

Design of an autonomous off-shore crane

Adrian Johnsson Hetland
Emilie Gjesdal

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Western Norway
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Applied Sciences

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Adrian Johnsson Hetland
Emilie Gjesdal

Department of Mechanical- and Marine Engineering
Western Norway University of Applied Sciences
NO-5063 Bergen, Norge

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Institutt for Maskin- og Marinfag
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NO-5063 Bergen, Norge

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Author(s), student number:

Adrian Johnsson Hetland 585059

Emilie Gjesdal 585926

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Supervisor at HVL:

Zhenhui Liu

Assigned by:

IKM Tech Team Solutions

Contact person:

Ingvar Wølner, Sofie Brun and Terje Solheim

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Preface

This bachelor thesis is written at the department of Mechanical and Marine engineering at Western University of Applied Sciences (WHUAS) in the Ocean and Marine Technology Engineering study programmes. The internal academic supervisor from WHUAS is Zhenhui Liu. The thesis represents 20 credit points which corresponds to 540 working hours. The subject is given by Ingvar Wølner, Terje Solheim and Sofie Brun from IKM Tech Team Solutions, Figure 1.

It has been both challenging and exciting to work on this project and use our engineering skills to design and structural analyse an autonomous crane. The thesis has presented calculation and information necessary to create a load chart in terms of the requirements stated in the introduction 1.

The writing process has been educational both in retrieving information from standards and managing different tools to handle the information and carry out the thesis. Excel [1], Mathcad [2] and Ansys [3] has been used for determining the affection of forces on the crane. Excel has been a useful tool to collect all information needed and create tables to display results. It has also been necessary to perform the calculations and optimize the crane where macros were essential, as described in Section 6.2.1. The load charts displayed in the results 6 were created by using the values from the macros in the Excel spread sheet. The calculations were also done in Mathcad which made it possible to display each formula in addition to check the answers with the Excel spreadsheet. The crane was also modelled in SpaceClaim and analysed in Ansys. Here the crane was optimized further by adding plates for strengthening. By testing the crane in Ansys, we were able to conclude with the calculated results as the crane could carry the necessary hook load in accordance with the calculated dimensions. It also gave an idea on what the crane looked like as a finished product with all the components.

We highly appreciate the assistance received from our supervisor Zhenhui Liu who has accompanied with weekly meetings, guiding us through this thesis. Thank you for providing relevant feedback and being available at all times of the day through the whole semester. We want to sincerely thank our supervisors from IKM, Ingvar Wølner, Terje Solheim and Sofie Brun for their advice and providing an office for us to work in. A special thanks to Ingvar Wølner for all support during calculations and for guidance in Excel and Ansys.



Figure 1: IKM logo [4].

Abstract

In this bachelor's thesis, a stress analysis has been presented for an offshore autonomous crane in accordance with the offshore crane standards NORSOK R-002 G11.1 [5] and NS-EN 13852-1:2013 [6]. The crane has been inspected for local and global buckling according to DNVGL-RP-C202 [7] and DNVGL-CG-0128 [8]. EN 1993-1-1: Eurocode 3 [9], EN 1993-1-5: Eurocode 3 [10] and DNVGL-ST-0378 [11] has also been used to carry out calculations for the crane components. The wire rope was checked according to CEN/TS 13001-3-2 [12].

A load chart has been created for significant wave heights, H_s , from 0 to 6 meters at different angles of the crane arm. The crane has been tested for lifting a minimum load of 15 tonnes at 0 meters significant wave height and 5 tonnes at 6 meters significant wave height with one fall. To give the crane the ability to lift heavier, it has also been designed capable of lifting with two falls. This gives the crane the ability to lift the double amount of weight. The thesis carries out a description of each crane component with calculations for the maximum utilization factors. All safety factors used for calculations are stated, and the most principal stress formulas has been explained. Excel and Mathcad are used to perform all the calculations for optimizing and strengthening the crane. Macros in Excel has also been used to adjust the maximum load weight at the different boom angles and significant wave heights by controlling the utilization of each crane component.

The crane was analysed in Ansys to conclude with the results of the empirical data and strengthen the necessary parts and avoid unwanted stress. To get the most critical results, the crane had to be checked where the moment and torsion had the highest impact. This implies, the crane had to be analysed at a straight boom angle and at a 90-degree boom angle. Finally, suggestions for future improvements have been made.

Sammendrag

I denne bacheloroppgaven er det presentert en spenningsanalyse for en autonom offshore kran i henhold til offshore standarden NORSOK R-002 G11.1 [5] og NS-EN 13852-1:2013 [6]. Kranen er undersøkt for lokal og global knekking i henhold til DNVGL-RP-C202 [7] og DNVGL-CG-0128 [8]. EN 1993-1-1: Eurocode 3 [9], EN 1993-1-5: Eurocode 3 [10] og DNVGL-ST-0378 [11] har også blitt brukt til å utføre beregninger for de forskjellige komponentene på kranen. Ståltauet ble kontrollert i henhold til CEN/TS 13001-3-2 [12].

Det har blitt laget et lastkart for signifikante bølgehøyder, H_s , fra 0 til 6 meter ved ulike vinkler på kranens arm. Kranen har blitt laget for å kunne løfte minimum 15 tonn ved 0 meter signifikant bølgehøyde og 5 tonn ved 6 meter signifikant bølgehøyde på ett fall. For å gi kranen muligheten til å løfte tyngre, er den også designet for å kunne løfte med to fall. Dette gir kranen muligheten til å løfte dobbel vekt. Oppgaven inneholder en beskrivelse av hver enkelt komponent med beregninger for maksimale utnyttelsesfaktorer. Alle sikkerhetsfaktorer som brukes til beregninger er oppgitt og de mest prinsipielle spenningsformlene er forklart. Excel og Mathcad ble benyttet for utføring av beregningene, samt optimalisering og forsterking av kranen. Makroer i Excel har blitt brukt til å justere maksimal lastvekt ved de forskjellige bomvinklene og signifikante bølgehøyder ved å kontrollere utnyttelse til de ulike kran delene.

Kranen ble analysert i Ansys for å konkludere med resultatene og styrke de nødvendige delene samt forminskning av uønskete spenninger. Kranen ble analysert ved de største spenningene for ett og to fall. Kranens arm gir ulike utfall av moment og torsjon, dermed blir kranen testet for rett bom og 90 grader vinkel mellom bommene. Til slutt har forslag til fremtidige forbedringer blitt redegjort for.

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Nomenclature

Inputs

f_{falls}	Number of falls	[-]
H_s	Significant wave height	[m]
R_n	Rated capacity	[tonne]
Rad	Radius	[m]
α	Degrees	[-]

Factors

K_H	Hosting velocity factor	[-]
K_R	Radial velocity factor	[-]
K_L	Lateral velocity factor	[-]
$\gamma_{selfweight}$	Load factor for selfweight	[-]
$\gamma_{hookload}$	Load factor for hook load	[-]
γ_n	Risk coefficient	[-]
γ_m	Resistance coefficient	[-]

Information

v_{Smax}	Max hosting speed	[m/s]
W_{limit}	Limit Weight	[tonne]
v_{Smin}	Min hosting speed	[m/s]
W_{max}	Max weight	[tonne]
v_{slew}	Max slewing speed	[m/s]
v_S	Max steady hosting velocity	[m/s]
v_D	Vertical velocity load	[m/s]
v_C	Vertical velocity crane boom tip	[m/s]
v_R	Relative velocity	[m/s]
v_H	Steady hosting velocity	[m/s]
E_w	Modulus of elasticity of rope	[kN/mm ²]
d_{rope}	Diameter of wire rope	[mm]
f	Fill factor	[-]
A_{eff}	Effective steel area of wire rope	[mm ²]
L_w	Length of wire rope	[mm]
L_s	Contribution to total hook deflection	[mm]
C	Crane stiffness	[kN/m]
ϕ_n	Dynamic amplification factor	[-]

Wire rope

W_{rope}	Weight of wire rope	[tonne]
$W_{hoistblock}$	Weight of hoist block	[tonne]
l_{rope}	Length of rope	[m]
MBL	Minimum breaking load	[kN]
ds	Minimum sheave diameter	[mm]
n_s	Number of fixed sheaves in boom	[-]
n_m	Mechanical advantage	[-]
D_{sheave}	Sheave diameter	[mm]
$d_{bearing}$	Bearing diameter	[mm]
η_s	Sheave efficiency	[-]
η_{tot}	Total rope reeving efficiency	[-]
Z_p	Safety factor for R_n	[-]
X_{RN}	Load reference factor	[-]
γ_{rb}	Dynamic DF	[-]
$W_{dynamic}$	Dynamic load	[tonne]
$UF_{staticwire_rop}$	Static utilization factor rope	[-]
$UF_{dynamicwire_rop}$	Dynamic utilization factor rope	[-]

Pedestal and pedestal adapter

OD	Outer diameter	[mm]
t	Wall thickness	[mm]
L	Buckling length	[mm]
E	Elastic modulus	[GPa]
f_y	Yield strength	[MPa]
W	Weight	[tonne]
S_a	Section area	[mm ²]
S_m	Section modulus	[mm ³]
y	y-centroid	[mm]
M	Moment of inertia	[mm ⁴]
Z	Z	[-]
ζ	Curvature factor	[-]
ρ	Imperfection factor	[-]
$C_{buckling}$	Reduced buckling coefficient	[-]
σ_{sig}	Elastic buckling stress	[MPa]
σ_{sigcr}	Allowable buckling stress in pedestal	[MPa]
F_{axial}	Axial load resistance	[kN]
$M_{r_{bending}}$	Bending moment resistance	[kN·m]
$M_{bending}$	Bending moment	[tonne·m]
F_{axial}	Axial force	[tonne]
$\sigma_{bending}$	Bending stress	[MPa]
σ_{axial}	Axial stress	[MPa]
$\sigma_{combined}$	Combined stress	[MPa]
UF	Utilization factor	[-]

Hoist winch

W_{winch}	Weight of hoist winch	[kg]
DAF_{winch}	Dynamic amplification factor winch	[-]
SL_{Rd}	Static pull capacity	[tonne]
DL_{Rd}	Dynamic winch capacity	[tonne]
DL_f	Dynamic load in hoist winch	[tonne]
$UF_{static_{winch}}$	Static utilization factor winch	[-]
$UF_{dynamic_{winch}}$	Dynamic utilization factor winch	[-]

Slewing bearing 1 and 2

W_{slew_1}	Weight of slew bearing 1	[kg]
W_{slew_2}	Weight of slew bearing 2	[kg]
$M_{bending_{slew}}$	Bending moment slew bearing	[N·mm]
$F_{axial_{slew}}$	Axial force slew bearing	[kN]
$F_{r_{slew}}$	Radial force on slew bearing	[kN]
R_{slew}	Bolt yield strength	[MPa]
A_{slew}	Stress area for M43 bolts	[mm ²]
pr_{slew}	Pretension of bolt relative to yield strength	[-]
m_{slew}	Number of bolts	[-]
D_{slew}	Raceway diameter	[mm]
β	β	[-]
$F_{A_{slew}}$	Force A	[kN]
$F_{R_{slew}}$	Force R	[kN]
x_{slew}	Rotation between horizontal and vertical raceway load per bolt sector	[-]
a_{slew}	a	[mm]
b_{slew}	b	[mm]
c_{slew}	c	[mm]
C_{slew}	Capacity of slew bearing	[kN]
$\gamma_{lae_{slew}}$	Lever arm effect of slew bearing	[-]
$\sigma_{bolt_{slew}}$	Bolt stress	[MPa]
UF_{slew}	Utilization factor slew bearing	[-]

Boom

E	Elastic modulus	[GPa]
f_y	Boom yield strength	[MPa]
l_{boom_1}	Boom 1 length	[mm]
l_{boom_2}	Boom 2 length	[mm]
y_{boom_1}	Boom 1 y	[mm]
y_{boom_2}	Boom 2 y	[mm]
l_{arm}	Arm length	[mm]
W_{boom_1}	Boom 1 weight	[kg]
W_{boom_2}	Boom 2 weight	[kg]
l_e	Length between points of zero bending moment	[mm]
ϵ	Strain	[-]

Boom sections

$W_{section_{2_1}}$	Weight section 2 to boom 1 tip	[kg]
$l_{section_{2_2}}$	Length section 2 to boom 2 tip	[mm]
$W_{section_{3_2}}$	Weight section 3 to boom 2 tip	[kg]
$l_{section_{3_2}}$	Length section 3 to boom 2 tip	[mm]
$Y_{section_{3_2}}$	Y section 3 to boom 2 tip	[mm]
$W_{section_{4_2}}$	Weight section 4 to boom 2 tip	[kg]
$l_{section_{4_2}}$	Length section 4 to boom 2 tip	[mm]
$Y_{section_{4_2}}$	Y section 4 to boom 2 tip	[mm]
x_m	Position of section distance from boom pivot	[m]
h_m	Height of boom at section	[mm]
b_m	Width of boom at section	[mm]
t_{fbm}	Bottom flange thickness	[mm]
t_{ftm}	Top flange thickness	[mm]
t_{fwm}	Web flange thickness	[mm]
A_{x_m}	Gross area	[mm ²]
A_1	Area 1	[mm ²]
A_2	2x Area 2	[mm ²]
A_3	Area 3	[mm ²]
W_{eym}	Section modulus, strong axis	[mm ³]
W_{ezm}	Section modulus, weak axis	[mm ³]
ψ_{bottom}	Stress ratio	[-]
$k_{\sigma_{bottom}}$	Buckling coefficient	[-]
$\lambda_{p_{bottom}}$	Lambda-p	[-]
ρ_{bottom}	Rho	[-]
$B_{eff_{bottom}}$	Effective length	[mm]
$A_{eff_{bottom}}$	Area bottom flange	[mm ²]
$A_{eff_{top}}$	Area top flange	[mm ²]
ψ_{web}	Stress ratio	[-]
$k_{\sigma_{web}}$	Buckling coefficient	[-]
$\lambda_{p_{web}}$	Lambda-p	[-]
ρ_{web}	Rho	[-]
$B_{eff_{web}}$	Effective length	[mm]
be_1	be1	[mm]
be_2	be2	[mm]
$A_{eff_{web}}$	Area web	[mm ²]
$A_{eff_{total}}$	Effective area	[mm ²]
A_{eff_1}	Effective area 1	[mm ²]
y_1	y 1	[mm]
$A_{eff_{2_1}}$	Effective area 2 ₁	[mm ²]
$A_{eff_{2_2}}$	Effective area 2 ₂	[mm ²]
$A_{eff_{2_3}}$	Effective area 2 ₃	[mm ²]
y_{2_1}	y 2-1	[mm ²]
y_{2_2}	y 2-2	[mm ²]
y_{2_3}	y 2-3	[mm ²]

A_{eff3}	Effective area 3	[mm ²]
y_3	y 3	[mm]
$Y_{effcentroid}$	Effective Y centroid	[mm]
$y_{1newcentroid}$	Y for new effective area 1	[mm]
$y_{21newcentroid}$	Y for new effective area 2 ₁	[mm]
$y_{22newcentroid}$	Y for new effective area 2 ₂	[mm]
$y_{23newcentroid}$	Y for new effective area 2 ₃	[mm]
$y_{3newcentroid}$	Y for new effective area 3	[mm]
S_{a1}	Section area 1	[mm ⁴]
S_{a21}	Section area 2 ₁	[mm ⁴]
S_{a22}	Section area 2 ₂	[mm ⁴]
S_{a23}	Section area 2 ₃	[mm ⁴]
S_{a3}	Section area 3	[mm ⁴]
I_{effy}	Second moment of area I _y	[mm ⁴]
W_{effy}	Effective area modulus	[mm ³]
$F_{shearselfweight}$	Shear boom selfweight only	[tonne]
$M_{bendingselfweight}$	Bending moment selfweight only	[tonne·m]
$F_{shearhookload}$	Shear boom hook load only	[tonne]
$M_{bendinghookload}$	Bending moment hook load only	[tonne·m]
M	Total design load	[tonne·m]
$\sigma_{bending}$	Bending stress	[MPa]
F_{shear}	Shear force	[tonne]
T	Torsion force	[tonne·m]
σ_{shear}	Shear stress	[MPa]
τ_{web}	Torsion web	[MPa]
τ_{flange}	Torsion flange	[MPa]
σ_{vweb}	Von Mises web	[MPa]
$\sigma_{vflange}$	Von Mises flange	[MPa]
UF_{web}	Utilization factor web	[-]
UF_{flange}	Utilization factor flange	[-]

1 Introduction

The thesis contains load chart calculations for an autonomous crane designed for offshore lifting. The crane is designed in accordance with the NS-EN 13852-1:2013 [6] standard. The crane layout is shown in Figure 11.

According to NORSOK R-002 G11.1 [5], the following requirements shall be met for the a standard purpose offshore crane:

- The crane shall be able to lift a minimum load of 15 tonnes from a supply vessel at a horizontal distance of 32 m from the outside of the installation, measured at sea level, at a significant wave height $H_s = 0$ m;
- The crane shall be able to lift a minimum load of 5 tonnes from a supply vessel at a horizontal distance of 20 m to 30 m from the outside of the installation at minimum required horizontal and vertically hook velocities, measured at sea level, at significant wave height $H_s = 6$ m.

Load charts are produced for single and double fall lifting. The calculations for lifting were performed in steps of 0,5 m H_s .

The thesis is provided by IKM Tech Team Solutions who is a specialist engineering company in structure calculation and drawing for the land and offshore industry. They have provided several stress analysis and load chart calculations for cranes [13].

1.1 Motivation and background

An autonomous offshore crane is a step in the autonomous revolution. The new technology and innovation in autonomous cranes will make operating possible only with surveillance from onshore. The use of autonomous cranes are therefore cost effective and prevent the risk of human lives. For this reason, structure calculation of an autonomous crane is exciting and can be highly relevant for future work.



Figure 2: Illustration showing the crane on a rig, from [14].

The design has been modified after the calculated utilization factors. Figure 2 shows an animated figure of the crane positioned on a rig.

1.2 Aim

The aim of the thesis is to carry out a stress analysis and load chart calculation of an autonomous offshore crane, which has an unconventional elbow boom design as shown in Figure 3.



Figure 3: Figure showing the crane.

1.3 Scope of work

This thesis will cover the following:

- Description of the crane structure.
- Manual calculations on stress and buckling to verify the numerical simulation results.
- Offboard and onboard dynamic load charts.
- A SpaceClaim 3D-model and simulation of the crane.
- A finite element analysis for the crane under various lift loads, performed in Ansys.
- The structural capacity of main components shall be checked.
- Design optimization recommendation will be performed based on the results.
- The structural integrity of the crane will be checked according to relevant standards/codes.
- The simplified dynamic load charts will be obtained.

1.4 Limitations and assumptions

The thesis is written based on information provided by IKM Tech Team Solutions.

Limitations and assumptions for the thesis have been listed below:

- Load charts are produced only for single and double fall lifting.
- Offlead and sidelead are not included to simplify calculations in this thesis.
- Existing slewing bearings, wire rope and hoist winch are used in calculations.
- Global buckling on boom is not calculated as the axial stress is negligible.
- The calculations are limited to the main parts only. Details such as bolts (except the bolts on the slewing bearings), welds and flanges are not calculated.
- Only load case I – crane without wind will be calculated as this is the dimensioning case for cranes with relative short boom length.
- The boom is designed with the same top and bottom flange thickness.
- The crane will not be used for personnel lifting.
- The DAF formulas used for calculations in this thesis are based on EN 13852-1:2013 [6].

1.5 Disposition

The thesis begins with a short introduction introducing the aim of the report.

Section 2 presents the theoretic background and relevant theories.

In Section 3 each part of the crane is described. Figures of the crane structure are also provided. The section also defines the material used and describes the standards and safety factors used to provide calculations.

Section 4 presents the different program tools used to carry out the thesis.

Section 5 contains the most principal calculations for calculating the utilization factors for each crane component. Information about the FEA analysis is also provided.

Section 6 presents the results and discussions. The capacity of each crane component is presented using tables. Load charts from the Excel sheet are displayed in addition to the macros used to conclude the loads. The FEA analysis is also submitted in this section and compared with the manual calculations.

Section 7 contains the conclusion with ideas for further work.

2 Theoretic background and relevant theories

In this section, the theoretic background and relevant theories are presented. The section describes principles and theories used in the calculations.

2.1 Theoretic background

This section presents the theoretic background.

This thesis is based on an industry report [13] which IKM Tech Team Solutions has provided as a guidance. The report consists of a stress analysis and load chart calculations of a more traditional offshore crane. The load chart in the report is accordance with the EN 13852-1 [6]. The report consist of crane data to a typical box boom crane with hydraulic cylinders to lift the boom. The utilization of the main crane components is illustrated in tables as well as the main capacity of crane formulas.

2.1.1 Autonomous crane

The concept in this thesis is based on slewing bearings instead of winches or hydraulic cylinders for lifting (luffing) the boom. This will give give less maintenance and easier functional testing before and after use, which is done from onshore through visual inspection camera.

The crane operates like a robot with pre-defined lifting sequences and only with surveillance from a crane operator sitting in a control room onshore. The lifting operations between supply vessels and the installation is the most dangerous place to operate offshore with consideration of human safety. The crane will be safer for the offshore personnel, because it is programmed to lift without any support from personnel at the installation of the vessel.

2.1.2 Auto hook

Auto hooking is key factor for success of the autonomous crane. The hook will detach and connect by itself. The auto hook includes a lifting head, a link plate, and a pennant with a lifting ball capable of connecting to the lifting head. It is used together with a guide system that is connected to the container roof with bolts [15]. The autonomous crane will survey the movements of the supply vessels and control the lifting operation by use of 3D compensation, anti-pendulum system, auto connect, auto-lift and landing systems. The handling and use are illustrated in Figure 4, Figure 5 and Figure 6.

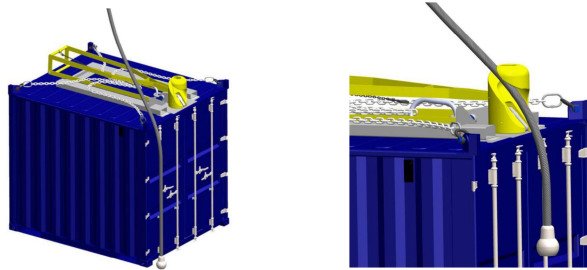


Figure 4: The forerunner slide along the edge of the container until it enters the track of the lifting head [15].

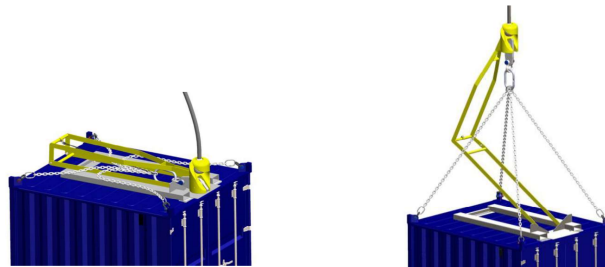


Figure 5: The crane start hoisting up the forerunner next to the lifting ball is locked into the lifting head. It lifts further up until system reaches lifting position [15].

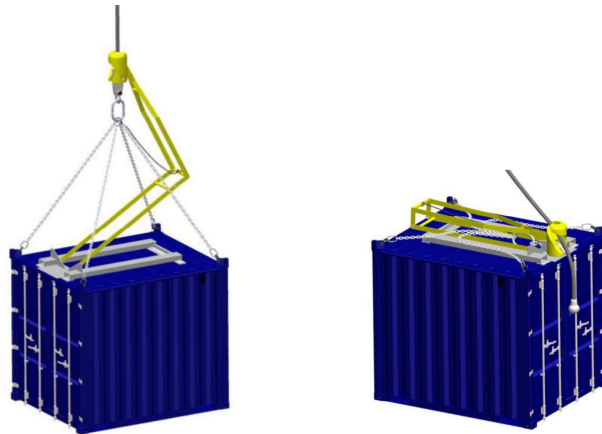


Figure 6: The container is moved to the desired location. The forerunner is lowered until the lift head lands, and the lifting ball slides out of the lifting head [15].

2.2 Relevant theories

In this section the most principal theories on the autonomous crane are defined.

2.2.1 Von Mises stress

The von Mises stress is used to determine if a given material will buckle or fracture [16]. The von Mises stress is the combined stress from moment stress, shear stress and torsional stress, as shown in Eq. 1. If the calculated value is higher than the material yield strength, the material will buckle.

$$\sigma_v = \sqrt{(\sigma_{bending} + \sigma_{shear})^2 + 3 \cdot (\tau_{torsion})^2} \quad (1)$$

where

$\sigma_{bending}$ is the moment stress [MPa]

σ_{shear} is the shear stress [MPa]

$\tau_{torsion}$ is the torsional stress [MPa] which is τ_{flange} or τ_{web}

2.2.2 Shear lag effect

The boom has a hollow rectangular/quadratic shape. As the forces will affect the boom in a vertical downwards direction, the boom will experience both stress and strain, as shown in Figure 7.

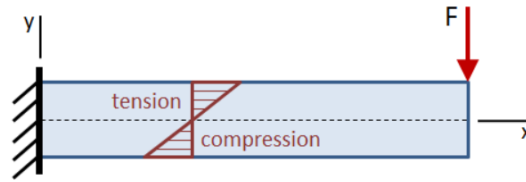


Figure 7: Tension and compression on a beam [17].

The non-uniform stress distribution on the hollow section, result in the cross section not being fully effective. This is referred to as the shear lag effect and reduces the design strength of the cross section. When the boom is bending, the stress section of the boom will be fully effective, however the compression will not be fully exploited [18].

The new effective gross section is specified in accordance with Table 1 for internal elements. Giving the reduction factor for plate buckling.

Stress distribution (compression positive)				Effective ^p width b_{eff}		
				$\underline{\psi} = 1:$ $b_{eff} = \rho \bar{b}$ $b_{e1} = 0,5 b_{eff} \quad b_{e2} = 0,5 b_{eff}$		
				$1 > \underline{\psi} \geq 0:$ $b_{eff} = \rho \bar{b}$ $b_{e1} = \frac{2}{5 - \underline{\psi}} b_{eff} \quad b_{e2} = b_{eff} - b_{e1}$		
				$\underline{\psi} < 0:$ $b_{eff} = \rho b_c = \rho \bar{b} / (1 - \underline{\psi})$ $b_{e1} = 0,4 b_{eff} \quad b_{e2} = 0,6 b_{eff}$		
$\underline{\psi} = \sigma_2 / \sigma_1$	1	$1 > \underline{\psi} > 0$	0	$0 > \underline{\psi} > -1$	-1	$\frac{AC_1}{AC_1} - 1 > \underline{\psi} \geq -3 \frac{AC_1}{AC_1}$
Buckling factor k_{σ}	4,0	$8,2 / (1,05 + \underline{\psi})$	7,81	$7,81 - 6,29\underline{\psi} + 9,78\underline{\psi}^2$	23,9	$5,98 (1 - \underline{\psi})^2$

Table 1: Internal compression elements, from Table 4.1 in [10].

2.2.3 Buckling theory

The pedestal, pedestal adapter and boom are all exposed to buckling when lifting heavy loads. A thin shell is prone for large deflection on bending deformation rather than strength failure. The used method for buckling analysis is semi-empirical method. The small deflection theory for buckling strength is not sufficient for the thin shell cylindrical because a discrepancy between theory and experiment data. The discrepancy is credible explained with geometric imperfections for cylindrical shell. The preferred semi-empirical method is a small deflection theory employed with buckling coefficients and used by DNV GL [7]. The computational analysis FEM analysis used in ANSYS for comparison of the buckling and controlling the theoretical buckling check illustrated in Figure 8 [19].

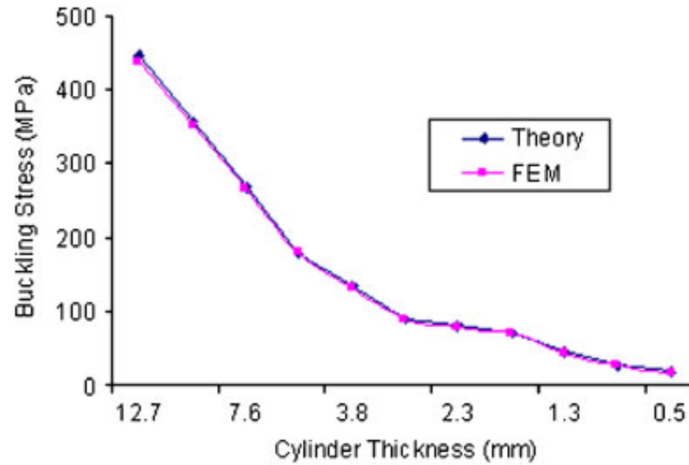


Figure 8: The discrepancy between theory and FEM data of thin shell buckling, from [19].

The buckling is calculated in cross sections of the boom. Since the cross sections have hollow rectangular/quadratic shapes, the buckling will appear differently on the top flange, bottom flange, and web. To prevent failure, the material has to be able to resist the forces [20], which is verified by the calculations in Appendix B and Appendix C.

2.2.4 Section modulus

The direction of the boom will have an impact on how the forces affects the cross section. The cross section used in this thesis has a greater height than width, as shown in Figure 9. In this case, the strong axis will be horizontal and it will be less available for buckling. This will make the boom stronger in the vertical direction as the crane is supposed to lift vertical loads. If the boom has a greater width than height, the strong direction will be horizontal and the cross section will not be able to lift the same vertical load without buckling. Since global buckling on the boom is neglected, the boom will only be calculated for local buckling.

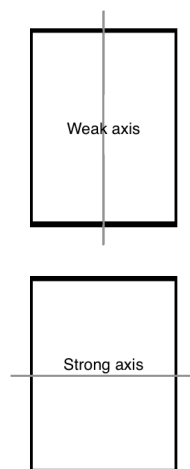


Figure 9: Weak and strong axis of cross section.

2.2.5 Lever arm effect

The lever arm effect can appear due to deformations in the joint. The force is pulling on the flange as the flange is connected to the wall with bolts. The flange will experience forces from two sides pushing on the bolt with the moment of the arm, as demonstrated in Figure 10.

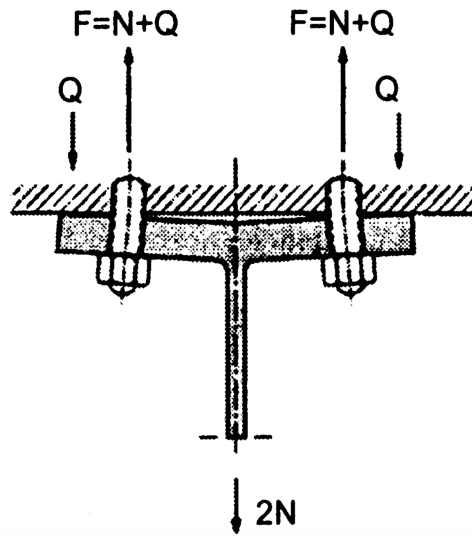


Figure 10: Figure showing the lever arm effect. Figure from [21].

where

N is the force affecting the object [kN]

Q is the lever arm effect [kN]

F is the counterforce from $N + Q$ kN

The applied force, N , will have a higher impact on the crane due to the lever arm effect, Q , that appears in the contact point between the crane and the flange. The counterforce, F , will therefore be a combination of the applied force and the force which occurs from the lever arm effect. This effect can in many cases be critical [21]. In this thesis this effect is relevant for the slewing bearing bolts.

3 Design basis

The offshore autonomous crane is a concept crane based on dock cranes with some given dimensions stated in Section 1. The description of the thesis also specifies the total height of the crane to be 20 m (12 m pedestal and 8 m adapter) and the two booms creating the arm shall be 16 m each. The coordination system is located at the bottom centre of the pedestal. It is coordinated with the y as vertical through the middle of the pedestal, z is horizontal along the centre of the crane and x is horizontal towards the crane, as shown in Figure 11.

3.1 Construction

The crane consists of the following parts, shown in Figure 11. Detailed information about each component is described in the following subsections.

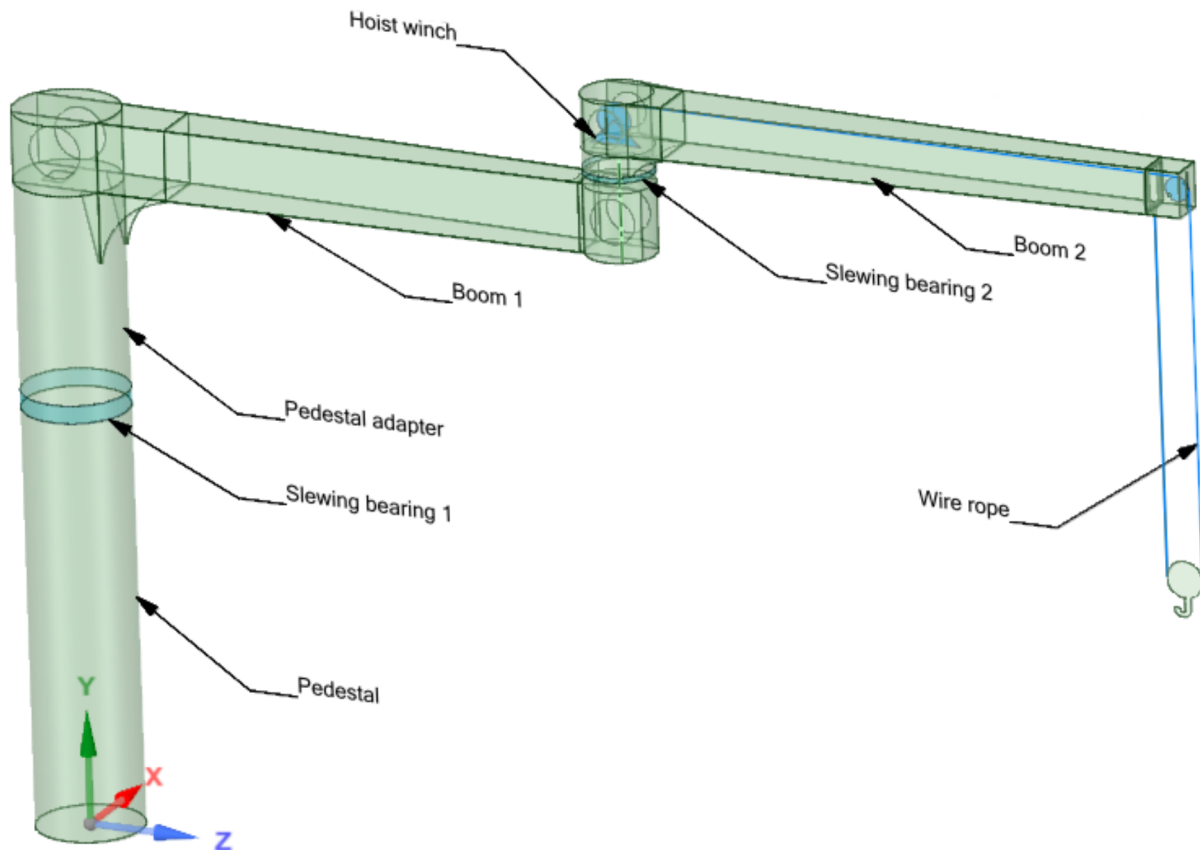


Figure 11: The general arrangement of the crane.

3.1.1 Pedestal

The pedestal is a 12-meter-high cylindrical steel pipe with a diameter of 3 meters. Since the pedestal is the support of the crane, it is exposed for vital forces as a result of the bending load combined with the harsh offshore climate affecting the structural capacity. If the crane gets hooked in a supply vessel. The wire rope and hook shall preferably be the first to failure and prevent hazardous situation. Therefore, a robust design is important for the pedestal structure. On this type of crane, an additional counterweight is not necessary because the pedestal shall be welded to the platform. The pedestal shall be one of the last parts to fail, as there shall be a failure sequence, where components closer to the load is preferably failing according to EN 13852-1:2013 [6]. A counterweight could provide a weaker pedestal.

3.1.2 Slew bearing

The slewing bearings allow the crane to rotate 360 degrees around a vertical axis. The crane has two different slewing bearings. The first slewing bearing is fixed to the pedestal and secured with bolts, making the top part of the crane able to rotate. The second slewing bearing is located at the tip of the first boom, in the connection point between the two booms, giving the boom arm the ability to bend and the lifting radius of the crane can be changed.

3.1.3 Pedestal adapter

Above the first slewing bearing, the pedestal adapter is located. This is fixed to the slewing bearing and secured with bolts. The adapter is an 8-meter cylinder with the same diameter and thickness as the pedestal which is welded to the first boom. This makes the crane 20 meters high in total.

3.1.4 Hoist rope

The hoist rope is a rotation-resistant steel rope. It is a stable rope, designed to be weather and corrosion resistant. The diameter of the rope is 30 mm. It is attached to the hoist winch and lowered to the optimal height for each lifting situation.

3.1.5 Boom

The boom is a closed construction welded with steel plates. The crane consists of two booms to make it able to rotate horizontally. On the tip of the first boom, the second slewing bearing is placed. This slewing bearing is smaller than the one located on the pedestal and connects the first boom to the second boom which also is a welded rectangular/square construction. The cross section will decrease through the booms to optimize it. The plates are welded to a cylinder to make it able to connect to the slewing bearing. Both booms are 16 m long, making the arm 32 meters in total.

The boom is sectioned into four parts as shown in in Figure 12.

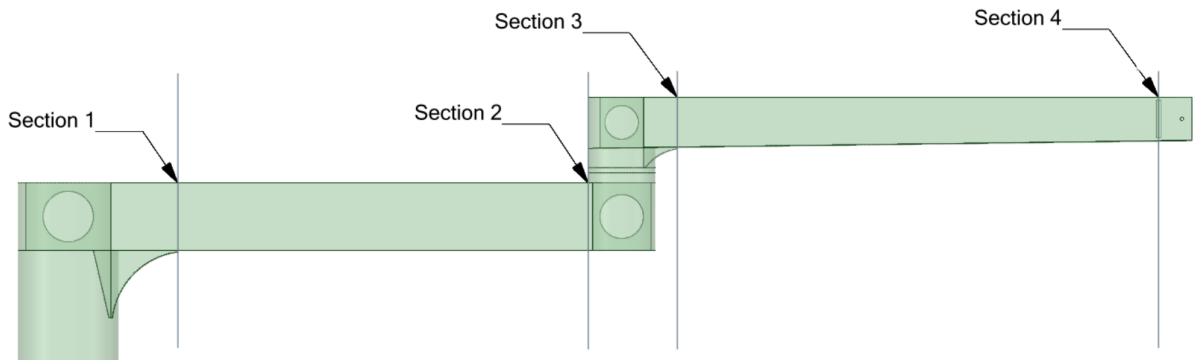


Figure 12: Illustration of the cross sections on the booms.

3.1.6 Hoist winch

As shown in Figure 13, the hoist winch is placed inside at the beginning of the second boom. When service is necessary, the first boom is designed to be 1.5 meter high, making it possible of walking through. This makes it easy to perform maintenance of the winch and other equipment located inside the boom. The wire rope runs through a sheave on the tip. Zollern winch gearboxes are high performance and have long operating life winches where maintenance is easy, making it preferable for an autonomous crane. Maintenance of the sheave will be performed through a hatch in the boom and available when the boom is folded.

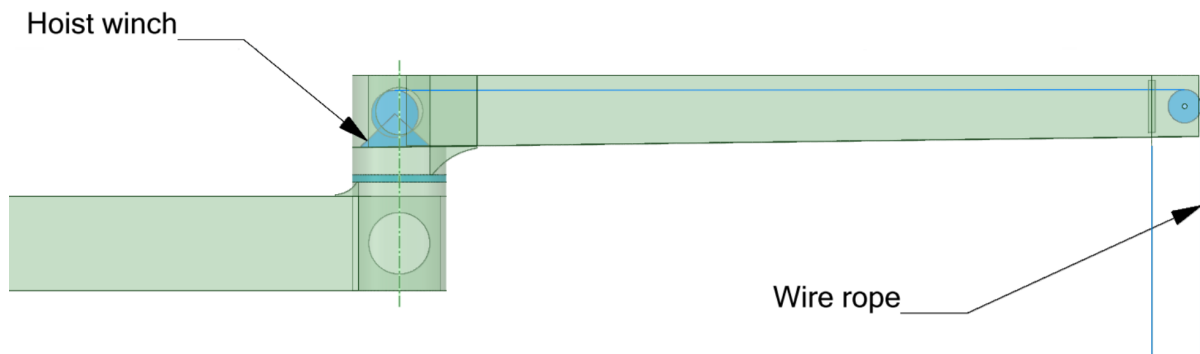


Figure 13: Placement of the winch.

3.1.7 Stiffener plates

To strengthen the crane, stiffener plates are used. A horizontal plate with a hatch is placed inside the cylindrical pipe at both ends of the first boom and in the beginning of the second boom. The plates are parallel with the bottom/top plates. Inside the cylindrical pipes there are two vertical plates, parallel with the boom web to support the cylinders. The plates are located at both ends of the first boom and in the beginning of the second boom. In the edge between the booms and cylinders, external vertical knee plates are placed. These plates are parallel to the web and supports the boom. The first boom has internal knee plates in addition to the external plates for extra support. All the plates are shown in Figure 14.

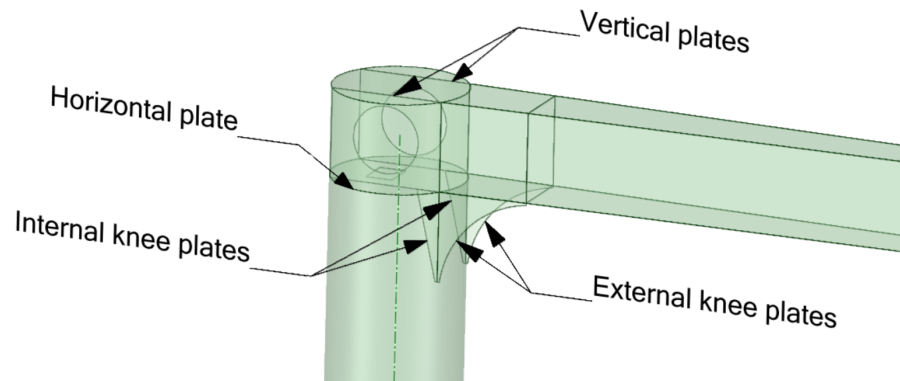


Figure 14: Figure showing the plates supporting the boom.

3.2 Material

The entire construction is constructed with S355 MPa steel. This structural steel is often used in construction, manufacturing, and offshore industries. The yield strength is calculated with standard steel property S355 with a thickness of 30 mm. The yield strength decreases if the thickness is below 40 mm and increases if the thickness is above 16 mm as shown in Table 2. The yield strength in this case is set to 355 MPa - 345 MPa [22].

Min. thickness	Max. thickness	Yield strength
16 mm	40 mm	345 MPa
40 mm	63 mm	335 MPa
63 mm	80 mm	325 MPa
80 mm	100 mm	315 MPa
100 mm	150 mm	295 MPa

Table 2: S355 yield strength.

The material properties for S355 is shown in Table 3.

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m ⁻³
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson's Ratio	
6	Young's Modulus	210	GPa
7	Poisson's Ratio	0,3	
8	Bulk Modulus	1,75E+11	Pa
9	Shear Modulus	8,0769E+10	Pa
10	Tensile Yield Strength	355	MPa
11	Tensile Ultimate Strength	490	MPa

Table 3: Material properties used in Ansys and calculations.

The stress-strain curve is shown in Figure 15. The figure shows true stress and true strain plotted for different strain rates. The strain rate is the deformation the strain causes during a corresponding time.

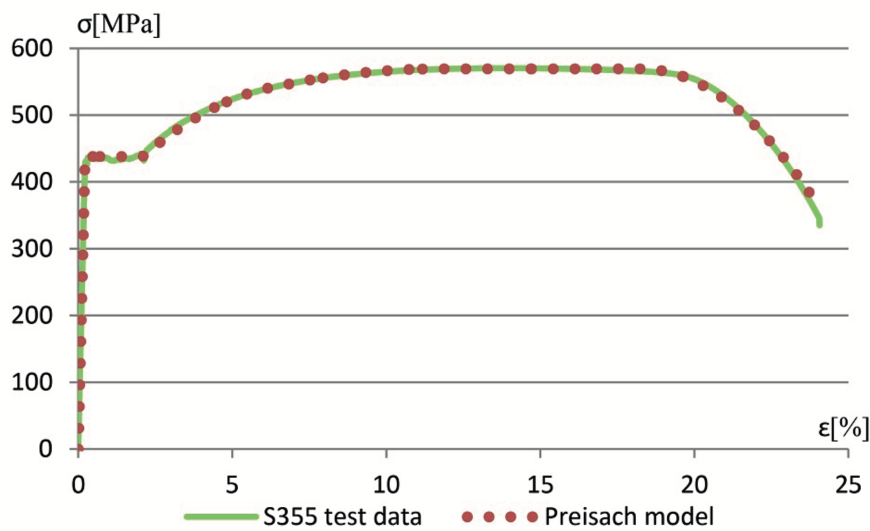


Figure 15: Stress-strain curve for S355 steel, from [23].

The table displays the Preisach model and a test data of the structural steel S355. The Preisach model shows the elastoplastic behavior under axial monotonic tension load [23].

3.3 Standards

Standards used to carry out this thesis are described in this chapter and referred to in the thesis as they have been used.

The Eurocode standards [9] [10] can sometimes be inconvenient, therefore the DNV GL standards [11] [8] are more preferable to use for the calculations. Buckling factors and formula for buckling in the pedestal and adapter are found in the DNV GL [7]. Different partial safety factors and material safety factors are given by the NS-EN 13852-1 [6] and NORSOK R-002 standard [5].

3.3.1 NS-EN 13852-1:2013

NS-EN 13852-1:2013 (General purpose offshore cranes) [6] is a European standard for offshore crane requirements where support and structural calculation are met with safety and health requirements. The safety depends on operation of the crane, as well as the environment. Maintenance requirements is necessary for the cranes health and provide protection for hazardous situation.

3.3.2 NORSOK R-002:2017

NORSOK R-002:2017 [5] is a standard for the Norwegian Petroleum industry with a common purpose to ensure the Petroleum resources with better technical and cost-effective solutions. The standard is managing the Petroleum resource extraction within an acceptable level. Safety for humans' life is the main priority. The standard is based on the Norwegian Petroleum industry experience.

3.3.3 EN 1993-1-1: Eurocode 3

EN 1993-1-1: Eurocode 3: Design of steel structures-Part 1-1 [9] is a standard for design and structural capacity in steel. It is extending the safety and serviceability for structure by defining structure requirements for resistance, durability, and fire resistance.

3.3.4 EN 1993-1-5: Eurocode 3

EN 1993-1-5: Eurocode 3: Design of steel structures-Part 1-5 [10] is giving requirements of stiffened and unstiffened plates. Shear lag effects and plate buckling is controlled for plates.

3.3.5 DNVGL-ST-0378

DNVGL-ST-0378: Offshore and platform lifting appliances [11] provides requirements for offshore cranes and operation.

3.3.6 DNVGL-RP-C202

DNVGL-RP-C202: Buckling Strength of Shells [7] is a standard where safety factors are combined by load and resistance factors. Buckling analysis for cylindrical shells to avoid buckling.

