515.65	For use with $C_g=2.0$		
30		q_{NBCC}	(psf)	10.77			
31	NBCC Hub $q_{NBCC} C_e C_t C_g I_W$	P_{HUB}	(pa)	1628			
32		P_{HUB}	(psf)	34.00			
33	NBCC Hub Wind Speed @ ρ_{NBCC}	V_{HUB}	(m/s)	52.68			
34							
35	Force equivalence is based on factored forces and is defined as follows:						
36	Set $(LF_{IEC})F_{XY_{IEC}} = (LF_{NBCC})F_{XY_{NBCC}}$						
37	IEC wind load factor	LF_{IEC}		1.35	@ DLC 6.1		
38	NBCC wind load factor	LF_{NBCC}		1.40			
39	$(LF_{IEC})\frac{1}{2}\rho V_{IEC}^2 (DAF)(NIF)A_{EFF} = (LF_{NBCC})\frac{1}{2}\rho V_{NBCC}^2 C_e C_t C_g I_W A_{EFF}$ (All in consistent units.)						
40	Then solve for (and iterate to find) V_{NBCC} and C_g						
41							
42	BASELINE (RIGID) PARAMETERS						
43	Gust Effect Factor	C_g		2.000			
44	NBCC Reference Wind Speed	V_{NBCC}	(m/s)	29.651	@ C_g		
45	NBCC Reference Velocity Pressure	q_{NBCC}	(pa)	568.358	@ 1.2929 kg/m ³		
46							

EARTHQUAKE FORCE

GENERAL NOTES

The project site's spectral parameters are less than the assumed seismic design parameters in the generic calculation in Section 7. The attached calculations show that the project site's design earthquake loads do not govern over the seismic design loads used in the generic design. Therefore, by inspection and the attached base shear calculations, it is concluded that the existing design is adequate for the Code seismic loading at the site.

SEISMIC 2020 NBCC

BY: NAA

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VESTAS V163 HH98M-TA36200 TOWER, SEVEN STARS WIND PROJECT, SK

DATE: 12/14/2025

ASE JOB NO.: 25-033 (PROJECT SITE)

FILE: 15_SEISMIC_2020 NBCC.xlsx

	A	B	C	D	E
1	DESCRIPTION	SYMBOL	UNITS		
2					
3	SEISMIC BASE SHEAR PER 2020 NATIONAL BUILDING CODE OF CANADA (NBCC)				
4					
5	Project Name			Seven Stars Wind Project	
6	Project Location			Near Weyburn, Saskatchewan, Canada	
7	Tower Designation			V163-4.5MW (IEC S) HH98M-TA36200	
8	NBCC Selected Map Location			NRC on-line Hazard Calculator values	
9					
10	Site Class	S		D	
11	Site Designation	X_s		X_p	
12	Site Modified Spectral Points S(T, X):				
13	$S_a(0.2, X)$	$S_a(0.2, X)$	(gee)	0.290	
14	$T \leq 0.2$ s: Use MAX[$S_a(0.2, X)$, $S_a(0.5, X)$]	$S_a(0.2, X)$	(gee)	0.290	
15	$T = 0.5$ s: $S_a(0.5, X)$	$S_a(0.5, X)$	(gee)	0.231	
16	$T = 1.0$ s: $S_a(1.0, X)$	$S_a(1.0, X)$	(gee)	0.116	
17	$T = 2.0$ s: $S_a(2.0, X)$	$S_a(2.0, X)$	(gee)	0.046	
18	$T = 5.0$ s: $S_a(5.0, X)$	$S_a(5.0, X)$	(gee)	0.010	
19	$T = 10.0$ s: $S_a(10.0, X)$	$S_a(10, X)$	(gee)	0.003	
20		PGA	(gee)	0.182	
21	Seismic Importance Factor	I_E	(-)	1.0	
22		$I_E S(0.2)$	(gee)	0.29	
23		SC _{0.2}		SC2	
24		$I_E S(1.0)$	(gee)	0.116	
25		SC _{1.0}		SC2	
26	Governing Seismic Category SC	SC		SC2	
27	Tower Height	h_n	(m)	98	
28	4.1.8.7(a): SC1 or SC2?			YES	
29	4.1.8.7(b): Regular structure < 60 m?			NO	
30	4.1.8.7(c): Irregularities?			NO	
31	4.1.8.11 Equivalent Static Force Proc?			YES	
32	Approximate Period	T_{a_prox}	(s)	1.557	
33	Analytical Period	T_B	(s)	5.375	
34	Coefficient for Upper Limit on T_{a_prox}	C_U		1.0	
35		T_{a_limit}	(s)	1.557	Note: This is N/A to nonbldg.
36	Period to Use for Calculation	T_a	(s)	5.375	
37		$S(T_a)$	(gee)	0.009	
38		R_d		1.00	
39		R_o		1.00	
40	Height Restrictions			n/a	Design by Proprietary Methods
41	$S(0.2)/S(5.0)$	Ratio		29.652	
42	Higher Mode Factor	M_v		1.50	
43	Base Overturning Reduction Factor	J		0.52	
44		C_{sl}	(gee)	0.014	
45		C_{s_min}	(gee)	0.069	
46		C_{s_max}	(gee)	N/A	V_{max} is N/A at $R_d < 1.5$
47		C_s	(gee)	0.069	
48		W	(k)	1075.700	
49	$V = C_s W$	V	(k)	74.713	Small, ∴ NBCC Seismic does NOT govern over Wind

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