3.3.7 DNV-GL-CG-0128

DNV-GL-CG-0128 [8] presents class guidelines giving methods and principles for buckling and ultimate strength limits of load carrying constructions.

3.3.8 CEN/TS 13001-3-2

CEN/TS 13001-3-2: Cranes - General design: Part 3-2: Limit states and proof of competence of wire ropes in reeving systems [12] is a standard for providing safety by defining mechanical design and theoretical verification of steel ropes in reeving systems for cranes.

3.4 Safety factors

The LRFD (Load-Resistance-Factor-Design) method is used as described in NS-EN 13852-1:2013[6]. This design method is used for preservation of structural criteria for ultimate strength, fatigue, accidental, and serviceability. A combination of several factors gives required safety factors for various loads. Resistance of structural capacity affects differently on gravitational loads and fatigue fractures, therefore specified factors are used [24].

The factors for safety consists of different factors for rated hook load, self-weight and material resistance factor as the selfweight is weighed with calibrated load cells and therefore with low degree of uncertainty [6]. All of the factors are used in the crane components resulting in higher total lifting capacity instead of one vital safety factor for the whole crane. The crane's self-weight does not need the same restriction as the external hook loads according to NS-EN 13852-1[6] and NORSOK R-002 [5] standards, and optimized the lifting capacity.

3.4.1 Cases of loading

There are three general cases of loading with different safety requirements.

- Case I - Crane working without wind
- Case II - Crane working with wind
- Case III - Crane subjected to exceptional loadings

This bachelor thesis will look further at the case I which is the main loading case under normal conditions. The autonomous crane will be parked for lifting under abnormal lifting conditions with harsh offshore winds. The out of service wind forces will be minimized when the crane is parked with both booms folded together and for the simplification of this structural analysis in this bachelor.

3.4.2 Risk coefficient

In accordance to NORSOK R-002[5], the risk coefficient γ_n for normal lifting is set to 1,0 as this crane is a general purpose crane without a personnel lifting mode [6].

3.4.3 Dynamic amplification factor (DAF)

The dynamic amplification factor σ_n is the ratio between static and dynamic load effects. It varies with the significant wave height, H_s . The DAF is calculated in accordance with NS-EN 13852-1:2013 [6]. It is determined by the Eq. 2. Calculations are also shown in Appendix B

The formulas used for calculating the DAF are found in NS-EN 13852-1:2013 [6], which is a standard that defines standard dynamic amplifying factor formulas for traditional manual operated offshore cranes. Since this is an autonomous crane with full 3D compensation and soft lifting system, the calculation of DAF may be less conservative in the future. New formulas for calculating the DAF are in the making, but since they are not complete yet, formulas for traditional manual offshore cranes are used in this thesis. However, the new standards could provide a lower dynamic amplification factor if the 3D compensation system compensate with high enough reliability. The 3D compensation could provide a softer lifting from supply vessel in the waves as the hoisting speed of hook is compensated to be the same as the velocity of the load on vessel deck. Thereby the dynamic amplification factor will be minimized when hoisting or landing the load.

Since the DAF formula in load case I and II is based on 50% of maximum hoisting velocity + vessel deck velocity for calculating the relative velocity in supply boat lifting, the 3D compensation could reduce the relative velocity close to zero. This will result in a lower DAF. For safety reasons the exceptional situation where 3D compensation system fails, will require that the traditional DAF formula is used in load case III for exceptional load cases. The partial safety factor of 1.1 for load case III instead of 1.34 for load case I, will theoretically improve the rated lifting capacity in the load chart for some waves up to 21.8% if the cranes can withstand the DAF found by applying emergency braking with full speed.[25]

$$\sigma_n = 1 + \frac{V_R}{g} * \sqrt{\frac{C}{R_n}} \quad (2)$$

where

- C is the crane stiffness [N/m]
- R_n is the rated capacity [kg] for a significant wave height $H_s = n$
- V_R is the relative velocity between the load and hook at the time for pick-up [m/s]
- g is the gravity $g = 9,81m/s^2$

V_R is calculated by Eq. 3:

$$V_R = 0,5V_s + \sqrt{V_D^2 + V_C^2} \quad (3)$$

where

V_s is the maximum steady hosting velocity for the capacity to be lifted [m/s]

V_D is the vertical velocity of the load's supporting deck [m/s]

V_C is the vertical velocity if the crane boom tip due to the movement of the crane base [m/s]

If the value $0,5V_s$ is less than V_H , V_H shall be used instead.

The velocities V_D and V_C are taken from Table B.2 in NS-EN 13852-1 [6]. Where V_D for lifting from a supply vessel is shown in Eq. 4 and V_C for a bottom supported crane is $V_C = 0$ m/s.

$$V_D = 6,0 \frac{H_s}{H_s + 8,0} \quad (4)$$

where

H_s is the significant wave height [m]

The crane stiffness C is calculated from the stiffness of the hoist rope, booms, adapter, and pedestal.

The minimum dynamic amplification factor is limited by $DAF = 1,3$ for offboard lifts and $DAF = 1,15$ for onboard lifts and when $H_s = 0$ m as defined in Table B.1 in NS-EN 13852-1:2013 [6].

For hoist winches, the dynamic amplification factor used in design is $DAF_{winch} = 1,6$ as defined in Appendix C.1.5.

3.4.4 Load factors

The load factors for load case I are specified in accordance with NS-EN 13852-1 [6].

Self-weight: $\gamma_P = 1,22$

Hook load: $\gamma_P = 1,34$

3.4.5 Resistance coefficient

The resistance coefficient (material factor) is specified in accordance with NS-EN 13852-1 [6].

Steel sections: $\gamma_{a_m} = 1,10$

3.4.6 Velocity factor

The velocity factor K_H is specified in accordance with NS-EN 13852-1 [6]. This factor varies with the number of falls.

At rated capacity:

Single fall: $K_H = 0,50$

Multiple fall: $K_H = 0,28$

4 Program tools

In this chapter, the softwares used in the study are presented.

4.1 Microsoft Office Excel

Microsoft Office Excel [1] is a spreadsheet program that is used for computing various functions and formulas. The crane is analysed in the spreadsheet to be optimized and easily managed with load charts and utilizations. The macro function manipulated the values for optimal utilization for single and double fall lifting, achieving a spreadsheet easily manageable for optimization for various options.

4.2 PTC Mathcad

To execute mathematical calculations and documenting formulas, PTC Mathcad [2] is used. The mathematical notation is combined with automatic computations, therefore easily manageable and illustrating.

4.3 ANSYS

Ansys [3] is a simulation software for finite element analysis. The crane is modelled using Ansys SpaceClaim and analysed in Ansys.

Ansys Workbench is utilized to perform an analysis of the strength distribution in the crane structure. The analysis is done with Finite Element Method (FEM), the concept of performing several numerical solutions for complex problems. This is done by making the problem easier to investigate by separating the large problem into smaller problems (finite elements).

The stress distribution in the crane structure is then analysed. A simulation is performed using Ansys Workbench, where each component is tested individually for forces, weight, and centre of gravity.

All information is then distributed to the Excel spreadsheet as presented in Appendix C.

5 Design of crane components

The analysis is done to determine the maximum utilization of each component of the crane. The most principal calculations from the analysis are presented in this chapter, in addition to a guidance on how the Excel spreadsheet and Mathcad script is used to conclude the results. For further information, see Appendix B and Appendix C. The calculations are done in both Mathcad and Excel where Mathcad displays each formula and Excel displays the results.

5.1 Wire rope

The safety factor is calculated for each running reeving and uses the maximum rated capacity of the crane in accordance to the EN 13852-1:2013 [6]. The rated capacity for the relevant lifting configuration determine the safety factors. Static and dynamic safety factors for steel wire ropes are accounted for running rigging in accordance with EN 13852-1:2013 [6]. Friction in sheaves is specified according to CEN/TS 13001-3-2 [12]. For this crane, a 30 mm rope from Appendix F is used.

The wire rope capacity is calculated by dividing the minimum breaking strength by the rope resistance factor. The maximum dynamic rope utilization is calculated according to CEN/TS 13001-3-2[12] and should prove $F_{Sd,s} < F_{Rd,s}$. $F_{Sd,s}$ is calculated as shown in Eq. 5. This is also shown in Appendix B.3 and Appendix C.1.2.

$$F_{Sd,s} = \frac{m_{Hr} \cdot g}{n_f} \cdot \phi_n \cdot f_{S1} \cdot f_{S2} \cdot f_{S3} \cdot \gamma_p \cdot \gamma_n \quad (5)$$

where

- m_{Hr} is the mass of the hoist load [tonne]
- g is the gravity constant [m/s^2]
- n_f is number of falls [-]
- ϕ_n is the dynamic amplification factor [-], as shown in Eq. 2
- f_{S1} , f_{S2} and f_{S3} are the rope force increasing factors [-]
- γ_p is the load factor for selfweight/hook load [-], as defined in 3.4.4
- γ_n is the risk coefficient [-]

The formula for $F_{Rd,s}$ is shown in Eq. 6

$$F_{Rd,s} = \frac{F_u}{\gamma_{rb}} \quad (6)$$

where

- F_u is the minimum breaking force [kN] as specified by the manufacturer, see Appendix F
- γ_{rb} is the minimum rope resistance factor [-]

5.2 Pedestal and pedestal adapter

The structural capacity of the pedestal is determined by local buckling and calculated from critical stress. High stiffness is required to avoid oscillation during lifting operations against supply vessels.

Tubular section class is checked according to Table 5.2 (sheet 3 of 3) - Maximum width-to-thickness ratios for compression parts [6]. The pedestal is checked for bending or compression.

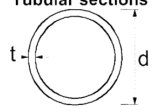
Tubular sections						
						
Class	Section in bending and/or compression					
1	$d/t \leq 50\epsilon^2$					
2	$d/t \leq 70\epsilon^2$					
3	$d/t \leq 90\epsilon^2$					
NOTE For $d/t > 90\epsilon^2$ see EN 1993-1-6.						
$\epsilon = \sqrt{235/f_y}$	f_v	235	275	355	420	460
	ϵ	1,00	0,92	0,81	0,75	0,71
	ϵ^2	1,00	0,85	0,66	0,56	0,51

Table 4: Maximum width-to-thickness ratios for compression parts, from Table 5.2 (sheet 3 of 3) in [9].

The section class is section class 4 since $\frac{d}{t} > 90\epsilon^2$

where

d is the section diameter [mm]

t is the section thickness [mm]

ϵ is the epsilon factor [-]

The Buckling strength for unstiffened cylinders is calculated from the buckling coefficient as specified in [7]. Shell buckling formulas due to bending are used since the main force is bending. Shear stresses and bending stresses are not combined because their maximum values appear on different places of the pedestal. All the information and bending results for the pedestal and pedestal adapter are shown in Appendix C.1.3 and Appendix C.1.4.

Column buckling stability requirements are shown in Eq. 7 and in Appendix B.4 and Appendix B.5. The equation describes the element length and checks for column buckling.

$$\left(\frac{kL_C}{i_C}\right)^2 \geq 2,5 \cdot \frac{E}{f_y} \quad (7)$$

where

k is the effective length factor [-]

L_C is length of column [mm]

i_C is radius of gyration [mm]

E is the elastic modulus of column [MPa]

f_y is yield strength [MPa]

5.3 Hoist winch

The winch is checked for static and dynamic capacities. The winch bolts and pins are neglected and design shear or bending capacity of winch components are therefore not considered in the utilizations as they are assumed to be adequate for the design capacity the winch is rated for. The winch used for this crane is type 4.26 from Appendix E.

The calculations for the dynamic winch capacity DL_{Rd} is determined in Eq. 8. It is also shown in Appendix B.6 and Appendix C.1.5.

$$DL_{Rd} = \frac{SL_{Rd}}{falls} \cdot DAF_{winch} \quad (8)$$

where

SL_{Rd} is the static pull capacity [tonne]

$falls$ is the number of falls for lifting [-]

DAF_{winch} is the dynamic amplification factor for the winch [-], as mentioned in 3.4.3

The static pull capacity varies depending on the number of falls. The crane will then be able to lift double the amount when managing two falls.

5.4 Slewing bearing 1 and 2

The failure capacity of the slewing bearings is normally determined by the connecting bolts. The capacity of bolts will be the weak points of the slewing bearing and therefore be first to fail. For both slewing bearings, M42 bolts from Appendix D are used.

Dimensions from the geometry of the slewing bearing are measured and used for calculating the lever arm effect. Bolts pretension is set to 75%, which prevent fatigue of bolts as the pretension stresses will normally be higher than normal stresses and the bolts will not experience cyclic loading in bolts threads. Pretension relative to yield strength should be between 65% to 80% [11].

The bolt fasteners shall have yield capacity per bolt higher than material yield stress multiplied with stress area of bolt, As shown in Eq. 9. The lever arm effect is taken into consideration and will press the bolts from the flange.

$$(F_B)_{0.2} \geq \frac{0.75}{pr} \cdot F_A \cdot \left(\frac{a + xb + c}{c} \right) \quad (9)$$

where

$(F_B)_{0.2}$ is the stress area of bolt A_S , times the bolt yield stress f_y [kN]

F_A is the maximum vertical load per bolt [kN]

pr is the permanent pre-stressing degree [-]

x is $\frac{F_R}{F_A}$ [-]

a, b, c, e are the distances [mm] shown in Figure 16

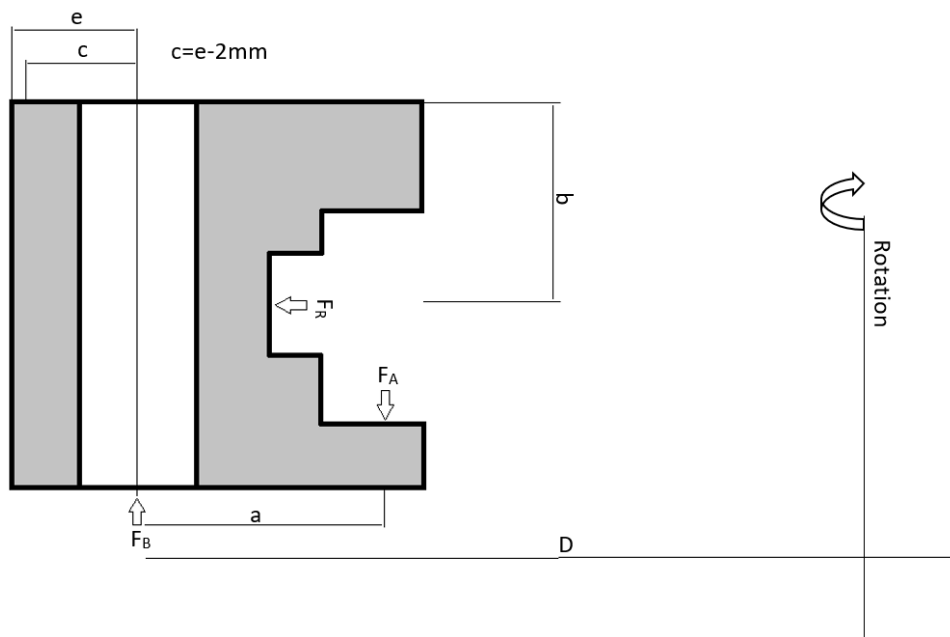


Figure 16: Drawing of slewing bearing, from [11].

The maximum forces on the slewing bearing is divided into vertical and horizontal forces. The force F_A is the maximum vertical force pushing down at the raceway dimension, giving it a load per bolt sector at the end of the slewing bearings raceway. The force F_R is maximum horizontal force at the radial per bolt, although it is minimized for vertical forces on a none angle boom in vertical height. The yield capacity of the bolts F_B is specified by the manufacturer and in accordance with [11] F_B shall not be less than Eq. 9. This is also shown in Mathcad in Appendix B.7 and Appendix B.8, and in Excel in Appendix C.1.6 and Appendix C.1.7.

5.5 Boom

The Mathcad and Excel sheets are the foundation of this bachelor thesis. They are presented in Appendix B and Appendix C. In this section, a detailed description of the progress of finding the utilization factors of the sections in the first boom are presented. The first boom, containing Section 1 and Section 2 from Figure 12, is used as an example for creating a guidance on how the calculations are done. The formulas are shown in the Mathcad script in Appendix B. The Mathcad calculations are used in the Excel sheet to determine the maximum utilization factors and hook loads R_n for each lifting radius with various significant wave height H_s .

The boom is checked for shear lag effect and local buckling. The cross section is sectioned into 4 sections, as shown in Figure 12. The area of the cross sections decreases through the booms. The design is high and wide since the second slewing bearing has a diameter of 2 meters, hence a higher and less wide section in the boom would be preferable.

In the hollow rectangle section, there is an upper part receiving stress, see Figure 17. This area is fully exploited. The lower part of the section is exposed to compression, here the area is not fully exploited, and calculations must be done to determine the effective area. Calculations for the effective area in the web are also computed.

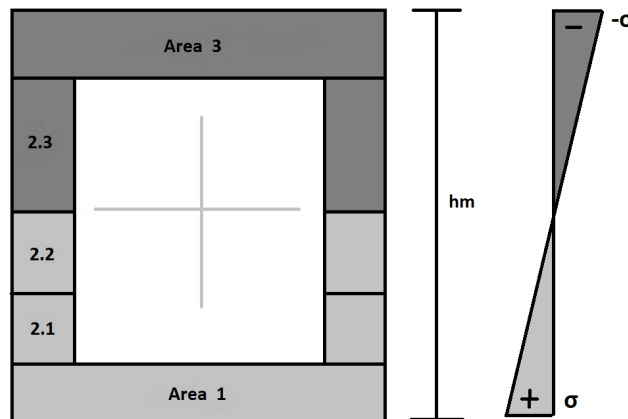


Figure 17: Cross section of the boom. Upper part is stress, lower part is compression

The shear lag effect is the effective area of compression zone without stiffeners. The new effective gross section is specified in accordance with Table 1 in Section 2.2.2. The effective area is used to calculate the second moment of area by looking at the displacement of the centroid. The second moment of area is used for calculating the effective section modulus. This is used to calculate the bending stress which is the bending moment divided by the effective section modulus.

The shear stress is the vertical forces affecting the boom and is calculated by dividing the forces by the effective area. This is shown in Eq. 1 in Section 2.2.1.

As a result of the joint connecting the two booms, the first boom will experience torsional forces when lifting in dissimilar angles. This implies that the only cross sections experiencing torsional forces is Section 1 and Section 2. The sections on the second boom will only experience forces by the moment. Figure 18 shows how the formula used for calculating the different moments, torsion and shear forces appearing when lifting in various angles.

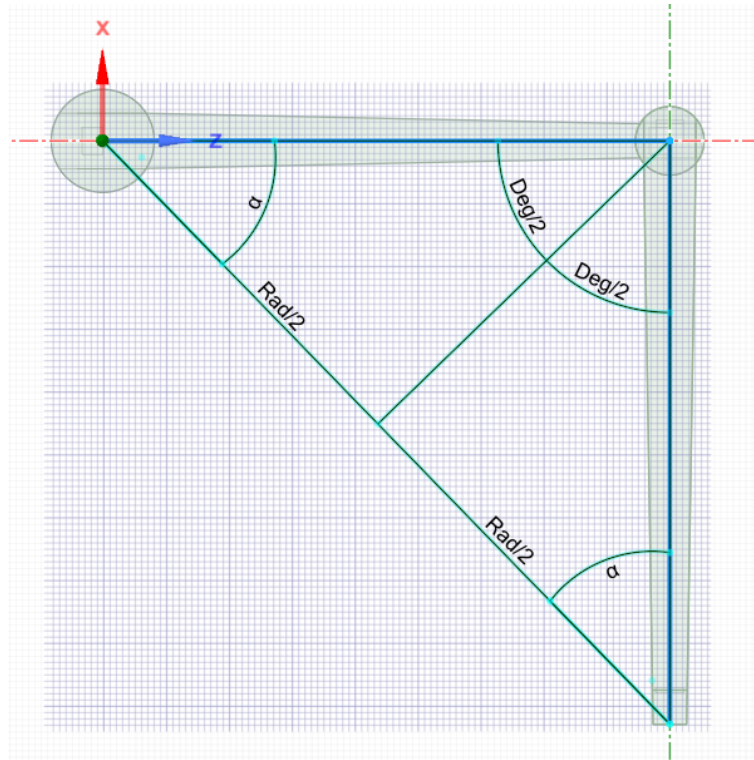


Figure 18: Figure showing the angle used for determining the moment.

The calculation for the angle according to the radius input is shown in Eq. 10. This is also shown in Appendix B.1.

$$\alpha = 2 \cdot \text{asin}\left(\frac{\text{Rad}}{l_{\text{boom}1}}\right) \quad (10)$$

where

Rad is the radius of the boom [m]

$l_{\text{boom}1}$ is the length of first boom [m]

The torsion will impact differently on web and flange and is calculated for both. The torsion moment reaches its maximum when the second boom is 90 degrees relative to the first boom. The torsional stress is found for web and flange and is evident with polar moment of inertia to flange and web. The torsional stress is calculated as shown in Appendix B.9.

The torsional stress, shear stress and moment stress are combined in the von Mises formula. The allowable material stress level is calculated by dividing the material yield stress by the material factor. This is the maximum stress possible for the boom. The utilization factors are found from here by dividing the von Mises stress by the yield strength. The results from boom cross section 1 are shown in Appendix C.1.8 and Appendix B.9. The results from boom cross section 2 are shown in Appendix C.1.9 and Appendix B.10. For the second boom, the results from boom cross section 3 are shown in Appendix C.1.10 and Appendix B.11, whilst the results from boom cross section 4 are shown in Appendix C.1.11 and Appendix B.12. All utilization factors are presented in Appendix B.13.

5.6 FEA analysis inputs

The crane is modelled in SpaceClaim with the dimensions determined by the calculations from Mathcad and Excel, as shown in Appendix B and Appendix C. The crane is optimized by using plates for stiffening to reduce the stresses due to the loads. The final design is shown in the drawings in Appendix A.

Figure 19 demonstrates the loads and boundary conditions used in the FEA analysis.

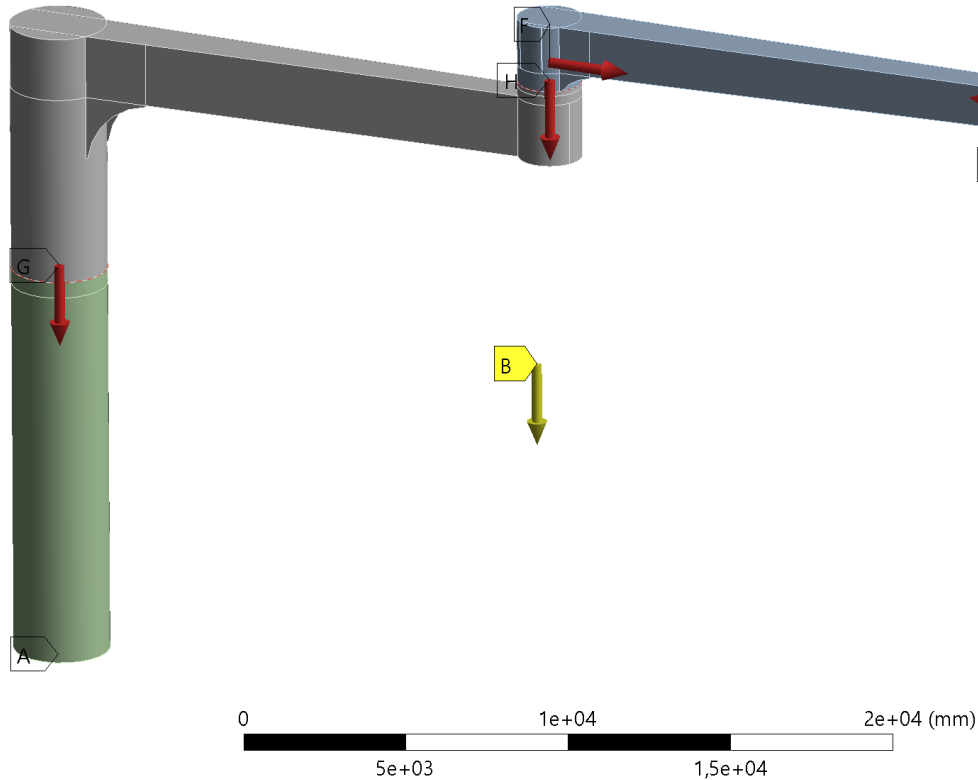


Figure 19: Figure illustrating the loads on the Ansys model.

where

Load A is the fixed support, connecting the crane to the platform.

Load B is standard earth gravity, $g = 9.81 \text{ m/s}^2$.

Load C is the hook load pulling in a vertical direction on the sheave located on the boom tip.

Load D is the hook load pulling on the second fall in a vertical direction. This force is only affecting the crane with two falls.

Load E is a remote counterforce in a horizontal direction from the hook load pulling on the winch.

Load F is the force from the hook load pulling on the winch. It is the corresponding force to Force E.

Load G is the load from slewing bearing 1 on the pedestal.

Load H is the load from slewing bearing 2 on boom 1.

Load C, E and F varies depending on the hook load. For single fall lifting the load is 209.01 kN and for double fall lifting the load is 357.88 kN. The force is calculated in accordance with Eq. 11.

$$F = W_{load} \cdot g \cdot R_n \quad (11)$$

where

W_{load} is the reference load [tonne]

g is the gravity [m/s^2]

R_n is the rated capacity as defined in Section 3.4.6

Figure 20 shows the mesh on the crane. Quadratic mesh is used with mesh size 50 mm.

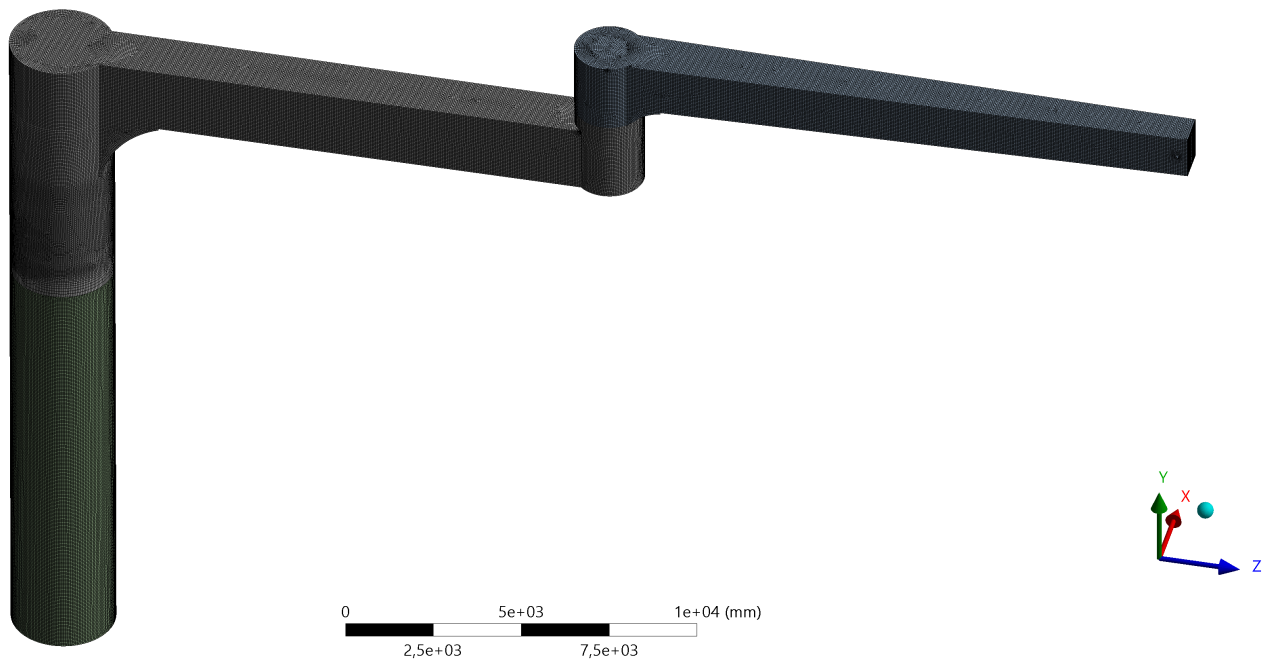


Figure 20: Meshed crane model.

Closeups of the mesh are shown in Figure 21 and Figure 21

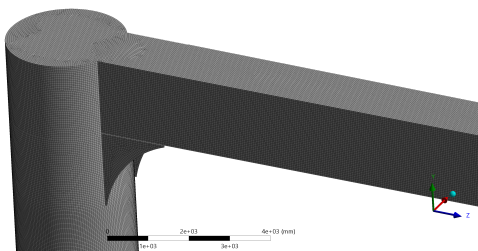


Figure 21: Mesh on the first boom and pedestal adapter.

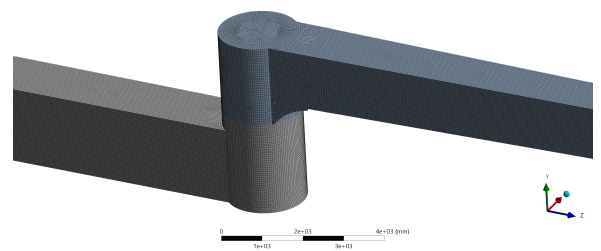


Figure 22: Mesh between the first and second boom.

Closeups of the mesh inside the crane are shown in Figure 23 and Figure 23

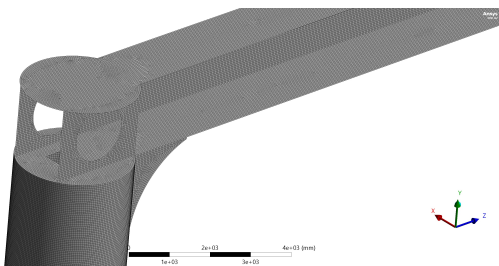


Figure 23: Mesh on inside of the first boom.

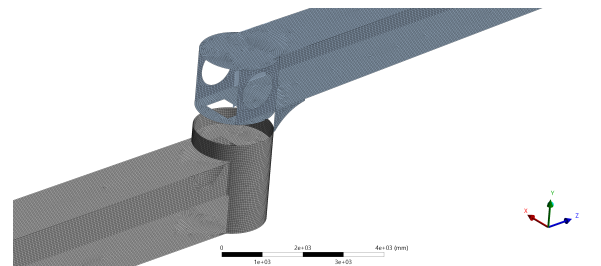


Figure 24: Mesh on the inside of the second boom.

6 Results and discussions

The crane is tested for single and double fall lifting. By switching to double fall, the crane is able to lift double the amount of weight. The results from calculations, load charts, and FEA analysis will be presented in this chapter.

The result from calculation shows the utilization of the crane components. The load chart results are from the Excel spreadsheet and illustrates the load capacities that appears in different lifting cases. The result from the FEA analysis presents screenshots from the Ansys simulation.

6.1 Capacity of crane components

The following sections declares the results from the calculations by using single and double fall for a lifting radius at 32 m at minimum and maximum H_s . Results from all H_s can be found in Appendix C.4 for single fall lifting and in Appendix C.5 for double fall lifting.

6.1.1 Maximum utilizations for single fall

Component	Maximum UF $H_s = 0$ m	Maximum UF $H_s = 6$ m
Hoist rope static UF	1.00	0.39
Hoist rope dynamic UF	0.59	0.90
Pedestal UF	0.30	0.22
Pedestal adapter UF	0.29	0.21
Slewing bearing 1 UF	0.57	0.43
Slewing bearing 2 UF	0.49	0.28
Hoist winch static UF	0.94	0.32
Hoist winch dynamic UF	0.67	1.00
Boom UF web section 1 UF	0.47	0.34
Boom UF flange section 1 UF	0.47	0.34
Boom UF web section 2 UF	0.39	0.23
Boom UF flange section 2 UF	0.29	0.17
Boom UF section 3 UF	0.23	0.13
Boom UF section 4 UF	0.01	0.01

Table 5: Utilization factors for single fall.

As shown in Table 5, the maximum utilized components when lifting with one fall, are the wire rope and the hoist winch. This sets the load capacity for every radius and significant wave height in Table 7. The wire rope has the highest utilization when $H_s = 0$ m and the hoist winch is highest utilized when $H_s = 6$ m. The utilization factors vary from 0.01 to 1, and the rest of the components have a medium to low utilization factor. Boom section 4 has the lowest utilization of 0.01 and is not necessary to check when lifting with single fall.

6.1.2 Maximum utilizations for double fall

Component	Maximum UF $H_s = 0$ m	Maximum UF $H_s = 6$ m
Hoist rope static UF	0.97	0.36
Hoist rope dynamic UF	0.57	0.89
Pedestal UF	0.42	0.26
Pedestal adapter UF	0.42	0.25
Slewing bearing 1 UF	0.83	0.50
Slewing bearing 2 UF	0.87	0.39
Hoist winch static UF	1.00	0.32
Hoist winch dynamic UF	0.72	1.00
Boom UF web section 1 UF	0.71	0.41
Boom UF flange section 1 UF	0.71	0.41
Boom UF web section 2 UF	0.67	0.31
Boom UF flange section 2 UF	0.50	0.23
Boom UF section 3 UF	0.41	0.18
Boom UF section 4 UF	0.03	0.01

Table 6: Utilization factors for double fall.

For double fall lifting, the highest utilized component is the hoist winch, as shown in Table 6. The hoist winch will therefore limit the load capacity for every radius and significant wave height in Table 8. The wire rope and both the slewing bearings are also high utilized when lifting at a $H_s = 0$ m. The lowest utilized component is the boom section 4.

6.2 Load charts

Tables for load charts are presented in this chapter. The tables are created by using macros in the Excel spreadsheet and show the maximum load for each angle and significant wave height, H_s .

6.2.1 Macros

To determine the maximum load for each radius, macros have been made in Excel. The macros set the maximum utilization factor cells for the crane total to be 1.0 as shown in Appendix C.4 and Appendix C.5 by changing the hook load in Appendix C.2 and Appendix C.3. The full macro is shown in Appendix C.6.

The macros are created by combining two formulas which gets repeated for each cell in the spreadsheet. The first sequence is shown and explained below:

<i>Sheets("Calculations").Select</i>	This line selects the "Calculations" sheet.
<i>Range("E3").Select</i>	This line selects the E3 column, which determines the hook load, in the sheet.
<i>ActiveCell.FormulaR1C1 = "5"</i>	This line sets the cell to "5", which is the minimum hook load. The first cell to get calculated is the cell for $H_s = 0$ m and $Radius = 4.0$ m
<i>ActiveCell.Offset(1, 0).Range("A1").Select</i>	This line moves the formula to the next cell which is one row down, $H_s = 0$ m and $Radius = 6.0$ m
<i>ActiveCell.FormulaR1C1 = "5"</i>	This line sets the new cell to "5".
<i>ActiveCell.Offset(1, 0).Range("A1").Select</i>	This line moves the formula one row further down.

This sequence will systematically work its way through all of the hook loads for the different significant wave heights and boom radiuses. The second sequence is shown and explained below:

<i>Sheets("Utilizations").Range("I5").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations") .Range("E3")</i>	At first, the "Utilizations" sheet is selected, then the cell I5 is selected. This cell determines the maximum utilization for the crane total when $H_s = 0$ m and $Radius = 4.0$ m. The Goal Seek function sets the goal to "1". The sheet will then determine the hook load in the corresponding cell (E3) in the "Calculations" sheet to make the maximum utilization reach its goal.
<i>Sheets("Utilizations").Range("I6").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations") .Range("E4")</i>	This line moves the sequence one row down and does the Goal Seek for $H_s = 0$ m and $Radius = 6.0$ m by using the cell E4 in the "Calculations" sheet.
<i>Sheets("Utilizations").Range("I7").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations") .Range("E5")</i>	This line does the same Goal Seek for the cell below.

The sequence is done when every H_s and radius has been Goal Searched. The calculated hook loads are then shown in a load chart.

The load chart determines when lifting is approved. The shaded area on the load chart advises the lifting operation with warnings that the slewing velocity can be too low to follow the horizontal movements of the load. This means that the velocity must be rapider to avoid unwanted situations. The lifting radius is therefore not recommended and would be avoided.

6.2.2 Single fall load chart

Results for lifting with single fall are shown in Table 7 and Figure 25.

Lifting is allowed, but the slewing velocity can be too low to follow the horizontal movements of the load														
Single fall														
Radius	Angle	Offboard lift												
		H _s = 0 m	H _s = 0,5 m	H _s = 1 m	H _s = 1,5 m	H _s = 2 m	H _s = 2,5 m	H _s = 3 m	H _s = 3,5 m	H _s = 4 m	H _s = 4,5 m	H _s = 5 m	H _s = 5,5 m	H _s = 6 m
(M)	(o)	(T)	(T)	(T)	(T)	(T)	(T)	(T)	(T)	(T)	(T)	(T)	(T)	(T)
4	14,36	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
6	21,61	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
8	28,96	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
10	36,42	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
12	44,05	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
14	51,89	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
16	60,00	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
18	68,46	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
20	77,36	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
22	86,87	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
24	97,18	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
26	108,68	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
28	122,09	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
30	139,27	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
32	180,00	15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5
MIN:		15,9	15,9	14,2	11,2	9,5	8,5	7,8	7,2	6,8	6,4	6,0	5,7	5,5

Table 7: Load chart with single fall shown as table.

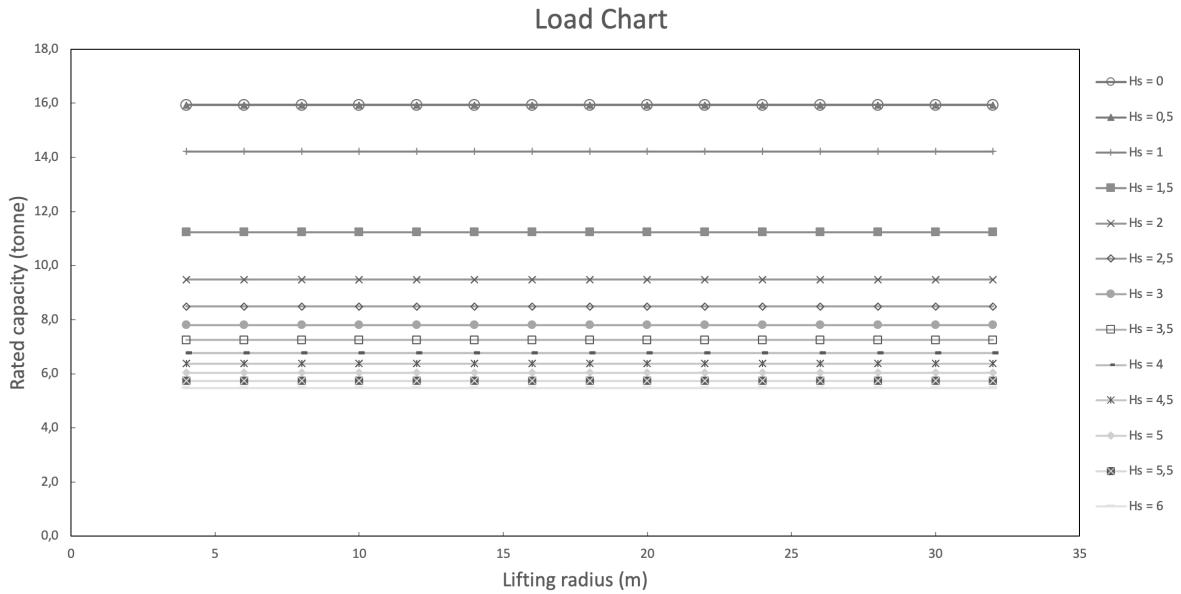


Figure 25: Load chart with single fall shown as graph.

The maximum lifting capacity decrease as the wave height increase due to dynamic amplifying forces in waves, and stay constant through all lifting angles. For some angles and wave heights, there is a warning saying that the slewing velocity is too slow. It is still safe to continue the lifting operation. When lifting with one fall, the maximum lifting capacity varies from 15.9 tonnes to 5.5 tonnes.

6.2.3 Double fall load chart

Results for lifting with double fall are shown in Table 8 and Figure 26.

Lifting is allowed, but the slewing velocity can be too low to follow the horizontal movements of the load														
Double fall														
Radius (M)	Angle (o)	Offboard lift												
		H _s = 0 m	H _s = 0,5 m	H _s = 1 m	H _s = 1,5 m	H _s = 2 m	H _s = 2,5 m	H _s = 3 m	H _s = 3,5 m	H _s = 4 m	H _s = 4,5 m	H _s = 5 m	H _s = 5,5 m	H _s = 6 m
4	14,36	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
6	21,61	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
8	28,96	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
10	36,42	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
12	44,05	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
14	51,89	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
16	60,00	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
18	68,46	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
20	77,36	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
22	86,87	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
24	97,18	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
26	108,68	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
28	122,09	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
30	139,27	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
32	180,00	34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8
MIN:		34,0	33,0	28,4	24,9	22,1	20,0	18,2	16,8	15,6	14,2	12,7	11,7	10,8

Table 8: Load chart with double fall.

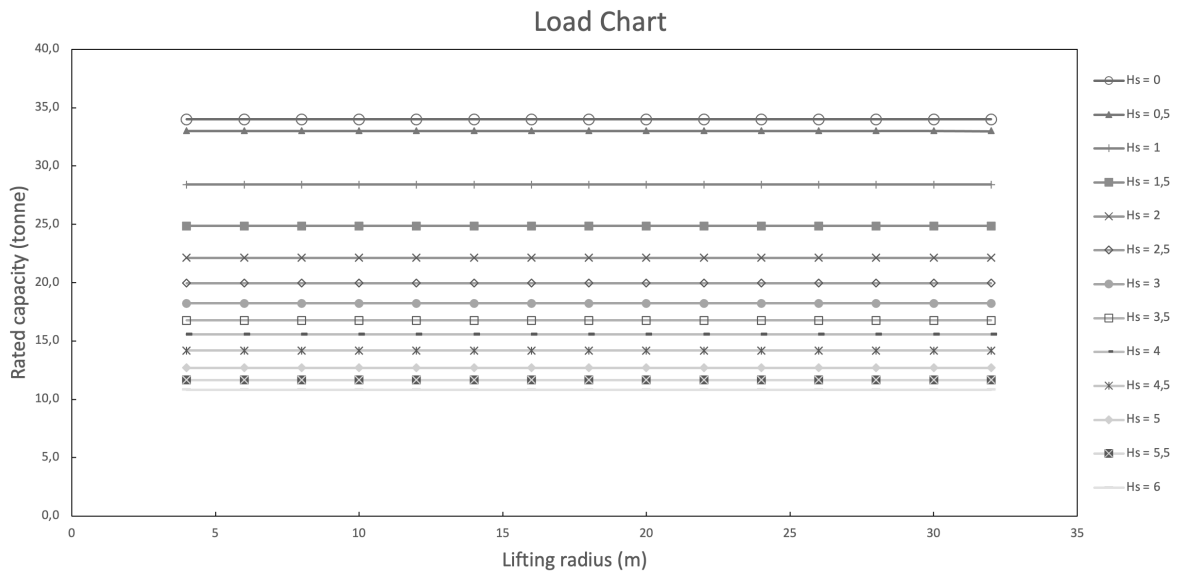


Figure 26: Load chart with double fall shown as graph.

When lifting with two falls, the maximum weight is significantly higher than lifting one fall. The capacity decrease from 34.0 tonnes to 10.8 tonnes as the wave height increase and stay constant through all lifting angles. For some angles and wave heights, there is a lifting warning, but lifting is still allowed.

6.3 FEA analysis

The crane is modelled and tested in Ansys [3]. To simplify the model, the winch and wire rope are not modelled. The slewing bearings are simplified by designing them as cylinders and adding the weights as loads. The model is tested with both a 180- and 90-degrees boom angle.

6.3.1 Single fall 180 degrees

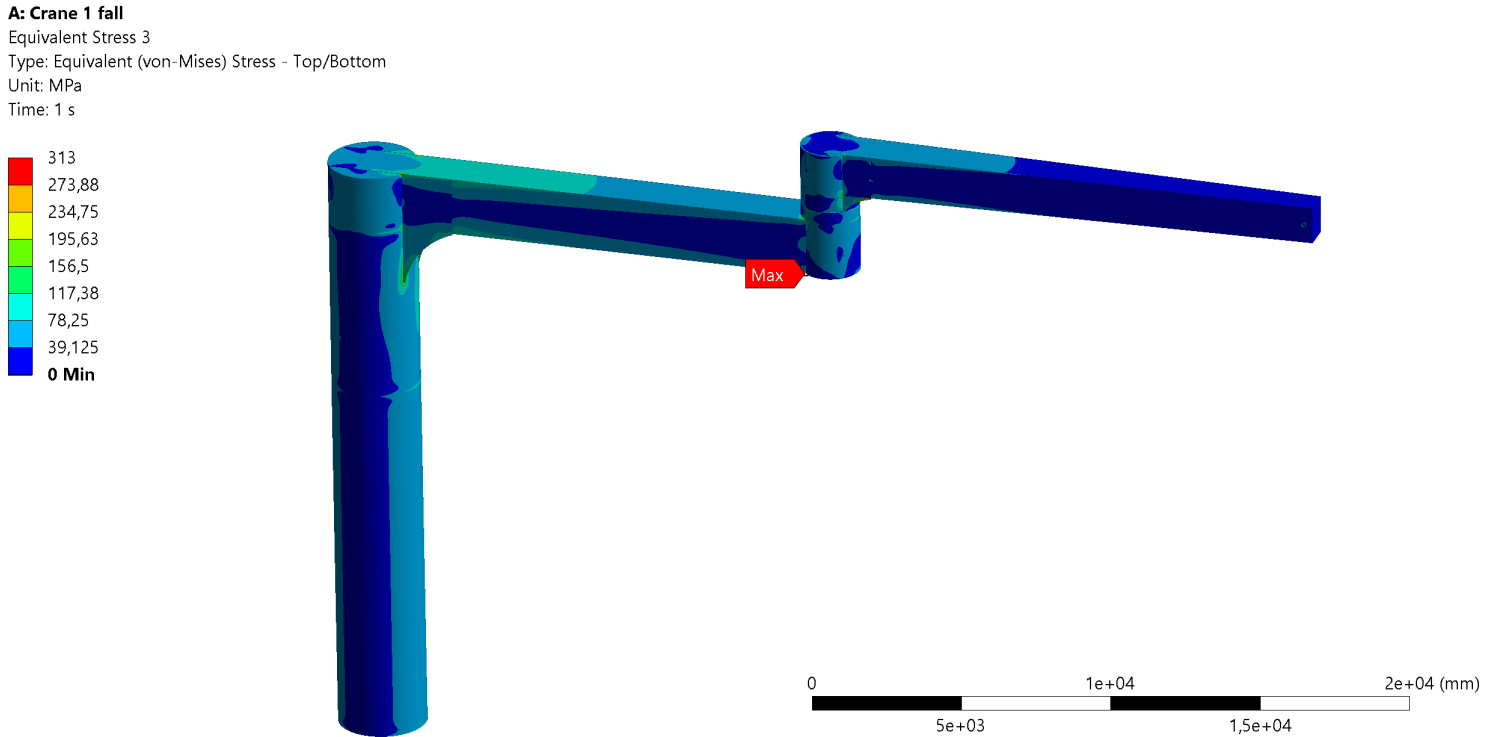


Figure 27: Stress when lifting with single fall with a 180-degree boom angle.

For single fall lifting the minor stress is noticeable, as shown in Figure 27. The crane has low utilization. The stress table is limited to 313 MPa because of the hot spots, as shown in Figure 28 and Figure 29. Hot spots are spots where singularities occur and produce high stress area in the different transition. The transition from boom to cylindrical pipe is the most exposed place and would be a spot there fatigued could occur. The stiffeners have the highest stresses due to singularities and has hot spots areas of red colour. The top and bottom flange has higher level of stress than the web plates of the boom, because of the moment effecting the crane.

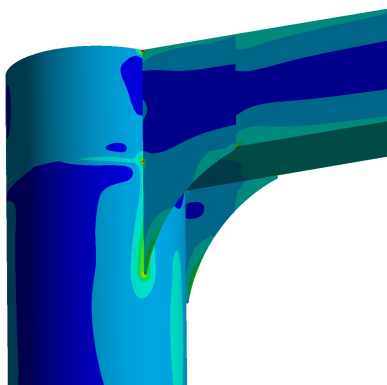


Figure 28: Local hotspots for single fall lifting.

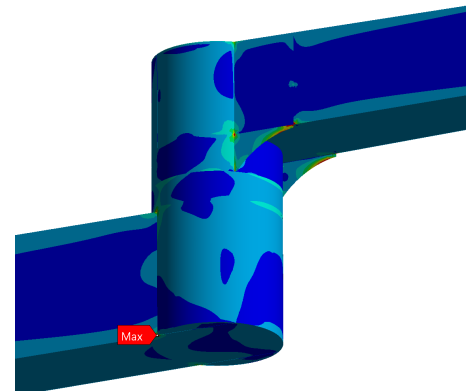


Figure 29: Local hotspots for single fall lifting.

6.3.2 Single fall 90 degrees

B: Crane 1 fall 90 deg

Equivalent Stress 3

Type: Equivalent (von-Mises) Stress - Top/Bottom

Unit: MPa

Time: 1 s

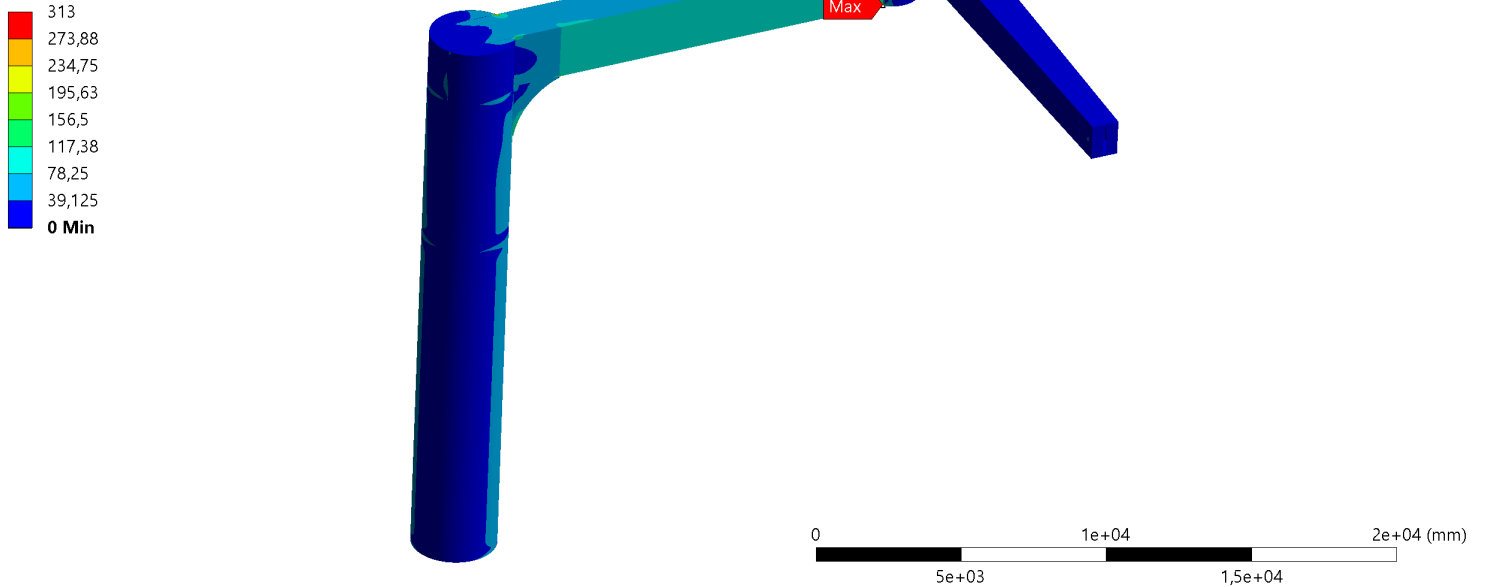


Figure 30: Stress when lifting with single fall with a 90-degree boom angle.

The crane's main boom is mainly affected by torsion. The web gets the highest stress results in boom section 2, as shown in Figure 30. Figure 31 and Figure 32 show a closeup of the most exposed areas. This is as expected according to the calculations. The stress area is mainly blue, however the connection points from cylindrical pipe to boom experience some higher stress.

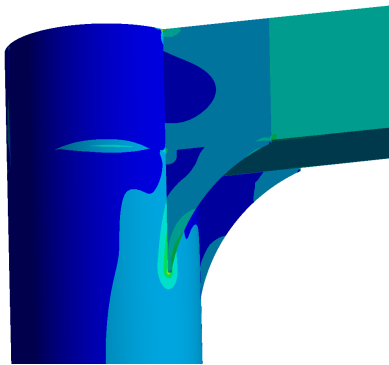


Figure 31: Local hotspots for single fall lifting in a 90-degree boom angle.

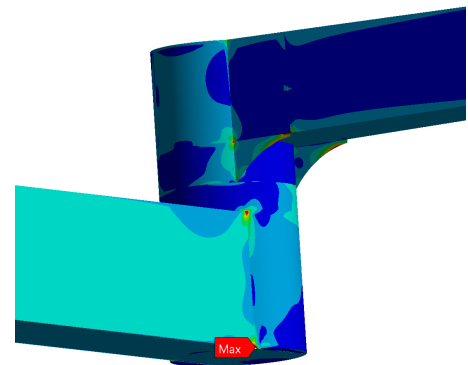


Figure 32: Local hotspots for single fall lifting in a 90-degree boom angle.

6.3.3 Double fall 180 degrees

D: Crane 2 fall

Equivalent Stress 3

Type: Equivalent (von-Mises) Stress - Top/Bottom

Unit: MPa

Time: 1 s

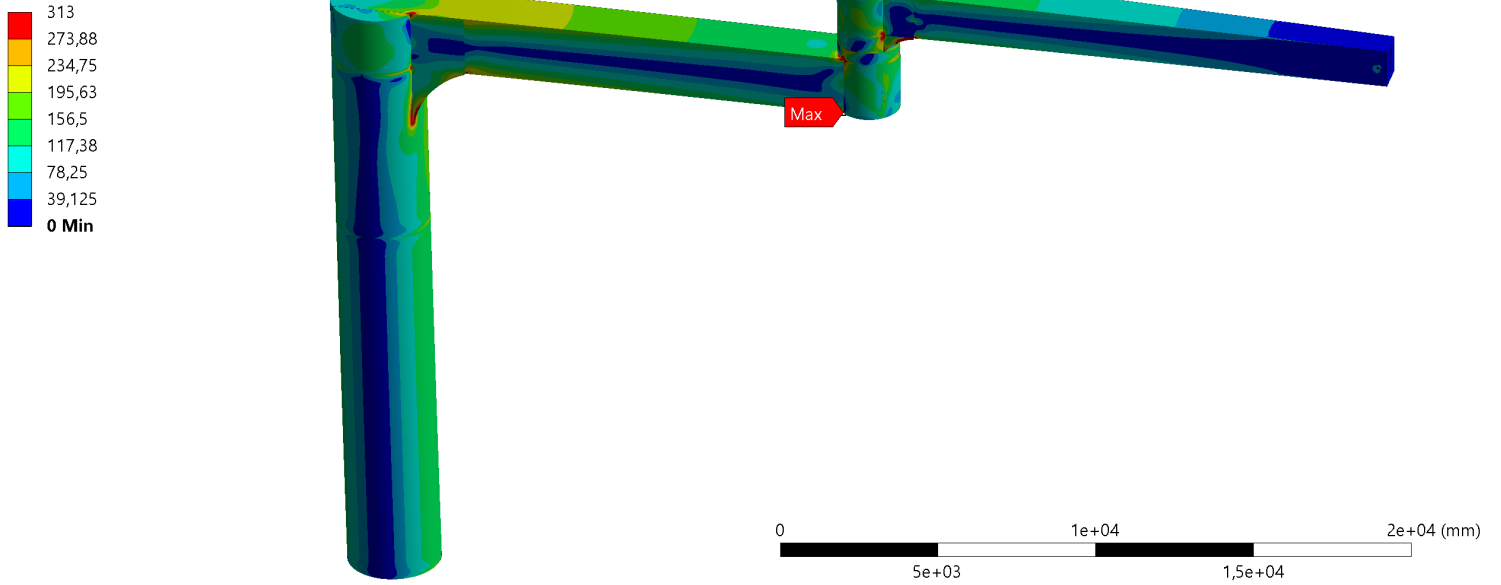


Figure 33: Stress when lifting with double fall with a 180-degree boom angle.

As seen in Figure 33, the crane has a significant higher stress when lifting with two falls. Here the stress is a lot higher than the crane for single fall in Figure 27. The hot spots on the stiffeners and in the edges are more noticeable, as shown in Figure 34 and Figure 35 and the overall crane has a lighter colour than the crane for single fall. As shown on the scale left for the crane.

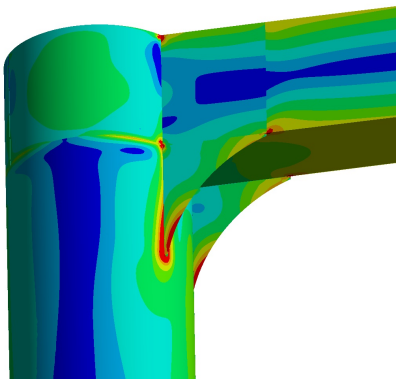


Figure 34: Local hotspots for double fall lifting.

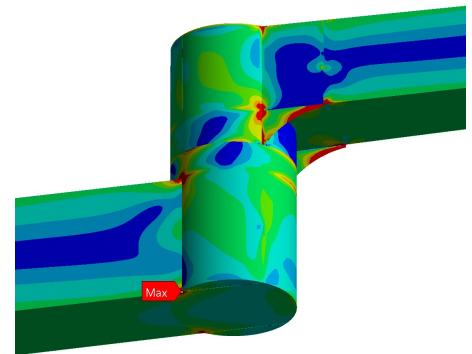


Figure 35: Local hotspots for single fall lifting.

6.3.4 Double fall 90 degrees

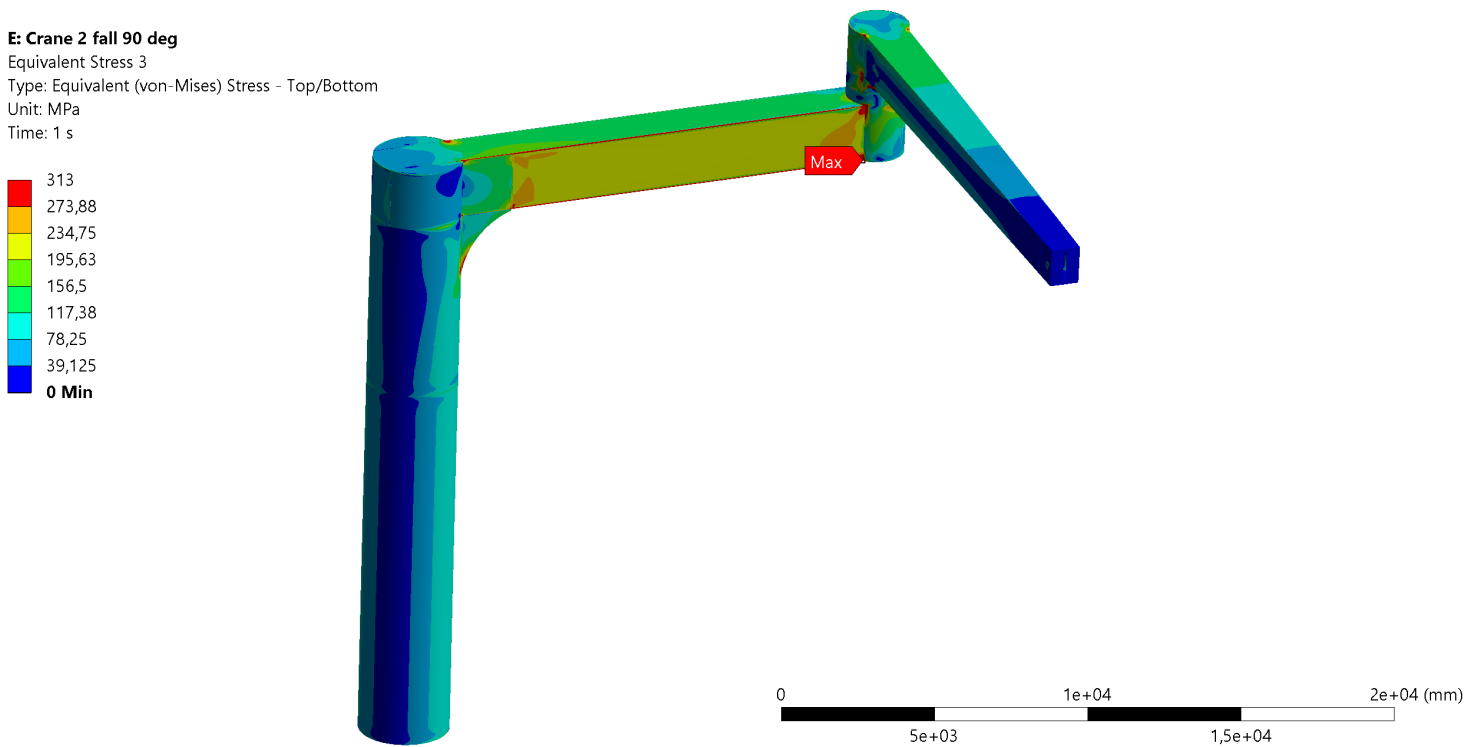


Figure 36: Stress when lifting with double fall with a 90-degree boom angle.

The torsion mainly effects the web at the first boom. When lifting with two falls, section 2 gets the highest results, as shown in 36. Figure 37 and Figure 38 shows a closeup of the areas most exposed to the forces. When lifting maximum weight at two falls and a 90-degree angle, the crane is experiencing severe torsional shear forces. This has a high impact on the edges of the first boom.

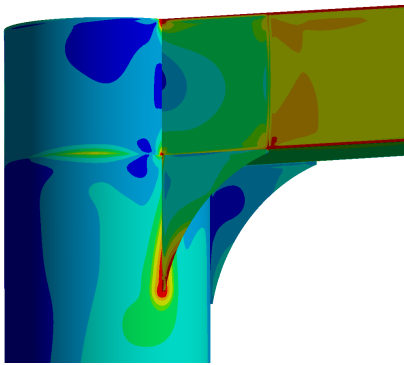


Figure 37: Local hotspots for double fall lifting in a 90-degree boom angle.

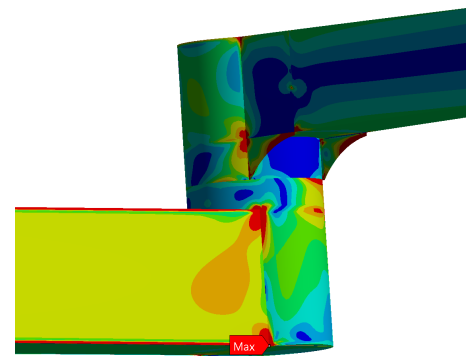


Figure 38: Local hotspots for double fall lifting in a 90-degree boom angle.

6.3.5 Comparison with manual calculations

The calculations in Mathcad and Excel, and the FEM analysis in Ansys has been presented in Section 6. The results were corresponding as the von Mises stress on the model was similar to the sections calculated in the Excel spreadsheet.

When comparing the Excel spreadsheet results with the Ansys analysis, the calculated areas contained the same tension force but a few divergent in the connection points. The simulation showed that the transition from boom to the cylindrical pipe created difficult spots with peak stress. Stress singularities are points where the stress gets high values and do not converge to a specific point. Where the refinement of mesh will cause the stress to increase in the specific point. Stress singularities could be improved by creating better transitions from boom to pipe. The corners could also be improved with a rounded edge.

After the initial analyses was performed, it was observed that the crane was preferable with stiffeners to avoid high stress areas. The simulation was then evaluated with different stiffener plates until a better result was archived. The crane was evaluated for maximum load in the FEM analysis. It was analysed for single and double fall lifting, although it would only be necessary with two falls.

The crane was simulated with a 180-degree boom angle in addition to a 90-degree boom angle. With the 90-degree boom angle, the torsion would be at its highest and therefore reasonable to check. Both angles were analysed with single and double fall lifting. The maximum load for each fall in Ansys was determined from the Excel spreadsheet as the maximum utilization of capable load.

7 Conclusion and recommendation for further work

The following sections state the conclusion of this thesis as well as further work.

7.1 Conclusion

The calculations and analyses performed herein shows that the elbow design of this autonomous crane, has adequate capacity according to the standards used and verified against NS-EN 13852-1:2013 [6] and NORSOK R-002 G11.1 [5]. The autonomous crane has been successfully designed. When lifting with one fall, it can lift a load of 15.9 tonnes from a supply vessel at a horizontal distance of 4 - 32 m from the outside of the installation, measured at sea level, at a significant wave height $H_s = 0$ m. It is also capable of lifting 5.5 tonnes at a horizontal distance of 4 - 32 m from the outside of the installation at minimum required horizontal and vertically hook velocities, measured at sea level, at significant wave height $H_s = 6$ m. In addition to this the crane is designed to lift with two falls which gives it the ability to lift double the amount of weight. When lifting with two falls, the crane can lift 34.0 tonnes at a horizontal distance of 4 - 32 m at a significant wave height $H_s = 0$ m. It can also lift 10.8 tonnes at a horizontal distance of 4 - 32 m at a significant wave height $H_s = 6$ m.

Detailed code checks have been performed for each component, such as buckling and maximum utilization. The checks have been done manual in Mathcad and Excel. Load charts have been obtained by optimizing the maximum utilization of each component. The load charts were obtained for single and double fall lifting and presents the maximum lifting ability for each significant wave height, H_s , at lifting radiuses from 4 to 32 m. The lifting loads were calculated by using macros in Excel.

An FEA analysis to the structure has been performed by ANSYS. Hot spots would occur in the connection points. To reduce these areas the structure was optimized by supporting areas using stiffener plates for preferable stress results. The crane was tested for lifting with one and two falls at a straight boom and at a 90-degree boom angle. When lifting with two falls, the lifting capacity was doubled. The results from the FEA analysis are in line with the analytical calculations and discussed.

7.2 Recommendation for further work

The simulation in Ansys and the excel spread sheet calculations are always possible to be further optimized. The crane should be simulated and tested for all load cases as described in the NS-EN 13852-1[6] and optimized for lifting with three falls. Finer mesh quality and optimized geometry of details and stiffeners could be used for optimizing the crane and reducing hot spots.

References

- [1] Microsoft Corporation. Microsoft® excel, 2022 (16.60).
- [2] PTC. Ptc® mathcad prime®, 2021 (Prime 8.0.0.0).
- [3] Ansys Inc. Ansys®, 2021 R2.
- [4] IKM Tech Team Solutions AS. Ikm tech team solutions as, 2019.
- [5] NORSOK Standard. Lifting equipment. Standard, R-002:2017.
- [6] Standard Norge. Kraner offshorekraner del 1: Offshorekraner til generell bruk. Standard, NS-EN 13852-1:2013.
- [7] DNV. Buckling strength of shells. Standard, DNV-RP-C202:2013.
- [8] DNV GL. Buckling. Standard, DNVGL-CG-0128:2015.
- [9] The European Union. Eurocode 3: Design of steel structures - part 1-1: General rules and rules for buildings. Standard, EN 1993-1-1:2005.
- [10] The European Union. Eurocode 3: Design of steel structures - part 1-5: General rules - plated structural elements. Standard, EN 1993-1-5:2006.
- [11] DNV GL. Standards for offshore and platform lifting appliances. Standard, DNVGL-ST-0378:2016.
- [12] Standard Norge. Kransikkerhet. generell konstruksjon. del 3.2: Grenseverdier og egnethet for arrangement for løpende wiresystemer. Standard, CEN/TS 13001-3-2:2004.
- [13] IKM Tech Team Solutions. Load chart report. Tech report, 2019.
- [14] iStock. Cartoon of offshore oil rig stock illustrations, 2022.
- [15] IKM Tech Team Solutions. Prosedyre for håndtering og bruk av auto-hook. Tech report, 2022.
- [16] T.H.G. Megson. Chapter 14 - complex stress and strain. *Structural and Stress Analysis (Fourth Edition)*, pages 423–466, 2019.
- [17] Inc MechaniCalc. Stresses deflections in beams.
- [18] W Samuel Easterling and Lisa Gonzalez Giroux. Shear lag effects in steel tension members. *Engineering Journal*, 3:77–89, 1993.
- [19] Himayat Ullah. Buckling of thin-walled cylindrical shells under axial compression. *International journal for numerical methods in engineering*, 79(11):1332–1353, 2009.
- [20] Jie Wang, Sheida Afshan, Nicole Schillo, Marios Theofanous, Markus Feldmann, and Leroy Gardner. Material properties and compressive local buckling response of high strength steel square and rectangular hollow sections. *Engineering Structures*, 130:297–315, 2017.
- [21] Audun Sagen. Kapasitetsberegning av skruer i gjenget blindhull. pages 1–102, 2011.
- [22] MEADinfo. Material properties of s355 steel. Tech report, 2015.
- [23] Zoran Perović Ćemal Dolićanin Zijah Burzić Petar Knežević1, Dragoslav Šumarac. A preisach model for monotonic tension response of structural mild steel with damage. 2020.
- [24] American Bureau of Shipping. Load and resistance factor design (lrfd) criteria for offshore structures. Tech report, 2016.
- [25] 1020 Wien Austrian Standards Institute/ Österreichisches Normungsinstitut Heinestraße 38. Crane safety — general design-part 2: Load actions. Standard, EN 13001-2:2014-08.
- [26] Rockside export limited. Properties of grade 10.9 bolt nut (iso). Tech report, 2010.
- [27] Zollern. Rope winches and gearboxes. Tech report, 2016.
- [28] CASAR. Casar eurolift. Tech report, 2019.

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Appendices

The following sections consists of appendices.

Disposition of appendices

Appendix A presents CAD drawing of the crane total and the different parts the crane is sectioned into when modeling.

Appendix B consists of the Mathcad script. It is calculated for lifting with two falls at 180 degrees for significant wave height , H_s , is 0 m. The appendix is divided into different parts to make it easier to orient. All the calculations are presented in this appendix.

Appendix C shows the Excel spreadsheet. This sheet is used to display the results from the Mathcad calculations and make tables to perform calculations for various significant wave heights H_s and radiuses. The appendix is divided into different parts. The first part shows the calculations for each crane component. The second and third part shows tables for calculating the load weight when lifting with one and two falls. The fourth and fifth part shows the calculations for the utilization factors when lifting with one and two falls. The macros are also added in this appendix.

Appendix D shows information about the bolt.

Appendix E shows information about the hoist winch.

Appendix F shows information about the wire rope.

A Appendix A: CAD drawings

A.1 CAD drawing of crane

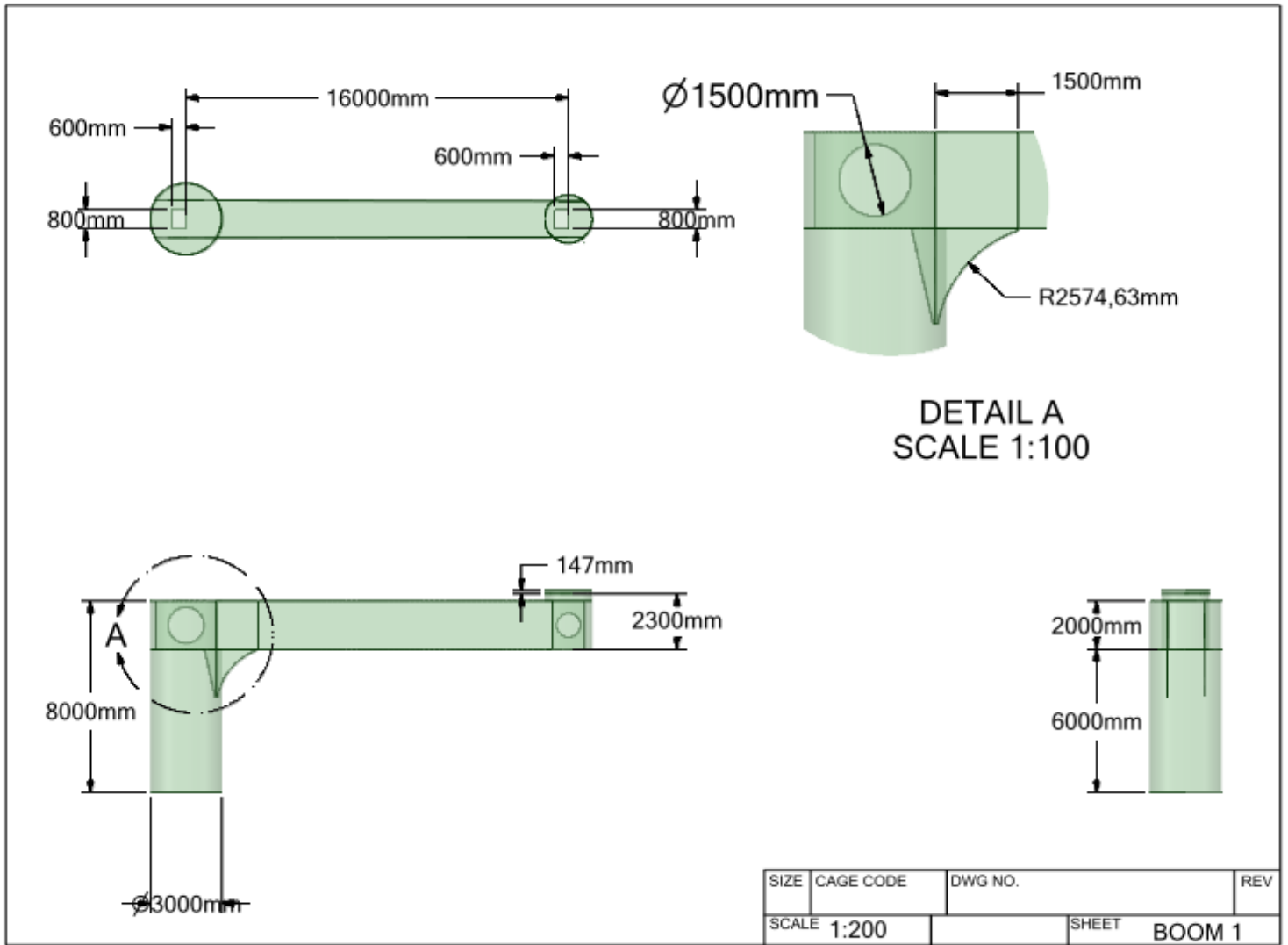
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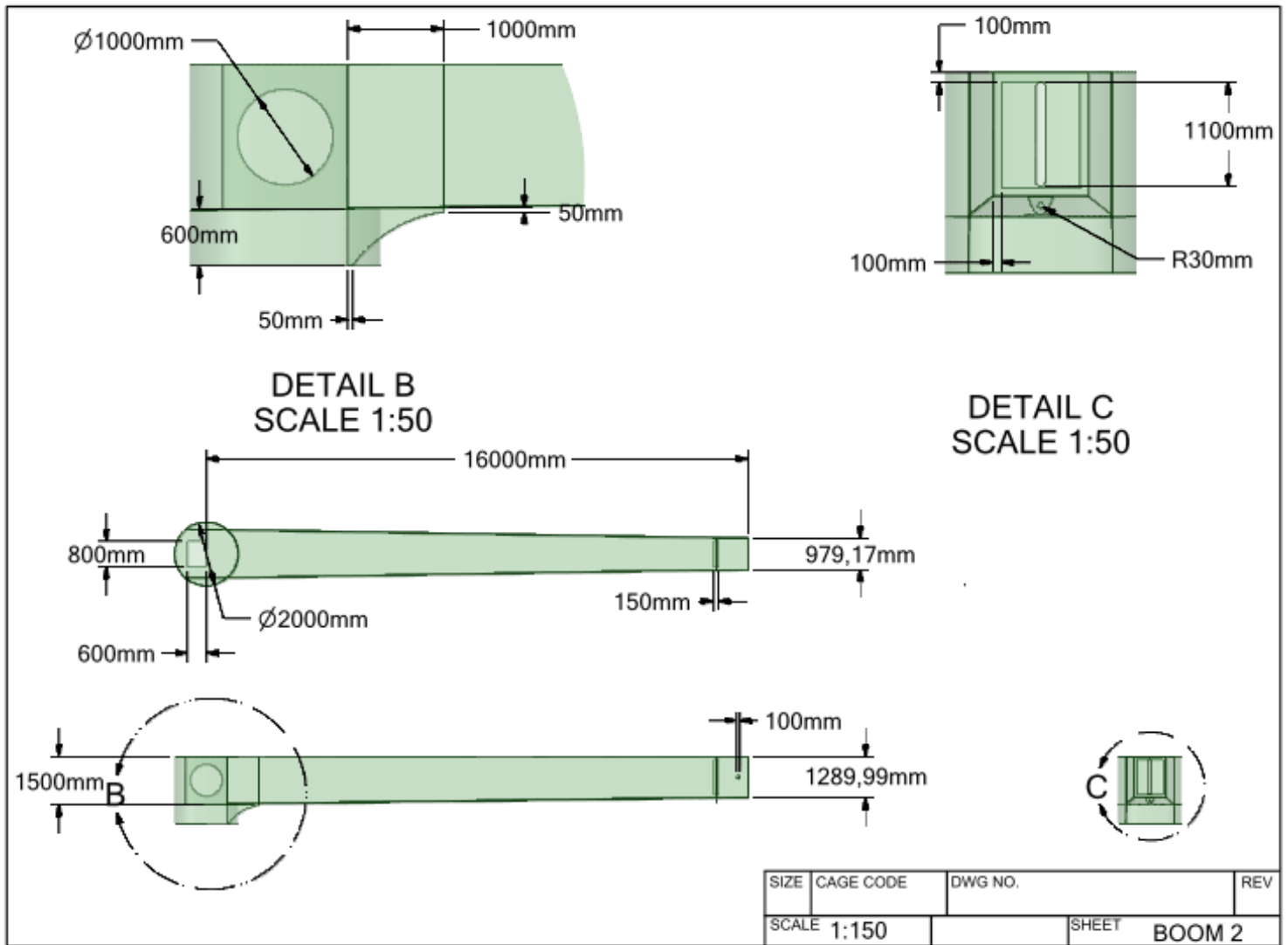
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APPROVALS	INITIALS	NAME (PRINT)	DATE		
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				SIZE	
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				CAGE CODE	
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					REV
				SCALE	
				1:300	
					SHEET

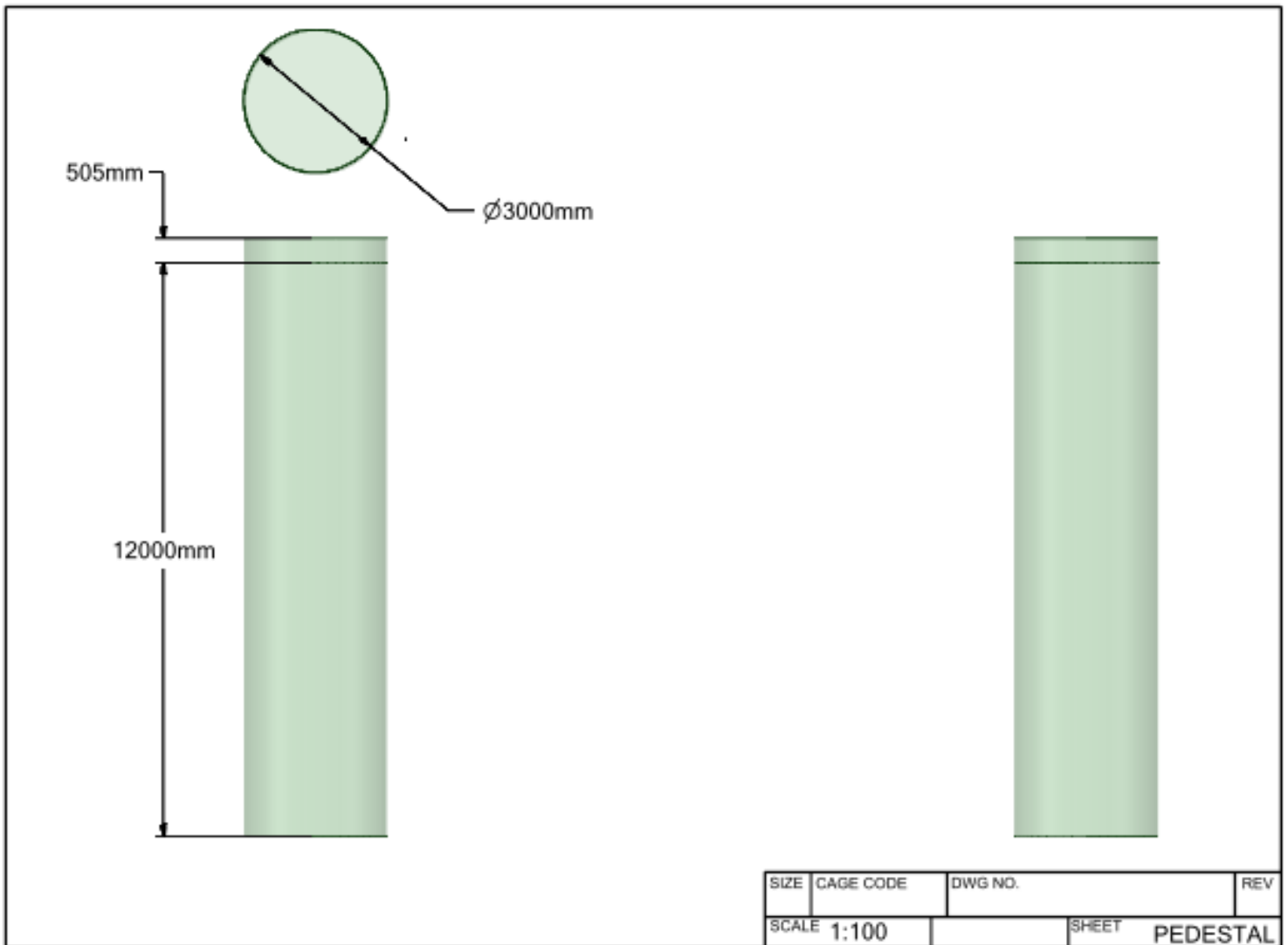
A.2 CAD drawing of boom 1



A.3 CAD drawing of boom 2



A.4 CAD drawing of pedestal



SIZE	CAGE CODE	DWG NO.	REV
SCALE 1:100		SHEET	PEDESTAL

B Appendix B: Mathcad script

B.1 Information

Autonomous crane	
Information	
Inputs	
Number of falls for hoisting rope	$falls := 2$
Wave height	$H_s := 0 \text{ m}$
Load weight	$R_n := 34 \text{ tonne}$
Radius	$Rad := 32 \text{ m}$
Gamman	$gamman := 1$
Gravity	$g = 9.807 \frac{\text{m}}{\text{s}^2}$
Factors	
Hoisting velocity factor	$K_H := \begin{cases} \text{if } falls > 1 & = 0.28 \\ \text{else} & \\ & 0.5 \end{cases}$
Radial velocity factor	$K_R := 0.25$
Lateral velocity factor	$K_L := 0.60$
Load factor for self-weight	$\gamma_{p_selfweight} := 1.22$
Load factor for hook load	$\gamma_{p_hook_load} := 1.34$
Risk coefficient	$\gamma_n := 1.00$
Resistance coefficient	$\gamma_m := 1.10$

Wire rope	
Weight rope	$W_{rope} := 5.74 \frac{kg}{m}$
Weight of hoist block	$W_{hoist_block} := 600 \text{ kg}$
Length of rope from first sheave to supply vessel	$h := 65 \text{ m}$
Pedestal	
Outer diameter	$OD_{pedestal} := 3000 \text{ mm}$
Wall thickness	$t_{pedestal} := 30 \text{ mm}$
Buckling length of pedestal	$L_{pedestal} := 12000 \text{ mm}$
Elastic modulus	$E := 210 \text{ GPa}$
Pedestal yield strength	$f_y := 345 \text{ MPa}$
Pedestal adapter	
Outer diameter	$OD_{adapter} := 3000 \text{ mm}$
Wall thickness	$t_{adapter} := 30 \text{ mm}$
Buckling length of pedestal adapter	$L_{adapter} := 8000 \text{ mm}$
Pedestal adapter weight	$W_{adapter} := 13317 \text{ kg}$
Hoist winch	
Hoist winch weight	$W_{winch} := 500 \text{ kg}$
Slew bearing	
Slew bearing 1 weight	$W_{slew_1} := 6253 \text{ kg}$
Slew bearing 2 weight	$W_{slew_2} := 1202 \text{ kg} = (1.202 \cdot 10^3) \text{ kg}$

Boom	
Youngs modulus	$E = 210 \text{ GPa}$
Boom material yield stress	$fy = 345 \text{ MPa}$
Boom 1 length	$l_{boom_1} := 16000 \text{ mm}$
Boom 2 length	$l_{boom_2} := 16000 \text{ mm}$
Boom 1 y	$y_{boom_1} := 7008.7 \text{ mm}$
Boom 2 y	$y_{boom_2} := 6780 \text{ mm}$
Arm length	$l_{arm} := 32000 \text{ mm}$
Boom 1 weight	$W_{boom_1} := 47682.37 \text{ kg}$
Boom 2 weight	$W_{boom_2} := 21779.51 \text{ kg}$
Total boom weight	$W_{arm} := W_{boom_1} + W_{boom_2} = (6.946 \cdot 10^4) \text{ kg}$
Length between points of zero bending moment	$L_e := 30000 \text{ mm}$
Epsilon	$\varepsilon_{boom} := \sqrt{\frac{235 \text{ MPa}}{fy}} = 0.825$
Boom sections	
Weight section 2 to boom 1 tip	$W_{section_2_1} := 6846.32 \text{ kg}$
Weight section 3 to boom 2 tip	$W_{section_3_2} := 15990.04 \text{ kg}$
Weight section 4 to boom 2 tip	$W_{section_4_2} := 1287.64 \text{ kg}$
Length section 2 to boom 2 tip	$l_{section_2_2} := 17 \text{ m}$
Length section 3 to boom 2 tip	$l_{section_3_2} := 15 \text{ m}$
Y to section 3 to boom 2 tip	$Y_{section_3_2} := 7494.2 \text{ mm}$
Length section 4 to boom 2 tip	$l_{section_4_2} := 0.5 \text{ m}$
Y to section 4 to boom 2 tip	$Y_{section_4_2} := 333 \text{ mm}$

Calculations

$$\alpha := 2 \cdot \text{asin} \left(\frac{\frac{\text{Rad}}{2}}{l_{\text{boom}_1}} \right) = 180 \text{ deg}$$

Degree

$$v_{S_{\text{max}}} := \frac{2.3 \frac{\text{m}}{\text{s}}}{\text{falls}} = 1.15 \frac{\text{m}}{\text{s}}$$

Max hosting speed

$$W_{\text{limit}} := 9 \text{ tonne} \cdot \text{falls} = 18 \text{ tonne}$$

Limit load

$$v_{S_{\text{min}}} := \frac{1.3 \frac{\text{m}}{\text{s}}}{\text{falls}} = 0.65 \frac{\text{m}}{\text{s}}$$

Mean hosting speed

$$W_{\text{max}} := 15 \text{ tonne} \cdot \text{falls} = 30 \text{ tonne}$$

Max load

$$v_{\text{slew}} := 0.126 \frac{\text{rad}}{\text{s}}$$

Max slewing speed

$$v_{S_{\text{ref}}} := v_{S_{\text{min}}} + (R_n - W_{\text{max}}) \cdot \frac{v_{S_{\text{max}}} - v_{S_{\text{min}}}}{W_{\text{limit}} - W_{\text{max}}}$$

$$v_{S_{\text{ref}}} = 0.483 \frac{\text{m}}{\text{s}}$$

Max steady hosting velocity ref

$$v_S := \begin{cases} v_{S_{\text{ref}}} \geq v_{S_{\text{max}}} & \\ \parallel v_{S_{\text{max}}} & \\ \text{else if } v_{S_{\text{ref}}} \leq v_{S_{\text{min}}} & \\ \parallel v_{S_{\text{min}}} & \\ \text{else} & \\ \parallel v_{S_{\text{ref}}} & \end{cases} = 0.65 \frac{\text{m}}{\text{s}}$$

Max steady hosting velocity

B.2 Dynamic amplification factor

Dynamic amplification factor	
Vertical velocity load	$v_D := \frac{6 \text{ m} \cdot H_s}{(H_s + 8 \text{ m}) \cdot s} = 0 \frac{\text{m}}{\text{s}}$
Vertical velocity, crane boom tip	$v_C := 0 \frac{\text{m}}{\text{s}}$
Relative velocity	$v_R := 0.5 \cdot v_S + \sqrt{v_D^2 + v_C^2} = 0.325 \frac{\text{m}}{\text{s}}$
	$v_H := 0.5 \cdot \sqrt{v_D^2} = 0 \frac{\text{m}}{\text{s}}$
Modulus of elasticity of rope	$E_w := 95 \frac{\text{kN}}{\text{mm}^2}$
Diameter of wire rope	$d_{\text{rope}} := 30 \text{ mm}$
Fill factor	$f := 0.72$
Effective steel area of wire rope	$A_{\text{eff}} := \frac{\pi \cdot d_{\text{rope}}^2}{4} \cdot f = 508.938 \text{ mm}^2$
Rope length	$L_w := (h - 6 \text{ m}) \cdot \text{falls} + l_{\text{boom}_2} = 134 \text{ m}$
Elongation of hoist rope	$L_s := \frac{R_n \cdot L_w \cdot g}{E_w \cdot A_{\text{eff}}} = 924.093 \text{ mm}$
Vertical displacement of hook	$UY_{\text{hook}} := \frac{L_s}{\text{falls}}$
Crane stiffness	$C := \frac{R_n \cdot g}{UY_{\text{hook}}} = 721.629 \frac{\text{kN}}{\text{m}}$
DAF ref	$\phi_{n_{\text{ref}}} := 1 + \frac{v_R}{g} \cdot \sqrt{\frac{C}{R_n}} = 1.153$
DAF	$\phi_n := \begin{cases} \text{if } H_s > 0 & = 1.15 \\ \quad \left\ \begin{array}{l} \text{if } \phi_{n_{\text{ref}}} > 1.3 \\ \quad \left\ \phi_{n_{\text{ref}}} \\ \quad \text{else} \\ \quad \left\ 1.3 \end{array} \right. \right. \\ \quad \text{else} \\ \quad \left\ 1.15 \end{array} \right. \end{cases}$

B.3 Wire rope

Wire rope	
Minimum breaking load	$MBL := 821 \text{ kN}$
Minimum sheave diameter	$ds := 704 \text{ mm}$
Number of fixed sheaves in boom	$n_s := 1$
Mechanical advantage	$n_m := \text{falls} = 2$
Sheave diameter	$D_{\text{sheave}} := 704 \text{ mm}$
Bearing diameter	$d_{\text{bearing}} := 150 \text{ mm}$
Type of bearings	<i>roller</i>
Single sheave efficiency	$\eta_s := 0.985$
Total rope reeving efficiency	$\eta_{\text{tot}} := \frac{\eta_s^{n_s} \cdot (1 - \eta_s^{n_m})}{n_m \cdot (1 - \eta_s)} = 0.978$
Running rigging	
Static DF	
Safety factor	$Z_p := \begin{cases} \text{if } R_n \leq 10 \text{ tonne} & 4.523 \\ \parallel 5.0 \\ \text{else} & \frac{10^4 \text{ tonne}}{(8.85 \cdot R_n) + 1910 \text{ tonne}} \end{cases}$
Load reference factor for running rigging	$X_{RN} := \begin{cases} \text{if } R_n \leq 10 \text{ tonne} & 3.448 \\ \parallel 4.0 \\ \text{else} & \frac{10^4 \text{ tonne}}{(43 \cdot R_n) + 1438 \text{ tonne}} \end{cases}$
Dynamic DF	$\gamma_{rb} := 1.34 + \frac{X_{RN}}{\left(\frac{ds}{d_{\text{rope}}}\right)^{0.8} - 4} = 1.746$
Dynamic load	$W_{\text{dynamic}} := R_n \cdot \phi_n = 39.1 \text{ tonne}$

Static UF

$$UF_{static_wire_rope} := \frac{((W_{hoist_block} + R_n + (W_{rope} \cdot h)) \cdot g \cdot Z_p)}{MBL \cdot \eta_{tot} \cdot falls} = 0.966$$

Dynamic UF

$$UF_{dynamic_wire_rope} := \frac{(W_{dynamic} \cdot \gamma_{p_hook_load} + (W_{hoist_block} + W_{rope} \cdot h) \cdot \gamma_{p_selfweight}) \cdot g \cdot \gamma_{rb}}{MBL \cdot \eta_{tot} \cdot falls}$$

$$UF_{dynamic_wire_rope} = 0.572$$

B.4 Pedestal

Pedestal	
Section area	$S_{a_pedestal} := \frac{\pi \cdot (OD_{pedestal}^2 - (OD_{pedestal} - 2 \cdot t_{pedestal})^2)}{4} = (2.799 \cdot 10^5) \text{ mm}^2$
Section modulus	$S_{m_pedestal} := \frac{\pi \cdot (OD_{pedestal}^4 - (OD_{pedestal} - 2 \cdot t_{pedestal})^4)}{32 \cdot OD_{pedestal}} = (2.058 \cdot 10^8) \text{ mm}^3$
y-centroid	$y := \frac{OD_{pedestal}}{2} - \frac{t_{pedestal}}{2} = (1.485 \cdot 10^3) \text{ mm}$
Moment of inertia	$M_{pedestal} := \frac{\pi \cdot (OD_{pedestal}^4 - (OD_{pedestal} - 2 \cdot t_{pedestal})^4)}{64} = (3.087 \cdot 10^{11}) \text{ mm}^4$
Z	$Z := \frac{L_{pedestal}^2}{y \cdot t_{pedestal}} \cdot \sqrt{1 - 0.3^2} = 3.083 \cdot 10^3$
Curvature factor	$zeta := 0.702 \cdot Z = 2.165 \cdot 10^3$
Imperfection factor	$rho := \frac{1}{2 \cdot \sqrt{1 + \frac{y}{300 \cdot t_{pedestal}}}} = 0.463$
Reduced buckling coefficient	$C_{buckling} := 1 \cdot \sqrt{1 + \left(\frac{rho \cdot zeta}{1}\right)^2} = 1.003 \cdot 10^3$
Elastic buckling stress	$sige := \frac{C_{buckling} \cdot \pi^2 \cdot E}{12 \cdot (1 - 0.3^2)} \cdot \left(\frac{t_{pedestal}}{L_{pedestal}}\right)^2 = (1.189 \cdot 10^3) \text{ MPa}$
	$i := \sqrt{\frac{M_{pedestal}}{S_{a_pedestal}}} = (1.05 \cdot 10^3) \text{ mm}$
	$\left(\frac{L_{pedestal}}{i}\right)^2 = 130.586$

$$\frac{2.5 \cdot E}{fy} = 1.522 \cdot 10^3$$

Check for global buckling

$$\left(\frac{L_{pedestal}}{i} \right)^2 < \frac{2.5 \cdot E}{fy} = 1$$

Allowable buckling stress in pedestal

$$sigcr := \frac{fy}{\gamma_m \sqrt{1 + \left(\sqrt{\frac{fy}{sigcr}} \right)^4}} = 301.222 \text{ MPa}$$

Control of section class

$$\varepsilon_{pedestal} := 0.81$$

$$\frac{OD_{pedestal}}{t_{pedestal}} = 100$$

Section class 1

$$50 \cdot \varepsilon_{pedestal}^2 = 32.805$$

Section class 2

$$70 \cdot \varepsilon_{pedestal}^2 = 45.927$$

Section class 3

$$90 \cdot \varepsilon_{pedestal}^2 = 59.049$$

Resulting section class:

$$4$$

UF pedestal

Bending moment

$$M_{bending_pedestal} := R_n \cdot (Rad) \cdot \gamma_{p_hook_load} \downarrow + \left((W_{slew_2} + W_{winch}) \cdot \left(\frac{Rad}{2} \right) \downarrow + (y_{boom_1}) \cdot \cos \left(\frac{180 \text{ deg} - \alpha}{2} \right) \cdot W_{boom_1} \downarrow + \left(Rad - y_{boom_2} \cdot \cos \left(\frac{180 \text{ deg} - \alpha}{2} \right) \right) \cdot W_{boom_2} \right) \cdot \gamma_{p_selfweight}$$

$$M_{bending_pedestal} = (2.569 \cdot 10^3) \text{ tonne} \cdot \text{m}$$

Axial force

$$F_{axial} := R_n \cdot \gamma_{p_hook_load} + (W_{arm} + W_{slew_1} + W_{winch} + W_{slew_2} + W_{adapter}) \cdot \gamma_{p_selfweight}$$

$$F_{axial} = 156.255 \text{ tonne}$$

Bending stress

$$\sigma_{bending} := \frac{M_{bending_pedestal} \cdot g}{S_{m_pedestal}} = 122.427 \text{ MPa}$$

Axial stress

$$\sigma_{axial} := \frac{F_{axial} \cdot g}{S_{a_pedestal}} = 5.474 \text{ MPa}$$

Combined stress

$$\sigma_{combined} := \sigma_{bending} + \sigma_{axial} = 127.901 \text{ MPa}$$

UF pedestal

$$UF_{pedestal} := \frac{\sigma_{combined} \cdot \gamma_n}{sigcr} = 0.425$$

B.5 Pedestal adapter

Pedestal adapter	
Section area	$S_{a_adapter} := \frac{\pi \cdot (OD_{adapter}^2 - (OD_{adapter} - 2 \cdot t_{adapter})^2)}{4} = (2.799 \cdot 10^5) \text{ mm}^2$
Section modulus	$S_{m_adapter} := \frac{\pi \cdot (OD_{adapter}^4 - (OD_{adapter} - 2 \cdot t_{adapter})^4)}{32 \cdot OD_{adapter}} = (2.058 \cdot 10^8) \text{ mm}^3$
y	$\bar{y} := \frac{OD_{adapter}}{2} - \frac{t_{adapter}}{2} = (1.485 \cdot 10^3) \text{ mm}$
Moment of inertia	$M_{adapter} := \frac{\pi \cdot (OD_{adapter}^4 - (OD_{adapter} - 2 \cdot t_{adapter})^4)}{64} = (3.087 \cdot 10^{11}) \text{ mm}^4$
Z	$\bar{Z} := \frac{I_{adapter}^2}{y \cdot t_{adapter}} \cdot \sqrt{1 - 0.3^2} = 1.37 \cdot 10^3$
Curvature factor	$\bar{zeta} := 0.702 \cdot Z = 962.033$
Imperfection factor	$\bar{\rho} := \frac{1}{2 \cdot \sqrt{1 + \frac{y}{300 \cdot t_{adapter}}}} = 0.463$
Reduced buckling stress	$\bar{C}_{buckling} := 1 \cdot \sqrt{1 + \left(\frac{\bar{\rho} \cdot \bar{zeta}}{1}\right)^2} = 445.654$
Elastic buckling coefficient	$\bar{\sigma}_{el} := \frac{C_{buckling} \cdot \pi^2 \cdot E}{12 \cdot (1 - 0.3^2)} \cdot \left(\frac{t_{adapter}}{L_{adapter}}\right)^2 = (1.189 \cdot 10^3) \text{ MPa}$
	$\bar{\sigma} := \sqrt{\frac{M_{adapter}}{S_{a_adapter}}} = (1.05 \cdot 10^3) \text{ mm}$
	$\left(\frac{L_{adapter}}{i}\right)^2 = 58.038$
	$\frac{2.5 \cdot E}{fy} = 1.522 \cdot 10^3$

Check for global buckling	$\left(\frac{I_{adapter}}{i}\right)^2 < \frac{2.5 \cdot E}{fy} = 1$
Allowable buckling stress in pedestal	$sigcr := \frac{fy}{\gamma_m \sqrt{1 + \left(\sqrt{\frac{fy}{sigc}}\right)^4}} = 301.222 \text{ MPa}$
Control of section class	
	$\varepsilon_{adapter} := 0.81$
Section class 1	$50 \cdot \varepsilon_{adapter}^2 = 32.805$
Section class 2	$70 \cdot \varepsilon_{adapter}^2 = 45.927$
Section class 3	$90 \cdot \varepsilon_{adapter}^2 = 59.049$
Resulting section class:	4 $\frac{OD_{adapter}}{t_{adapter}} = 100$

UF adapter

Bending moment

$$M_{bending_adapter} := R_n \cdot (Rad) \cdot \gamma_{p_hook_load} \downarrow + \left((W_{slew_2} + W_{winch}) \cdot \left(\frac{Rad}{2} \right) \downarrow + (y_{boom_1}) \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \cdot W_{boom_1} \downarrow + \left(Rad - y_{boom_2} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) \cdot W_{boom_2} \right) \cdot \gamma_{p_selfweight}$$

$$M_{bending_adapter} = (2.569 \cdot 10^3) \text{ tonne} \cdot \text{m}$$

Axial force

$$F_{axial} := (W_{arm} + W_{winch} + W_{slew_2}) \cdot \gamma_{p_selfweight} + R_n \cdot \gamma_{p_hook_load} = 132.38 \text{ tonne}$$

Bending stress

$$\sigma_{bending} := \frac{(M_{bending_adapter} \cdot g)}{S_{m_adapter}} = 122.427 \text{ MPa}$$

Axial stress

$$\sigma_{axial} := \frac{(F_{axial} \cdot g)}{S_{a_adapter}} = 4.638 \text{ MPa}$$

Combined stress

$$\sigma_{combined} := \sigma_{bending} + \sigma_{axial} = 127.065 \text{ MPa}$$

UF pedestal adapter

$$UF_{adapter} := \frac{\sigma_{combined} \cdot \gamma_n}{sigcr} = 0.422$$

B.6 Hoist winch

Hoist winch	
Dynamic amplification factor winch	$DAF_{winch} := 1.6$
Static pull capacity	$SL_{Rd} := 17 \text{ tonne}$
Dynamic winch capacity	$DL_{Rd} := SL_{Rd} \cdot DAF_{winch} = 27.2 \text{ tonne}$
Dynamic load in hoist winch	$Dl_f := \frac{W_{dynamic}}{falls} = 19.55 \text{ tonne}$
UF hoist winch	
Static UF	$UF_{static_winch} := \frac{\left(\frac{R_n}{falls}\right)}{SL_{Rd}} = 1$
Dynamic UF	$UF_{dynamic_winch} := \frac{Dl_f}{DL_{Rd}} = 0.719$

B.7 Slewing bearing 1

Slewing bearing 1

Overturning moment for slewing bearing

$$M_{bending_slew_1} := \left(\begin{array}{l} (R_n \cdot Rad) \cdot \gamma_{p_hook_load} \cdot \downarrow \\ + \left(W_{slew_2} \cdot \frac{Rad}{2} + y_{boom_1} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \cdot W_{boom_1} \cdot \downarrow \right) \cdot \gamma_{p_selfweight} \\ + \left(Rad - y_{boom_2} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) \cdot W_{boom_2} \end{array} \right)$$

$$M_{bending_slew_1} = (2.559 \cdot 10^3) \text{ tonne} \cdot \text{m}$$

Axial force on slewing bearing

$$F_{axial_slew_1} := \left(R_n \cdot \gamma_{p_hook_load} + \left(W_{arm} + W_{slew_2} + W_{adapter} + \frac{W_{slew_1}}{2} \right) \cdot \gamma_{p_selfweight} \right)$$

$$F_{axial_slew_1} = 151.831 \text{ tonne}$$

Radial force on slewing bearing

$$F_{r_slew_1} := 0 \text{ kN}$$

Bolt yield strength

$$R_{slew_1} := 900 \text{ MPa}$$

Stress area for M43 bolts

$$A_{s_slew_1} := 1120 \text{ mm}^2$$

Pretension of bolt relative to yield strength

$$pr_{slew_1} := 0.75$$

Number of bolts

$$m_{slew_1} := 86$$

Raceway diameter

$$D_{slew_1} := 3000 \text{ mm}$$

β

$$\beta := 0$$

Force A

$$F_{A_slew_1} := \left(\frac{4 \cdot M_{bending_slew_1} \cdot g}{D_{slew_1}} - F_{axial_slew_1} \cdot g \right) \cdot \frac{1}{m_{slew_1}}$$

$$F_{A_slew_1} = 371.793 \text{ kN}$$

Force R

$$F_{R_slew_1} := \frac{1}{m_{slew_1}} \left(4 \cdot F_{r_slew_1} + \left(\frac{4 \cdot M_{bending_slew_1} \cdot g}{D_{slew_1}} + F_{axial_slew_1} \cdot g \right) \cdot \tan(\beta) \right)$$

$$F_{R_slew_1} = 0 \text{ N}$$

Relation between horizontal and vertical raceway load per bolt sector

$$x_{slew_1} := \frac{F_{R_slew_1}}{F_{A_slew_1}} = 0$$

$$a \quad a_{slew_1} := 83 \text{ mm}$$

$$b \quad b_{slew_1} := 143 \text{ mm}$$

$$c \quad c_{slew_1} := 67 \text{ mm}$$

Capacity of slewing bearing

$$C_{slew_1} := \frac{0.75}{pr_{slew_1}} \cdot \left(\frac{4 \cdot M_{bending_slew_1} \cdot g}{D_{slew_1}} - F_{axial_slew_1} \cdot g \right) \cdot \frac{1}{m_{slew_1}} \cdot \left(\frac{a_{slew_1} + x_{slew_1} \cdot b_{slew_1} + c_{slew_1}}{c_{slew_1}} \right)$$

$$C_{slew_1} = 832.372 \text{ kN}$$

$$C_{slew_1} \leq R_{slew_1} \cdot A_{s_slew_1}$$

Lever arm effect of slewing bearing 1

$$\gamma_{lae_slew_1} := \frac{(a_{slew_1} + c_{slew_1})}{c_{slew_1}}$$

$$\gamma_{lae_slew_1} = 2.239$$

UF slewing bearing 1

$$\text{Bolt stress} \quad \sigma_{bolt_slew_1} := \frac{0.75}{pr_{slew_1}} \cdot \frac{(F_{A_slew_1} \cdot \gamma_{lae_slew_1})}{A_{s_slew_1}} = 743.189 \text{ MPa}$$

$$\text{UF slewing bearing 1} \quad UF_{slew_1} := \frac{\sigma_{bolt_slew_1}}{R_{slew_1}} = 0.826$$

B.8 Slewing bearing 2

Slewing bearing 2	
Overturning moment for slewing bearing	$M_{bending_slew_2} := (\gamma_{p_hook_load} \cdot l_{boom_2} \cdot R_n + y_{boom_2} \cdot W_{boom_2} \cdot \gamma_{p_selfweight})$ $M_{bending_slew_2} = 909.111 \text{ tonne} \cdot m$
Axial force on slewing bearing	$F_{axial_slew_2} := \left(R_n \cdot \gamma_{p_hook_load} + \left(W_{boom_2} + \frac{W_{slew_2}}{2} \right) \cdot \gamma_{p_selfweight} \right) = 72.864 \text{ tonne}$
Radial force on slewing bearing	$F_{r_slew_2} := 0 \text{ kN}$
Bolt yield strength	$R_{slew_2} := 900 \text{ MPa}$
Stress area for M42 bolts	$A_{s_slew_2} := 1120 \text{ mm}^2$
Pretension of bolt relative to yield strength	$pr_{slew_2} := 0.75$
Number of bolts	$m_{slew_2} := 56$
Raceway diameter	$D_{slew_2} := 2000 \text{ mm}$
β	$\beta := 0$
Force A	$F_{A_slew_2} := \left(\frac{4 \cdot M_{bending_slew_2} \cdot g}{D_{slew_2}} - F_{axial_slew_2} \cdot g \right) \cdot \frac{1}{m_{slew_2}}$ $F_{A_slew_2} = 305.645 \text{ kN}$
Force R	$F_{R_slew_2} := \frac{1}{m_{slew_2}} \left(4 \cdot F_{r_slew_2} + \left(\frac{4 \cdot M_{bending_slew_2} \cdot g}{D_{slew_2}} + F_{axial_slew_2} \cdot g \right) \cdot \tan(\beta) \right)$ $F_{R_slew_2} = 0 \text{ N}$
Relation between horizontal and vertical raceway load per bolt sector	$x_{slew_2} := \frac{F_{R_slew_2}}{F_{A_slew_2}} = 0$
a	$a_{slew_2} := 57.5 \text{ mm}$
b	$b_{slew_2} := 73.5 \text{ mm}$
c	$c_{slew_2} := 31 \text{ mm}$

Capacity of slewing bearing

$$C_{slew_2} := \frac{0.75}{pr_{slew_2}} \cdot \left(\frac{4 \cdot M_{bending_slew_2} \cdot g}{D_{slew_2}} - F_{axial_slew_2} \cdot g \right) \cdot \frac{1}{m_{slew_2}} \cdot \left(\frac{a_{slew_2} + x_{slew_2} \cdot b_{slew_2} + c_{slew_2}}{c_{slew_2}} \right)$$

$$C_{slew_2} = 872.567 \text{ kN}$$

$$C_{slew_2} \leq R_{slew_2} \cdot A_{s_slew_2}$$

Lever arm effect of slewing bearing 2 $\gamma_{lae_slew_2} := \frac{(a_{slew_2} + c_{slew_2})}{c_{slew_2}} = 2.855$

UF slewing bearing 2

Bolt stress $\sigma_{bolt_slew_2} := \frac{0.75}{pr_{slew_2}} \cdot \frac{(F_{A_slew_2} \cdot \gamma_{lae_slew_2})}{A_{s_slew_2}} = 779.078 \text{ MPa}$

UF slewing bearing 2 $UF_{slew_2} := \frac{\sigma_{bolt_slew_2}}{R_{slew_2}} = 0.866$

B.9 Boom section 1

Boom	
Section 1	
Position of section. Dist. from boom pivot	$x_m := 3 \text{ m}$
Height of boom at section	$hm := 2000 \text{ mm}$
Width of boom at section	$bm := 1600 \text{ mm}$
Bottom flange thickness	$t_{fbm} := 30 \text{ mm}$
Top flange thickness	$t_{ftm} := 30 \text{ mm}$
Web thickness at section	$t_{fwm} := 20 \text{ mm}$
Local buckling at section	
Gross area	$A_{xm} := hm \cdot bm - (hm - (t_{fbm} + t_{ftm})) \cdot (bm - 2 \cdot t_{fwm})$ $A_{xm} = (1.736 \cdot 10^5) \text{ mm}^2$
Y centroid of beam:	
Area 1	$A_1 := bm \cdot t_{fbm} = (4.8 \cdot 10^4) \text{ mm}^2$
2* Area 2	$A_2 := 2 \cdot (hm - (t_{fwm} + t_{ftm})) \cdot t_{fwm} = (7.8 \cdot 10^4) \text{ mm}^2$
Area 3	$A_3 := bm \cdot t_{ftm} = (4.8 \cdot 10^4) \text{ mm}^2$
Section modulus, strong axis	$W_{eym} := \frac{bm \cdot hm^3 - (bm - 2 \cdot t_{fwm}) \cdot (hm - (t_{fbm} + t_{ftm}))^3}{6 \cdot hm}$ $W_{eym} = (1.175 \cdot 10^8) \text{ mm}^3$
Section modulus, weak axis	$W_{ezm} := \frac{bm^3 \cdot hm - (bm - 2 \cdot t_{fwm})^3 \cdot (hm - (t_{fbm} + t_{ftm}))}{6 \cdot bm}$ $W_{ezm} = (8.614 \cdot 10^7) \text{ mm}^3$

Effective area	
Stress ratio	$\psi_{bottom} := 1$
Buckling coefficient	$k_{\sigma_bottom} := 4$
Lambda-p	$\lambda_{p_bottom} := \frac{(bm - tfwm - tftm)}{28.4 \cdot \epsilon_{boom} \cdot \sqrt{k_{\sigma_bottom}}} = 1.109$
Rho	$\rho_{bottom_ref} := \frac{\lambda_{p_bottom} - 0.055 \cdot (3 + \psi_{bottom})}{\lambda_{p_bottom}^2} = 0.723$
	$\rho_{bottom} := \begin{cases} \text{if } \lambda_{p_bottom} > \sqrt{0.085 - 0.055 \cdot \psi_{bottom}} \\ \rho_{bottom_ref} \\ \text{else} \\ 1.00 \end{cases} = 0.723$
Effective length	$B_{eff_bottom} := \rho_{bottom} \cdot bm = (1.156 \cdot 10^3) \text{ mm}$
Area bottom flange	$A_{eff_bottom} := B_{eff_bottom} \cdot tfbm = (3.469 \cdot 10^4) \text{ mm}^2$
Area top	$A_{eff_top} := bm \cdot tftm = (4.8 \cdot 10^4) \text{ mm}^2$
Stress ratio	$\psi_{web} := -1$
Buckling coefficient	$k_{\sigma_web} := 23.9$
Lambda-p	$\lambda_{p_web} := \frac{hm - tfbm - tftm}{28.4 \cdot \epsilon_{boom} \cdot \sqrt{k_{\sigma_web}}} = 0.847$
Rho	$\rho_{web_ref} := \frac{\lambda_{p_web} - (0.055 \cdot (3 + \psi_{web}))}{\lambda_{p_web}^2} = 1.028$
	$\rho_{web} := \begin{cases} \text{if } \lambda_{p_web} > \sqrt{0.085 - 0.055 \cdot \psi_{web}} \\ \rho_{web_ref} \\ \text{else} \\ 1.00 \end{cases} = 1.028$

Effective length	$B_{eff_web_ref} := \rho_{web} \cdot \frac{hm - t_{fbm} - t_{ftm}}{1 - \psi_{web}} = 996.983 \text{ mm}$
	$B_{eff_web} := \begin{cases} \frac{hm - t_{fbm} - t_{ftm}}{2} & \text{if } B_{eff_web_ref} > \frac{hm - t_{fbm} - t_{ftm}}{2} \\ B_{eff_web_ref} & \text{else} \end{cases} = 970 \text{ mm}$
	$be1 := 0.4 \cdot B_{eff_web} = 388 \text{ mm}$
	$be2 := 0.6 \cdot B_{eff_web} = 582 \text{ mm}$
Area bottom flange	$A_{eff_web} := (be1 + be2) \cdot 2 \cdot t_{fw} = (3.88 \cdot 10^4) \text{ mm}^2$
Effective area	$A_{eff_total} := A_{eff_bottom} + A_{eff_top} + 2 \cdot A_{eff_web} = (1.603 \cdot 10^5) \text{ mm}^2$
Effective Y centroid of beam	
Effective area 1	$A_{eff_1} := B_{eff_bottom} \cdot t_{fbm} = (3.469 \cdot 10^4) \text{ mm}^2$
y 1	$y_{eff_1} := -\frac{hm}{2} + \frac{t_{fbm}}{2} = -985 \text{ mm}$
Effective area 2_1	$A_{eff_2_1} := be1 \cdot 2 \cdot t_{fw} = (1.552 \cdot 10^4) \text{ mm}^2$
Effective area 2_2	$A_{eff_2_2} := 2 \cdot be2 \cdot t_{fw} = (2.328 \cdot 10^4) \text{ mm}^2$
Effective area 2_3	$A_{eff_2_3} := 2 \cdot \frac{(hm - t_{ftm} - t_{fbm})}{2} \cdot t_{fw} = (3.88 \cdot 10^4) \text{ mm}^2$
y 2.1	$y_{eff_2_1} := -\frac{(hm - t_{ftm} - t_{fbm})}{2} + \frac{0.4 \cdot B_{eff_web}}{2} = -776 \text{ mm}$
y 2.2	$y_{eff_2_2} := -\frac{0.6 \cdot B_{eff_web}}{2} = -291 \text{ mm}$

y 2.3	$y_{eff_2.3} := \frac{(hm - tftm - tfbm)}{2} = 485 \text{ mm}$
Effective area 3	$A_{eff_3} := bm \cdot tftm = (4.8 \cdot 10^4) \text{ mm}^2$
y 3	$y_{eff_3} := \frac{hm}{2} - \frac{tfbm}{2} = 985 \text{ mm}$
Effective Y centroid	$Y_{eff_centroid} := \frac{(y_{eff_1} \cdot A_{eff_1}) + (A_{eff_2.1} \cdot y_{eff_2.1}) + (A_{eff_2.2} \cdot y_{eff_2.2}) + (A_{eff_2.3} \cdot y_{eff_2.3}) + (A_{eff_3} \cdot y_{eff_3})}{A_{eff_1} + A_{eff_2.1} + A_{eff_2.2} + A_{eff_2.3} + A_{eff_3}}$ $Y_{eff_centroid} = 81.791 \text{ mm} \quad 107.3 \text{ mm}$
Y for new effective area 1	$y_{1_new_centroid} := y_{eff_1} - Y_{eff_centroid} = -1.067 \cdot 10^3 \text{ mm}$
Y for new effective area 2.1	$y_{2_1_new_centroid} := y_{eff_2.1} - Y_{eff_centroid} = -857.791 \text{ mm}$
Y for new effective area 2.2	$y_{2_2_new_centroid} := y_{eff_2.2} - Y_{eff_centroid} = -372.791 \text{ mm}$
Y for new effective area 2.3	$y_{2_3_new_centroid} := y_{eff_2.3} - Y_{eff_centroid} = 403.209 \text{ mm}$
Y for new effective area 3	$y_{3_new_centroid} := y_{eff_3} - Y_{eff_centroid} = 903.209 \text{ mm}$
Second moment of area	
Section area 1	$S_{a_1} := \frac{B_{eff_bottom} \cdot tftm^3}{12} = (2.602 \cdot 10^6) \text{ mm}^4$
Section area 2_1	$S_{a_2.1} := 2 \cdot \frac{tfwm \cdot be1^3}{12} = (1.947 \cdot 10^8) \text{ mm}^4$
Section area 2_2	$S_{a_2.2} := 2 \cdot \frac{tfwm \cdot be2^3}{12} = (6.571 \cdot 10^8) \text{ mm}^4$
Section area 2_3	$S_{a_2.3} := 2 \cdot \frac{tfwm \cdot \left(\frac{hm - tftm - tfbm}{2}\right)^3}{12} = (3.042 \cdot 10^9) \text{ mm}^4$
Section area 3	$S_{a_3} := \frac{bm \cdot tftm^3}{12} = (3.6 \cdot 10^6) \text{ mm}^4$

Second moment of area I_y

$$I_{effy} := (S_{a_1} + A_{eff_1} \cdot y_{1_new_centroid}^2) + (S_{a_2_1} + A_{eff_2_1} \cdot y_{2_1_new_centroid}^2) \downarrow \\ + (S_{a_2_2} + A_{eff_2_2} \cdot y_{2_2_new_centroid}^2) + (S_{a_2_3} + A_{eff_2_3} \cdot y_{2_3_new_centroid}^2) \downarrow \\ + (S_{a_3} + A_{eff_3} \cdot y_{3_new_centroid}^2)$$

$$I_{effy} = (1.035 \cdot 10^{11}) \text{ mm}^4$$

Effective section modulus

$$W_{effy} := \frac{I_{effy}}{Y_{eff_centroid} + \frac{hm}{2} - \frac{t_{fbm}}{2}} = (9.702 \cdot 10^7) \text{ mm}^3$$

Boom UF**Section 1**

Shear boom selfweight only $F_{shear_selfweight} := W_{arm} + W_{slew_2} = 70.664 \text{ tonne}$

Bending moment selfweight only

$$M_{bending_selfweight} := (W_{slew_2} + W_{winch}) \cdot \left(\frac{Rad}{2} - xm \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) \downarrow \\ + \left(y_{boom_1} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) - xm \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) \cdot W_{boom_1} \downarrow \\ + \left(\frac{Rad}{2} - xm \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) + y_{boom_2} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) \cdot W_{boom_2}$$

$$M_{bending_selfweight} = 644.069 \text{ m} \cdot \text{tonne}$$

Shear boom hook load only $F_{shear_hook_load} := R_n = 34 \text{ tonne}$

Bending moment hook load only

$$M_{bending_hook_load} := R_n \cdot \left(Rad - xm \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) = 986 \text{ m} \cdot \text{tonne}$$

Total design load $M := M_{bending_selfweight} \cdot \gamma_{p_selfweight} + M_{bending_hook_load} \cdot \gamma_{p_hook_load}$

$$M = (2.107 \cdot 10^3) \text{ tonne} \cdot \text{m}$$

Bending stress $\sigma_{bending} := \frac{M \cdot g}{W_{effy}} = 212.974 \text{ MPa}$

Shear force $F_{shear} := F_{shear_selfweight} \cdot \gamma_{p_selfweight} + F_{shear_hook_load} \cdot \gamma_{p_hook_load}$

$$F_{shear} = 131.77 \text{ tonne}$$

Torsion force

$$T := \sin(180 \text{ deg} - \alpha) \cdot \left(\left(l_{boom_2} - \frac{D_{slew_2}}{2} \right) F_{shear_hook_load} \cdot \gamma_{p_hook_load} \right) \downarrow \\ + \left(\sin(180 \text{ deg} - \alpha) \cdot y_{boom_2} \cdot W_{boom_2} \cdot \gamma_{p_selfweight} \right)$$

$$T = 0 \text{ tonne} \cdot \text{m}$$

Shear stress	$\sigma_{shear} := \frac{F_{shear} \cdot g}{A_{eff_total}} = 8.062 \text{ MPa}$
Torsion web	$\tau_{web} := \frac{T \cdot g}{2 \cdot tfwm \cdot (bm - tfwm) \cdot (hm - tfbm)} = 0 \text{ MPa}$
Torsion flange	$\tau_{flange} := \frac{T \cdot g}{2 \cdot tfbm \cdot (bm - tfwm) \cdot (hm - tfbm)} = 0 \text{ MPa}$
Von mises web	$\sigma_{v_web} := \sqrt{(\sigma_{bending} + \sigma_{shear})^2 + 3 \cdot \tau_{web}^2} = 221.035 \text{ MPa}$
Von mises flange	$\sigma_{v_flange} := \sqrt{(\sigma_{bending} + \sigma_{shear})^2 + 3 \cdot \tau_{flange}^2} = 221.035 \text{ MPa}$
UF web section 1	$UF_{web_section_1} := \frac{\sigma_{v_web}}{\left(\frac{fy}{\gamma_m}\right)} = 0.705$
UF flange section 1	$UF_{flange_section_1} := \frac{\sigma_{v_flange}}{\left(\frac{fy}{\gamma_m}\right)} = 0.705$

centering

B.10 Boom section 2

Boom	
Section 2	
Position of section from senter of pedestal	$xm := 15 \text{ m}$
Height of boom at section	$hm := 2000 \text{ mm}$
Width of boom at section	$bm := 1000 \text{ mm}$
Bottom flange thickness	$tfbm := 30 \text{ mm}$
Top flange thickness	$tftm := 30 \text{ mm}$
Web thickness at section	$tfwm := 20 \text{ mm}$
Local buckling at section	
Gross area	$A_{xm} := hm \cdot bm - (hm - (tfbm + tftm)) \cdot (bm - 2 \cdot tfwm)$ $A_{xm} = (1.376 \cdot 10^5) \text{ mm}^2$
Y centroid of beam:	
Area 1	$A_1 := bm \cdot tfbm = (3 \cdot 10^4) \text{ mm}^2$
2* Area 2	$A_2 := 2 \cdot (hm - (tfwm + tftm)) \cdot tfwm = (7.8 \cdot 10^4) \text{ mm}^2$
Area 3	$A_3 := bm \cdot tftm = (3 \cdot 10^4) \text{ mm}^2$
Section modulus, strong axis	$Weym := \frac{bm \cdot hm^3 - (bm - 2 \cdot tfwm) \cdot (hm - (tfbm + tftm))^3}{6 \cdot hm}$ $Weym = (8.256 \cdot 10^7) \text{ mm}^3$
Section modulus, weak axis	$Wezm := \frac{bm^3 \cdot hm - (bm - 2 \cdot tfwm)^3 \cdot (hm - (tfbm + tftm))}{6 \cdot bm}$ $Wezm = (4.727 \cdot 10^7) \text{ mm}^3$

Effective area	
Stress ratio	$\psi_{bottom} := 1$
Buckling coefficient	$k_{\sigma_bottom} := 4$
Lambda-p	$\lambda_{p_bottom} := \frac{tfbm}{28.4 \cdot \epsilon_{boom} \cdot \sqrt{k_{\sigma_bottom}}} = 0.683$
Rho	$\rho_{bottom_ref} := \frac{\lambda_{p_bottom} - 0.055 \cdot (3 + \psi_{bottom})}{\lambda_{p_bottom}^2} = 0.993$
	$\rho_{bottom} := \begin{cases} \text{if } \lambda_{p_bottom} > \sqrt{0.085 - 0.055 \cdot \psi_{bottom}} \\ \rho_{bottom_ref} \\ \text{else} \\ 1.00 \end{cases} = 0.993$
Effective length	$B_{eff_bottom} := \rho_{bottom} \cdot bm = 992.813 \text{ mm}$
Area bottom flange	$A_{eff_bottom} := B_{eff_bottom} \cdot tfbm = (2.978 \cdot 10^4) \text{ mm}^2$
Area top	$A_{eff_top} := bm \cdot tftm = (3 \cdot 10^4) \text{ mm}^2$
Stress ratio	$\psi_{web} := -1$
Buckling coefficient	$k_{\sigma_web} := 23.9$
Lambda-p	$\lambda_{p_web} := \frac{hm - tfbm - tftm}{28.4 \cdot \epsilon_{boom} \cdot \sqrt{k_{\sigma_web}}} = 0.847$
Rho	$\rho_{web_ref} := \frac{\lambda_{p_web} - (0.055 \cdot (3 + \psi_{web}))}{\lambda_{p_web}^2} = 1.028$
	$\rho_{web} := \begin{cases} \text{if } \lambda_{p_web} > \sqrt{0.085 - 0.055 \cdot \psi_{web}} \\ \rho_{web_ref} \\ \text{else} \\ 1.00 \end{cases} = 1.028$

Effective length	$B_{eff_web_ref} := \rho_{web} \cdot \frac{hm - t_{fbm} - t_{ftm}}{1 - \psi_{web}} = 996.983 \text{ mm}$
	$B_{eff_web} := \text{if } B_{eff_web_ref} > \frac{hm - t_{fbm} - t_{ftm}}{2} = 970 \text{ mm}$ $\left\ \begin{array}{l} \frac{hm - t_{fbm} - t_{ftm}}{2} \\ \text{else} \\ B_{eff_web_ref} \end{array} \right.$
	$be1 := 0.4 \cdot B_{eff_web} = 388 \text{ mm}$
	$be2 := 0.6 \cdot B_{eff_web} = 582 \text{ mm}$
Area bottom flange	$A_{eff_web} := (be1 + be2) \cdot 2 \cdot t_{fwm} = (3.88 \cdot 10^4) \text{ mm}^2$
Effective area	$A_{eff_total} := A_{eff_bottom} + A_{eff_top} + 2 \cdot A_{eff_web} = (1.374 \cdot 10^5) \text{ mm}^2$
Effective Y centroid of beam	
Effective area 1	$A_{eff_1} := B_{eff_bottom} \cdot t_{fbm} = (2.978 \cdot 10^4) \text{ mm}^2$
y 1	$y_{eff_1} := -\frac{hm}{2} + \frac{t_{fbm}}{2} = -985 \text{ mm}$
Effective area 2_1	$A_{eff_2_1} := be1 \cdot 2 \cdot t_{fwm} = (1.552 \cdot 10^4) \text{ mm}^2$
Effective area 2_2	$A_{eff_2_2} := 2 \cdot be2 \cdot t_{fwm} = (2.328 \cdot 10^4) \text{ mm}^2$
Effective area 2_3	$A_{eff_2_3} := 2 \cdot \frac{(hm - t_{ftm} - t_{fbm})}{2} \cdot t_{fwm} = (3.88 \cdot 10^4) \text{ mm}^2$
y 2.1	$y_{eff_2_1} := -\frac{(hm - t_{ftm} - t_{fbm})}{2} + \frac{0.4 \cdot B_{eff_web}}{2} = -776 \text{ mm}$
y 2.2	$y_{eff_2_2} := -\frac{0.6 \cdot B_{eff_web}}{2} = -291 \text{ mm}$

y 2.3	$y_{eff_2.3} := \frac{(hm - tftm - tfbm)}{2} = 485 \text{ mm}$
Effective area 3	$A_{eff_3} := bm \cdot tftm = (3 \cdot 10^4) \text{ mm}^2$
y 3	$y_{eff_3} := \frac{hm}{2} - \frac{tfbm}{2} = 985 \text{ mm}$
Effective Y centroid	$Y_{eff_centroid} := \frac{(y_{eff_1} \cdot A_{eff_1}) + (A_{eff_2.1} \cdot y_{eff_2.1}) + (A_{eff_2.2} \cdot y_{eff_2.2}) + (A_{eff_2.3} \cdot y_{eff_2.3}) + (A_{eff_3} \cdot y_{eff_3})}{A_{eff_1} + A_{eff_2.1} + A_{eff_2.2} + A_{eff_2.3} + A_{eff_3}}$ $Y_{eff_centroid} = 1.546 \text{ mm}$
Y for new effective area 1	$y_{1_new_centroid} := y_{eff_1} - Y_{eff_centroid} = -986.546 \text{ mm}$
Y for new effective area 2.1	$y_{2_1_new_centroid} := y_{eff_2.1} - Y_{eff_centroid} = -777.546 \text{ mm}$
Y for new effective area 2.2	$y_{2_2_new_centroid} := y_{eff_2.2} - Y_{eff_centroid} = -292.546 \text{ mm}$
Y for new effective area 2.3	$y_{2_3_new_centroid} := y_{eff_2.3} - Y_{eff_centroid} = 483.454 \text{ mm}$
Y for new effective area 3	$y_{3_new_centroid} := y_{eff_3} - Y_{eff_centroid} = 983.454 \text{ mm}$
Second moment of area	
Section area 1	$S_{a_1} := \frac{B_{eff_bottom} \cdot tftm^3}{12} = (2.234 \cdot 10^6) \text{ mm}^4$
Section area 2_1	$S_{a_2.1} := 2 \cdot \frac{tfwm \cdot be1^3}{12} = (1.947 \cdot 10^8) \text{ mm}^4$
Section area 2_2	$S_{a_2.2} := 2 \cdot \frac{tfwm \cdot be2^3}{12} = (6.571 \cdot 10^8) \text{ mm}^4$
Section area 2_3	$S_{a_2.3} := 2 \cdot \frac{tfwm \cdot \left(\frac{hm - tftm - tfbm}{2}\right)^3}{12} = (3.042 \cdot 10^9) \text{ mm}^4$
Section area 3	$S_{a_3} := \frac{bm \cdot tfbm^3}{12} = (2.25 \cdot 10^6) \text{ mm}^4$

Second moment of area I_y

$$\boxed{I_{effy}} := (S_{a_1} + A_{eff_1} \cdot y_{1_new_centroid}^2) + (S_{a_2_1} + A_{eff_2_1} \cdot y_{2_1new_centroid}^2) \downarrow \\ + (S_{a_2_2} + A_{eff_2_2} \cdot y_{2_2new_centroid}^2) + (S_{a_2_3} + A_{eff_2_3} \cdot y_{2_3new_centroid}^2) \downarrow \\ + (S_{a_3} + A_{eff_3} \cdot y_{3_new_centroid}^2)$$

$$I_{effy} = (8.235 \cdot 10^{10}) \text{ mm}^4$$

Effective section modulus

$$\boxed{W_{effy}} := \frac{I_{effy}}{Y_{eff_centroid} + \frac{hm}{2} - \frac{tfbm}{2}} = (8.347 \cdot 10^7) \text{ mm}^3$$

Boom UF**Section 2**

Shear boom selfweight only $F_{shear_selfweight} := W_{boom_2} + W_{slew_2} + W_{section_2_1} = 29.828 \text{ tonne}$

Bending moment selfweight only

$$M_{bending_selfweight} := (W_{slew_2} + W_{winch}) \cdot 1 \text{ m} + W_{section_2_1} \cdot 1 \text{ m} \cdot l \\ + \left(y_{boom_2} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right) \right) \cdot W_{boom_2}$$

$$M_{bending_selfweight} = 156.213 \text{ tonne} \cdot \text{m}$$

Shear boom hook load only $F_{shear_hook_load} := R_n = 34 \text{ tonne}$

Bending moment hook load only

$$M_{bending_hook_load} := R_n \cdot l_{section_2_2} \cdot \cos\left(\frac{180 \text{ deg} - \alpha}{2}\right)$$

$$M_{bending_hook_load} = 578 \text{ tonne} \cdot \text{m}$$

Total design load $M := M_{bending_selfweight} \cdot \gamma_{p_selfweight} + M_{bending_hook_load} \cdot \gamma_{p_hook_load}$

$$M = 965.1 \text{ tonne} \cdot \text{m}$$

Bending stress $\sigma_{bending} := \frac{M \cdot g}{W_{effy}} = 113.388 \text{ MPa}$

Shear force $F_{shear} := F_{shear_selfweight} \cdot \gamma_{p_selfweight} + F_{shear_hook_load} \cdot \gamma_{p_hook_load}$

$$F_{shear} = 81.95 \text{ tonne}$$

Torsion force

$$T := \sin(180 \text{ deg} - \alpha) \cdot \left(l_{boom_2} - \frac{D_{slew_2}}{2} \right) \cdot F_{shear_hook_load} \cdot \gamma_{p_hook_load} \cdot l \\ + \sin(180 \text{ deg} - \alpha) \cdot y_{boom_2} \cdot W_{boom_2} \cdot \gamma_{p_selfweight}$$

$$T = 0 \text{ tonne} \cdot \text{m}$$

Shear stress	$\sigma_{shear} := \frac{F_{shear} \cdot g}{A_{eff_total}} = 5.85 \text{ MPa}$
Torsion web	$\tau_{web} := \frac{T \cdot g}{2 \cdot tf_{wm} \cdot (bm - tf_{wm}) \cdot (hm - tf_{bm})} = 0 \text{ MPa}$
Torsion flange	$\tau_{flange} := \frac{T \cdot g}{2 \cdot tf_{bm} \cdot (bm - tf_{wm}) \cdot (hm - tf_{bm})} = 0 \text{ MPa}$
Von mises web	$\sigma_{v_web} := \sqrt{(\sigma_{bending} + \sigma_{shear})^2 + 3 \cdot \tau_{web}^2} = 119.237 \text{ MPa}$
Von mises flange	$\sigma_{v_flange} := \sqrt{(\sigma_{bending} + \sigma_{shear})^2 + 3 \cdot \tau_{flange}^2} = 119.237 \text{ MPa}$
UF web section 2	$UF_{web_section_2} := \frac{\sigma_{v_web}}{\left(\frac{fy}{\gamma_m}\right)} = 0.38$
UF flange section 2	$UF_{flange_section_2} := \frac{\sigma_{v_flange}}{\left(\frac{fy}{\gamma_m}\right)} = 0.38$

B.11 Boom section 3

Boom	
Section 3	
Position of section from senter of pedestal	$x_m := 18 \text{ m}$
Height of boom at section	$h_m := 1500 \text{ mm}$
Width of boom at section	$b_m := 1500 \text{ mm}$
Bottom flange thickness	$t_{fbm} := 30 \text{ mm}$
Top flange thickness	$t_{ftm} := 30 \text{ mm}$
Web thickness at section	$t_{fwm} := 20 \text{ mm}$
Local buckling at section	
Gross area	$A_{xm} := h_m \cdot b_m - (h_m - (t_{fbm} + t_{ftm})) \cdot (b_m - 2 \cdot t_{fwm})$ $A_{xm} = (1.476 \cdot 10^5) \text{ mm}^2$
Y centroid of beam:	
Area 1	$A_1 := b_m \cdot t_{fbm} = (4.5 \cdot 10^4) \text{ mm}^2$
2* Area 2	$A_2 := 2 \cdot (h_m - (t_{fwm} + t_{ftm})) \cdot t_{fwm} = (5.8 \cdot 10^4) \text{ mm}^2$
Area 3	$A_3 := b_m \cdot t_{ftm} = (4.5 \cdot 10^4) \text{ mm}^2$
Section modulus, strong axis	$W_{eym} := \frac{b_m \cdot h_m^3 - (b_m - 2 \cdot t_{fwm}) \cdot (h_m - (t_{fbm} + t_{ftm}))^3}{6 \cdot h_m}$ $W_{eym} = (7.811 \cdot 10^7) \text{ mm}^3$
Section modulus, weak axis	$W_{ezm} := \frac{b_m^3 \cdot h_m - (b_m - 2 \cdot t_{fwm})^3 \cdot (h_m - (t_{fbm} + t_{ftm}))}{6 \cdot b_m}$ $W_{ezm} = (6.456 \cdot 10^7) \text{ mm}^3$

Effective area	
Stress ratio	$\psi_{bottom} := 1$
Buckling coefficient	$k_{\sigma_bottom} := 4$
Lambda-p	$\lambda_{p_bottom} := \frac{bm - tfwm - tfwm}{tfbm} = 1.038$
Rho	$\rho_{bottom_ref} := \frac{\lambda_{p_bottom} - (0.055 \cdot (3 + \psi_{bottom}))}{\lambda_{p_bottom}^2} = 0.759$
	$\rho_{bottom} := \begin{cases} \text{if } \lambda_{p_bottom} > \sqrt{0.085 - 0.055 \cdot \psi_{bottom}} \\ \rho_{bottom_ref} \\ \text{else} \\ 1.00 \end{cases} = 0.759$
Effective length	$B_{eff_bottom} := \rho_{bottom} \cdot bm = (1.139 \cdot 10^3) \text{ mm}$
Area bottom flange	$A_{eff_bottom} := B_{eff_bottom} \cdot tfbm = (3.416 \cdot 10^4) \text{ mm}^2$
Area top	$A_{eff_top} := bm \cdot tftm = (4.5 \cdot 10^4) \text{ mm}^2$
Stress ratio	$\psi_{web} := -1$
Buckling coefficient	$k_{\sigma_web} := 23.9$
Lambda-p	$\lambda_{p_web} := \frac{hm - tfbm - tftm}{tfwm} = 0.628$
Rho	$\rho_{web_ref} := \frac{\lambda_{p_web} - (0.055 \cdot (3 + \psi_{web}))}{\lambda_{p_web}^2} = 1.313$
	$\rho_{web} := \begin{cases} \text{if } \lambda_{p_web} > \sqrt{0.085 - 0.055 \cdot \psi_{web}} \\ \rho_{web_ref} \\ \text{else} \\ 1.00 \end{cases} = 1.313$

Effective length	$B_{eff_web_ref} := \rho_{web} \cdot \frac{hm - t_{fbm} - t_{ftm}}{1 - \psi_{web}} = 945.281 \text{ mm}$
	$B_{eff_web} := \text{if } B_{eff_web_ref} > \frac{hm - t_{fbm} - t_{ftm}}{2} = 720 \text{ mm}$ $\left\ \begin{array}{l} \frac{hm - t_{fbm} - t_{ftm}}{2} \\ \text{else} \\ B_{eff_web_ref} \end{array} \right.$
	$be1 := 0.4 \cdot B_{eff_web} = 288 \text{ mm}$
	$be2 := 0.6 \cdot B_{eff_web} = 432 \text{ mm}$
Area bottom flange	$A_{eff_web} := (be1 + be2) \cdot 2 \cdot t_{fw} = (2.88 \cdot 10^4) \text{ mm}^2$
Effective area	$A_{eff_total} := A_{eff_bottom} + A_{eff_top} + 2 \cdot A_{eff_web} = (1.368 \cdot 10^5) \text{ mm}^2$
Effective Y centroid of beam	
Effective area 1	$A_{eff_1} := B_{eff_bottom} \cdot t_{fbm} = (3.416 \cdot 10^4) \text{ mm}^2$
y 1	$y_{eff_1} := -\frac{hm}{2} + \frac{t_{fbm}}{2} = -735 \text{ mm}$
Effective area 2_1	$A_{eff_2_1} := be1 \cdot 2 \cdot t_{fw} = (1.152 \cdot 10^4) \text{ mm}^2$
Effective area 2_2	$A_{eff_2_2} := 2 \cdot be2 \cdot t_{fw} = (1.728 \cdot 10^4) \text{ mm}^2$
Effective area 2_3	$A_{eff_2_3} := 2 \cdot \frac{(hm - t_{ftm} - t_{fbm})}{2} \cdot t_{fw} = (2.88 \cdot 10^4) \text{ mm}^2$
y 2.1	$y_{eff_2_1} := -\frac{hm}{2} + \frac{0.4 \cdot B_{eff_web}}{2} + t_{ftm} = -576 \text{ mm}$
y 2.2	$y_{eff_2_2} := -\frac{0.6 \cdot B_{eff_web}}{2} = -216 \text{ mm}$
y 2.3	$y_{eff_2_3} := \frac{(hm - t_{ftm} - t_{fbm})}{2} = 360 \text{ mm}$
Effective area 3	$A_{eff_3} := bm \cdot t_{ftm} = (4.5 \cdot 10^4) \text{ mm}^2$

y 3	$y_{eff_3} := \frac{hm}{2} - \frac{tfbm}{2} = 735 \text{ mm}$
Effective Y centroid	$Y_{eff_centroid} := \frac{(y_{eff_1} \cdot A_{eff_1}) + (A_{eff_2_1} \cdot y_{eff_2_1}) + (A_{eff_2_2} \cdot y_{eff_2_2}) + (A_{eff_2_3} \cdot y_{eff_2_3}) + (A_{eff_3} \cdot y_{eff_3})}{A_{eff_1} + A_{eff_2_1} + A_{eff_2_2} + A_{eff_2_3} + A_{eff_3}}$ $Y_{eff_centroid} = 58.254 \text{ mm}$
Y for new effective area 1	$y_{1_new_centroid} := y_{eff_1} - Y_{eff_centroid} = -793.254 \text{ mm}$
Y for new effective area 2.1	$y_{2_1_new_centroid} := y_{eff_2_1} - Y_{eff_centroid} = -634.254 \text{ mm}$
Y for new effective area 2.2	$y_{2_2_new_centroid} := y_{eff_2_2} - Y_{eff_centroid} = -274.254 \text{ mm}$
Y for new effective area 2.3	$y_{2_3_new_centroid} := y_{eff_2_3} - Y_{eff_centroid} = 301.746 \text{ mm}$
Y for new effective area 3	$y_{3_new_centroid} := y_{eff_3} - Y_{eff_centroid} = 676.746 \text{ mm}$
Second moment of area	
Section area 1	$S_{a_1} := \frac{B_{eff_bottom} \cdot tftm^3}{12} = (2.562 \cdot 10^6) \text{ mm}^4$
Section area 2_1	$S_{a_2_1} := 2 \cdot \frac{tfwm \cdot be1^3}{12} = (7.963 \cdot 10^7) \text{ mm}^4$
Section area 2_2	$S_{a_2_2} := 2 \cdot \frac{tfwm \cdot be2^3}{12} = (2.687 \cdot 10^8) \text{ mm}^4$
Section area 2_3	$S_{a_2_3} := 2 \cdot \frac{tfwm \cdot \left(\frac{hm - tftm - tfbm}{2}\right)^3}{12} = (1.244 \cdot 10^9) \text{ mm}^4$
Section area 3	$S_{a_3} := \frac{bm \cdot tfbm^3}{12} = (3.375 \cdot 10^6) \text{ mm}^4$

Second moment of area I_y

$$\begin{aligned} I_{effy} := & (S_{a_1} + A_{eff_1} \cdot y_{1_new_centroid}^2) + (S_{a_2_1} + A_{eff_2_1} \cdot y_{2_1_new_centroid}^2) \downarrow \\ & + (S_{a_2_2} + A_{eff_2_2} \cdot y_{2_2_new_centroid}^2) + (S_{a_2_3} + A_{eff_2_3} \cdot y_{2_3_new_centroid}^2) \downarrow \\ & + (S_{a_3} + A_{eff_3} \cdot y_{3_new_centroid}^2) \end{aligned}$$

$$I_{effy} = (5.226 \cdot 10^{10}) \text{ mm}^4$$

Effective section modulus

$$W_{effy} := \frac{I_{effy}}{Y_{eff_centroid} + \frac{hm}{2} - \frac{tfbm}{2}} = (6.588 \cdot 10^7) \text{ mm}^3$$

Boom UF

Section 3

Shear boom selfweight only $F_{shear_selfweight} := W_{section_3_2} = 15.99 \text{ tonne}$

Bendin moment selfweight only $M_{bending_selfweight} := W_{section_3_2} \cdot Y_{section_3_2}$

$$M_{bending_selfweight} = 119.833 \text{ tonne} \cdot \text{m}$$

Shear boom hook load only $F_{shear_hook_load} := R_n = 34 \text{ tonne}$

Bendin moment hook load only $M_{bending_hook_load} := R_n \cdot (l_{section_3_2}) = 510 \text{ tonne} \cdot \text{m}$

Total design load $M := M_{bending_selfweight} \cdot \gamma_{p_selfweight} + M_{bending_hook_load} \cdot \gamma_{p_hook_load}$

$$M = 829.596 \text{ tonne} \cdot \text{m}$$

Bending stress $\sigma_{bending} := \frac{M \cdot g}{W_{effy}} = 123.49 \text{ MPa}$

Shear force $F_{shear} := F_{shear_selfweight} \cdot \gamma_{p_selfweight} + F_{shear_hook_load} \cdot \gamma_{p_hook_load} = 65.068 \text{ tonne}$

Shear stress $\sigma_{shear} := \frac{F_{shear} \cdot g}{A_{eff_total}} = 4.666 \text{ MPa}$

Von mises $\sigma_v := \sigma_{bending} + \sigma_{shear} = 128.156 \text{ MPa}$

UF section 3 $UF_{section_3} := \frac{\sigma_v}{\left(\frac{fy}{\gamma_m}\right)} = 0.409$

B.12 Boom section 4

Boom	
Section 4	
Position of section from pivot	$xm := 31.5 \text{ m}$
Height of boom at section	$hm := 1300 \text{ mm}$
Width of boom at section	$bm := 1000 \text{ mm}$
Bottom flange thickness	$tfbm := 30 \text{ mm}$
Top flange thickness	$tftm := 30 \text{ mm}$
Web thickness at section	$tfwm := 20 \text{ mm}$
Local buckling at section	
Gross area	$A_{xm} := hm \cdot bm - (hm - (tfbm + tftm)) \cdot (bm - 2 \cdot tfwm)$ $A_{xm} = (1.096 \cdot 10^5) \text{ mm}^2$
Y centroid of beam:	
Area 1	$A_1 := bm \cdot tfbm = (3 \cdot 10^4) \text{ mm}^2$
2* Area 2	$A_2 := 2 \cdot (hm - (tfwm + tftm)) \cdot tfwm = (5 \cdot 10^4) \text{ mm}^2$
Area 3	$A_3 := bm \cdot tftm = (3 \cdot 10^4) \text{ mm}^2$
Section modulus, strong axis	$Weym := \frac{bm \cdot hm^3 - (bm - 2 \cdot tfwm) \cdot (hm - (tfbm + tftm))^3}{6 \cdot hm}$ $Weym = (4.701 \cdot 10^7) \text{ mm}^3$
Section modulus, weak axis	$Wezm := \frac{bm^3 \cdot hm - (bm - 2 \cdot tfwm)^3 \cdot (hm - (tfbm + tftm))}{6 \cdot bm}$ $Wezm = (3.382 \cdot 10^7) \text{ mm}^3$

Effective area	
Stress ratio	$\psi_{bottom} := 1$
Buckling coefficient	$k_{\sigma_bottom} := 4$
Lambda-p	$\lambda_{p_bottom} := \frac{bm - tfwm - tfwm}{tfbm} = 0.683$
Rho	$\rho_{bottom_ref} := \frac{\lambda_{p_bottom} - (0.055 \cdot (3 + \psi_{bottom}))}{\lambda_{p_bottom}^2} = 0.993$
	$\rho_{bottom} := \begin{cases} \text{if } \lambda_{p_bottom} > \sqrt{0.085 - 0.055 \cdot \psi_{bottom}} \\ \rho_{bottom_ref} \\ \text{else} \\ 1.00 \end{cases} = 0.993$
Effective length	$B_{eff_bottom} := \rho_{bottom} \cdot bm = 992.813 \text{ mm}$
Area bottom flange	$A_{eff_bottom} := B_{eff_bottom} \cdot tfbm = (2.978 \cdot 10^4) \text{ mm}^2$
Area top	$A_{eff_top} := bm \cdot tftm = (3 \cdot 10^4) \text{ mm}^2$
Stress ratio	$\psi_{web} := -1$
Buckling coefficient	$k_{\sigma_web} := 23.9$
Lambda-p	$\lambda_{p_web} := \frac{hm - tfbm - tftm}{tfwm} = 0.541$
Rho	$\rho_{web_ref} := \frac{\lambda_{p_web} - (0.055 \cdot (3 + \psi_{web}))}{\lambda_{p_web}^2} = 1.472$
	$\rho_{web} := \begin{cases} \text{if } \lambda_{p_web} > \sqrt{0.085 - 0.055 \cdot \psi_{web}} \\ \rho_{web_ref} \\ \text{else} \\ 1.00 \end{cases} = 1.472$

Effective length	$B_{eff_web_ref} := \rho_{web} \cdot \frac{hm - t_{fbm} - t_{ftm}}{1 - \psi_{web}} = 912.925 \text{ mm}$
	$B_{eff_web} := \text{if } B_{eff_web_ref} > \frac{hm - t_{fbm} - t_{ftm}}{2} = 620 \text{ mm}$ $\left\ \frac{hm - t_{fbm} - t_{ftm}}{2} \right.$ else $\left\ B_{eff_web_ref} \right.$
	$be1 := 0.4 \cdot B_{eff_web} = 248 \text{ mm}$
	$be2 := 0.6 \cdot B_{eff_web} = 372 \text{ mm}$
Area bottom flange	$A_{eff_web} := (be1 + be2) \cdot 2 \cdot t_{fwm} = (2.48 \cdot 10^4) \text{ mm}^2$
Effective area	$A_{eff_total} := A_{eff_bottom} + A_{eff_top} + 2 \cdot A_{eff_web} = (1.094 \cdot 10^5) \text{ mm}^2$
Effective Y centroid of beam	
Effective area 1	$A_{eff_1} := B_{eff_bottom} \cdot t_{fbm} = (2.978 \cdot 10^4) \text{ mm}^2$
y 1	$y_{eff_1} := -\frac{hm}{2} + \frac{t_{fbm}}{2} = -635 \text{ mm}$
Effective area 2_1	$A_{eff_2_1} := be1 \cdot 2 \cdot t_{fwm} = (9.92 \cdot 10^3) \text{ mm}^2$
Effective area 2_2	$A_{eff_2_2} := 2 \cdot be2 \cdot t_{fwm} = (1.488 \cdot 10^4) \text{ mm}^2$
Effective area 2_3	$A_{eff_2_3} := 2 \cdot \frac{(hm - t_{ftm} - t_{fbm})}{2} \cdot t_{fwm} = (2.48 \cdot 10^4) \text{ mm}^2$
y 2.1	$y_{eff_2_1} := -\frac{hm}{2} + \frac{0.4 \cdot B_{eff_web}}{2} + t_{ftm} = -496 \text{ mm}$
y 2.2	$y_{eff_2_2} := -\frac{0.6 \cdot B_{eff_web}}{2} = -186 \text{ mm}$

y 2.3	$y_{eff_2.3} := \frac{(hm - tftm - tfbm)}{2} = 310 \text{ mm}$
Effective area 3	$A_{eff_3} := bm \cdot tftm = (3 \cdot 10^4) \text{ mm}^2$
y 3	$y_{eff_3} := \frac{hm}{2} - \frac{tfbm}{2} = 635 \text{ mm}$
Effective Y centroid	$Y_{eff_centroid} := \frac{(y_{eff_1} \cdot A_{eff_1}) + (A_{eff_2.1} \cdot y_{eff_2.1}) + (A_{eff_2.2} \cdot y_{eff_2.2}) + (A_{eff_2.3} \cdot y_{eff_2.3}) + (A_{eff_3} \cdot y_{eff_3})}{A_{eff_1} + A_{eff_2.1} + A_{eff_2.2} + A_{eff_2.3} + A_{eff_3}}$
	$Y_{eff_centroid} = 1.252 \text{ mm}$
Y for new effective area 1	$y_{1_new_centroid} := y_{eff_1} - Y_{eff_centroid} = -636.252 \text{ mm}$
Y for new effective area 2.1	$y_{2_1_new_centroid} := y_{eff_2.1} - Y_{eff_centroid} = -497.252 \text{ mm}$
Y for new effective area 2.2	$y_{2_2_new_centroid} := y_{eff_2.2} - Y_{eff_centroid} = -187.252 \text{ mm}$
Y for new effective area 2.3	$y_{2_3_new_centroid} := y_{eff_2.3} - Y_{eff_centroid} = 308.748 \text{ mm}$
Y for new effective area 3	$y_{3_new_centroid} := y_{eff_3} - Y_{eff_centroid} = 633.748 \text{ mm}$
Second moment of area	
Section area 1	$S_{a_1} := \frac{B_{eff_bottom} \cdot tftm^3}{12} = (2.234 \cdot 10^6) \text{ mm}^4$
Section area 2_1	$S_{a_2.1} := 2 \cdot \frac{tfwm \cdot be1^3}{12} = (5.084 \cdot 10^7) \text{ mm}^4$
Section area 2_2	$S_{a_2.2} := 2 \cdot \frac{tfwm \cdot be2^3}{12} = (1.716 \cdot 10^8) \text{ mm}^4$
Section area 2_3	$S_{a_2.3} := 2 \cdot \frac{tfwm \cdot \left(\frac{hm - tftm - tfbm}{2}\right)^3}{12} = (7.944 \cdot 10^8) \text{ mm}^4$
Section area 3	$S_{a_3} := \frac{bm \cdot tftm^3}{12} = (2.25 \cdot 10^6) \text{ mm}^4$

Second moment of area I_y

$$\begin{aligned} I_{effy} := & (S_{a_1} + A_{eff_1} \cdot y_{1_new_centroid}^2) + (S_{a_2_1} + A_{eff_2_1} \cdot y_{2_1_new_centroid}^2) \downarrow \\ & + (S_{a_2_2} + A_{eff_2_2} \cdot y_{2_2_new_centroid}^2) + (S_{a_2_3} + A_{eff_2_3} \cdot y_{2_3_new_centroid}^2) \downarrow \\ & + (S_{a_3} + A_{eff_3} \cdot y_{3_new_centroid}^2) \end{aligned}$$

$$I_{effy} = (3.047 \cdot 10^{10}) \text{ mm}^4$$

Effective section modulus

$$W_{effy} := \frac{I_{effy}}{Y_{eff_centroid} + \frac{hm}{2} - \frac{tfbm}{2}} = (4.788 \cdot 10^7) \text{ mm}^3$$

Boom UF**Section 4**

Shear boom selfweight only $F_{shear_selfweight} := W_{section_4_2} = 1.288 \text{ tonne}$

Bendin moment selfweight only $M_{bending_selfweight} := W_{section_4_2} \cdot Y_{section_4_2} = 0.429 \text{ m} \cdot \text{tonne}$
 Shear boom hook load only

$$F_{shear_hook_load} := R_n = 34 \text{ tonne}$$

Bendin moment hook load only $M_{bending_hook_load} := R_n \cdot l_{section_4_2} = 17 \text{ tonne} \cdot \text{m}$

Total design load $M := M_{bending_selfweight} \cdot \gamma_{p_selfweight} + M_{bending_hook_load} \cdot \gamma_{p_hook_load}$

$$M = 23.303 \text{ tonne} \cdot \text{m}$$

Bending stress $\sigma_{bending} := \frac{M \cdot g}{W_{effy}} = 4.772 \text{ MPa}$

Shear force $F_{shear} := F_{shear_selfweight} \cdot \gamma_{p_selfweight} + F_{shear_hook_load} \cdot \gamma_{p_hook_load} = 47.131 \text{ tonne}$

Shear stress $\sigma_{shear} := \frac{F_{shear} \cdot g}{A_{eff_total}} = 4.225 \text{ MPa}$

Von mises $\sigma_v := \sigma_{bending} + \sigma_{shear} = 8.998 \text{ MPa}$

UF section 4 $UF_{section_4} := \frac{\sigma_v}{\left(\frac{fy}{\gamma_m} \right)} = 0.029$

B.13 Utilisation factors

Utilisation factors	
$H_s = 0 \text{ m}$	
$R_{ad} = 32 \text{ m}$	$\alpha = 3.142$
$R_n = 34 \text{ tonne}$	
UF wire rope	$UF_{static_wire_rope} = 0.966$
	$UF_{dynamic_wire_rope} = 0.572$
UF pedestal	$UF_{pedestal} = 0.425$
UF pedestal adapter	$UF_{adapter} = 0.422$
UF hoist winch	$UF_{static_winch} = 1$
	$UF_{dynamic_winch} = 0.719$
UF slewing bearing 1	$UF_{slew_1} = 0.826$
UF slewing bearing 2	$UF_{slew_2} = 0.866$
UF web boom section 1	$UF_{web_section_1} = 0.705$
UF flange boom section 1	$UF_{flange_section_1} = 0.705$
UF web boom section 2	$UF_{web_section_2} = 0.38$
UF flange boom section 2	$UF_{flange_section_2} = 0.38$
UF boom section 3	$UF_{section_3} = 0.409$
UF boom section 4	$UF_{section_4} = 0.029$

C Appendix C: Excel

C.1 Calculations for each component in Excel sheet

C.1.1 Information sheet

Max hosting speed	V_{s_max}	2,3 m/s	9 tonne
Mean hosting speed	V_s	1,3 m/s	15 tonne
Max slewing speed	V_{slew}	0,126 rad/s	
Number of falls for hoisting rope	fall	2 -	
Gamman	gamman	1 -	
Length of boom 1	l_{boom_1}	16000 mm	
Length of boom 2	l_{boom_2}	16000 mm	
y of boom 1	Y_{boom_1}	7,01 m	
y of boom 2	Y_{boom_2}	6,78 m	
Total boom length	l_{arm}	32000 mm	
Total weight of boom 1	W_{boom_1}	47682,37 kg	
Total weight of boom 2	W_{boom_2}	21779,51 kg	
Total weight of boom	W_{arm}	69461,88 kg	
Weight hoist winch	W_{hoist_winch}	500 kg	
Weight slew bearing 1	$W_{slew_bearing_1}$	6253 kg	
Weight slew bearing 2	$W_{slew_bearing_2}$	1702 kg	
Load	R_n	15000 kg	
Weight section 2 to boom 1 tip	$W_{section_2_1}$	6846,32 kg	
Weight section 3 to boom 2 tip	$W_{section_3_2}$	15990,04 kg	
Weight section 4 to boom 2 tip	$W_{section_4_2}$	1287,64 kg	
Length section 2 to boom 2 tip	$l_{section_2_2}$	17 m	
Length section 3 to boom 2 tip	$l_{section_3_2}$	15 m	
Y to section 3 to boom 2 tip	$Y_{section_3_2}$	7,49 m	
Length section 4 to boom 2 tip	$l_{section_4_2}$	0,5 m	
Y to section 4 to boom 2 tip	$Y_{section_4_2}$	0,33 m	
Length of rope from first sheave to supply vessel	l_{rope}	65 m	
Weight of pedestal adapter	$W_{adapter}$	13317 kg	
Weight of pedestal	$W_{pedestal}$	26634 kg	
Weight rope	W_{rope}	5,74 kg/m	
Weight of swivel/hoist block	W_{hoist_block}	600 kg	
Hosting velocity factor	K_H	0,28 -	
Radial velocity factor	K_R	0,25 -	
Lateral velocity factor	K_L	0,6 -	
Minimum dynamic amplification factor for platform internal lifts	σ_n internal	1,15 -	
Minimum dynamic amplification factor for offboard lifts	σ_n offboard	1,3 -	
Load factor for self-weight, LC 1	γ_p selfweight	1,22 -	
Load factor for hook load, LC 1	γ_p hook load	1,34 -	
Risk coefficient	γ_n	1,0 -	
Resistance coefficient (material factor)	γ_m	1,1 -	

C.1.2 Wire rope

Hoist rope		
Rope spec	Casar Eurolift	
Diameter	d_{rope}	30 mm
Minimum breaking load	MBL	821 kN
Minimum breaking load	MBL	83,6901 tonne
Fill factor	f	0,72 -
Effective steel area	A_{eff}	508,94 mm ²
Effective modulus of elongation	Ehr	95 kN/mm ²
Minimum sheave diameter	d_s	704 mm
Numbers of fixed sheaves in boom	n_s	1 -
Mechanical advantage	n_m	2 -
Sheave diameter	D_{sheave}	704 mm
Bearing diameter	d_{bearing}	150 mm
Type of bearings (roller/plain)		roller
Single sheave efficiency	η_s	0,985 -
Total rope reeving efficiency	η_{tot}	0,978 -

C.1.3 Pedestal

Pedestal			
Outer diameter	$OD_{pedestal}$	3000	mm
Wall thickness	$t_{pedestal}$	30	mm
Buckling length of pedestal	$L_{pedestal}$	12000	mm
Elastic modulus	E	210000	MPa
Pedestal yield strength	f_y	345	MPa
Section area	$S_{a_pedestal}$	279915,9054	mm ²
Section modulus	$S_{m_pedestal}$	205780177,9	mm ³
y	$y_{pedestal}$	1485	mm
Moment of inertia	$M_{pedestal}$	3,0867E+11	mm ⁴
	Z	3083,439843	
Curvature factor	zeta	2164,57	
Imperfection factor	rho	0,46	
Reduced bucling coefficient	$C_{buckling}$	1002,72	
Elastic buckling stress	σ_{ige}	1189,48	MPa
	i	1050,11	mm
	$(l/i)^2$	130,59	
	$2.5 * E / \sigma_{igy}$	1521,74	
Check for global buckling:		SANN	
Allowable buckling stress in pedestal	σ_{gr}	301,22	MPa
Control of section class:			
	ϵ	0,81	
	d/t	100	
Section class 1	$50 \epsilon^2$	32,81	
Section class 2	$70 \epsilon^2$	45,93	
Section class 3	$90 \epsilon^2$	59,05	
Resulting section class		4	

C.1.4 Pedestal adapter

Pedestal adapter			
Outer diameter	OD_{adapter}	3000	mm
Wall thickness	t_{adapter}	30	mm
Buckling length of pedestal	L_{adapter}	8000	mm
Elastic modulus	E	210000	MPa
Pedestal yield strength	f_y	345	MPa
Section area	$S_{a_adapter}$	279915,905	mm ²
Section modulus	$S_{m_adapter}$	205780178	mm ³
y	y_{adapter}	1485	mm
Moment of inertia	M_{adapter}	3,0867E+11	mm ⁴
	Z	1370,41771	
Curvature factor	ζ	962,03	
Imperfection factor	ρ	0,46	
Reduced buckling coefficient	C_{buckling}	445,65	
Elastic buckling stress	σ_{ge}	1189,48	MPa
	i	1050,11	mm
	$(l/i)^2$	58,04	
	$2.5 * E / \sigma_{\text{gy}}$	1521,74	
Check for global buckling:		SANN	
Allowable buckling stress in pedestal	σ_{gr}	301,22	MPa
Control of section class:			
	ϵ	0,81	
	d/t	100	
Section class 1	$50 \epsilon^2$	32,81	
Section class 2	$70 \epsilon^2$	45,93	
Section class 3	$90 \epsilon^2$	59,05	
Resulting section class		4	

C.1.5 Hoist winch

Hoist winch 4.26	
Static pull capacity	17,0 tonne
Dynamic amplification factor (DAF)	1,6
Dynamic pull capacity	27,2 tonne

C.1.6 Slewing bearing 1

Slewing bearing 1			
Number of bolt sectors	m	86	-
Bolt stress area	A_s	1120	mm ²
Raceway diameter	D	3000	mm
Multirow bearing	β	0	deg
Weight	$W_{\text{slew_bearing_1}}$	6253	kg
Pretension relative to yield	pr	0,75	-
	a	83	mm
	b	143	mm
	c	67	mm
Yield strength for bolts	R	900	MPa
Moment	M	1,41E+10	Nmm
Axial design force	F_a	906609,593	N
Radial force	F_r	0	N
	$\text{tg}\beta$	0	
Force A	F_A	208,54	kN
Force R	F_R	0	kN
Lever arm effect	γ_{lae}	2,24	-

C.1.7 Slewing bearig 2

Slewing bearing 2			
Number of bolt sectors	m	56	-
Bolt stress area	A_s	1120	mm ²
Raceway diameter	D	2000	mm
Multirow bearing	β	0	deg
Weight	$W_{\text{slew_bearing_2}}$	1202	kg
Pretension relative to yield	pr	0,75	-
	a	57,5	mm
	b	73,5	mm
	c	31	mm
Yield strength for bolts	R	900	MPa
Moment	M	4,28E+09	Nmm
Axial design force	F_a	294300	N
Radial force	F_r	0	kN
	$\text{tg}\beta$	0	
Force A	F_A	147,51	kN
Force R	F_R	0	kN
Lever arm effect	γ_{lae}	2,85	-

C.1.8 Boom section 1

Boom Section 1		
Length between points of zero bending moment	L_e	30000 mm
Youngs modulus	E	210000 MPa
Boom material yield stress	f_y	345 MPa
	ε	0,83 -
Position of section from pedestal	x_m	3 m
Height of boom at section	h_m	2000 mm
Width of boom at section	b_m	1600 mm
Bottom flange thickness	t_{fbm}	30 mm
Top flange thickness	t_{ftm}	30 mm
Web thickness at section	t_{fwm}	20 mm
Gross area	A_{x_m}	173600 mm ²
Eccentricity in section	e_{ym}	676,77 mm
Gross moment of inertia, strong axis	I_{ym}	1,17E+11 mm ⁴
Gross moment of inertia, weak axis	I_{zm}	6,89E+10 mm ⁴
Section modulus, strong axis	W_{eym}	1,17E+08 mm ³
Section modulus, weak axis	W_{ezm}	8,61E+07 mm ³
Area 1	A_1	48000 mm ²
2' Area 2	A_2	77600 mm ²
Area 3	A_3	48000 mm ²
Stress ratio	ψ_{bottom}	1
Buckling coefficient	$k_{\psi_{bottom}}$	4
lambda-p	$\lambda_{p_{bottom}}$	1,11
rho1	ρ_{bottom}	0,72 <1
Effective length	$B_{off_{bottom}}$	1156,34 mm
Area bottom flange	$A_{off_{bottom}}$	34690,08 mm ²
Area top	$A_{off_{top}}$	48000 mm ²
Stress ratio	ψ_{uob}	-1
Buckling factor	$k_{\psi_{uob}}$	23,9
lambda-p	$\lambda_{p_{uob}}$	0,85
		OK
rho	ρ_{uob}	1,03
Effective length	$B_{off_{uob}}$	970,00 mm
	be_1	388,00 mm
	be_2	582,00 mm
Area web	$A_{off_{uob}}$	38800,00 mm ²
Effective area	$A_{off_{total}}$	160290,08 mm ²
Effective area 1	A_{off_1}	34690,08 mm ²
Y for effective area 1	y_{off_1}	-985 mm
Effective area 2,1	$A_{off_2,1}$	15520,00 mm ²
Effective area 2,2	$A_{off_2,2}$	23280,00 mm ²
Effective area 2,3	$A_{off_2,3}$	38800,00 mm ²
Y for effective area 2.1	$y_{off_2,1}$	-776,00 mm
Y for effective area 2.2	$y_{off_2,2}$	-291,00 mm
Y for effective area 2.3	$y_{off_2,3}$	485,00 mm
Effective area 3	A_{off_3}	48000 mm ²
Y for effective area 3	y_{off_3}	985 mm
Yeff centroid	$y_{off_{centroid}}$	82 mm
Y1 from new centroid for effective area	$y_{1_{new_{centroid}}}$	-1066,79 mm
Y2.1 from new centroid for effective area	$y_{2,1_{new_{centroid}}}$	-857,79 mm
Y2.2 from new centroid for effective area	$y_{2,2_{new_{centroid}}}$	-372,79 mm
Y2.3 from new centroid for effective area	$y_{2,3_{new_{centroid}}}$	403,21 mm
Y3 from new centroid for effective area	$y_{3_{new_{centroid}}}$	903,21 mm
Section area part 1	S_{a_1}	2,60E+06 mm ⁴
Section area part 2.1	$S_{a_2,1}$	1,95E+08 mm ⁴
Section area part 2.2	$S_{a_2,2}$	6,57E+08 mm ⁴
Section area part 2.3	$S_{a_2,3}$	3,04E+09 mm ⁴
Section area part 3	S_{a_3}	3,60E+06 mm ⁴
Second moment of area Iy	I_{off_y}	1,03E+11 mm ⁴
Effective section modulus	W_{off_y}	9,70E+07 mm ³

C.1.9 Boom section 2

Boom Section 2		
Length between points of zero bending moment	L_o	30000 mm
Youngs modulus	E	210000 MPa
Boom material yield stress	f_y	345 MPa
	ϵ	0,83 -
Position of section from pedestal	x_m	15 m
Height of boom at section	h_m	2000 mm
Width of boom at section	b_m	1000 mm
Bottom flange thickness	t_{fbm}	30 mm
Top flange thickness	t_{ftm}	30 mm
Web thickness at section	t_{fwm}	20 mm
Gross area	A_{x_m}	137600 mm ²
Eccentricity in section	e_{ym}	599,97 mm
Gross moment of inertia, strong axis	I_{ym}	8,26E+10 mm ⁴
Gross moment of inertia, weak axis	I_{zm}	2,36E+10 mm ⁴
Section modulus, strong axis	W_{eym}	8,26E+07 mm ³
Section modulus, weak axis	W_{ezm}	4,73E+07 mm ³
Area 1	A_1	30000 mm ²
2* Area 2	A_2	77600 mm ²
Area 3	A_3	30000 mm ²
Stress ratio	ψ_{bottom}	1
Buckling coefficient	$k_{\psi_{bottom}}$	4
lambda-p	$\lambda_{p_{bottom}}$	0,68
rho1	ρ_{bottom}	0,99 <1
Effective length	$B_{off_{bottom}}$	992,81 mm
Area bottom flange	$A_{off_{bottom}}$	29784,38 mm ²
Area top	$A_{off_{top}}$	30000 mm ²
Stress ratio	ψ_{uob}	-1
Buckling factor	$k_{\psi_{uob}}$	23,9
lambda-p	$\lambda_{p_{uob}}$	0,85
		OK
rho	ρ_{uob}	1,03
Effective length	$B_{off_{uob}}$	970,00 mm
	be_1	388,00 mm
	be_2	582,00 mm
Area web	$A_{off_{uob}}$	38800,00 mm ²
Effective area	$A_{off_{total}}$	137384,38 mm ²
Effective area 1	A_{off_1}	29784,38 mm ²
Y for effective area 1	y_{off_1}	-985 mm
Effective area 2,1	$A_{off_2,1}$	15520,00 mm ²
Effective area 2,2	$A_{off_2,2}$	23280,00 mm ²
Effective area 2,3	$A_{off_2,3}$	38800,00
Y for effective area 2.1	$y_{off_2,1}$	-776,00 mm
Y for effective area 2.2	$y_{off_2,2}$	-291,00 mm
Y for effective area 2.3	$y_{off_2,3}$	485,00
Effective area 3	A_{off_3}	30000 mm ²
Y for effective area 3	y_{off_3}	985 mm
Yeff centroid	$y_{off_{centroid}}$	2 mm
Y1 from new centroid for effective area	$y_{1_{nou_{centroid}}}$	-986,55 mm
Y2.1 from new centroid for effective area	$y_{2,1_{nou_{centroid}}}$	-777,55 mm
Y2.2 from new centroid for effective area	$y_{2,2_{nou_{centroid}}}$	-292,55 mm
Y2.3 from new centroid for effective area	$y_{2,3_{nou_{centroid}}}$	483,45
Y3 from new centroid for effective area	$y_{3_{nou_{centroid}}}$	983,45 mm
Section area part 1	$S_{a,1}$	2,23E+06 mm ⁴
Section area part 2.1	$S_{a,2,1}$	1,95E+08 mm ⁴
Section area part 2.2	$S_{a,2,2}$	6,57E+08 mm ⁴
Section area part 2.3	$S_{a,2,3}$	3,04E+09
Section area part 3	$S_{a,3}$	2,25E+06 mm ⁴
Second moment of area Iy	I_{off_y}	8,23E+10 mm ⁴
Effective section modulus	W_{off_y}	8,35E+07 mm ³

C.1.10 Boom section 3

Boom Section 3		
Length between points of zero bending moment	L_o	30000 mm
Youngs modulus	E	210000 MPa
Boom material yield stress	f_y	345 MPa
	ϵ	0,83 -
Position of section from pedestal	xm	18 m
Height of boom at section	hm	1500 mm
Width of boom at section	bm	1500 mm
Bottom flange thickness	tfbm	30 mm
Top flange thickness	tftm	30 mm
Web thickness at section	tfwm	20 mm
Gross area	A_{xm}	147600 mm ²
Eccentricity in section	eym	529,18 mm
Gross moment of inertia, strong axis	I_{ym}	5,86E+10 mm ⁴
Gross moment of inertia, weak axis	I_{zm}	4,84E+10 mm ⁴
Section modulus, strong axis	W_{eym}	7,81E+07 mm ³
Section modulus, weak axis	W_{ezm}	6,46E+07 mm ³
Area 1	A_1	45000 mm ²
2* Area 2	A_2	57600 mm ²
Area 3	A_3	45000 mm ²
Stress ratio	ψ_{bottom}	1
Buckling coefficient	k_o_{bottom}	4
lambda-p	$\lambda_{p_{bottom}}$	1,04
rho1	ρ_{bottom}	0,76 <1
Effective length	$B_{off_{bottom}}$	1138,69 mm
Area bottom flange	$A_{off_{bottom}}$	34160,65 mm ²
Area top	$A_{off_{top}}$	45000 mm ²
Stress ratio	ψ_{uob}	-1
Buckling factor	k_o_{uob}	23,9
lambda-p	$\lambda_{p_{uob}}$	0,63
		OK
rho	ρ_{uob}	1,31
Effective length	$B_{off_{uob}}$	720,00 mm
	be1	288,00 mm
	be2	432,00 mm
Area web	$A_{off_{uob}}$	28800,00 mm ²
Effective area	$A_{off_{total}}$	136760,65 mm ²
Effective area 1	$A_{off_{1}}$	34160,65 mm ²
Y for effective area 1	$y_{off_{1}}$	-735 mm
Effective area 2,1	$A_{off_{2,1}}$	11520,00 mm ²
Effective area 2,2	$A_{off_{2,2}}$	17280,00 mm ²
Effective area 2,3	$A_{off_{2,3}}$	28800,00 mm ²
Y for effective area 2.1	$y_{off_{2,1}}$	-576,00 mm
Y for effective area 2.2	$y_{off_{2,2}}$	-216,00 mm
Y for effective area 2.3	$y_{off_{2,3}}$	360,00 mm
Effective area 3	$A_{off_{3}}$	45000 mm ²
Y for effective area 3	$y_{off_{3}}$	735 mm
Yeff centroid	$y_{off_{centroid}}$	58 mm
Y1 from new centroid for effective area	$y_{1_{new_{centroid}}}$	-793,25 mm
Y2.1 from new centroid for effective area	$y_{2,1_{new_{centroid}}}$	-634,25 mm
Y2.2 from new centroid for effective area	$y_{2,2_{new_{centroid}}}$	-274,25 mm
Y2.3 from new centroid for effective area	$y_{2,3_{new_{centroid}}}$	301,75 mm
Y3 from new centroid for effective area	$y_{3_{new_{centroid}}}$	676,75 mm
Section area part 1	$S_{a,1}$	2,56E+06 mm ⁴
Section area part 2.1	$S_{a,2,1}$	7,96E+07 mm ⁴
Section area part 2.2	$S_{a,2,2}$	2,69E+08 mm ⁴
Section area part 2.3	$S_{a,2,3}$	1,24E+09 mm ⁴
Section area part 3	$S_{a,3}$	3,38E+06 mm ⁴
Second moment of area Iy	I_{offy}	5,23E+10 mm ⁴
Effective section modulus	W_{offy}	6,59E+07 mm ³

C.1.11 Boom section 4

Boom Section 4		
Length between points of zero bending moment	L_0	30000 mm
Youngs modulus	E	210000 MPa
Boom material yield stress	f_y	345 MPa
	ε	0,83 -
Position of section from boom tip	x_m	31,5 m
Height of boom at section	h_m	1300 mm
Width of boom at section	b_m	1000 mm
Bottom flange thickness	t_{fbm}	30 mm
Top flange thickness	t_{ftm}	30 mm
Web thickness at section	t_{fwm}	20 mm
Gross area	A_{xm}	109600 mm ²
Eccentricity in section	e_{ym}	428,88 mm
Gross moment of inertia, strong axis	I_{ym}	3,06E+10 mm ⁴
Gross moment of inertia, weak axis	I_{zm}	1,69E+10 mm ⁴
Section modulus, strong axis	W_{eym}	4,70E+07 mm ³
Section modulus, weak axis	W_{ezm}	3,38E+07 mm ³
Area 1	A_1	30000 mm ²
2* Area 2	A_2	49600 mm ²
Area 3	A_3	30000 mm ²
Stress ratio	ψ_{bottom}	1
Buckling coefficient	$k_{\psi_{bottom}}$	4
lambda-p	$\lambda_{p_{bottom}}$	0,68
rho1	ρ_{bottom}	0,99 <1
Effective length	$B_{off_{bottom}}$	992,81 mm
Area bottom flange	$A_{off_{bottom}}$	29784,38 mm ²
Area top	$A_{off_{top}}$	30000 mm ²
Stress ratio	ψ_{uob}	-1
Buckling factor	$k_{\psi_{uob}}$	23,9
lambda-p	$\lambda_{p_{uob}}$	0,54
		OK
rho	ρ_{uob}	1,47
Effective length	$B_{off_{uob}}$	620,00 mm
	be_1	248,00 mm
	be_2	372,00 mm
Area web	$A_{off_{uob}}$	24800,00 mm ²
Effective area	$A_{off_{total}}$	##### mm ²
Effective area 1	A_{off_1}	29784,38 mm ²
Y for effective area 1	y_{off_1}	-635 mm
Effective area 2,1	$A_{off_2,1}$	9920,00 mm ²
Effective area 2,2	$A_{off_2,2}$	14880,00 mm ²
Effective area 2,3	$A_{off_2,3}$	24800,00
Y for effective area 2.1	$y_{off_2,1}$	-496,00 mm
Y for effective area 2.2	$y_{off_2,2}$	-186,00 mm
Y for effective area 2.3	$y_{off_2,3}$	310,00
Effective area 3	A_{off_3}	30000 mm ²
Y for effective area 3	y_{off_3}	635 mm
Yeff centroid	$y_{off_{centroid}}$	1 mm
Y1 from new centroid for effective area	$y_{1_{nou_{centroid}}}$	-636,25 mm
Y2.1 from new centroid for effective area	$y_{2,1_{nou_{centroid}}}$	-497,25 mm
Y2.2 from new centroid for effective area	$y_{2,2_{nou_{centroid}}}$	-187,25 mm
Y2.3 from new centroid for effective area	$y_{2,3_{nou_{centroid}}}$	308,75
Y3 from new centroid for effective area	$y_{3_{nou_{centroid}}}$	633,75 mm
Section area part 1	S_{a_1}	2,23E+06 mm ⁴
Section area part 2.1	$S_{a_2,1}$	5,08E+07 mm ⁴
Section area part 2.2	$S_{a_2,2}$	1,72E+08 mm ⁴
Section area part 2.3	$S_{a_2,3}$	7,94E+08
Section area part 3	S_{a_3}	2,25E+06 mm ⁴
Second moment of area Iy	I_{off_y}	3,05E+10 mm ⁴
Effective section modulus	W_{off_y}	4,79E+07 mm ³

C.2 Calculations from Excel sheet for single fall lifting

C.2.1 Calculations for $H_s = 0$ with one fall

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
(o)	(M)	(T)	(T)	(m)									(m)	(mm)	(mm)			
14,36	4,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	0,50	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
21,61	6,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	0,76	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
28,96	8,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	1,01	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
36,42	10,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	1,26	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
44,05	12,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	1,51	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
51,89	14,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	1,76	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
60,00	16,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	2,02	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
68,46	18,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	2,27	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
77,36	20,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	2,52	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
86,87	22,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	2,77	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
97,18	24,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	3,02	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
108,68	26,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	3,28	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
122,09	28,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	3,53	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
139,27	30,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	3,78	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32
180,00	32,00	18,3	15,9	0,00	0,00	1,30	0,00	0,00	0,65	4,03	0,00	OK	81,00	261,84	261,84	596,90	1,15	18,32

C.2.2 Calculations for $H_s = 0.5$ with one fall

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
(o)	(M)	(T)	(T)	(m)									(m)	(mm)	(mm)			
14,36	4,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	0,50	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
21,61	6,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	0,76	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
28,96	8,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	1,01	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
36,42	10,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	1,26	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
44,05	12,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	1,51	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
51,89	14,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	1,76	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
60,00	16,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	2,02	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
68,46	18,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	2,27	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
77,36	20,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	2,52	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
86,87	22,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	2,77	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
97,18	24,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	3,02	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
108,68	26,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	3,28	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
122,09	28,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	3,53	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
139,27	30,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	3,78	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91
180,00	32,00	25,9	15,9	0,50	0,18	1,30	0,35	0,00	1,00	4,03	0,21	OK	81,00	261,89	261,89	596,90	1,63	25,91

C.2.3 Calculations for $H_s = 1$ with one fall

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	0,50	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
21,61	6,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	0,76	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
28,96	8,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	1,01	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
36,42	10,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	1,26	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
44,05	12,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	1,51	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
51,89	14,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	1,76	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
60,00	16,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	2,02	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
68,46	18,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	2,27	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
77,36	20,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	2,52	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
86,87	22,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	2,77	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
97,18	24,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	3,02	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
108,68	26,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	3,28	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
122,09	28,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	3,53	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
139,27	30,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	3,78	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20
180,00	32,00	27,2	14,2	1,00	0,33	1,43	0,67	0,00	1,38	4,03	0,40	OK	81,00	233,73	233,73	596,90	1,91	27,20

C.2.4 Calculations for $H_s = 1.5$ with one fall

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	0,50	0,57	RESTR.	81,00	184,68	184,68	596,90	2,42	27,19
21,61	6,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	0,76	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
28,96	8,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	1,01	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
36,42	10,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	1,26	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
44,05	12,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	1,51	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
51,89	14,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	1,76	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
60,00	16,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	2,02	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
68,46	18,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	2,27	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
77,36	20,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	2,52	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
86,87	22,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	2,77	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
97,18	24,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	3,02	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
108,68	26,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	3,28	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
122,09	28,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	3,53	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
139,27	30,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	3,78	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19
180,00	32,00	27,2	11,2	1,50	0,47	1,93	0,95	0,00	1,91	4,03	0,57	OK	81,00	184,68	184,68	596,90	2,42	27,19

C.2.5 Calculations for $H_s = 2$ with one fall

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	0,50	0,72	RESTR.	81,00	155,88	155,88	596,90	2,87	27,20
21,61	6,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	0,76	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
28,96	8,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	1,01	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
36,42	10,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	1,26	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
44,05	12,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	1,51	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
51,89	14,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	1,76	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
60,00	16,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	2,02	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
68,46	18,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	2,27	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
77,36	20,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	2,52	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
86,87	22,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	2,77	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
97,18	24,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	3,02	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
108,68	26,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	3,28	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
122,09	28,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	3,53	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
139,27	30,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	3,78	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20
180,00	32,00	27,2	9,5	2,00	0,60	2,22	1,20	0,00	2,31	4,03	0,72	OK	81,00	155,88	155,88	596,90	2,87	27,20

C.2.6 Calculations for $H_s = 2.5$ with one fall

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	0,50	0,86	RESTR.	81,00	139,46	139,46	596,90	3,20	27,19
21,61	6,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	0,76	0,86	RESTR.	81,00	139,46	139,46	596,90	3,20	27,19
28,96	8,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	1,01	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
36,42	10,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	1,26	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
44,05	12,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	1,51	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
51,89	14,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	1,76	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
60,00	16,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	2,02	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
68,46	18,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	2,27	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
77,36	20,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	2,52	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
86,87	22,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	2,77	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
97,18	24,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	3,02	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
108,68	26,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	3,28	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
122,09	28,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	3,53	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
139,27	30,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	3,78	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19
180,00	32,00	27,2	8,5	2,50	0,71	2,30	1,43	0,00	2,58	4,03	0,86	OK	81,00	139,46	139,46	596,90	3,20	27,19

C.2.7 Calculations for $H_s = 3$ with one fall

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	0,50	0,98	RESTR.	81,00	128,31	128,31	596,90	3,48	27,20
21,61	6,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	0,76	0,98	RESTR.	81,00	128,31	128,31	596,90	3,48	27,20
28,96	8,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	1,01	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
36,42	10,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	1,26	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
44,05	12,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	1,51	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
51,89	14,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	1,76	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
60,00	16,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	2,02	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
68,46	18,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	2,27	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
77,36	20,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	2,52	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
86,87	22,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	2,77	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
97,18	24,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	3,02	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
108,68	26,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	3,28	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
122,09	28,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	3,53	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
139,27	30,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	3,78	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20
180,00	32,00	27,2	7,8	3,00	0,82	2,30	1,64	0,00	2,79	4,03	0,98	OK	81,00	128,31	128,31	596,90	3,48	27,20

C.2.8 Calculations for $H_s = 3.5$ with one fall

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	0,50	1,10	RESTR.	81,00	119,10	119,10	596,90	3,75	27,20
21,61	6,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	0,76	1,10	RESTR.	81,00	119,10	119,10	596,90	3,75	27,20
28,96	8,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	1,01	1,10	RESTR.	81,00	119,10	119,10	596,90	3,75	27,20
36,42	10,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	1,26	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
44,05	12,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	1,51	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
51,89	14,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	1,76	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
60,00	16,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	2,02	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
68,46	18,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	2,27	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
77,36	20,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	2,52	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
86,87	22,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	2,77	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
97,18	24,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	3,02	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
108,68	26,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	3,28	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
122,09	28,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	3,53	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
139,27	30,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	3,78	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20
180,00	32,00	27,2	7,2	3,50	0,91	2,30	1,83	0,00	2,98	4,03	1,10	OK	81,00	119,10	119,10	596,90	3,75	27,20

C.2.9 Calculations for $H_s = 4$ with one fall

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
(o)	(M)	(T)	(T)	(m)									(m)	(mm)	(mm)			
14,36	4,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	0,50	1,20	RESTR.	81,00	111,27	111,27	596,90	4,01	27,18
21,61	6,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	0,76	1,20	RESTR.	81,00	111,27	111,27	596,90	4,01	27,18
28,96	8,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	1,01	1,20	RESTR.	81,00	111,27	111,27	596,90	4,01	27,18
36,42	10,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	1,26	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
44,05	12,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	1,51	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
51,89	14,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	1,76	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
60,00	16,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	2,02	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
68,46	18,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	2,27	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
77,36	20,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	2,52	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
86,87	22,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	2,77	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
97,18	24,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	3,02	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
108,68	26,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	3,28	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
122,09	28,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	3,53	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
139,27	30,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	3,78	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18
180,00	32,00	27,2	6,8	4,00	1,00	2,30	2,00	0,00	3,15	4,03	1,20	OK	81,00	111,27	111,27	596,90	4,01	27,18

C.2.10 Calculations for $H_s = 4.5$ with one fall

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
(o)	(M)	(T)	(T)	(m)									(m)	(mm)	(mm)			
14,36	4,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	0,50	1,30	RESTR.	81,00	104,83	104,83	596,90	4,26	27,20
21,61	6,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	0,76	1,30	RESTR.	81,00	104,83	104,83	596,90	4,26	27,20
28,96	8,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	1,01	1,30	RESTR.	81,00	104,83	104,83	596,90	4,26	27,20
36,42	10,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	1,26	1,30	RESTR.	81,00	104,83	104,83	596,90	4,26	27,20
44,05	12,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	1,51	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
51,89	14,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	1,76	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
60,00	16,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	2,02	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
68,46	18,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	2,27	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
77,36	20,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	2,52	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
86,87	22,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	2,77	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
97,18	24,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	3,02	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
108,68	26,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	3,28	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
122,09	28,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	3,53	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
139,27	30,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	3,78	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20
180,00	32,00	27,2	6,4	4,50	1,08	2,30	2,16	0,00	3,31	4,03	1,30	OK	81,00	104,83	104,83	596,90	4,26	27,20

C.2.11 Calculations for $H_s = 5$ with one fall

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
(o)	(M)	(T)	(T)	(m)									(m)	(mm)	(mm)			
14,36	4,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	0,50	1,38	RESTR.	81,00	99,24	99,24	596,90	4,50	27,20
21,61	6,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	0,76	1,38	RESTR.	81,00	99,24	99,24	596,90	4,50	27,20
28,96	8,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	1,01	1,38	RESTR.	81,00	99,24	99,24	596,90	4,50	27,20
36,42	10,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	1,26	1,38	RESTR.	81,00	99,24	99,24	596,90	4,50	27,20
44,05	12,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	1,51	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
51,89	14,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	1,76	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
60,00	16,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	2,02	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
68,46	18,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	2,27	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
77,36	20,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	2,52	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
86,87	22,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	2,77	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
97,18	24,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	3,02	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
108,68	26,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	3,28	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
122,09	28,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	3,53	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
139,27	30,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	3,78	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20
180,00	32,00	27,2	6,0	5,00	1,15	2,30	2,31	0,00	3,46	4,03	1,38	OK	81,00	99,24	99,24	596,90	4,50	27,20

C.2.12 Calculations for $H_s = 5.5$ with one fall

Angle ($^\circ$)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	0,50	1,47	RESTR.	81,00	94,34	94,34	596,90	4,74	27,19
21,61	6,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	0,76	1,47	RESTR.	81,00	94,34	94,34	596,90	4,74	27,19
28,96	8,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	1,01	1,47	RESTR.	81,00	94,34	94,34	596,90	4,74	27,19
36,42	10,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	1,26	1,47	RESTR.	81,00	94,34	94,34	596,90	4,74	27,19
44,05	12,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	1,51	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
51,89	14,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	1,76	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
60,00	16,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	2,02	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
68,46	18,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	2,27	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
77,36	20,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	2,52	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
86,87	22,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	2,77	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
97,18	24,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	3,02	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
108,68	26,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	3,28	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
122,09	28,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	3,53	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
139,27	30,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	3,78	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19
180,00	32,00	27,2	5,7	5,50	1,22	2,30	2,44	0,00	3,59	4,03	1,47	OK	81,00	94,34	94,34	596,90	4,74	27,19

C.2.13 Calculations for $H_s = 6$ with one fall

Angle ($^\circ$)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope (m)	Elongation of hoisting rope (mm)	Vertical displacement of hook (mm)	Crane stiffness C (kN/m)	Dynamic amplifying factor Φ (-)	Dynamic hook load Hv
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)							
14,36	4,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	0,50	1,54	RESTR.	81,00	90,08	90,08	596,90	4,96	27,18
21,61	6,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	0,76	1,54	RESTR.	81,00	90,08	90,08	596,90	4,96	27,18
28,96	8,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	1,01	1,54	RESTR.	81,00	90,08	90,08	596,90	4,96	27,18
36,42	10,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	1,26	1,54	RESTR.	81,00	90,08	90,08	596,90	4,96	27,18
44,05	12,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	1,51	1,54	RESTR.	81,00	90,08	90,08	596,90	4,96	27,18
51,89	14,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	1,76	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
60,00	16,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	2,02	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
68,46	18,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	2,27	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
77,36	20,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	2,52	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
86,87	22,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	2,77	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
97,18	24,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	3,02	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
108,68	26,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	3,28	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
122,09	28,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	3,53	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
139,27	30,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	3,78	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18
180,00	32,00	27,2	5,5	6,00	1,29	2,30	2,57	0,00	3,72	4,03	1,54	OK	81,00	90,08	90,08	596,90	4,96	27,18

C.3 Calculations from Excel sheet for double fall lifting

C.3.1 Calculations for $H_s = 0m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH	vS	vD	vC	vR	vSlew	vL							
					(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)							
14,36	4,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	0,50	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
21,61	6,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	0,76	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
28,96	8,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	1,01	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
36,42	10,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	1,26	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
44,05	12,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	1,51	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
51,89	14,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	1,76	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
60,00	16,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	2,02	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
68,46	18,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	2,27	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
77,36	20,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	2,52	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
86,87	22,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	2,77	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
97,18	24,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	3,02	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
108,68	26,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	3,28	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
122,09	28,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	3,53	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
139,27	30,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	3,78	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10
180,00	32,00	39,1	34,0	0,00	0,00	1,30	0,00	0,00	0,65	4,03	0,00	OK	146,00	503,60	251,80	1324,63	1,15	39,10

C.3.2 Calculations for $H_s = 0.5m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH	vS	vD	vC	vR	vSlew	vL							
					(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)							
14,36	4,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	0,50	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
21,61	6,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	0,76	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
28,96	8,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	1,01	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
36,42	10,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	1,26	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
44,05	12,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	1,51	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
51,89	14,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	1,76	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
60,00	16,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	2,02	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
68,46	18,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	2,27	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
77,36	20,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	2,52	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
86,87	22,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	2,77	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
97,18	24,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	3,02	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
108,68	26,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	3,28	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
122,09	28,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	3,53	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
139,27	30,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	3,78	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40
180,00	32,00	54,4	33,0	0,50	0,10	1,30	0,35	0,00	1,00	4,03	0,21	OK	146,00	489,06	244,53	1324,63	1,65	54,40

C.3.3 Calculations for $H_s = 1m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
14,36	4,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	0,50	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
21,61	6,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	0,76	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
28,96	8,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	1,01	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
36,42	10,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	1,26	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
44,05	12,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	1,51	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
51,89	14,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	1,76	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
60,00	16,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	2,02	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
68,46	18,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	2,27	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
77,36	20,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	2,52	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
86,87	22,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	2,77	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
97,18	24,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	3,02	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
108,68	26,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	3,28	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
122,09	28,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	3,53	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
139,27	30,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	3,78	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45
180,00	32,00	54,4	28,4	1,00	0,19	1,30	0,67	0,00	1,32	4,03	0,40	OK	146,00	420,82	210,41	1324,63	1,92	54,45

C.3.4 Calculations for $H_s = 1.5m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
14,36	4,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	0,50	0,57	RESTR.	146,00	368,32	184,16	1324,63	2,19	54,42
21,61	6,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	0,76	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
28,96	8,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	1,01	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
36,42	10,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	1,26	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
44,05	12,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	1,51	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
51,89	14,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	1,76	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
60,00	16,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	2,02	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
68,46	18,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	2,27	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
77,36	20,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	2,52	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
86,87	22,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	2,77	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
97,18	24,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	3,02	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
108,68	26,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	3,28	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
122,09	28,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	3,53	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
139,27	30,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	3,78	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42
180,00	32,00	54,4	24,9	1,50	0,27	1,30	0,95	0,00	1,60	4,03	0,57	OK	146,00	368,32	184,16	1324,63	2,19	54,42

C.3.5 Calculations for $H_s = 2m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	C (kN/m)						
14,36	4,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	0,50	0,72	RESTR.	146,00	327,65	163,83	1324,63	2,46	54,40
21,61	6,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	0,76	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
28,96	8,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	1,01	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
36,42	10,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	1,26	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
44,05	12,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	1,51	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
51,89	14,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	1,76	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
60,00	16,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	2,02	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
68,46	18,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	2,27	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
77,36	20,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	2,52	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
86,87	22,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	2,77	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
97,18	24,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	3,02	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
108,68	26,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	3,28	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
122,09	28,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	3,53	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
139,27	30,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	3,78	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40
180,00	32,00	54,4	22,1	2,00	0,34	1,30	1,20	0,00	1,85	4,03	0,72	OK	146,00	327,65	163,83	1324,63	2,46	54,40

C.3.6 Calculations for $H_s = 2.5m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
(o)	(M)	(T)	(T)	(m)														
14,36	4,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	0,50	0,86	RESTR.	146,00	295,54	147,77	1324,63	2,73	54,40
21,61	6,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	0,76	0,86	RESTR.	146,00	295,54	147,77	1324,63	2,73	54,40
28,96	8,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	1,01	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
36,42	10,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	1,26	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
44,05	12,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	1,51	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
51,89	14,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	1,76	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
60,00	16,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	2,02	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
68,46	18,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	2,27	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
77,36	20,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	2,52	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
86,87	22,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	2,77	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
97,18	24,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	3,02	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
108,68	26,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	3,28	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
122,09	28,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	3,53	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
139,27	30,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	3,78	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40
180,00	32,00	54,4	20,0	2,50	0,40	1,30	1,43	0,00	2,08	4,03	0,86	OK	146,00	295,54	147,77	1324,63	2,73	54,40

C.3.7 Calculations for $H_s = 3m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
(o)	(M)	(T)	(T)	(m)														
14,36	4,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	0,50	0,98	RESTR.	146,00	269,85	134,92	1324,63	2,99	54,42
21,61	6,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	0,76	0,98	RESTR.	146,00	269,85	134,92	1324,63	2,99	54,42
28,96	8,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	1,01	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
36,42	10,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	1,26	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
44,05	12,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	1,51	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
51,89	14,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	1,76	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
60,00	16,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	2,02	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
68,46	18,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	2,27	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
77,36	20,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	2,52	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
86,87	22,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	2,77	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
97,18	24,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	3,02	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
108,68	26,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	3,28	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
122,09	28,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	3,53	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
139,27	30,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	3,78	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42
180,00	32,00	54,4	18,2	3,00	0,46	1,30	1,64	0,00	2,29	4,03	0,98	OK	146,00	269,85	134,92	1324,63	2,99	54,42

C.3.8 Calculations for $H_s = 3.5m$ with two falls

Angle	Radius	Dynamic hook load	Hook load	Significant wave height	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
(o)	(M)	(T)	(T)	(m)														
14,36	4,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	0,50	1,10	RESTR.	146,00	248,47	124,24	1324,63	3,24	54,40
21,61	6,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	0,76	1,10	RESTR.	146,00	248,47	124,24	1324,63	3,24	54,40
28,96	8,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	1,01	1,10	RESTR.	146,00	248,47	124,24	1324,63	3,24	54,40
36,42	10,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	1,26	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
44,05	12,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	1,51	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
51,89	14,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	1,76	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
60,00	16,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	2,02	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
68,46	18,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	2,27	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
77,36	20,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	2,52	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
86,87	22,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	2,77	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
97,18	24,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	3,02	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
108,68	26,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	3,28	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
122,09	28,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	3,53	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
139,27	30,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	3,78	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40
180,00	32,00	54,4	16,8	3,50	0,51	1,30	1,83	0,00	2,48	4,03	1,10	OK	146,00	248,47	124,24	1324,63	3,24	54,40

C.3.9 Calculations for $H_s = 4m$ with two falls

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
14,36	4,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	0,50	1,20	RESTR.	146,00	230,85	115,43	1324,63	3,49	54,40
21,61	6,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	0,76	1,20	RESTR.	146,00	230,85	115,43	1324,63	3,49	54,40
28,96	8,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	1,01	1,20	RESTR.	146,00	230,85	115,43	1324,63	3,49	54,40
36,42	10,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	1,26	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
44,05	12,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	1,51	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
51,89	14,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	1,76	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
60,00	16,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	2,02	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
68,46	18,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	2,27	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
77,36	20,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	2,52	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
86,87	22,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	2,77	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
97,18	24,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	3,02	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
108,68	26,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	3,28	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
122,09	28,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	3,53	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
139,27	30,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	3,78	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40
180,00	32,00	54,4	15,6	4,00	0,56	1,30	2,00	0,00	2,65	4,03	1,20	OK	146,00	230,85	115,43	1324,63	3,49	54,40

C.3.10 Calculations for $H_s = 4.5m$ with two falls

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
14,36	4,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	0,50	1,30	RESTR.	146,00	210,07	105,03	1324,63	3,84	54,40
21,61	6,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	0,76	1,30	RESTR.	146,00	210,07	105,03	1324,63	3,84	54,40
28,96	8,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	1,01	1,30	RESTR.	146,00	210,07	105,03	1324,63	3,84	54,40
36,42	10,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	1,26	1,30	RESTR.	146,00	210,07	105,03	1324,63	3,84	54,40
44,05	12,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	1,51	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
51,89	14,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	1,76	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
60,00	16,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	2,02	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
68,46	18,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	2,27	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
77,36	20,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	2,52	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
86,87	22,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	2,77	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
97,18	24,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	3,02	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
108,68	26,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	3,28	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
122,09	28,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	3,53	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
139,27	30,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	3,78	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40
180,00	32,00	54,4	14,2	4,50	0,60	1,44	2,16	0,00	2,88	4,03	1,30	OK	146,00	210,07	105,03	1324,63	3,84	54,40

C.3.11 Calculations for $H_s = 5m$ with two falls

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
14,36	4,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	0,50	1,38	RESTR.	146,00	188,20	94,10	1324,63	4,28	54,35
21,61	6,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	0,76	1,38	RESTR.	146,00	188,20	94,10	1324,63	4,28	54,35
28,96	8,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	1,01	1,38	RESTR.	146,00	188,20	94,10	1324,63	4,28	54,35
36,42	10,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	1,26	1,38	RESTR.	146,00	188,20	94,10	1324,63	4,28	54,35
44,05	12,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	1,51	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
51,89	14,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	1,76	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
60,00	16,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	2,02	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
68,46	18,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	2,27	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
77,36	20,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	2,52	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
86,87	22,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	2,77	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
97,18	24,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	3,02	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
108,68	26,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	3,28	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
122,09	28,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	3,53	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
139,27	30,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	3,78	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35
180,00	32,00	54,3	12,7	5,00	0,65	1,68	2,31	0,00	3,15	4,03	1,38	OK	146,00	188,20	94,10	1324,63	4,28	54,35

C.3.12 Calculations for $H_s = 5.5m$ with two falls

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
14,36	4,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	0,50	1,47	RESTR.	146,00	172,62	86,31	1324,63	4,67	54,38
21,61	6,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	0,76	1,47	RESTR.	146,00	172,62	86,31	1324,63	4,67	54,38
28,96	8,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	1,01	1,47	RESTR.	146,00	172,62	86,31	1324,63	4,67	54,38
36,42	10,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	1,26	1,47	RESTR.	146,00	172,62	86,31	1324,63	4,67	54,38
44,05	12,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	1,51	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
51,89	14,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	1,76	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
60,00	16,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	2,02	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
68,46	18,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	2,27	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
77,36	20,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	2,52	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
86,87	22,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	2,77	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
97,18	24,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	3,02	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
108,68	26,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	3,28	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
122,09	28,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	3,53	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
139,27	30,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	3,78	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38
180,00	32,00	54,4	11,7	5,50	0,68	1,86	2,44	0,00	3,37	4,03	1,47	OK	146,00	172,62	86,31	1324,63	4,67	54,38

C.3.13 Calculations for $H_s = 6m$ with two falls

Angle (o)	Radius (M)	Dynamic hook load (T)	Hook load (T)	Significant wave height (m)	Minimum steady hosting velocity	Maximum steady hosting velocity	Vertical deck velocity	Vertical crane boom tip velocity	Relative velocity load/ hook	Maximum lateral hook velocity	Lateral hook velocity	Velocity checks for sea lifts	Effective length hosting rope	Elongation of hoisting rope	Vertical displacement of hook	Crane stiffness	Dynamic amplifying factor	Dynamic hook load
					vH (m/s)	vS (m/s)	vD (m/s)	vC (m/s)	vR (m/s)	vSlew (m/s)	vL (m/s)	(m)	(mm)	(mm)	C (kN/m)	Φ (-)	Hv	
14,36	4,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	0,50	1,54	RESTR.	146,00	160,31	80,15	1324,63	5,03	54,39
21,61	6,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	0,76	1,54	RESTR.	146,00	160,31	80,15	1324,63	5,03	54,39
28,96	8,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	1,01	1,54	RESTR.	146,00	160,31	80,15	1324,63	5,03	54,39
36,42	10,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	1,26	1,54	RESTR.	146,00	160,31	80,15	1324,63	5,03	54,39
44,05	12,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	1,51	1,54	RESTR.	146,00	160,31	80,15	1324,63	5,03	54,39
51,89	14,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	1,76	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
60,00	16,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	2,02	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
68,46	18,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	2,27	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
77,36	20,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	2,52	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
86,87	22,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	2,77	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
97,18	24,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	3,02	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
108,68	26,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	3,28	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
122,09	28,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	3,53	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
139,27	30,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	3,78	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39
180,00	32,00	54,4	10,8	6,00	0,72	2,00	2,57	0,00	3,57	4,03	1,54	OK	146,00	160,31	80,15	1324,63	5,03	54,39

C.4 Utilization calculations when lifting with single fall

C.4.1 Calculations for each component for $H_s = 0 - 1m$ with one fall

Crane total										
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook	Load factor hook	Load factor hook	Maximum utilization	
[°]	[m]	[T]	[m]	[-]	[-]	[-]	[-]	[-]		
14.36	4.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
21.61	6.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
28.96	8.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
36.42	10.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
44.05	12.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
51.89	14.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
60	16.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
68.46	18.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
77.36	20.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
86.87	22.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
97.18	24.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
108.68	26.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
122.09	28.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
139.27	30.0	15.9	0	1.15	1.22	1.34	1.44	1.00		
180	32.0	15.9	0	1.15	1.22	1.34	1.44	1.00		

Wire rope 0-160 tonne										
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope		
[°]	[m]	[T]	State DF	Dynamic DF	[T]	[T]	Static UF	Dynamic UF		
14.36	4.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
21.61	6.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
28.96	8.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
36.42	10.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
44.05	12.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
51.89	14.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
60	16.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
68.46	18.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
77.36	20.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
86.87	22.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
97.18	24.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
108.68	26.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
122.09	28.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
139.27	30.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		
180	32.0	15.93	4.88	4.71	1.90	18.32	1.00	0.59		

Pedestal										
Angle	Radius	Dynamic amplifying factor (DAF)	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF		
[°]	[m]	[-]	[kNm]	[kN]	[MPa]	[MPa]	[MPa]			
14.36	4.0	1.15	22.93	13.04	16.04	4.63	20.67	0.75		
21.61	6.0	1.15	44.87	26.08	32.08	4.63	41.34	0.75		
28.96	8.0	1.15	67.31	39.12	48.12	4.63	62.01	0.75		
36.42	10.0	1.15	90.16	52.16	64.16	4.63	82.68	0.75		
44.05	12.0	1.15	113.41	65.20	80.20	4.63	103.35	0.75		
51.89	14.0	1.15	137.06	78.24	96.24	4.63	124.02	0.75		
60	16.0	1.15	161.11	91.28	112.28	4.63	144.69	0.75		
68.46	18.0	1.15	185.66	104.32	128.32	4.63	165.36	0.75		
77.36	20.0	1.15	210.71	117.36	144.36	4.63	186.03	0.75		
86.87	22.0	1.15	236.26	130.40	160.40	4.63	206.70	0.75		
97.18	24.0	1.15	261.31	143.44	176.44	4.63	227.37	0.75		
108.68	26.0	1.15	286.86	156.48	192.48	4.63	248.04	0.75		
122.09	28.0	1.15	311.91	169.52	208.52	4.63	268.71	0.75		
139.27	30.0	1.15	336.96	182.56	224.56	4.63	289.38	0.75		
180	32.0	1.15	362.01	195.60	240.60	4.63	310.05	0.75		

Crane total										
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook	Load factor hook	Load factor hook	Maximum utilization	
[°]	[m]	[T]	[m]	[-]	[-]	[-]	[-]	[-]		
14.36	4.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
21.61	6.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
28.96	8.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
36.42	10.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
44.05	12.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
51.89	14.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
60	16.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
68.46	18.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
77.36	20.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
86.87	22.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
97.18	24.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
108.68	26.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
122.09	28.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
139.27	30.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		
180	32.0	15.9	0.5	1.63	1.22	1.34	1.44	1.00		

Wire rope 0-160 tonne										
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope		
[°]	[m]	[T]	State DF	Dynamic DF	[T]	[T]	Static UF	Dynamic UF		
14.36	4.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
21.61	6.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
28.96	8.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
36.42	10.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
44.05	12.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
51.89	14.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
60	16.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
68.46	18.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
77.36	20.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
86.87	22.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
97.18	24.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
108.68	26.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
122.09	28.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
139.27	30.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		
180	32.0	15.94	4.88	4.71	1.90	25.91	1.00	0.83		

Pedestal										
Angle	Radius	Dynamic amplifying factor (DAF)	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF		
[°]	[m]	[-]	[kNm]	[kN]	[MPa]	[MPa]	[MPa]			
14.36	4.0	1.63	22.90	10.67	16.04	3.74	14.48	0.95		
21.61	6.0	1.63	45.81	21.34	32.08	3.74	28.97	0.95		
28.96	8.0	1.63	68.72	32.01	48.12	3.74	43.96	0.95		
36.42	10.0	1.63	91.63	42.68	64.16	3.74	58.95	0.95		
44.05	12.0	1.63	114.54	53.35	80.20	3.74	73.94	0.95		
51.89	14.0	1.63	137.45	64.02	96.24	3.74	88.93	0.95		
60	16.0	1.63	160.36	74.69	112.28	3.74	103.92	0.95		
68.46	18.0	1.63	183.27	85.36	128.32	3.74	118.91	0.95		
77.36	20.0	1.63	206.18	96.03	144.36	3.74	133.90	0.95		
86.87	22.0	1.63	229.09	106.70	160.40	3.74	148.89	0.95		
97.18	24.0	1.63	252.00	117.37	176.44	3.74	163.88	0.95		
108.68	26.0	1.63	274.91	128.04	192.48	3.74	178.87	0.95		
122.09	28.0	1.63	297.82	138.71	208.52	3.74	193.86	0.95		
139.27	30.0	1.63	320.73	149.38	224.56	3.74	208.85	0.95		
180	32.0	1.63	343.64	160.05	240.60	3.74	223.84	0.95		

Crane total										
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook	Load factor hook	Load factor hook	Maximum utilization	
[°]	[m]	[T]	[m]	[-]	[-]	[-]	[-]	[-]		
14.36	4.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
21.61	6.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
28.96	8.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
36.42	10.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
44.05	12.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
51.89	14.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
60	16.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
68.46	18.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
77.36	20.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
86.87	22.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
97.18	24.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
108.68	26.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
122.09	28.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
139.27	30.0	14.2	1	1.91	1.22	1.34	1.44	1.00		
180	32.0	14.2	1	1.91	1.22	1.34	1.44	1.00		

Wire rope 0-160 tonne										
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope		
[°]	[m]	[T]	State DF	Dynamic DF	[T]	[T]	Static UF	Dynamic UF		
14.36	4.0	14.22	4.91	4.88	1.92	27.20	0.91	0.87		

Pedestal adapter												
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	[0,04]	[°]	[m]	[-]
14,36	4,0	1,15	15,93	224,29	108,17	10,69	0,37	11,07	0,04	14,36	4,0	1,15
21,61	6,0	1,15	15,93	336,46	108,17	16,04	0,56	16,60	0,06	21,61	6,0	1,15
28,86	8,0	1,15	15,93	448,61	108,17	21,39	0,75	22,13	0,07	28,86	8,0	1,15
36,12	10,0	1,15	15,93	560,72	108,17	26,73	0,94	27,67	0,09	36,12	10,0	1,15
44,05	12,0	1,15	15,93	672,86	108,17	32,08	1,12	33,20	0,11	44,05	12,0	1,15
51,89	14,0	1,15	15,93	785,01	108,17	37,42	1,31	38,73	0,13	51,89	14,0	1,15
60	16,0	1,15	15,93	897,15	108,17	42,77	1,50	44,27	0,15	60	16,0	1,15
68,46	18,0	1,15	15,93	1009,29	108,17	48,12	1,69	49,80	0,17	68,46	18,0	1,15
77,36	20,0	1,15	15,93	1121,44	108,17	53,46	1,87	55,33	0,18	77,36	20,0	1,15
86,87	22,0	1,15	15,93	1233,58	108,17	58,81	2,06	60,87	0,20	86,87	22,0	1,15
97,18	24,0	1,15	15,93	1345,72	108,17	64,15	2,25	66,40	0,22	97,18	24,0	1,15
108,68	26,0	1,15	15,93	1457,87	108,17	69,50	2,44	71,94	0,24	108,68	26,0	1,15
122,09	28,0	1,15	15,93	1570,01	108,17	74,85	2,62	77,47	0,26	122,09	28,0	1,15
139,27	30,0	1,15	15,93	1682,15	108,17	80,19	2,81	83,00	0,28	139,27	30,0	1,15
180	32,0	1,15	15,93	1794,30	108,17	85,54	3,00	88,54	0,29	180	32,0	1,15

Slewing bearing 1												
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[m]	[MPa]	[0,04]	[°]	[m]	[-]
14,36	4,0	1,15	128,23	224,29	19,49	0	2,24	38,95	0,04	14,36	4,0	1,15
21,61	6,0	1,15	128,23	336,46	36,54	0	2,24	73,05	0,12	21,61	6,0	1,15
28,86	8,0	1,15	128,23	448,61	53,60	0	2,24	107,15	0,18	28,86	8,0	1,15
36,12	10,0	1,15	128,23	560,72	70,66	0	2,24	141,24	0,24	36,12	10,0	1,15
44,05	12,0	1,15	128,23	672,86	87,72	0	2,24	175,34	0,29	44,05	12,0	1,15
51,89	14,0	1,15	128,23	785,01	104,77	0	2,24	209,44	0,35	51,89	14,0	1,15
60	16,0	1,15	128,23	897,15	121,82	0	2,24	243,52	0,42	60	16,0	1,15
68,46	18,0	1,15	128,23	1009,29	138,88	0	2,24	277,61	0,48	68,46	18,0	1,15
77,36	20,0	1,15	128,23	1121,44	155,94	0	2,24	311,70	0,55	77,36	20,0	1,15
86,87	22,0	1,15	128,23	1233,58	172,99	0	2,24	345,80	0,62	86,87	22,0	1,15
97,18	24,0	1,15	128,23	1345,72	190,05	0	2,24	379,89	0,68	97,18	24,0	1,15
108,68	26,0	1,15	128,23	1457,87	207,10	0	2,24	413,98	0,74	108,68	26,0	1,15
122,09	28,0	1,15	128,23	1570,01	224,16	0	2,24	448,08	0,80	122,09	28,0	1,15
139,27	30,0	1,15	128,23	1682,15	241,22	0	2,24	482,18	0,86	139,27	30,0	1,15
180	32,0	1,15	128,23	1794,30	258,27	0	2,24	516,27	0,92	180	32,0	1,15

Slewing bearing 2												
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[m]	[MPa]	[0,49]	[°]	[m]	[-]
14,36	4,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	14,36	4,0	1,15
21,61	6,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	21,61	6,0	1,15
28,86	8,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	28,86	8,0	1,15
36,12	10,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	36,12	10,0	1,15
44,05	12,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	44,05	12,0	1,15
51,89	14,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	51,89	14,0	1,15
60	16,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	60	16,0	1,15
68,46	18,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	68,46	18,0	1,15
77,36	20,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	77,36	20,0	1,15
86,87	22,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	86,87	22,0	1,15
97,18	24,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	97,18	24,0	1,15
108,68	26,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	108,68	26,0	1,15
122,09	28,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	122,09	28,0	1,15
139,27	30,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	139,27	30,0	1,15
180	32,0	1,15	48,96	521,80	174,24	0	2,85	444,13	0,49	180	32,0	1,15

Pedestal adapter												
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	[0,04]	[°]	[m]	[-]
14,36	4,0	1,91	14,22	215,12	105,88	10,26	0,50	10,75	0,04	14,36	4,0	1,91
21,61	6,0	1,91	14,22	322,68	105,88	15,38	0,50	15,88	0,05	21,61	6,0	1,91
28,86	8,0	1,91	14,22	430,24	105,88	20,51	0,50	21,01	0,07	28,86	8,0	1,91
36,12	10,0	1,91	14,22	537,80	105,88	25,64	0,50	26,14	0,09	36,12	10,0	1,91
44,05	12,0	1,91	14,22	645,36	105,88	30,77	0,50	31,26	0,10	44,05	12,0	1,91
51,89	14,0	1,91	14,22	752,92	105,88	35,89	0,50	36,39	0,12	51,89	14,0	1,91
60	16,0	1,91	14,22	860,48	105,88	41,02	0,50	41,52	0,14	60	16,0	1,91
68,46	18,0	1,91	14,22	968,04	105,88	46,15	0,50	46,65	0,15	68,46	18,0	1,91
77,36	20,0	1,91	14,22	1075,60	105,88	51,28	0,50	51,77	0,17	77,36	20,0	1,91
86,87	22,0	1,91	14,22	1183,16	105,88	56,40	0,50	56,90	0,19	86,87	22,0	1,91
97,18	24,0	1,91	14,22	1290,72	105,88	61,53	0,50	62,03	0,21	97,18	24,0	1,91
108,68	26,0	1,91	14,22	1398,28	105,88	66,66	0,50	67,16	0,22	108,68	26,0	1,91
122,09	28,0	1,91	14,22	1505,84	105,88	71,79	0,50	72,28	0,24	122,09	28,0	1,91
139,27	30,0	1,91	14,22	1613,40	105,88	76,91	0,50	77,41	0,26	139,27	30,0	1,91
180	32,0	1,91	14,22	1720,96	105,88	82,04	0,50	82,54	0,27	180	32,0	1,91

Slewing bearing 1												
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[m]	[MPa]	[0,04]	[°]	[m]	[-]
14,36	4,0	1,91	125,94	215,12	18,35	0	2,24	36,69	0,04	14,36	4,0	1,91
21,61	6,0	1,91	125,94	322,68	34,71	0	2,24	102,09	0,11	21,61	6,0	1,91
28,86	8,0	1,91	125,94	430,24	51,07	0	2,24	162,99	0,18	28,86	8,0	1,91
36,12	10,0	1,91	125,94	537,80	67,39	0	2,24	214,96	0,25	36,12	10,0	1,91
44,05	12,0	1,91	125,94	645,36	83,72	0	2,24	266,93	0,32	44,05	12,0	1,91
51,89	14,0	1,91	125,94	752,92	100,05	0	2,24	318,90	0,39	51,89	14,0	1,91
60	16,0	1,91	125,94	860,48	116,37	0	2,24	370,87	0,46	60	16,0	1,91
68,46	18,0	1,91	125,94	968,04	132,69	0	2,24	422,84	0,53	68,46	18,0	1,91
77,36	20,0	1,91	125,94	1075,60	149,02	0	2,24	474,81	0,60	77,36	20,0	1,91
86,87	22,0	1,91	125,94	1183,16	165,35	0	2,24	526,78	0,67	86,87	22,0	1,91
97,18	24,0	1,91	125,94	1290,72	181,68	0	2,24	578,75	0,74	97,18	24,0	1,91
108,68	26,0	1,91	125,94	1398,28	198,00	0	2,24	630,72	0,81	108,68	26,0	1,91
122,09	28,0	1,91	125,94	1505,84	214,33	0	2,24	682,69	0,88	122,09	28,0	1,91
139,27	30,0	1,91	125,94	1613,40	230,65	0	2,24	734,66	0,95	139,27	30,0	1,91
180	32,0	1,91	125,94	1720,96	247,98	0	2,24	786,63	1,02	180	32,0	1,91

Slewing bearing 2												
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[m]	[MPa]	[0,46]	[°]	[m]	[-]
14,36	4,0	1,91	46,67	485,06	161,77	0	2,85	412,35	0,46	14,36	4,0	1,91
21,61	6,0	1,91	46,67	485,06	161,77	0	2,85	412,35	0,46	21,61	6,0	1,91
28,86	8,0	1,91	46,67	485,06	161,77	0	2,85	412,35	0,46	28,86	8,0	1,91
36,12	10,0	1,91	46,67	485,06	161,77	0	2,85	412,35	0,46	36,12	10,0	1,91
44,05	12,0	1,91	46,67	485,06	161,77	0	2,85	412,35	0,46	44,05	12,0	1,91
51,89	14,0	1,91	46,67	485,06	161,77	0	2,85	412,35	0,46	51,89	14,0	1,91
60												

Section 4				TOTAL DESIGN				Section 4	
Self weight only	Self weight only	Hook load only	Hook load only	load	Bending stress	Shear stress	Von mises	UF	
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1					
Section 1	Section 1	Section 1	Section 1						
[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]		
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.93	7.97	11	2.29	2.06	4.35	0.01	

Velocity check				VH/VS	
Minimum steady hosting velocity	Maximum steady hosting velocity	VH	VS		
		(m/s)	(m/s)		
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00
0.00	2.30	0.00	0.00	0.00	0.00

Section 4				TOTAL DESIGN				Section 4	
Self weight only	Self weight only	Hook load only	Hook load only	load	Bending stress	Shear stress	Von mises	UF	
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1					
Section 1	Section 1	Section 1	Section 1						
[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]		
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	
1.29	0.42	15.94	7.97	11	2.29	2.06	4.35	0.01	

Velocity check				VH/VS	
Minimum steady hosting velocity	Maximum steady hosting velocity	VH	VS		
		(m/s)	(m/s)		
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14
0.07	2.30	0.07	0.14	0.14	0.14

Section 4				TOTAL DESIGN				Section 4	
Self weight only	Self weight only	Hook load only	Hook load only	load	Bending stress	Shear stress	Von mises	UF	
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1					
Section 1	Section 1	Section 1	Section 1						
[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]		
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	
1.29	0.42	14.22	7.11	10	2.06	1.85	3.91	0.01	

Velocity check				VH/VS	
Minimum steady hosting velocity	Maximum steady hosting velocity	VH	VS		
		(m/s)	(m/s)		
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23
0.12	2.30	0.12	0.23	0.23	0.23

C.4.2 Calculations for each component for $H_s = 1.5 - 2.5m$ with one fall

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load selfweight	Load factor	Load hook	Maximum utilization
[°]	[m]	[T]	[H]	[-]	[-]	[-]	[-]	[-]	
14.36	4.0	8.5	2.5	3.20	1.22	1.34	1.34	1.34	1.00
21.61	6.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
28.96	8.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
36.42	10.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
44.05	12.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
51.89	14.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
60.00	16.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
68.46	18.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
77.36	20.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
86.87	22.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
97.18	24.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
108.68	26.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
122.09	28.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
139.27	30.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
180	32.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load selfweight	Load factor	Load hook	Maximum utilization
[°]	[m]	[T]	[H]	[-]	[-]	[-]	[-]	[-]	
14.36	4.0	9.5	2	2.87	1.22	1.34	1.34	1.34	1.00
21.61	6.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
28.96	8.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
36.42	10.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
44.05	12.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
51.89	14.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
60.00	16.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
68.46	18.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
77.36	20.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
86.87	22.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
97.18	24.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
108.68	26.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
122.09	28.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
139.27	30.0	9.5	2	2.87	1.22	1.34	1.34	1.00	
180	32.0	9.5	2	2.87	1.22	1.34	1.34	1.00	

Wire rope 0.160 tonne									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope	Dynamic UF
[°]	[m]	[T]	[T]		[T]	[T]	[T]	[T]	
14.36	4.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
21.61	6.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
28.96	8.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
36.42	10.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
44.05	12.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
51.89	14.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
60.00	16.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
68.46	18.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
77.36	20.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
86.87	22.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
97.18	24.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
108.68	26.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
122.09	28.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
139.27	30.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89
180	32.0	8.49	5.00	5.35	1.97	27.19	0.63	0.90	0.89

Wire rope 0.160 tonne									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope	Dynamic UF
[°]	[m]	[T]	[T]		[T]	[T]	[T]	[T]	
14.36	4.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
21.61	6.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
28.96	8.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
36.42	10.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
44.05	12.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
51.89	14.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
60.00	16.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
68.46	18.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
77.36	20.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
86.87	22.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
97.18	24.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
108.68	26.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
122.09	28.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
139.27	30.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90
180	32.0	9.48	5.00	5.35	1.97	27.20	0.63	0.90	0.90

Pedestal									
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	
14.36	4.0	3.20	8.49	184.37	95.22	8.79	3.48	12.27	0.94
21.61	6.0	3.20	8.49	276.56	99.22	13.18	3.48	16.66	0.96
28.96	8.0	3.20	8.49	360.99	99.22	17.58	3.48	21.06	0.97
36.42	10.0	3.20	8.49	448.93	99.22	21.97	3.48	25.45	0.98
44.05	12.0	3.20	8.49	535.12	99.22	26.37	3.48	29.85	0.10
51.89	14.0	3.20	8.49	624.31	99.22	30.76	3.48	34.24	0.11
60.00	16.0	3.20	8.49	716.92	99.22	35.15	3.48	38.63	0.12
68.46	18.0	3.20	8.49	813.29	99.22	39.54	3.48	43.02	0.13
77.36	20.0	3.20	8.49	912.87	99.22	43.93	3.48	47.42	0.14
86.87	22.0	3.20	8.49	1014.05	99.22	48.34	3.48	51.82	0.15
97.18	24.0	3.20	8.49	1116.24	99.22	52.74	3.48	56.21	0.19
108.68	26.0	3.20	8.49	1220.62	99.22	57.13	3.48	60.61	0.22
122.09	28.0	3.20	8.49	1328.80	99.22	61.53	3.48	65.00	0.27
139.27	30.0	3.20	8.49	1441.99	99.22	65.92	3.48	69.40	0.33
180	32.0	3.20	8.49	1571.84	100.22	72.36	3.51	75.79	0.24

Pedestal									
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	
14.36	4.0	2.87	9.48	189.73	100.22	9.04	3.51	12.56	0.94
21.61	6.0	2.87	9.48	284.60	100.22	13.57	3.51	17.06	0.96
28.96	8.0	2.87	9.48	379.46	100.22	18.09	3.51	21.60	0.97
36.42	10.0	2.87	9.48	474.33	100.22	22.61	3.51	26.12	0.99
44.05	12.0	2.87	9.48	569.19	100.22	27.13	3.51	30.65	0.10
51.89	14.0	2.87	9.48	664.06	100.22	31.66	3.51	35.17	0.12
60.00	16.0	2.87	9.48	758.92	100.22	36.18	3.51	39.69	0.14
68.46	18.0	2.87	9.48	853.79	100.22	40.70	3.51	44.21	0.15
77.36	20.0	2.87	9.48	948.52	100.22	45.22	3.51	48.74	0.16
86.87	22.0	2.87	9.48	1043.25	100.22	49.75	3.51	53.26	0.18
97.18	24.0	2.87	9.48	1138.25	100.22	54.28	3.51	57.79	0.21
108.68	26.0	2.87	9.48	1233.25	100.22	58.79	3.51	62.30	0.24
122.09	28.0	2.87	9.48	1328.11	100.22	63.31	3.51	66.83	0.27
139.27	30.0	2.87	9.48	1422.88	100.22	67.84	3.51	71.35	0.32
180	32.0	2.87	9.48	1517.84	100.22	72.36	3.51	75.87	0.25

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load selfweight	Load factor	Load hook	Maximum utilization
[°]	[m]	[T]	[H]	[-]	[-]	[-]	[-]	[-]	
14.36	4.0	8.5	2.5	3.20	1.22	1.34	1.34	1.34	1.00
21.61	6.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
28.96	8.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
36.42	10.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
44.05	12.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
51.89	14.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
60.00	16.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
68.46	18.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
77.36	20.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
86.87	22.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
97.18	24.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
108.68	26.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
122.09	28.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
139.27	30.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	
180	32.0	8.5	2.5	3.20	1.22	1.34	1.34	1.00	

Crane total									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope	Dynamic UF
[°]	[m]	[T]	[T]		[T]	[T]	[T]	[T]	
14.36	4.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
21.61	6.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
28.96	8.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
36.42	10.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
44.05	12.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
51.89	14.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
60.00	16.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
68.46	18.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
77.36	20.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
86.87	22.0	8.49	5.00	5.35	1.97	27.19	0.57	0.90	0.90
97.18	24.0	8.49	5.00						

Pedestal adapter								Sewing bearing 1								Sewing bearing 2													
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Lever arm	Bolt stress	UF
14.36	4.0	2.42	11.24	139.12	101.88	9.49	0.39	9.89	0.03	14.36	4.0	2.42	121.94	139.12	16.38	0	2.24	32.73	0.04	14.36	4.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
21.61	6.0	2.42	11.24	298.68	101.88	14.24	0.39	14.63	0.05	21.61	6.0	2.42	121.94	298.68	31.52	0	2.24	63.00	0.07	21.61	6.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
28.86	8.0	2.42	11.24	398.24	101.88	18.99	0.39	19.38	0.06	28.86	8.0	2.42	121.94	398.24	46.66	0	2.24	93.27	0.10	28.86	8.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
36.42	10.0	2.42	11.24	497.80	101.88	23.73	0.39	24.13	0.08	36.42	10.0	2.42	121.94	497.80	61.80	0	2.24	123.54	0.14	36.42	10.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
44.05	12.0	2.42	11.24	597.37	101.88	28.48	0.39	28.87	0.10	44.05	12.0	2.42	121.94	597.37	76.95	0	2.24	153.81	0.17	44.05	12.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
51.89	14.0	2.42	11.24	696.93	101.88	33.22	0.39	33.62	0.11	51.89	14.0	2.42	121.94	696.93	92.09	0	2.24	184.08	0.20	51.89	14.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
60	16.0	2.42	11.24	796.49	101.88	37.97	0.39	38.36	0.13	60	16.0	2.42	121.94	796.49	107.23	0	2.24	214.35	0.24	60	16.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
68.46	18.0	2.42	11.24	896.05	101.88	42.72	0.39	43.11	0.14	68.46	18.0	2.42	121.94	896.05	122.37	0	2.24	244.62	0.27	68.46	18.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
77.36	20.0	2.42	11.24	995.61	101.88	47.46	0.39	47.86	0.16	77.36	20.0	2.42	121.94	995.61	137.52	0	2.24	274.88	0.31	77.36	20.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
86.87	22.0	2.42	11.24	1095.17	101.88	52.21	0.39	52.60	0.17	86.87	22.0	2.42	121.94	1095.17	152.66	0	2.24	305.15	0.34	86.87	22.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
97.18	24.0	2.42	11.24	1194.73	101.88	56.96	0.39	57.35	0.19	97.18	24.0	2.42	121.94	1194.73	167.80	0	2.24	335.42	0.37	97.18	24.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
108.68	26.0	2.42	11.24	1294.29	101.88	61.70	0.39	62.10	0.21	108.68	26.0	2.42	121.94	1294.29	182.94	0	2.24	365.68	0.41	108.68	26.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
122.09	28.0	2.42	11.24	1393.85	101.88	66.45	0.39	66.84	0.22	122.09	28.0	2.42	121.94	1393.85	198.09	0	2.24	395.94	0.44	122.09	28.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
139.27	30.0	2.42	11.24	1493.41	101.88	71.19	0.39	71.59	0.23	139.27	30.0	2.42	121.94	1493.41	213.23	0	2.24	426.21	0.47	139.27	30.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40
180	32.0	2.42	11.24	1592.97	101.88	75.94	0.39	76.33	0.25	180	32.0	2.42	121.94	1592.97	228.37	0	2.24	456.50	0.51	180	32.0	2.42	42.67	421.07	1400.5	0	2.85	356.99	0.40

Pedestal adapter								Sewing bearing 1								Sewing bearing 2													
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Lever arm	Bolt stress	UF
14.36	4.0	2.87	9.48	189.73	99.53	9.04	0.33	9.38	0.03	14.36	4.0	2.87	119.59	189.73	15.21	0	2.24	30.41	0.03	14.36	4.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
21.61	6.0	2.87	9.48	284.60	99.53	13.57	0.33	13.90	0.05	21.61	6.0	2.87	119.59	284.60	29.64	0	2.24	59.25	0.07	21.61	6.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
28.86	8.0	2.87	9.48	379.46	99.53	18.09	0.33	18.42	0.06	28.86	8.0	2.87	119.59	379.46	44.07	0	2.24	88.10	0.10	28.86	8.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
36.42	10.0	2.87	9.48	474.33	99.53	22.61	0.33	22.94	0.08	36.42	10.0	2.87	119.59	474.33	58.50	0	2.24	116.94	0.13	36.42	10.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
44.05	12.0	2.87	9.48	569.19	99.53	27.13	0.33	27.47	0.09	44.05	12.0	2.87	119.59	569.19	72.93	0	2.24	145.78	0.16	44.05	12.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
51.89	14.0	2.87	9.48	664.06	99.53	31.66	0.33	31.99	0.11	51.89	14.0	2.87	119.59	664.06	87.36	0	2.24	174.62	0.19	51.89	14.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
60	16.0	2.87	9.48	758.92	99.53	36.18	0.33	36.51	0.12	60	16.0	2.87	119.59	758.92	101.78	0	2.24	203.46	0.23	60	16.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
68.46	18.0	2.87	9.48	853.79	99.53	40.70	0.33	41.03	0.14	68.46	18.0	2.87	119.59	853.79	116.21	0	2.24	232.30	0.26	68.46	18.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
77.36	20.0	2.87	9.48	948.65	99.53	45.22	0.33	45.56	0.15	77.36	20.0	2.87	119.59	948.65	130.64	0	2.24	261.14	0.28	77.36	20.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
86.87	22.0	2.87	9.48	1043.52	99.53	49.75	0.33	50.08	0.17	86.87	22.0	2.87	119.59	1043.52	145.07	0	2.24	289.98	0.32	86.87	22.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
97.18	24.0	2.87	9.48	1138.38	99.53	54.27	0.33	54.60	0.18	97.18	24.0	2.87	119.59	1138.38	159.50	0	2.24	318.83	0.35	97.18	24.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
108.68	26.0	2.87	9.48	1233.25	99.53	58.79	0.33	59.12	0.20	108.68	26.0	2.87	119.59	1233.25	173.93	0	2.24	347.67	0.39	108.68	26.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
122.09	28.0	2.87	9.48	1328.11	99.53	63.31	0.33	63.65	0.21	122.09	28.0	2.87	119.59	1328.11	188.35	0	2.24	376.51	0.42	122.09	28.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
139.27	30.0	2.87	9.48	1422.98	99.53	67.84	0.33	68.17	0.22	139.27	30.0	2.87	119.59	1422.98	202.78	0	2.24	405.35	0.45	139.27	30.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36
180	32.0	2.87	9.48	1517.84	99.53	72.36	0.33	72.69	0.24	180	32.0	2.87	119.59	1517.84	217.21	0	2.24	434.19	0.48	180	32.0	2.87	40.32	383.51	127.30	0	2.85	324.49	0.36

Pedestal adapter								Sewing bearing 1								Sewing bearing 2													
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Lever arm	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Lever arm	Bolt stress	UF
14.36	4.0	3.20	8.49	184.37	98.19	8.79	0.30	9.09	0.03	14.36	4.0	3.20	118.25	184.37	14.55	0	2.24	29.09	0.03	14.36	4.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
21.61	6.0	3.20	8.49	276.56	98.19	13.48	0.30	13.48	0.04	21.61	6.0	3.20	118.25	276.56	28.57	0	2.24	57.12	0.06	21.61	6.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
28.86	8.0	3.20	8.49	368.75	98.19	17.58	0.30	17.88	0.06	28.86	8.0	3.20	118.25	368.75	42.64	0	2.24	85.14	0.09	28.86	8.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
36.42	10.0	3.20	8.49	460.93	98.19	21.67	0.30	22.27	0.07	36.42	10.0	3.20	118.25	460.93	56.62	0	2.24	113.17	0.13	36.42	10.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
44.05	12.0	3.20	8.49	553.12	98.19	25.77	0.30	26.67	0.08	44.05	12.0	3.20	118.25	553.12	70.64	0	2.24	141.20	0.16	44.05	12.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
51.89	14.0	3.20	8.49	645.31	98.19	29.87	0.30	31.06	0.10	51.89	14.0	3.20	118.25	645.31	84.66	0	2.24	169.23	0.18	51.89	14.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
60	16.0	3.20	8.49	737.49	98.19	33.96	0.30	35.46	0.12	60	16.0	3.20	118.25	737.49	98.68	0	2.24	197.25	0.22	60	16.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34
68.46	18.0	3.20	8.49	829.68	98.19	38.05	0.30	39.85	0.13	68.46	18.0	3.20	118.25	829.68	112.70	0	2.24	225.28	0.25	68.46	18.0	3.20	38.98	362.08	1200.3	0	2.85	305.95	0.34

Hoist winch				Dynamic				Hoist winch			
Angle	Radius	Hook load	Dynamic hook load	hook load	hook load	load in hoist	load in hoist	winch	winch	winch	Dynamic UF
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
21.61	6.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
28.96	8.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
36.42	10.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
44.05	12.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
51.89	14.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
60	16.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
68.46	18.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
77.36	20.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
86.87	22.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
97.18	24.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
108.68	26.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
122.09	28.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
139.27	30.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00
180	32.0	8.5	27.19	27.19	27.19	0.66	0.66	1.00	1.00	1.00	1.00

Hoist winch				Dynamic				Hoist winch			
Angle	Radius	Hook load	Dynamic hook load	hook load	hook load	load in hoist	load in hoist	winch	winch	winch	Dynamic UF
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
21.61	6.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
28.96	8.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
36.42	10.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
44.05	12.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
51.89	14.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
60	16.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
68.46	18.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
77.36	20.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
86.87	22.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
97.18	24.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
108.68	26.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
122.09	28.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
139.27	30.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00
180	32.0	9.5	27.20	27.20	27.20	0.56	0.56	1.00	1.00	1.00	1.00

Boom				Section 1				Section 1				Section 1				Total design				web				Flange			
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	Bending horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises	Von mises	Von mises	Von mises	UF	UF	UF	UF					
[o]	[m]	[T]	[-]	[T]	[Tm]	[T]	[Tm]	[Tm]	[MPa]	[MPa]	[Tm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]					
14.36	4.0	8.5	3.20	71.16	80.52	11.24	40.73	100.71	7.94	5.29	15.45	6.24	25.67	23.54	23.54	0.08	0.08	0.08	0.08	0.08	0.08						
21.61	6.0	8.5	3.20	71.16	120.77	8.49	61.40	149.56	11.78	7.86	22.9	21.18	35.81	32.41	32.41	0.11	0.10	0.10	0.10	0.10	0.09						
28.96	8.0	8.5	3.20	71.16	161.03	8.49	81.07	196.56	15.49	10.33	30.6	30.90	45.81	41.22	41.22	0.15	0.13	0.13	0.13	0.13	0.12						
36.42	10.0	8.5	3.20	71.16	201.29	8.49	101.84	241.05	18.99	12.66	38.2	38.63	55.63	49.94	49.94	0.18	0.16	0.16	0.16	0.16	0.14						
44.05	12.0	8.5	3.20	71.16	241.55	8.49	122.20	282.29	22.24	14.83	45.8	46.35	62.4	55.19	55.19	0.21	0.19	0.19	0.19	0.19	0.17						
51.89	14.0	8.5	3.20	71.16	281.81	8.49	142.57	319.46	25.17	16.78	53.5	54.08	74.42	66.95	66.95	0.24	0.21	0.21	0.21	0.21	0.19						
60	16.0	8.5	3.20	71.16	322.07	8.49	162.94	351.66	27.70	18.47	61.1	61.81	83.26	75.19	75.19	0.27	0.24	0.24	0.24	0.24	0.21						
68.46	18.0	8.5	3.20	71.16	362.32	8.49	183.30	377.65	29.76	19.84	68.8	69.53	91.63	83.19	83.19	0.29	0.27	0.27	0.27	0.27	0.24						
77.36	20.0	8.5	3.20	71.16	402.58	8.49	203.67	396.18	31.22	20.81	76.4	77.26	99.47	90.94	90.94	0.32	0.29	0.29	0.29	0.29	0.26						
86.87	22.0	8.5	3.20	71.16	442.84	8.49	224.04	405.41	31.94	21.30	84.0	84.98	106.69	98.39	98.39	0.34	0.31	0.31	0.31	0.31	0.28						
97.18	24.0	8.5	3.20	71.16	483.10	8.49	244.40	423.80	32.31	21.76	91.7	92.71	113.19	105.51	105.51	0.36	0.34	0.34	0.34	0.34	0.31						
108.68	26.0	8.5	3.20	71.16	523.36	8.49	264.77	384.62	30.31	20.20	99.3	100.43	120.43	118.89	118.89	0.38	0.36	0.36	0.36	0.36	0.33						
122.09	28.0	8.5	3.20	71.16	563.61	8.49	285.14	349.58	27.10	18.07	107.0	108.16	127.36	123.65	123.65	0.39	0.38	0.38	0.38	0.38	0.36						
139.27	30.0	8.5	3.20	71.16	603.87	8.49	305.51	284.91	20.87	13.92	114.6	115.89	137.36	129.85	129.85	0.41	0.41	0.41	0.41	0.41	0.38						
180	32.0	8.5	3.20	71.16	644.13	8.49	325.87	0.00	1.74E-15	1.16E-15	123.3	123.61	146.24	139.85	139.85	0.41	0.41	0.41	0.41	0.41	0.38						

Boom				Section 1				Section 1				Section 1				Total design				web				Flange			
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	Bending horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises	Von mises	Von mises	Von mises	UF	UF	UF	UF					
[o]	[m]	[T]	[-]	[T]	[Tm]	[T]	[Tm]	[Tm]	[MPa]	[MPa]	[Tm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]					
14.36	4.0	9.5	2.87	71.16	80.52	9.48	34.38	91.97	7.25	4.83	14.4	14.59	6.09	24.19	22.31	0.08	0.08	0.08	0.08	0.08	0.07						
21.61	6.0	9.5	2.87	71.16	120.77	9.48	51.57	136.58	10.76	7.17	21.6	21.88	33.62	30.61	30.61	0.11	0.10	0.10	0.10	0.10	0.09						
28.96	8.0	9.5	2.87	71.16	161.03	9.48	68.76	179.51	14.14	9.43	28.9	29.18	42.95	38.87	38.87	0.14	0.12	0.12	0.12	0.12	0.10						
36.42	10.0	9.5	2.87	71.16	201.29	9.48	85.96	221.80	17.35	11.56	36.1	36.48	52.00	47.05	47.05	0.17	0.15	0.15	0.15	0.15	0.12						
44.05	12.0	9.5	2.87	71.16	241.55	9.48	103.15	257.80	20.31	13.54	43.3	43.77	60.99	54.03	54.03	0.19	0.18	0.18	0.18	0.18	0.15						
51.89	14.0	9.5	2.87	71.16	281.81	9.48	121.34	291.75	22.99	15.33	50.5	51.07	72.94	63.02	63.02	0.22	0.20	0.20	0.20	0.20	0.18						
60	16.0	9.5	2.87	71.16	322.07	9.48	137.53	323.12	25.30	16.87	57.7	58.36	85.36	70.77	70.77	0.25	0.23	0.23	0.23	0.23	0.20						
68.46	18.0	9.5	2.87	71.16	362.32	9.48	154.72	344.89	27.18	18.12	64.9	65.66	95.66	78.31	78.31	0.27	0.25	0.25	0.25	0.25	0.22						
77.36	20.0	9.5	2.87	71.16	402.58	9.48	171.91	361.82	28.51	19.01	72.2	72.95	105.69	85.81	85.81	0.30	0.27	0.27	0.27	0.27	0.24						
86.87	22.0	9.5	2.87	71.16	442.84	9.48	189.10	370.24	29.17	19.65	79.4	80.25	113.20	92.68	92.68	0.32	0.30	0.30	0.30	0.30	0.27						
97.18	24.0	9.5	2.87	71.16	483.10	9.48	206.29	367.89	28.99	19.52	86.6	87.55	120.43	99.44	99.44	0.34	0.32	0.32	0.32	0.32	0.29						
108.68	26.0	9.5	2.87	71.16	523.36	9.48	223.49	353.26	27.68	19.45	93.8	94.84	127.36	105.87	105.87	0.36	0.34	0.34	0.34	0.34	0.31						
122.09	28.0	9.5	2.87	71.16	563.61	9.48	240.68	314.14	24.75	16.50	101.0	102.14	134.14	111.61	111.61	0.37	0.36	0.36	0.36	0.36	0.33						
139.27	30.0	9.5	2.87	71.16	603.87	9.48	257.87	241.93	19.06	12.71	108.2	109.43	140.15	120.15	120.15	0.38	0.37	0.37	0.37	0.37	0.34						
180	32.0	9.5	2.87	71.16	644.13	9.48	275.06	0.00	1.74E-15	1.16E-15	115.4	116.73	146.24	122.82	122.82	0.39	0.39	0.39	0.39	0.39	0.36						

Hoist winch				Dynamic				Hoist winch			
Angle	Radius	Hook load	Dynamic hook load	hook load	hook load	load in hoist	load in hoist	winch	winch	winch	Dynamic UF
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	8.5	27.19	27.19	27.19	0.50	0.50	1.00	1.00	1.00	1.00
21.61	6.0	8.5	27.19	27.19	27.19	0.50	0.50	1.00	1.00	1.00	1.00
28.96	8.0	8.5	27.19	27.19	27.19	0.50	0.50	1.00	1.00	1.00	1.00
36.42	10.0	8.5	27.19	27.19	27.19	0.50	0.50	1.00	1.00	1.00	1.00
44.05	12.0	8.5	27.19	27.19	27.19	0.50					

Section 4				TOTALDESIGN			
Self weight only	Self weight only	Hook load only	Hook load only	load	Bending stress	Shear stress	Von mises
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1	[MPa]	[MPa]	[MPa]
Section 1	Section 1	Section 1	Section 1				Section 4
[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14
1.29	0.42	11.24	5.62	8	1.65	1.49	3.14

Velocity check	
Minimum steady hosting velocity	Maximum steady hosting velocity
VH	VS
(m/s)	(m/s)
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30

Section 4				TOTALDESIGN			
Self weight only	Self weight only	Hook load only	Hook load only	load	Bending stress	Shear stress	Von mises
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1	[MPa]	[MPa]	[MPa]
Section 1	Section 1	Section 1	Section 1				Section 4
[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69
1.29	0.42	9.48	4.74	7	1.41	1.28	2.69

Velocity check	
Minimum steady hosting velocity	Maximum steady hosting velocity
VH	VS
(m/s)	(m/s)
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30
0.14	2.30

Section 4				TOTALDESIGN			
Self weight only	Self weight only	Hook load only	Hook load only	load	Bending stress	Shear stress	Von mises
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1	[MPa]	[MPa]	[MPa]
Section 1	Section 1	Section 1	Section 1				Section 4
[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43
1.29	0.42	8.49	4.24	6	1.27	1.16	2.43

Velocity check	
Minimum steady hosting velocity	Maximum steady hosting velocity
VH	VS
(m/s)	(m/s)
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30
0.16	2.30

C.4.3 Calculations for each component for $H_s = 3 - 4m$ with one fall

Crane total						
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook
[°]	[m]	[T]	[H]	[-]	[-]	[-]
14.36	4.0	6.8	4	4.01	1.22	1.34
21.61	6.0	7.8	3	3.48	1.22	1.34
28.96	8.0	7.8	3	3.48	1.22	1.34
36.42	10.0	7.8	3	3.48	1.22	1.34
44.05	12.0	7.8	3	3.48	1.22	1.34
51.89	14.0	7.8	3	3.48	1.22	1.34
60	16.0	7.8	3	3.48	1.22	1.34
68.46	18.0	7.8	3	3.48	1.22	1.34
77.36	20.0	7.8	3	3.48	1.22	1.34
86.87	22.0	7.8	3	3.48	1.22	1.34
97.18	24.0	7.8	3	3.48	1.22	1.34
108.68	26.0	7.8	3	3.48	1.22	1.34
122.09	28.0	7.8	3	3.48	1.22	1.34
139.27	30.0	7.8	3	3.48	1.22	1.34
180	32.0	7.8	3	3.48	1.22	1.34

Wire rope 0.160 tonne						
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load
[°]	[m]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	7.81	5.00	5.35	1.97	27.20
21.61	6.0	7.81	5.00	5.35	1.97	27.20
28.96	8.0	7.81	5.00	5.35	1.97	27.20
36.42	10.0	7.81	5.00	5.35	1.97	27.20
44.05	12.0	7.81	5.00	5.35	1.97	27.20
51.89	14.0	7.81	5.00	5.35	1.97	27.20
60	16.0	7.81	5.00	5.35	1.97	27.20
68.46	18.0	7.81	5.00	5.35	1.97	27.20
77.36	20.0	7.81	5.00	5.35	1.97	27.20
86.87	22.0	7.81	5.00	5.35	1.97	27.20
97.18	24.0	7.81	5.00	5.35	1.97	27.20
108.68	26.0	7.81	5.00	5.35	1.97	27.20
122.09	28.0	7.81	5.00	5.35	1.97	27.20
139.27	30.0	7.81	5.00	5.35	1.97	27.20
180	32.0	7.81	5.00	5.35	1.97	27.20

Pedestal						
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress
[°]	[m]	[-]	[T]	[Tm]	[T]	[MPa]
14.36	4.0	4.01	6.77	175.18	97.50	8.35
21.61	6.0	4.01	6.77	262.77	97.50	12.53
28.96	8.0	4.01	6.77	330.36	97.50	16.70
36.42	10.0	4.01	6.77	437.95	97.50	20.88
44.05	12.0	4.01	6.77	573.54	97.50	28.42
51.89	14.0	4.01	6.77	741.13	97.50	38.55
60	16.0	4.01	6.77	940.72	97.50	50.81
68.46	18.0	4.01	6.77	1172.31	97.50	66.31
77.36	20.0	4.01	6.77	1445.91	97.50	86.39
86.87	22.0	4.01	6.77	1761.50	97.50	112.21
97.18	24.0	4.01	6.77	2119.09	97.50	144.07
108.68	26.0	4.01	6.77	2518.68	97.50	182.28
122.09	28.0	4.01	6.77	2960.27	97.50	227.28
139.27	30.0	4.01	6.77	3453.86	97.50	289.45
180	32.0	4.01	6.77	4000.45	97.50	359.22

Crane total						
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook
[°]	[m]	[T]	[H]	[-]	[-]	[-]
14.36	4.0	7.2	3.5	3.75	1.22	1.34
21.61	6.0	7.2	3.5	3.75	1.22	1.34
28.96	8.0	7.2	3.5	3.75	1.22	1.34
36.42	10.0	7.2	3.5	3.75	1.22	1.34
44.05	12.0	7.2	3.5	3.75	1.22	1.34
51.89	14.0	7.2	3.5	3.75	1.22	1.34
60	16.0	7.2	3.5	3.75	1.22	1.34
68.46	18.0	7.2	3.5	3.75	1.22	1.34
77.36	20.0	7.2	3.5	3.75	1.22	1.34
86.87	22.0	7.2	3.5	3.75	1.22	1.34
97.18	24.0	7.2	3.5	3.75	1.22	1.34
108.68	26.0	7.2	3.5	3.75	1.22	1.34
122.09	28.0	7.2	3.5	3.75	1.22	1.34
139.27	30.0	7.2	3.5	3.75	1.22	1.34
180	32.0	7.2	3.5	3.75	1.22	1.34

Wire rope 0.160 tonne						
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load
[°]	[m]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	7.25	5.00	5.35	1.97	27.20
21.61	6.0	7.25	5.00	5.35	1.97	27.20
28.96	8.0	7.25	5.00	5.35	1.97	27.20
36.42	10.0	7.25	5.00	5.35	1.97	27.20
44.05	12.0	7.25	5.00	5.35	1.97	27.20
51.89	14.0	7.25	5.00	5.35	1.97	27.20
60	16.0	7.25	5.00	5.35	1.97	27.20
68.46	18.0	7.25	5.00	5.35	1.97	27.20
77.36	20.0	7.25	5.00	5.35	1.97	27.20
86.87	22.0	7.25	5.00	5.35	1.97	27.20
97.18	24.0	7.25	5.00	5.35	1.97	27.20
108.68	26.0	7.25	5.00	5.35	1.97	27.20
122.09	28.0	7.25	5.00	5.35	1.97	27.20
139.27	30.0	7.25	5.00	5.35	1.97	27.20
180	32.0	7.25	5.00	5.35	1.97	27.20

Pedestal						
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress
[°]	[m]	[-]	[T]	[Tm]	[T]	[MPa]
14.36	4.0	3.75	7.25	177.73	97.98	8.47
21.61	6.0	3.75	7.25	266.60	97.98	12.71
28.96	8.0	3.75	7.25	355.47	97.98	16.95
36.42	10.0	3.75	7.25	444.33	97.98	21.18
44.05	12.0	3.75	7.25	533.20	97.98	25.42
51.89	14.0	3.75	7.25	622.07	97.98	29.66
60	16.0	3.75	7.25	710.93	97.98	33.83
68.46	18.0	3.75	7.25	799.80	97.98	38.13
77.36	20.0	3.75	7.25	888.67	97.98	42.56
86.87	22.0	3.75	7.25	977.54	97.98	47.12
97.18	24.0	3.75	7.25	1066.41	97.98	51.77
108.68	26.0	3.75	7.25	1155.27	97.98	56.57
122.09	28.0	3.75	7.25	1244.13	97.98	61.49
139.27	30.0	3.75	7.25	1333.00	97.98	66.55
180	32.0	3.75	7.25	1421.87	97.98	71.82

Crane total						
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook
[°]	[m]	[T]	[H]	[-]	[-]	[-]
14.36	4.0	6.8	4	4.01	1.22	1.34
21.61	6.0	6.8	4	4.01	1.22	1.34
28.96	8.0	6.8	4	4.01	1.22	1.34
36.42	10.0	6.8	4	4.01	1.22	1.34
44.05	12.0	6.8	4	4.01	1.22	1.34
51.89	14.0	6.8	4	4.01	1.22	1.34
60	16.0	6.8	4	4.01	1.22	1.34
68.46	18.0	6.8	4	4.01	1.22	1.34
77.36	20.0	6.8	4	4.01	1.22	1.34
86.87	22.0	6.8	4	4.01	1.22	1.34
97.18	24.0	6.8	4	4.01	1.22	1.34
108.68	26.0	6.8	4	4.01	1.22	1.34
122.09	28.0	6.8	4	4.01	1.22	1.34
139.27	30.0	6.8	4	4.01	1.22	1.34
180	32.0	6.8	4	4.01	1.22	1.34

Wire rope 0.160 tonne						
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load
[°]	[m]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	6.77	5.00	5.35	1.97	27.18
21.61	6.0	6.77	5.00	5.35	1.97	27.18
28.96	8.0	6.77	5.00	5.35	1.97	27.18
36.42	10.0	6.77	5.00	5.35	1.97	27.18
44.05	12.0	6.77	5.00	5.35	1.97	27.18
51.89	14.0	6.77	5.00	5.35	1.97	27.18
60	16.0	6.77	5.00	5.35	1.97	27.18
68.46	18.0	6.77	5.00	5.35	1.97	27.18
77.36	20.0	6.77	5.00	5.35	1.97	27.18
86.87	22.0	6.77	5.00	5.35	1.97	27.18
97.18	24.0	6.77	5.00	5.35	1.97	27.18
108.68	26.0	6.77	5.00	5.35	1.97	27.18
122.09	28.0	6.77	5.00	5.35	1.97	27.18
139.27	30.0	6.77	5.00	5.35	1.97	27.18
180	32.0	6.77	5.00	5.35	1.97	27.18

Pedestal						
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress
[°]	[m]	[-]	[T]	[Tm]	[T]	[MPa]
14.36	4.0	4.01	6.77	175.18	97.50	8.35
21.61	6.0	4.01	6.77	262.77	97.50	12.53
28.96	8.0	4.01	6.77	330.36	97.50	16.70
36.42	10.0	4.01	6.77	437.95	97.50	20.88
44.05	12.0	4.01	6.77	573.54	97.50	28.42
51.89	14.0	4.01	6.77	741.13	97.50	38.55
60	16.0	4.01	6.77	940.72	97.50	50.81
68.46	18.0	4.01	6.77	1172.31	97.50	66.31
77.36	20.0	4.01	6.77	1445.91	97.50	86.39
86.87	22.0	4.01	6.77	1761.50	97.50	112.21
97.18	24.0	4.01	6.77	2119.09	97.50	144.07
108.68	26.0	4.01	6.77	2518.68	97.50	182.28
122.09	28.0	4.01	6.77	2960.27	97.50	227.28
139.27	30.0	4.01	6.77	3453.86		

Pedestal adapter

Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
14.36	4.0	4.01	6.77	175.38	95.89	8.35	0.24	8.59	0.03
21.61	6.0	4.01	6.77	262.77	12.76	12.53	0.24	13.20	0.04
28.96	8.0	4.01	6.77	350.36	95.89	16.30	0.24	16.94	0.06
36.42	10.0	4.01	6.77	437.95	20.88	20.88	0.24	21.12	0.07
44.05	12.0	4.01	6.77	525.54	95.89	25.05	0.24	25.29	0.08
51.89	14.0	4.01	6.77	613.13	95.89	29.47	0.24	29.47	0.10
6.0	16.0	4.01	6.77	700.72	95.89	33.41	0.24	33.64	0.11
68.46	18.0	4.01	6.77	788.32	95.89	37.58	0.24	37.82	0.13
77.36	20.0	4.01	6.77	875.91	95.89	41.76	0.24	41.99	0.14
86.87	22.0	4.01	6.77	963.50	95.89	45.93	0.24	46.17	0.15
97.18	24.0	4.01	6.77	1051.09	95.89	50.11	0.24	50.34	0.17
108.68	26.0	4.01	6.77	1138.68	95.89	54.28	0.24	54.52	0.18
122.09	28.0	4.01	6.77	1226.27	95.89	58.46	0.24	58.70	0.19
139.27	30.0	4.01	6.77	1313.86	95.89	62.63	0.24	62.87	0.21
180	32.0	4.01	6.77	1401.45	95.89	66.81	0.24	67.05	0.22

Sewing bearing 1

Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	4.01	115.95	175.38	13.42	0	0	0	2.24	28.37	0.03
21.61	6.0	4.01	115.95	262.77	20.74	0	0	0	2.24	53.45	0.06
28.96	8.0	4.01	115.95	350.36	40.06	0	2.24	0	2.24	83.14	0.09
36.42	10.0	4.01	115.95	437.95	53.38	0	2.24	0	2.24	110.62	0.12
44.05	12.0	4.01	115.95	525.54	66.70	0	2.24	133.34	0.15	138.09	0.15
51.89	14.0	4.01	115.95	613.13	80.03	0	2.24	159.97	0.18	165.56	0.18
6.0	16.0	4.01	115.95	700.72	93.35	0	2.24	186.60	0.21	193.04	0.21
68.46	18.0	4.01	115.95	788.32	106.67	0	2.24	213.23	0.24	220.51	0.24
77.36	20.0	4.01	115.95	875.91	119.99	0	2.24	239.86	0.27	247.99	0.27
86.87	22.0	4.01	115.95	963.50	133.31	0	2.24	266.49	0.30	275.46	0.31
97.18	24.0	4.01	115.95	1051.09	146.64	0	2.24	293.12	0.33	302.94	0.34
108.68	26.0	4.01	115.95	1138.68	159.96	0	2.24	319.75	0.36	330.41	0.37
122.09	28.0	4.01	115.95	1226.27	173.28	0	2.24	346.38	0.38	357.88	0.40
139.27	30.0	4.01	115.95	1313.86	186.60	0	2.24	373.01	0.41	385.36	0.43
180	32.0	4.01	115.95	1401.45	199.92	0	2.24	399.63	0.44	412.83	0.46

Sewing bearing 2

Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	
14.36	4.0	2.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
21.61	6.0	3.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
28.96	8.0	4.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
36.42	10.0	5.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
44.05	12.0	6.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
51.89	14.0	7.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
6.0	16.0	8.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
68.46	18.0	9.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
77.36	20.0	10.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
86.87	22.0	11.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
97.18	24.0	12.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
108.68	26.0	13.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
122.09	28.0	14.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
139.27	30.0	15.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33
180	32.0	16.0	4.01	36.68	325.31	110.75	0	2.85	115.09	0	2.85	293.37	0.33

Pedestal adapter

Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
14.36	4.0	3.75	7.25	177.73	96.53	8.47	0.25	8.73	0.03
21.61	6.0	3.75	7.25	266.60	96.53	12.71	0.25	12.96	0.04
28.96	8.0	3.75	7.25	355.47	96.53	16.95	0.25	17.20	0.06
36.42	10.0	3.75	7.25	444.33	96.53	21.18	0.25	21.44	0.07
44.05	12.0	3.75	7.25	533.20	96.53	25.42	0.25	25.67	0.09
51.89	14.0	3.75	7.25	622.07	96.53	29.66	0.25	29.91	0.10
6.0	16.0	3.75	7.25	710.93	96.53	33.89	0.25	34.15	0.11
68.46	18.0	3.75	7.25	799.80	96.53	38.13	0.25	38.38	0.13
77.36	20.0	3.75	7.25	888.67	96.53	42.36	0.25	42.62	0.14
86.87	22.0	3.75	7.25	977.53	96.53	46.60	0.25	46.86	0.16
97.18	24.0	3.75	7.25	1066.40	96.53	50.84	0.25	51.09	0.17
108.68	26.0	3.75	7.25	1155.27	96.53	55.07	0.25	55.33	0.18
122.09	28.0	3.75	7.25	1244.13	96.53	59.31	0.25	59.56	0.20
139.27	30.0	3.75	7.25	1333.00	96.53	63.55	0.25	63.80	0.21
180	32.0	3.75	7.25	1421.87	96.53	67.78	0.25	68.04	0.23

Sewing bearing 1

Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	3.75	116.59	177.73	13.73	0	0	0	2.24	27.45	0.03
21.61	6.0	3.75	116.59	266.60	27.25	0	0	0	2.24	54.47	0.06
28.96	8.0	3.75	116.59	355.47	40.76	0	2.24	0	2.24	81.49	0.09
36.42	10.0	3.75	116.59	444.33	54.28	0	2.24	108.50	0.12	108.50	0.12
44.05	12.0	3.75	116.59	533.20	67.80	0	2.24	135.52	0.15	135.52	0.15
51.89	14.0	3.75	116.59	622.07	81.31	0	2.24	162.54	0.18	162.54	0.18
6.0	16.0	3.75	116.59	710.93	94.83	0	2.24	189.56	0.21	189.56	0.21
68.46	18.0	3.75	116.59	799.80	108.34	0	2.24	216.57	0.24	216.57	0.24
77.36	20.0	3.75	116.59	888.67	121.86	0	2.24	243.59	0.27	243.59	0.27
86.87	22.0	3.75	116.59	977.53	135.38	0	2.24	270.61	0.30	270.61	0.30
97.18	24.0	3.75	116.59	1066.40	148.89	0	2.24	297.63	0.33	297.63	0.33
108.68	26.0	3.75	116.59	1155.27	162.41	0	2.24	324.65	0.36	324.65	0.36
122.09	28.0	3.75	116.59	1244.13	175.92	0	2.24	351.66	0.39	351.66	0.39
139.27	30.0	3.75	116.59	1333.00	189.44	0	2.24	378.68	0.42	378.68	0.42
180	32.0	3.75	116.59	1421.87	202.96	0	2.24	405.70	0.45	405.70	0.45

Sewing bearing 2

Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	
14.36	4.0	2.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
21.61	6.0	3.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
28.96	8.0	4.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
36.42	10.0	5.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
44.05	12.0	6.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
51.89	14.0	7.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
6.0	16.0	8.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
68.46	18.0	9.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
77.36	20.0	10.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
86.87	22.0	11.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
97.18	24.0	12.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
108.68	26.0	13.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
122.09	28.0	14.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
139.27	30.0	15.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31
180	32.0	16.0	3.75	37.32	335.52	111.01	0	2.85	111.01	0	2.85	282.97	0.31

Pedestal adapter

Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
14.36	4.0	4.01	6.77	175.38	95.89	8.35	0.24	8.59	0.03
21.61	6.0	4.01	6.77	262.77	12.76	12.53	0.24	13.20	0.04
28.96	8.0	4.01	6.77	350.36	95.89	16.30	0.24	16.94	0.06
36.42	10.0	4.01	6.77	437.95	20.88	20.88	0.24	21.12	0.07
44.05	12.0	4.01	6.77	525.54	95.89	25.05	0.24	25.29	0.08

Hoist winch										
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Hoist winch	Hoist winch	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
21.61	6.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
28.96	8.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
36.42	10.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
44.05	12.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
51.89	14.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
60	16.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
68.46	18.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
77.36	20.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
86.87	22.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
97.18	24.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
108.68	26.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
122.09	28.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
139.27	30.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00
180	32.0	7.8	27.20	27.20	0.46	0.46	1.00	1.00	1.00	1.00

Boom																	
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	φ	Section 1	Section 1	Section 1	Section 1	Section 1	Section 1	Total design load	Web	Flange	UF	UF		
[o]	[m]	[T]	[-]	[-]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	
14.36	4.0	7.8	3.48	7.16	80.52	7.81	28.30	83.61	6.59	4.39	136	13.77	5.95	22.78	21.14	0.07	0.07
21.61	6.0	7.8	3.48	7.16	120.77	7.81	42.45	124.16	9.78	6.52	202	20.65	5.95	31.54	28.90	0.10	0.09
28.96	8.0	7.8	3.48	7.16	161.03	7.81	56.60	163.19	12.86	8.57	274	27.53	5.95	40.22	36.63	0.13	0.12
36.42	10.0	7.8	3.48	7.16	201.29	7.81	70.75	200.12	15.47	10.51	340	34.42	5.95	48.74	44.29	0.16	0.14
44.05	12.0	7.8	3.48	7.16	241.55	7.81	84.90	234.36	18.47	12.31	408	41.30	5.95	57.06	51.84	0.18	0.17
51.89	14.0	7.8	3.48	7.16	281.81	7.81	99.05	269.52	20.90	13.93	477	48.18	5.95	65.12	59.27	0.21	0.19
60	16.0	7.8	3.48	7.16	322.07	7.81	113.20	302.67	22.90	15.33	545	55.05	5.95	72.87	66.55	0.23	0.21
68.46	18.0	7.8	3.48	7.16	362.32	7.81	127.36	335.83	24.70	16.47	613	61.95	5.95	80.26	73.65	0.26	0.23
77.36	20.0	7.8	3.48	7.16	402.58	7.81	141.51	369.00	25.92	17.28	683	68.83	5.95	87.22	80.55	0.28	0.26
86.87	22.0	7.8	3.48	7.16	442.84	7.81	155.66	402.16	26.56	17.68	749	75.72	5.95	93.70	87.22	0.30	0.28
97.18	24.0	7.8	3.48	7.16	483.10	7.81	169.81	435.33	26.56	17.57	817	82.60	5.95	99.63	93.64	0.32	0.30
108.68	26.0	7.8	3.48	7.16	523.36	7.81	183.96	468.50	25.16	16.77	885	88.49	5.95	104.92	99.76	0.33	0.32
122.09	28.0	7.8	3.48	7.16	563.61	7.81	198.11	501.67	22.50	15.00	953	96.37	5.95	109.49	105.57	0.35	0.34
139.27	30.0	7.8	3.48	7.16	603.87	7.81	212.26	534.84	17.33	11.50	1021	102.25	5.95	113.26	111.02	0.35	0.34
180	32.0	7.8	3.48	7.16	644.13	7.81	226.41	568.01	1.74E-15	1.16E-15	1089	110.14	5.95	116.09	116.09	0.37	0.37

Hoist winch										
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Hoist winch	Hoist winch	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
21.61	6.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
28.96	8.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
36.42	10.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
44.05	12.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
51.89	14.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
60	16.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
68.46	18.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
77.36	20.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
86.87	22.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
97.18	24.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
108.68	26.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
122.09	28.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
139.27	30.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00
180	32.0	7.2	27.20	27.20	0.43	0.43	1.00	1.00	1.00	1.00

Boom																	
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	φ	Section 1	Section 1	Section 1	Section 1	Section 1	Section 1	Total design load	Web	Flange	UF	UF		
[o]	[m]	[T]	[-]	[-]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	
14.36	4.0	7.2	3.75	7.16	80.52	7.25	26.27	80.81	6.37	4.24	133	13.49	5.91	22.32	20.75	0.07	0.07
21.61	6.0	7.2	3.75	7.16	120.77	7.25	39.40	120.77	9.46	6.30	200	20.24	5.91	30.85	28.33	0.10	0.09
28.96	8.0	7.2	3.75	7.16	161.03	7.25	52.54	157.73	12.43	8.34	267	26.98	5.91	39.31	35.89	0.13	0.11
36.42	10.0	7.2	3.75	7.16	201.29	7.25	65.67	193.43	15.25	10.16	334	33.73	5.91	47.62	43.37	0.15	0.14
44.05	12.0	7.2	3.75	7.16	241.55	7.25	78.81	231.55	17.84	11.96	400	40.47	5.91	55.74	50.76	0.18	0.16
51.89	14.0	7.2	3.75	7.16	281.81	7.25	91.94	265.65	20.20	13.47	467	47.22	5.91	63.61	58.02	0.20	0.18
60	16.0	7.2	3.75	7.16	322.07	7.25	105.08	282.16	22.23	14.82	534	53.97	5.91	71.19	65.15	0.23	0.21
68.46	18.0	7.2	3.75	7.16	362.32	7.25	118.21	303.55	23.88	16.20	600	60.71	5.91	78.41	72.10	0.25	0.23
77.36	20.0	7.2	3.75	7.16	402.58	7.25	131.35	317.92	25.05	16.70	667	67.46	5.91	85.23	78.86	0.27	0.25
86.87	22.0	7.2	3.75	7.16	442.84	7.25	144.48	323.52	25.63	17.09	734	74.20	5.91	91.99	85.40	0.29	0.27
97.18	24.0	7.2	3.75	7.16	483.10	7.25	157.61	328.53	24.92	16.98	801	80.95	5.91	97.42	91.70	0.31	0.29
108.68	26.0	7.2	3.75	7.16	523.36	7.25	170.75	308.64	24.32	16.21	867	87.01	5.91	102.64	97.72	0.33	0.31
122.09	28.0	7.2	3.75	7.16	563.61	7.25	183.88	276.03	21.75	14.50	934	94.44	5.91	107.19	103.84	0.34	0.33
139.27	30.0	7.2	3.75	7.16	603.87	7.25	197.02	212.58	16.75	11.17	1001	101.19	5.91	110.95	108.83	0.35	0.35
180	32.0	7.2	3.75	7.16	644.13	7.25	210.15	0.00	1.74E-15	1.16E-15	1067	107.93	5.91	113.84	113.84	0.36	0.36

Hoist winch										
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Hoist winch	Hoist winch	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
21.61	6.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
28.96	8.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
36.42	10.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
44.05	12.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
51.89	14.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
60	16.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
68.46	18.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
77.36	20.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
86.87	22.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
97.18	24.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
108.68	26.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
122.09	28.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
139.27	30.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00
180	32.0	6.8	27.18	27.18	0.40	0.40	1.00	1.00	1.00	1.00

Boom																	
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	φ	Section 1	Section 1	Section 1	Section 1	Section 1	Section 1	Total design load	Web	Flange	UF	UF		
[o]	[m]	[T]	[-]	[-]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	[T]	
14.36	4.0	6.8	4.01	7.16	80.52	6.77	24.54	78.44	6.18	4.12	131	13.26	5.87	21.92	20.41	0.07	0.07
21.61	6.0	6.8	4.01	7.16	120.77	6.77	36.81	116.49	9.18	6.12	197	19.89	5.87	30.27	27.85	0.10	0.09
28.96	8.0	6.8	4.01	7.16	161.03	6.77	49.09	153.10	12.06	8.04	262	26.52	5.87	38.54	35.25	0.12	0.11
36.42	10.0	6.8	4.01	7.16													

C.4.4 Calculations for each component for $H_s = 4.5 - 5.5m$ with one fall

Crate total											
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Significant wave height	Load factor selfweight	Load factor hook	Load factor utilization				
[°]	[m]	[T]	[-]	[H]	[-]	[-]	[-]				
14.36	4.0	5.7	4.74	5.5	1.22	1.34	1.00				
21.61	6.0	5.7	4.74	5.5	1.22	1.34	1.00				
28.96	8.0	5.7	4.74	5.5	1.22	1.34	1.00				
36.42	10.0	5.7	4.74	5.5	1.22	1.34	1.00				
44.05	12.0	5.7	4.74	5.5	1.22	1.34	1.00				
51.89	14.0	5.7	4.74	5.5	1.22	1.34	1.00				
59.85	16.0	5.7	4.74	5.5	1.22	1.34	1.00				
68.46	18.0	5.7	4.74	5.5	1.22	1.34	1.00				
77.36	20.0	5.7	4.74	5.5	1.22	1.34	1.00				
86.87	22.0	5.7	4.74	5.5	1.22	1.34	1.00				
97.18	24.0	5.7	4.74	5.5	1.22	1.34	1.00				
108.68	26.0	5.7	4.74	5.5	1.22	1.34	1.00				
122.09	28.0	5.7	4.74	5.5	1.22	1.34	1.00				
137.27	30.0	5.7	4.74	5.5	1.22	1.34	1.00				
150	32.0	5.7	4.74	5.5	1.22	1.34	1.00				

Wire rope 0.160 tonne											
Angle	Radius	Hook load	Running rigging factor	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope			
[°]	[m]	[T]	Static DF	Dynamic DF	[T]	[T]	Static UF	Dynamic UF			
14.36	4.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
21.61	6.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
28.96	8.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
36.42	10.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
44.05	12.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
51.89	14.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
59.85	16.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
68.46	18.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
77.36	20.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
86.87	22.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
97.18	24.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
108.68	26.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
122.09	28.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
137.27	30.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			
150	32.0	5.74	5.00	5.35	1.97	27.20	0.43	0.90			

Pedestal											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF		
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]			
14.36	4.0	4.74	5.74	169.66	96.47	8.09	3.38	11.47	0.04		
21.61	6.0	4.74	5.74	254.49	96.47	12.13	3.38	15.51	0.05		
28.96	8.0	4.74	5.74	339.32	96.47	16.18	3.38	19.56	0.06		
36.42	10.0	4.74	5.74	424.15	96.47	20.23	3.38	23.60	0.08		
44.05	12.0	4.74	5.74	508.98	96.47	24.28	3.38	27.65	0.09		
51.89	14.0	4.74	5.74	593.81	96.47	28.33	3.38	31.69	0.11		
59.85	16.0	4.74	5.74	678.64	96.47	32.38	3.38	35.74	0.12		
68.46	18.0	4.74	5.74	763.47	96.47	36.43	3.38	39.78	0.13		
77.36	20.0	4.74	5.74	848.30	96.47	40.48	3.38	43.83	0.14		
86.87	22.0	4.74	5.74	933.13	96.47	44.53	3.38	47.87	0.16		
97.18	24.0	4.74	5.74	1017.96	96.47	48.58	3.38	51.91	0.17		
108.68	26.0	4.74	5.74	1102.79	96.47	52.63	3.38	55.95	0.19		
122.09	28.0	4.74	5.74	1187.62	96.47	56.68	3.38	60.00	0.20		
137.27	30.0	4.74	5.74	1272.45	96.47	60.73	3.38	64.04	0.21		
150	32.0	4.74	5.74	1357.28	96.47	64.78	3.38	68.09	0.23		

Crate total											
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Significant wave height	Load factor selfweight	Load factor hook	Load factor utilization				
[°]	[m]	[T]	[-]	[H]	[-]	[-]	[-]				
14.36	4.0	6.0	4.50	5	1.22	1.34	1.00				
21.61	6.0	6.0	4.50	5	1.22	1.34	1.00				
28.96	8.0	6.0	4.50	5	1.22	1.34	1.00				
36.42	10.0	6.0	4.50	5	1.22	1.34	1.00				
44.05	12.0	6.0	4.50	5	1.22	1.34	1.00				
51.89	14.0	6.0	4.50	5	1.22	1.34	1.00				
59.85	16.0	6.0	4.50	5	1.22	1.34	1.00				
68.46	18.0	6.0	4.50	5	1.22	1.34	1.00				
77.36	20.0	6.0	4.50	5	1.22	1.34	1.00				
86.87	22.0	6.0	4.50	5	1.22	1.34	1.00				
97.18	24.0	6.0	4.50	5	1.22	1.34	1.00				
108.68	26.0	6.0	4.50	5	1.22	1.34	1.00				
122.09	28.0	6.0	4.50	5	1.22	1.34	1.00				
137.27	30.0	6.0	4.50	5	1.22	1.34	1.00				
150	32.0	6.0	4.50	5	1.22	1.34	1.00				

Wire rope 0.160 tonne											
Angle	Radius	Hook load	Running rigging factor	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope			
[°]	[m]	[T]	Static DF	Dynamic DF	[T]	[T]	Static UF	Dynamic UF			
14.36	4.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
21.61	6.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
28.96	8.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
36.42	10.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
44.05	12.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
51.89	14.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
59.85	16.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
68.46	18.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
77.36	20.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
86.87	22.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
97.18	24.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
108.68	26.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
122.09	28.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
137.27	30.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			
150	32.0	6.04	5.00	5.35	1.97	27.20	0.43	0.90			

Pedestal											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF		
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]			
14.36	4.0	4.50	6.04	171.26	96.77	8.16	3.39	11.56	0.04		
21.61	6.0	4.50	6.04	256.89	96.77	12.25	3.39	15.64	0.05		
28.96	8.0	4.50	6.04	342.52	96.77	16.33	3.39	19.72	0.07		
36.42	10.0	4.50	6.04	428.15	96.77	20.41	3.39	23.80	0.08		
44.05	12.0	4.50	6.04	513.77	96.77	24.49	3.39	27.88	0.09		
51.89	14.0	4.50	6.04	599.40	96.77	28.57	3.39	31.97	0.11		
59.85	16.0	4.50	6.04	685.03	96.77	32.66	3.39	36.05	0.12		
68.46	18.0	4.50	6.04	770.66	96.77	36.74	3.39	40.13	0.13		
77.36	20.0	4.50	6.04	856.29	96.77	40.82	3.39	44.21	0.15		
86.87	22.0	4.50	6.04	941.92	96.77	44.90	3.39	48.29	0.16		
97.18	24.0	4.50	6.04	1027.55	96.77	48.98	3.39	52.37	0.18		
108.68	26.0	4.50	6.04	1113.18	96.77	53.07	3.39	56.45	0.19		
122.09	28.0	4.50	6.04	1198.81	96.77	57.15	3.39	60.54	0.20		
137.27	30.0	4.50	6.04	1284.44	96.77	61.23	3.39	64.62	0.21		
150	32.0	4.50	6.04	1370.07	96.77	65.31	3.39	68.71	0.23		

Table for Pedestal adapter, Sewing bearing 1, and Sewing bearing 2. Columns include Angle, Radius, Dynamic amplifying factor (DAF), Hook load, Bending moment, Axial force, Bending stress, Axial stress, Combined stress, and UF.

Table for Pedestal adapter, Sewing bearing 1, and Sewing bearing 2. Columns include Angle, Radius, Dynamic amplifying factor (DAF), Hook load, Bending moment, Axial force, Bending stress, Axial stress, Combined stress, and UF.

Table for Pedestal adapter, Sewing bearing 1, and Sewing bearing 2. Columns include Angle, Radius, Dynamic amplifying factor (DAF), Hook load, Bending moment, Axial force, Bending stress, Axial stress, Combined stress, and UF.

Table for Sewing bearing 1, Sewing bearing 2, and Sewing bearing 3. Columns include Angle, Radius, Dynamic amplifying factor (DAF), Vertical load, Bending Moment, Vertical sector load, Horiz. sector load, Lever arm, Bolt stress, and UF.

Table for Sewing bearing 1, Sewing bearing 2, and Sewing bearing 3. Columns include Angle, Radius, Dynamic amplifying factor (DAF), Vertical load, Bending Moment, Vertical sector load, Horiz. sector load, Lever arm, Bolt stress, and UF.

Table for Sewing bearing 1, Sewing bearing 2, and Sewing bearing 3. Columns include Angle, Radius, Dynamic amplifying factor (DAF), Vertical load, Bending Moment, Vertical sector load, Horiz. sector load, Lever arm, Bolt stress, and UF.

Table for Sewing bearing 2, Sewing bearing 3, and Sewing bearing 4. Columns include Angle, Radius, Radius slew bearing 2, Dynamic amplifying factor (DAF), Vertical load, Bending Moment, Vertical sector load, Horiz. sector load, Lever arm, Bolt stress, and UF.

Table for Sewing bearing 2, Sewing bearing 3, and Sewing bearing 4. Columns include Angle, Radius, Radius slew bearing 2, Dynamic amplifying factor (DAF), Vertical load, Bending Moment, Vertical sector load, Horiz. sector load, Lever arm, Bolt stress, and UF.

Table for Sewing bearing 2, Sewing bearing 3, and Sewing bearing 4. Columns include Angle, Radius, Radius slew bearing 2, Dynamic amplifying factor (DAF), Vertical load, Bending Moment, Vertical sector load, Horiz. sector load, Lever arm, Bolt stress, and UF.

Hoist winch					Dynamic					Hoist				
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Dynamic hook load	Dynamic hook load	Dynamic hoist	Dynamic winch	Static UF	Dynamic UF	Dynamic hook load	Dynamic hook load	Dynamic hoist	Dynamic winch
14.36	4.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.38	1.00	5.7	27.19	27.19	0.38
21.61	6.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
28.96	8.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
36.42	10.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
44.05	12.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
51.89	14.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
60	16.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
68.46	18.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
77.36	20.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
86.87	22.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
97.18	24.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
108.68	26.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
122.09	28.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
139.27	30.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38
180	32.0	5.7	27.19	27.19	6.4	27.20	27.20	27.20	0.38	1.00	6.4	27.20	27.20	0.38

Hoist winch					Dynamic					Hoist				
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Dynamic hook load	Dynamic hook load	Dynamic hoist	Dynamic winch	Static UF	Dynamic UF	Dynamic hook load	Dynamic hook load	Dynamic hoist	Dynamic winch
14.36	4.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
21.61	6.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
28.96	8.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
36.42	10.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
44.05	12.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
51.89	14.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
60	16.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
68.46	18.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
77.36	20.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
86.87	22.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
97.18	24.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
108.68	26.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
122.09	28.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
139.27	30.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36
180	32.0	6.0	27.20	27.20	6.0	27.20	27.20	27.20	0.36	1.00	6.0	27.20	27.20	0.36

Hoist winch					Dynamic					Hoist				
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Dynamic hook load	Dynamic hook load	Dynamic hoist	Dynamic winch	Static UF	Dynamic UF	Dynamic hook load	Dynamic hook load	Dynamic hoist	Dynamic winch
14.36	4.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
21.61	6.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
28.96	8.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
36.42	10.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
44.05	12.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
51.89	14.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
60	16.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
68.46	18.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
77.36	20.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
86.87	22.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
97.18	24.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
108.68	26.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
122.09	28.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
139.27	30.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34
180	32.0	5.7	27.19	27.19	5.7	27.19	27.19	27.19	0.34	1.00	5.7	27.19	27.19	0.34

Boom																			
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Dynamic ϕ	Section 1			Section 1			Section 1			Total design load horizontal at x=x1	web			UF	UF
					Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	Bending horizontal at x=x1	Shear stress		Von mises	Von mises			
14.36	4.0	6.4	4.26	[-]	71.16	80.52	6.38	23.12	76.49	6.03	4.02	12.9	13.07	5.84	21.59	20.14	0.07	0.06	
21.61	6.0	6.4	4.26	[-]	71.16	80.52	6.38	34.68	113.58	8.95	5.97	19.4	16.60	5.84	29.79	27.45	0.09	0.09	
28.96	8.0	6.4	4.26	[-]	71.16	161.03	6.38	46.25	149.28	11.76	7.84	25.8	26.13	5.84	37.91	34.73	0.12	0.11	
36.42	10.0	6.4	4.26	[-]	71.16	201.29	6.38	57.81	183.07	14.42	9.62	32.6	32.66	5.84	45.90	41.95	0.15	0.13	
44.05	12.0	6.4	4.26	[-]	71.16	241.55	6.38	69.37	214.39	16.89	11.26	38.8	39.20	5.84	53.70	49.08	0.17	0.16	
51.89	14.0	6.4	4.26	[-]	71.16	281.81	6.38	80.93	242.82	19.12	12.74	45.2	45.73	5.84	61.28	56.09	0.20	0.18	
60	16.0	6.4	4.26	[-]	71.16	322.07	6.38	92.49	267.05	21.04	14.03	51.7	52.26	5.84	68.58	62.97	0.22	0.20	
68.46	18.0	6.4	4.26	[-]	71.16	362.32	6.38	104.05	286.82	22.60	15.07	58.1	58.79	5.84	75.56	69.70	0.24	0.22	
77.36	20.0	6.4	4.26	[-]	71.16	402.58	6.38	115.61	300.99	23.71	15.81	64.6	65.33	5.84	82.16	76.25	0.26	0.24	
86.87	22.0	6.4	4.26	[-]	71.16	442.84	6.38	127.17	307.90	24.26	16.17	71.1	71.86	5.84	88.33	82.59	0.28	0.26	
97.18	24.0	6.4	4.26	[-]	71.16	483.10	6.38	138.74	305.94	24.61	16.07	77.5	78.39	5.84	94.01	88.71	0.30	0.28	
108.68	26.0	6.4	4.26	[-]	71.16	523.36	6.38	150.30	292.11	23.02	15.34	84.0	84.92	5.84	99.13	94.57	0.32	0.30	
122.09	28.0	6.4	4.26	[-]	71.16	563.61	6.38	161.86	261.25	20.58	13.72	90.4	91.46	5.84	103.62	100.15	0.33	0.32	
139.27	30.0	6.4	4.26	[-]	71.16	603.87	6.38	173.42	201.20	15.85	10.57	96.9	97.99	5.84	107.40	105.43	0.34	0.34	
180	32.0	6.4	4.26	[-]	71.16	644.13	6.38	184.98	0.00	1.74E-15	1.16E-15	103.4	104.52	5.84	110.36	110.36	0.35	0.35	

Boom																			
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Dynamic ϕ	Section 1			Section 1			Section 1			Total design load horizontal at x=x1	web			UF	UF
					Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	Bending horizontal at x=x1	Shear stress		Von mises	Von mises			
14.36	4.0	6.0	4.50	[-]	71.16	80.52	6.04	21.89	74.79	5.89	3.93	12.8	12.90	5.81	21.31	19.91	0.07	0.06	
21.61	6.0	6.0	4.50	[-]	71.16	120.77	6.04	32.83	110.07	8.75	5.83	19.1	19.35	5.81	29.37	27.11	0.09	0.09	
28.96	8.0	6.0	4.50	[-]	71.16	161.03	6.04	43.78	145.98	11.50	7.67	25.5	25.80	5.81	37.36	34.28	0.12	0.11	
36.42	10.0	6.0	4.50	[-]	71.16	201.29	6.04	54.72	179.02	14.11	9.40	31.9	32.25	5.81	45.22	41.99	0.14	0.13	
44.05	12.0	6.0	4.50	[-]	71.16	241.55	6.04	65.67	209.64	16.52	11.01	38.3	38.69	5.81	52.91	48.42	0.17	0.15	
51.89	14.0	6.0	4.50	[-]	71.16	281.81	6.04	76.61	237.35	18.69	12.46	44.6	45.14	5.81	60.37	55.34	0.19	0.18	
60	16.0	6.0	4.50	[-]	71.16	322.07	6.04	87.56	261.13	20.58	13.72	51.0	51.59	5.81	67.56	62.12	0.22	0.20	
68.46	18.0	6.0	4.50	[-]	71.16	362.32	6.04	98.50	280.66	22.10	14.73	57.4	58.04	5.81	74.44	68.76	0.24	0.22	
77.36	20.0	6.0	4.50	[-]	71.16	402.58	6.04	109.45	298.02	22.10	15.66	63.8	64.49	5.81	80.96	75.22	0.26	0.24	
86.87	22.0	6.0	4.50	[-]	71.16	442.84													

C.4.5 Calculations for each component for $H_s = 6m$ with one fall

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF) Φ	Load factor	Load factor selfweight	Load factor hook load	Maximum utilization	
[°]	[m]	[T]	[H]	[-]	[-]	[-]	[-]		
14.36	4.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
21.61	6.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
28.96	8.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
36.42	10.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
44.05	12.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
51.89	14.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
60	16.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
68.46	18.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
77.36	20.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
86.97	22.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
97.36	24.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
108.68	26.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
122.09	28.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
139.27	30.0	5.5	6	4.96	1.22	1.34	1.34	1.00	
180	32.0	5.5	6	4.96	1.22	1.34	1.34	1.00	

Wire rope 0-160 (zome)										
Angle	Radius	Hook load	Static DF	Dynamic DF	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope
[°]	[m]	[T]						[T]	Static UF	Dynamic UF
14.36	4.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
21.61	6.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
28.96	8.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
36.42	10.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
44.05	12.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
51.89	14.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
60	16.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
68.46	18.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
77.36	20.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
86.97	22.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
97.36	24.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
108.68	26.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
122.09	28.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
139.27	30.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90
180	32.0	5.48	5.00	1.97	27.18	5.35	1.97	27.18	0.39	0.90

Redeferal									
Angle	Radius	Dynamic amplifying factor (DAF) Φ	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	
14.36	4.0	4.96	5.48	188.27	96.22	8.02	3.37	11.39	0.04
21.61	6.0	4.96	5.48	252.41	96.22	12.03	3.37	15.40	0.05
28.96	8.0	4.96	5.48	336.54	96.22	16.04	3.37	19.42	0.06
36.42	10.0	4.96	5.48	420.68	96.22	20.05	3.37	23.43	0.08
44.05	12.0	4.96	5.48	504.81	96.22	24.07	3.37	27.44	0.09
51.89	14.0	4.96	5.48	588.95	96.22	28.08	3.37	31.45	0.10
60	16.0	4.96	5.48	673.08	96.22	32.09	3.37	35.46	0.12
68.46	18.0	4.96	5.48	757.22	96.22	36.10	3.37	39.47	0.13
77.36	20.0	4.96	5.48	841.35	96.22	40.11	3.37	43.48	0.14
86.97	22.0	4.96	5.48	925.49	96.22	44.12	3.37	47.49	0.16
97.36	24.0	4.96	5.48	1009.62	96.22	48.14	3.37	51.50	0.18
108.68	26.0	4.96	5.48	1093.76	96.22	52.14	3.37	55.51	0.20
122.09	28.0	4.96	5.48	1177.89	96.22	56.15	3.37	59.52	0.21
139.27	30.0	4.96	5.48	1262.03	96.22	60.16	3.37	63.54	0.21
180	32.0	4.96	5.48	1346.16	96.22	64.17	3.37	67.55	0.22

Pedestal adapter										Stewing bearing 1										Stewing bearing 2										
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- ontal sector load	Lever arm effect	Bolt stress	UF Bolts	Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horiz- ontal sector load	Lever arm effect	Bolt stress	UF Bolts
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]		[°]	[m]	[-]	[T]	[TM]	[KN]	[KN]	[-]	[MPa]		[°]	[m]	[m]	[-]	[T]	[TM]	[KN]	[KN]	[-]	[MPa]	
14,36	4,0	4,96	5,48	188,27	94,16	8,02	0,19	8,21	0,03	14,36	4,0	4,96	114,23	188,27	12,36	0	2,24	25,11	0,03	14,36	4,0	2,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
21,61	6,0	4,96	5,48	252,41	94,16	12,03	0,19	12,22	0,04	21,61	6,0	4,96	114,23	252,41	25,36	0	2,24	50,69	0,06	21,61	3,0	3,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
28,96	8,0	4,96	5,48	336,54	94,16	16,04	0,19	16,24	0,05	28,96	8,0	4,96	114,23	336,54	38,16	0	2,24	76,27	0,08	28,96	4,0	4,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
36,42	10,0	4,96	5,48	420,68	94,16	20,05	0,19	20,25	0,07	36,42	10,0	4,96	114,23	420,68	50,95	0	2,24	101,85	0,11	36,42	5,0	5,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
44,05	12,0	4,96	5,48	504,81	94,16	24,07	0,19	24,26	0,08	44,05	12,0	4,96	114,23	504,81	63,75	0	2,24	127,43	0,14	44,05	6,0	6,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
51,89	14,0	4,96	5,48	588,95	94,16	28,08	0,19	28,27	0,09	51,89	14,0	4,96	114,23	588,95	76,55	0	2,24	153,01	0,17	51,89	7,0	7,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
60	16,0	4,96	5,48	673,08	94,16	32,09	0,19	32,28	0,11	60	16,0	4,96	114,23	673,08	89,34	0	2,24	178,59	0,20	60	8,0	8,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
68,46	18,0	4,96	5,48	757,22	94,16	36,10	0,19	36,29	0,12	68,46	18,0	4,96	114,23	757,22	102,14	0	2,24	204,17	0,23	68,46	9,0	9,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
77,36	20,0	4,96	5,48	841,35	94,16	40,11	0,19	40,30	0,13	77,36	20,0	4,96	114,23	841,35	114,93	0	2,24	229,75	0,26	77,36	10,0	10,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
86,87	22,0	4,96	5,48	925,49	94,16	44,12	0,19	44,31	0,15	86,87	22,0	4,96	114,23	925,49	127,73	0	2,24	255,33	0,28	86,87	11,0	11,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
97,18	24,0	4,96	5,48	1009,62	94,16	48,13	0,19	48,32	0,16	97,18	24,0	4,96	114,23	1009,62	140,53	0	2,24	280,90	0,31	97,18	12,0	12,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
108,68	26,0	4,96	5,48	1093,76	94,16	52,14	0,19	52,33	0,17	108,68	26,0	4,96	114,23	1093,76	153,32	0	2,24	306,48	0,34	108,68	13,0	13,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
122,09	28,0	4,96	5,48	1177,89	94,16	56,15	0,19	56,34	0,19	122,09	28,0	4,96	114,23	1177,89	166,12	0	2,24	332,06	0,37	122,09	14,0	14,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
139,27	30,0	4,96	5,48	1262,03	94,16	60,16	0,19	60,36	0,20	139,27	30,0	4,96	114,23	1262,03	178,92	0	2,24	357,64	0,40	139,27	15,0	15,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28
180	32,0	4,96	5,48	1346,16	94,16	64,17	0,19	64,37	0,21	180	32,0	4,96	114,23	1346,16	191,71	0	2,24	383,22	0,43	180	16,0	16,0	4,96	34,95	297,67	98,17	0	2,85	250,22	0,28

Hoist winch									
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist winch	Hoist winch Static UF	Hoist winch Dynamic UF			
[°]	[m]	[T]	[T]	[T]					
14,36	4,0	5,5	27,18	27,18	0,32	1,00			
21,61	6,0	5,5	27,18	27,18	0,32	1,00			
28,96	8,0	5,5	27,18	27,18	0,32	1,00			
36,42	10,0	5,5	27,18	27,18	0,32	1,00			
44,05	12,0	5,5	27,18	27,18	0,32	1,00			
51,89	14,0	5,5	27,18	27,18	0,32	1,00			
60	16,0	5,5	27,18	27,18	0,32	1,00			
68,46	18,0	5,5	27,18	27,18	0,32	1,00			
77,36	20,0	5,5	27,18	27,18	0,32	1,00			
86,87	22,0	5,5	27,18	27,18	0,32	1,00			
97,18	24,0	5,5	27,18	27,18	0,32	1,00			
108,68	26,0	5,5	27,18	27,18	0,32	1,00			
122,09	28,0	5,5	27,18	27,18	0,32	1,00			
139,27	30,0	5,5	27,18	27,18	0,32	1,00			
180	32,0	5,5	27,18	27,18	0,32	1,00			

Boom																										
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Section 1				Section 1				Torsion		Torsion web	Torsion flange	Torsion design load horizontal at x=1	Web				Flange		UF Web	UF Flange		
				Shear boom	Moment horizontal	Hook load only Shear boom	Hook load only Moment horizontal	Torsion	Torsion web	Torsion flange	Bending stress	Shear stress	Von mises				Von mises	Von mises	Von mises							
[°]	[m]	[T]	[-]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]
14,36	4,0	5,5	4,96	71,16	80,52	5,48	19,87	7,201	5,67	3,78	125	12,62	5,76	20,85	19,52	0,07	0,06									
21,61	6,0	5,5	4,96	71,16	120,77	5,48	29,80	10,694	8,43	5,62	187	18,94	5,76	28,69	19,52	0,09	0,08									
28,96	8,0	5,5	4,96	71,16	161,03	5,48	39,74	14,055	11,07	7,38	250	25,25	5,76	36,46	33,55	0,12	0,11									
36,42	10,0	5,5	4,96	71,16	201,29	5,48	49,67	17,236	13,58	9,05	312	31,56	5,76	44,12	40,48	0,14	0,13									
44,05	12,0	5,5	4,96	71,16	241,55	5,48	59,61	20,185	15,90	10,60	375	37,87	5,76	51,60	47,34	0,16	0,15									
51,89	14,0	5,5	4,96	71,16	281,81	5,48	69,54	22,843	18,00	12,00	437	44,19	5,76	58,88	54,10	0,19	0,17									
60	16,0	5,5	4,96	71,16	322,07	5,48	79,48	25,143	19,81	13,21	499	50,50	5,76	65,90	60,73	0,21	0,19									
68,46	18,0	5,5	4,96	71,16	362,32	5,48	89,41	27,004	21,28	14,18	562	56,81	5,76	72,62	67,22	0,23	0,21									
77,36	20,0	5,5	4,96	71,16	402,58	5,48	99,35	28,329	22,32	14,88	624	63,12	5,76	78,99	73,55	0,25	0,23									
86,87	22,0	5,5	4,96	71,16	442,84	5,48	109,28	28,989	22,84	15,23	687	69,43	5,76	84,97	79,69	0,27	0,25									
97,18	24,0	5,5	4,96	71,16	483,10	5,48	119,22	28,805	22,70	15,13	749	75,75	5,76	90,49	85,62	0,29	0,27									
108,68	26,0	5,5	4,96	71,16	523,36	5,48	129,15	27,503	21,67	14,45	812	82,06	5,76	95,51	91,32	0,30	0,29									
122,09	28,0	5,5	4,96	71,16	563,61	5,48	139,08	24,597	19,38	12,92	874	88,37	5,76	99,94	96,76	0,31	0,31									
139,27	30,0	5,5	4,96	71,16	603,87	5,48	149,02	18,943	14,93	9,95	936	94,68	5,76	103,72	101,91	0,32	0,32									
180	32,0	5,5	4,96	71,16	644,13	5,48	158,95	0,00	1,74E-15	1,16E-15	999	101,00	5,76	106,76	106,76	0,34	0,34									

Section 2										Section 3														
Self weight only	Self weight only	Hook load only	Hook load only	Torsion	Torsion	Torsion	Torsion	Torsion	Torsion	TOTALDESIGN	Self weight only	Self weight only	Hook load only	Hook load only	TOTALDESIGN	Self weight only	Self weight only	Hook load only	Hook load only	TOTALDESIGN	UF			
Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion web	Torsion flange	Bending horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises	Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1	Shear boom	Moment horizontal	Shear boom	Moment horizontal	Bending horizontal at x=x1	Shear stress	Shear stress	Von mises	UF
[T]	[TM]	[T]	[TM]	[MPa]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]	[T]	[TM]	[T]	[TM]	[TM]	[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]	
30,33	2,701	5,48	11,65	7,201	9,15	49	5,71	3,17	18,16	13,80	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	3,624	5,48	17,47	10,95	13,58	68	7,95	3,17	26,02	19,22	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	4,546	5,48	23,29	14,055	17,85	87	10,19	3,17	33,69	24,56	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	5,469	5,48	29,12	17,366	21,90	106	12,43	3,17	41,01	29,71	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	6,392	5,48	34,94	20,855	25,64	125	14,67	3,17	47,86	34,57	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	7,315	5,48	40,77	22,843	29,02	144	16,91	3,17	54,12	39,06	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	8,238	5,48	46,59	25,143	31,94	163	19,15	3,17	59,65	43,11	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	9,161	5,48	52,41	27,004	34,30	182	21,39	3,17	64,29	46,61	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	10,084	5,48	58,24	28,829	35,99	201	23,63	3,17	67,85	49,45	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	11,007	5,48	64,06	28,899	36,83	220	25,87	3,17	70,08	51,49	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	11,930	5,48	69,88	28,805	36,59	239	28,11	3,17	70,68	52,57	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	12,853	5,48	75,71	27,503	34,94	258	30,35	3,17	69,18	52,45	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	13,776	5,48	81,53	24,597	31,25	277	32,59	3,17	64,87	50,80	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	14,698	5,48	87,36	18,943	24,06	296	34,83	3,17	56,40	47,07	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13
30,33	15,621	5,48	93,18	0,00	2,80E-15	315	37,07	3,17	40,24	40,24	15,99	119,77	5,48	8,222	256	38,16	1,93	40,09	8,222	256	38,16	1,93	40,09	0,13

Section 4						Totalrestiggt			Section 4		
Self weight only	Self weight only	Hook load only	Hook load only	Bending load horizontal at x=x1	Bending stress	Shear stress	Von mises	UF			
	Moment horizontal	Shear boom	Moment horizontal	[Nm]	[Mpa]	[Mpa]	[Mpa]	Section 4			
Section 1	Section 1	Section 1	Section 1								
[T]	[Nm]	[T]	[Nm]	[Nm]	[Mpa]	[Mpa]	[Mpa]	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			
1.29	0.42	5.48	2.74	4	0.86	0.80	1.66	0.01			

Velocity check				VH/VS
Minimum steady hosting velocity	Maximum steady hosting velocity	VH	VS	VH/VS
(m/s)	(m/s)	(m/s)	(m/s)	
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56
0.28	2.30	0.28	2.30	0.56

C.5 Utilization calculations when lifting with double fall

C.5.1 Calculations for each component for $H_s = 0 - 1m$ with two falls

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor hook	Load factor hook	Maximum utilization	
[°]	[m]	[T]	[m]	[-]	[-]	[-]	[-]		
14.36	4.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
21.61	6.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
28.96	8.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
36.42	10.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
44.05	12.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
51.89	14.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
60	16.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
68.46	18.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
77.36	20.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
86.87	22.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
97.18	24.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
108.68	26.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
122.09	28.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
139.27	30.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
180	32.0	33.0	0.5	1.65	1.22	1.24	1.34	1.00	
Crane total									

Wire rope 0-160 tonne									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Host rope	Host rope	
[°]	[m]	[T]	State DF	Dynamic DF	[-]	[T]	Static UF	Dynamic UF	
14.36	4.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
21.61	6.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
28.96	8.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
36.42	10.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
44.05	12.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
51.89	14.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
60	16.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
68.46	18.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
77.36	20.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
86.87	22.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
97.18	24.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
108.68	26.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
122.09	28.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
139.27	30.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
180	32.0	34.00	4.52	3.45	1.75	39.10	0.97	0.57	
Wire rope 0-160 tonne									

Wire rope 0-180 tonne									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Host rope	Host rope	
[°]	[m]	[T]	State DF	Dynamic DF	[-]	[T]	Static UF	Dynamic UF	
14.36	4.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
21.61	6.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
28.96	8.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
36.42	10.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
44.05	12.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
51.89	14.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
60	16.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
68.46	18.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
77.36	20.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
86.87	22.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
97.18	24.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
108.68	26.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
122.09	28.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
139.27	30.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
180	32.0	33.02	4.54	3.50	1.75	54.40	0.94	0.79	
Wire rope 0-180 tonne									

Pedestal									
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
[°]	[m]	[-]	[T]	[kNm]	[kN]	[MPa]	[MPa]	[MPa]	
14.36	4.0	1.92	28.41	291.18	119.15	13.88	4.18	18.06	0.05
21.61	6.0	1.92	28.41	436.77	119.15	20.82	4.18	25.00	0.08
28.96	8.0	1.92	28.41	582.35	119.15	27.76	4.18	31.94	0.11
36.42	10.0	1.92	28.41	727.94	119.15	34.70	4.18	38.89	0.13
44.05	12.0	1.92	28.41	873.52	119.15	41.64	4.18	45.82	0.15
51.89	14.0	1.92	28.41	1019.12	119.15	48.58	4.18	52.76	0.18
60	16.0	1.92	28.41	1164.71	119.15	55.52	4.18	59.70	0.20
68.46	18.0	1.92	28.41	1310.31	119.15	62.46	4.18	66.64	0.23
77.36	20.0	1.92	28.41	1455.91	119.15	69.40	4.18	73.58	0.26
86.87	22.0	1.92	28.41	1601.51	119.15	76.34	4.18	80.52	0.29
97.18	24.0	1.92	28.41	1747.11	119.15	83.28	4.18	87.46	0.32
108.68	26.0	1.92	28.41	1892.71	119.15	90.22	4.18	94.40	0.35
122.09	28.0	1.92	28.41	2038.31	119.15	97.17	4.18	101.34	0.38
139.27	30.0	1.92	28.41	2183.91	119.15	104.11	4.18	108.28	0.41
180	32.0	1.92	28.41	2329.51	119.15	111.05	4.18	115.22	0.44
Pedestal									

Pedestal adapter										
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	
14.36	4.0	1.15	34.00	321.13	13.38	15.31	0.54	15.85	0.05	
21.61	6.0	1.15	34.00	481.70	22.96	0.87	0.80	23.77	0.08	
28.86	8.0	1.15	34.00	642.26	33.28	30.62	1.00	31.69	0.11	
36.22	10.0	1.15	34.00	802.83	43.93	38.27	1.34	39.61	0.13	
44.05	12.0	1.15	34.00	963.99	53.58	45.93	1.61	47.54	0.16	
51.89	14.0	1.15	34.00	1123.96	63.38	53.58	1.88	55.46	0.18	
60	16.0	1.15	34.00	1284.53	73.38	61.24	2.15	63.38	0.21	
68.46	18.0	1.15	34.00	1445.09	83.38	68.89	2.41	71.31	0.24	
77.36	20.0	1.15	34.00	1605.66	93.38	76.55	2.68	79.23	0.26	
86.87	22.0	1.15	34.00	1766.22	103.28	84.20	2.95	87.15	0.28	
97.18	24.0	1.15	34.00	1926.79	113.28	91.85	3.22	95.07	0.32	
108.68	26.0	1.15	34.00	2087.36	123.28	99.51	3.49	103.00	0.34	
122.09	28.0	1.15	34.00	2247.92	133.28	107.16	3.76	110.92	0.37	
139.27	30.0	1.15	34.00	2408.49	143.28	114.82	4.02	118.84	0.39	
180	32.0	1.15	34.00	2569.05	153.28	122.47	4.29	126.76	0.42	

Sewing bearing 1											
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Vertical sector load	Horz- sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	1.15	152.44	321.13	31.45	0	2.24	62.87	0.07		
21.61	6.0	1.15	152.44	481.70	55.87	0	2.24	111.69	0.12		
28.86	8.0	1.15	152.44	642.26	80.32	0	2.24	160.50	0.18		
36.22	10.0	1.15	152.44	802.83	104.72	0	2.24	209.32	0.23		
44.05	12.0	1.15	152.44	963.99	129.14	0	2.24	258.14	0.29		
51.89	14.0	1.15	152.44	1123.96	153.56	0	2.24	306.95	0.34		
60	16.0	1.15	152.44	1284.53	177.98	0	2.24	355.77	0.40		
68.46	18.0	1.15	152.44	1445.09	202.40	0	2.24	404.58	0.45		
77.36	20.0	1.15	152.44	1605.66	226.82	0	2.24	453.40	0.50		
86.87	22.0	1.15	152.44	1766.22	251.24	0	2.24	502.21	0.56		
97.18	24.0	1.15	152.44	1926.79	275.66	0	2.24	551.03	0.61		
108.68	26.0	1.15	152.44	2087.36	300.08	0	2.24	599.85	0.67		
122.09	28.0	1.15	152.44	2247.92	324.50	0	2.24	648.66	0.72		
139.27	30.0	1.15	152.44	2408.49	348.93	0	2.24	697.48	0.77		
180	32.0	1.15	152.44	2569.05	373.35	0	2.24	746.29	0.83		

Sewing bearing 2												
Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Vertical sector load	Horz- sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	2.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
21.61	6.0	3.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
28.86	8.0	4.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
36.22	10.0	5.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
44.05	12.0	6.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
51.89	14.0	7.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
60	16.0	8.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
68.46	18.0	9.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
77.36	20.0	10.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
86.87	22.0	11.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
97.18	24.0	12.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
108.68	26.0	13.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
122.09	28.0	14.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
139.27	30.0	15.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		
180	32.0	16.0	1.15	73.17	909.11	305.70	0	2.85	779.21	0.87		

Pedestal adapter										
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	
14.36	4.0	1.65	33.02	315.87	13.06	15.06	1.16	16.22	0.05	
21.61	6.0	1.65	33.02	473.81	22.59	22.92	1.16	23.74	0.08	
28.86	8.0	1.65	33.02	631.74	33.06	30.12	1.16	31.27	0.10	
36.22	10.0	1.65	33.02	789.68	43.17	37.65	1.16	38.80	0.13	
44.05	12.0	1.65	33.02	947.61	53.06	45.17	1.16	46.33	0.15	
51.89	14.0	1.65	33.02	1105.55	62.70	52.20	1.16	53.86	0.18	
60	16.0	1.65	33.02	1263.48	72.13	60.22	1.16	61.39	0.20	
68.46	18.0	1.65	33.02	1421.42	81.06	67.76	1.16	68.92	0.22	
77.36	20.0	1.65	33.02	1579.35	90.06	75.29	1.16	76.45	0.23	
86.87	22.0	1.65	33.02	1737.29	99.06	82.82	1.16	83.98	0.24	
97.18	24.0	1.65	33.02	1895.22	108.06	90.35	1.16	91.51	0.25	
108.68	26.0	1.65	33.02	2053.16	117.06	97.88	1.16	99.04	0.26	
122.09	28.0	1.65	33.02	2211.09	126.06	105.41	1.16	106.56	0.27	
139.27	30.0	1.65	33.02	2369.03	135.06	112.94	1.16	114.09	0.28	
180	32.0	1.65	33.02	2526.96	144.06	120.47	1.16	121.62	0.30	

Sewing bearing 1											
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Vertical sector load	Horz- sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	1.65	151.13	315.87	30.80	0	2.24	61.57	0.07		
21.61	6.0	1.65	151.13	473.81	54.82	0	2.24	109.59	0.12		
28.86	8.0	1.65	151.13	631.74	78.84	0	2.24	157.60	0.18		
36.22	10.0	1.65	151.13	789.68	102.87	0	2.24	205.62	0.23		
44.05	12.0	1.65	151.13	947.61	126.89	0	2.24	253.64	0.28		
51.89	14.0	1.65	151.13	1105.55	150.91	0	2.24	301.65	0.34		
60	16.0	1.65	151.13	1263.48	174.93	0	2.24	349.67	0.38		
68.46	18.0	1.65	151.13	1421.42	198.95	0	2.24	397.68	0.44		
77.36	20.0	1.65	151.13	1579.35	222.97	0	2.24	445.70	0.50		
86.87	22.0	1.65	151.13	1737.29	246.99	0	2.24	493.72	0.55		
97.18	24.0	1.65	151.13	1895.22	271.01	0	2.24	541.73	0.60		
108.68	26.0	1.65	151.13	2053.16	295.03	0	2.24	589.75	0.66		
122.09	28.0	1.65	151.13	2211.09	319.05	0	2.24	637.76	0.71		
139.27	30.0	1.65	151.13	2369.03	343.07	0	2.24	685.78	0.76		
180	32.0	1.65	151.13	2526.96	367.09	0	2.24	733.80	0.82		

Sewing bearing 2												
Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- sector load	Vertical sector load	Horz- sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	2.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
21.61	6.0	3.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
28.86	8.0	4.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
36.22	10.0	5.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
44.05	12.0	6.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
51.89	14.0	7.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
60	16.0	8.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
68.46	18.0	9.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
77.36	20.0	10.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
86.87	22.0	11.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
97.18	24.0	12.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
108.68	26.0	13.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
122.09	28.0	14.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
139.27	30.0	15.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		
180	32.0	16.0	1.65	71.85	888.07	298.55	0	2.85	761.00	0.85		

Pedestal adapter										
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	
14.36	4.0	1.92	28.41	291.18	12.489	13.88	1.00	14.88	0.05	
21.61	6.0	1.92	28.41	436.77	12.489	20.76	1.00	21.82	0.07	
28.86	8.0	1.92	28.41	582.35	12.489	27.76	1.00	28.76	0.10	
36.22	10.0	1.92	28.41	727.94	12.489	34.70	1.00	35.70	0.12	
44.05	12.0	1.92	28.41	873.53	12.489	41.64	1.00	42.64	0.14	
51.89	14.0	1.92	28.41	1019.12	12.489	48.58	1.00	49.58	0.16	
60	16.0	1.92	28.41	1164.71	12.489	55.52	1.00	56.52	0.18	
68.46	18.0	1.92	28.41	1310.30	12.489	62.46	1.00	63.46	0.21	
77.36	20.0	1.92	28.41	1455.89	12.489	69.41	1.00	70.40	0.23	
86.87	22.0	1.92	28.41	1601.47	12.489	76.35	1.00	77.34	0.26	
97.18	24.0	1.92	28.41	1747.06	12.489	83.29	1.00	84.28	0.28	
108.68	26.0	1.92	28.41	1892.65	12.489	90.23	1.00	91.22	0.30	
122.09	28.0	1.92	28.41	2038.24	12.489	97.17	1.00	98.16	0.33	
139.27	30.0	1.92	28.41	2183.83	12.489	104.11	1.00	105.10	0.35	

Hoist winch		Dynamic		Hoist	
Angle	Radius	Hook load	Dynamic hook load	load in hoist	winch
[o]	[m]	[T]	[T]	[T]	[T]
14.36	4.0	34.0	39.10	19.55	1.00
21.61	6.0	34.0	39.10	19.55	1.00
28.96	8.0	34.0	39.10	19.55	1.00
36.42	10.0	34.0	39.10	19.55	1.00
44.05	12.0	34.0	39.10	19.55	1.00
51.89	14.0	34.0	39.10	19.55	1.00
60	16.0	34.0	39.10	19.55	1.00
68.46	18.0	34.0	39.10	19.55	1.00
77.36	20.0	34.0	39.10	19.55	1.00
86.87	22.0	34.0	39.10	19.55	1.00
97.18	24.0	34.0	39.10	19.55	1.00
108.68	26.0	34.0	39.10	19.55	1.00
122.09	28.0	34.0	39.10	19.55	1.00
139.27	30.0	34.0	39.10	19.55	1.00
180	32.0	34.0	39.10	19.55	1.00

Hoist winch		Dynamic		Hoist	
Angle	Radius	Hook load	Dynamic hook load	load in hoist	winch
[o]	[m]	[T]	[T]	[T]	[T]
14.36	4.0	33.0	54.40	27.20	0.97
21.61	6.0	33.0	54.40	27.20	0.97
28.96	8.0	33.0	54.40	27.20	0.97
36.42	10.0	33.0	54.40	27.20	0.97
44.05	12.0	33.0	54.40	27.20	0.97
51.89	14.0	33.0	54.40	27.20	0.97
60	16.0	33.0	54.40	27.20	0.97
68.46	18.0	33.0	54.40	27.20	0.97
77.36	20.0	33.0	54.40	27.20	0.97
86.87	22.0	33.0	54.40	27.20	0.97
97.18	24.0	33.0	54.40	27.20	0.97
108.68	26.0	33.0	54.40	27.20	0.97
122.09	28.0	33.0	54.40	27.20	0.97
139.27	30.0	33.0	54.40	27.20	0.97
180	32.0	33.0	54.40	27.20	0.97

Hoist winch		Dynamic		Hoist	
Angle	Radius	Hook load	Dynamic hook load	load in hoist	winch
[o]	[m]	[T]	[T]	[T]	[T]
14.36	4.0	28.4	54.45	27.22	0.84
21.61	6.0	28.4	54.45	27.22	0.84
28.96	8.0	28.4	54.45	27.22	0.84
36.42	10.0	28.4	54.45	27.22	0.84
44.05	12.0	28.4	54.45	27.22	0.84
51.89	14.0	28.4	54.45	27.22	0.84
60	16.0	28.4	54.45	27.22	0.84
68.46	18.0	28.4	54.45	27.22	0.84
77.36	20.0	28.4	54.45	27.22	0.84
86.87	22.0	28.4	54.45	27.22	0.84
97.18	24.0	28.4	54.45	27.22	0.84
108.68	26.0	28.4	54.45	27.22	0.84
122.09	28.0	28.4	54.45	27.22	0.84
139.27	30.0	28.4	54.45	27.22	0.84
180	32.0	28.4	54.45	27.22	0.84

Boom		Section 1		Total design		WEB		Flange						
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Hook load only	Moment horizontal	Torsion	Torsion Flange	Bending load horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises
[o]	[m]	[T]	[-]	[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]
14.36	4.0	34.0	1.15	71.16	80.52	34.00	123.25	214.19	16.88	26.63	26.63	8.10	45.40	39.83
21.61	6.0	34.0	1.15	71.16	120.77	34.00	184.88	318.09	25.06	39.5	39.5	8.10	63.76	56.09
28.96	8.0	34.0	1.15	71.16	161.03	34.00	246.50	418.07	32.94	52.56	52.56	8.10	83.79	72.20
36.42	10.0	34.0	1.15	71.16	201.29	34.00	308.13	512.69	40.40	66.58	66.58	8.10	102.34	88.05
44.05	12.0	34.0	1.15	71.16	241.55	34.00	369.75	600.40	47.31	79.0	79.0	8.10	120.24	103.57
51.89	14.0	34.0	1.15	71.16	281.81	34.00	431.38	679.46	53.54	92.2	92.2	8.10	137.34	118.68
60	16.0	34.0	1.15	71.16	322.07	34.00	493.00	747.86	58.93	105.4	105.4	8.10	153.48	133.30
68.46	18.0	34.0	1.15	71.16	362.32	34.00	554.63	803.23	63.29	118.5	118.5	8.10	168.48	147.34
77.36	20.0	34.0	1.15	71.16	402.58	34.00	616.25	862.64	66.39	131.7	131.7	8.10	182.15	160.72
86.87	22.0	34.0	1.15	71.16	442.84	34.00	677.88	922.06	67.51	144.9	144.9	8.10	194.27	173.34
97.18	24.0	34.0	1.15	71.16	483.10	34.00	739.50	982.47	67.51	157.9	157.9	8.10	204.60	185.11
108.68	26.0	34.0	1.15	71.16	523.36	34.00	801.13	1042.88	64.46	171.2	171.2	8.10	212.84	195.90
122.09	28.0	34.0	1.15	71.16	563.61	34.00	862.75	1103.29	57.65	184.4	184.4	8.10	218.65	205.60
139.27	30.0	34.0	1.15	71.16	603.87	34.00	924.38	1163.70	44.40	197.5	197.5	8.10	221.61	214.07
180	32.0	34.0	1.15	71.16	644.13	34.00	986.00	1224.11	0.00	210.7	210.7	8.10	221.16	221.16

Boom		Section 1		Total design		WEB		Flange						
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Hook load only	Moment horizontal	Torsion	Torsion Flange	Bending load horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises
[o]	[m]	[T]	[-]	[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]
14.36	4.0	33.0	1.65	71.16	80.52	33.02	119.69	209.30	16.49	10.99	26.15	8.02	44.54	39.12
21.61	6.0	33.0	1.65	71.16	120.77	33.02	179.54	310.82	24.49	16.33	38.8	8.02	63.49	55.06
28.96	8.0	33.0	1.65	71.16	161.03	33.02	239.38	408.51	32.19	21.46	51.7	8.02	82.14	70.65
36.42	10.0	33.0	1.65	71.16	201.29	33.02	299.23	500.98	39.47	26.32	64.7	8.02	100.31	86.40
44.05	12.0	33.0	1.65	71.16	241.55	33.02	359.07	586.68	46.23	30.82	77.6	8.02	117.85	101.62
51.89	14.0	33.0	1.65	71.16	281.81	33.02	418.92	663.93	52.31	34.88	90.5	8.02	134.61	116.44
60	16.0	33.0	1.65	71.16	322.07	33.02	478.77	739.27	57.58	38.99	103.4	8.02	150.43	130.78
68.46	18.0	33.0	1.65	71.16	362.32	33.02	538.61	784.88	61.84	41.23	116.4	8.02	165.14	144.56
77.36	20.0	33.0	1.65	71.16	402.58	33.02	598.46	829.58	64.88	43.25	129.3	8.02	178.56	157.70
86.87	22.0	33.0	1.65	71.16	442.84	33.02	658.30	842.36	66.39	44.26	142.2	8.02	190.47	170.10
97.18	24.0	33.0	1.65	71.16	483.10	33.02	718.15	855.20	65.97	43.98	155.0	8.02	200.63	182.66
108.68	26.0	33.0	1.65	71.16	523.36	33.02	778.00	899.56	62.98	41.99	168.1	8.02	208.76	191.28
122.09	28.0	33.0	1.65	71.16	563.61	33.02	837.84	914.90	56.33	37.55	181.0	8.02	214.54	201.84
139.27	30.0	33.0	1.65	71.16	603.87	33.02	897.69	950.57	43.38	28.92	196.12	8.02	217.53	210.20
180	32.0	33.0	1.65	71.16	644.13	33.02	957.53	975.33	0.00	1.74E-15	209.20	8.02	217.22	217.22

Boom		Section 1		Total design		WEB		Flange						
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Hook load only	Moment horizontal	Torsion	Torsion Flange	Bending load horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises
[o]	[m]	[T]	[-]	[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]
14.36	4.0	28.4	1.92	71.16	80.52	28.41	102.99	186.33	14.68	9.79	23.89	7.64	40.51	35.80
21.61	6.0	28.4	1.92	71.16	120.77	28.41	154.49	276.71	21.80	14.54	37.2	7.64	57.59	50.24
28.96	8.0	28.4	1.92	71.16	161.03	28.41	205.98	363.68	28.66	19.10	43.4	7.64	74.39	64.54
36.42	10.0	28.4	1.92	71.16	201.29	28.41	257.48	446.60	35.14	23.44	49.1	7.64	90.78	72.65
44.05	12.0	28.4	1.92	71.16	241.55	28.41	308.97	520.55	41.15	27.44	55.2	7.64	106.63	98.64
51.89	14.0	28.4	1.92	71.16	281.81	28.41	360.47	591.07	46.57	31.05	61.3	7.64	121.79	105.92
60	16.0	28.4	1.92	71.16	322.07	28.41	411.97	630.58	51.28	34.17	67.5	7.64	136.13	105.92
68.46	18.0	28.4	1.92	71.16	362.32	28.41	463.46	690.75	55.06	36.70	73.8	7.64	149.50	111.52
77.36	20.0	28.4	1.92	71.16	402.58	28.41	514.96	730.03	57.76	38.50	80.3	7.64	161.73	113.52
86.87	22.0	28.4	1.92	71.16	442.84	28.41	566.45	750.10	59.10	39.40	86.9	7.64	172.64	114.87
97.18	24.0	28.4	1.92	71.16	483.10	28.41	617.95	745.33	58.73	39.15	93.5	7.64	182.04	115.50
108.68	26.0	28.4	1.92	71.16	523.36	28.41	669.45	711.64	56.07	37.38	100.2	7.64	189.66	115.30
122.09	28.0	28.4	1.92	71.16	563.61	28.41	720.94	636.45	50.15	33.43	106.9	7.64	195.24	114.19
139.27	30.0	28.4	1.92	71.16	603.87	28.41	772.44	490.15						

C.5.2 Calculations for each component for $H_s = 1.5 - 2.5m$ with two falls

Crane total											
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Load factor selfweight	Load factor hook load	Maximum utilization					
14.36	4.0	24.9	1.5	2.19	1.22	1.34	1.00				
21.61	6.0	24.9	1.5	2.19	1.22	1.34	1.00				
28.96	8.0	24.9	1.5	2.19	1.22	1.34	1.00				
36.42	10.0	24.9	1.5	2.19	1.22	1.34	1.00				
44.05	12.0	24.9	1.5	2.19	1.22	1.34	1.00				
51.89	14.0	24.9	1.5	2.19	1.22	1.34	1.00				
60	16.0	24.9	1.5	2.19	1.22	1.34	1.00				
68.46	18.0	24.9	1.5	2.19	1.22	1.34	1.00				
77.36	20.0	24.9	1.5	2.19	1.22	1.34	1.00				
86.87	22.0	24.9	1.5	2.19	1.22	1.34	1.00				
97.18	24.0	24.9	1.5	2.19	1.22	1.34	1.00				
108.68	26.0	24.9	1.5	2.19	1.22	1.34	1.00				
122.09	28.0	24.9	1.5	2.19	1.22	1.34	1.00				
137.27	30.0	24.9	1.5	2.19	1.22	1.34	1.00				
180	32.0	24.9	1.5	2.19	1.22	1.34	1.00				
Wire rope 0.160 tonne											
Angle	Radius	Hook load	Running rigging factor for running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope			
14.36	4.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
21.61	6.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
28.96	8.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
36.42	10.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
44.05	12.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
51.89	14.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
60	16.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
68.46	18.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
77.36	20.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
86.87	22.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
97.18	24.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
108.68	26.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
122.09	28.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
137.27	30.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
180	32.0	24.87	4.69	3.99	1.31	54.42	0.74	0.82			
Pedestal											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Axial stress	Combined stress	UF	
14.36	4.0	2.73	19.95	245.84	110.69	11.72	3.88	3.88	15.60	0.05	
21.61	6.0	2.73	19.95	368.76	110.69	17.58	3.88	21.46	0.07		
28.96	8.0	2.73	19.95	491.68	110.69	23.40	3.88	27.32	0.10		
36.42	10.0	2.73	19.95	614.60	110.69	29.30	3.88	33.18	0.11		
44.05	12.0	2.73	19.95	737.52	110.69	35.16	3.88	39.04	0.13		
51.89	14.0	2.73	19.95	860.45	110.69	41.02	3.88	44.90	0.15		
60	16.0	2.73	19.95	983.37	110.69	46.88	3.88	50.76	0.17		
68.46	18.0	2.73	19.95	1106.30	110.69	52.74	3.88	56.62	0.19		
77.36	20.0	2.73	19.95	1229.22	110.69	58.60	3.88	62.48	0.21		
86.87	22.0	2.73	19.95	1352.15	110.69	64.46	3.88	68.34	0.23		
97.18	24.0	2.73	19.95	1475.07	110.69	70.32	3.88	74.20	0.25		
108.68	26.0	2.73	19.95	1597.97	110.69	76.18	3.88	80.06	0.27		
122.09	28.0	2.73	19.95	1720.89	110.69	82.04	3.88	85.92	0.29		
137.27	30.0	2.73	19.95	1843.81	110.69	87.90	3.88	91.78	0.30		
180	32.0	2.73	19.95	1966.73	110.69	93.76	3.88	97.64	0.32		

Crane total											
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Load factor selfweight	Load factor hook load	Maximum utilization					
14.36	4.0	22.1	2	2.46	1.22	1.34	1.00				
21.61	6.0	22.1	2	2.46	1.22	1.34	1.00				
28.96	8.0	22.1	2	2.46	1.22	1.34	1.00				
36.42	10.0	22.1	2	2.46	1.22	1.34	1.00				
44.05	12.0	22.1	2	2.46	1.22	1.34	1.00				
51.89	14.0	22.1	2	2.46	1.22	1.34	1.00				
60	16.0	22.1	2	2.46	1.22	1.34	1.00				
68.46	18.0	22.1	2	2.46	1.22	1.34	1.00				
77.36	20.0	22.1	2	2.46	1.22	1.34	1.00				
86.87	22.0	22.1	2	2.46	1.22	1.34	1.00				
97.18	24.0	22.1	2	2.46	1.22	1.34	1.00				
108.68	26.0	22.1	2	2.46	1.22	1.34	1.00				
122.09	28.0	22.1	2	2.46	1.22	1.34	1.00				
137.27	30.0	22.1	2	2.46	1.22	1.34	1.00				
180	32.0	22.1	2	2.46	1.22	1.34	1.00				
Wire rope 0.160 tonne											
Angle	Radius	Hook load	Running rigging factor for running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope			
14.36	4.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
21.61	6.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
28.96	8.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
36.42	10.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
44.05	12.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
51.89	14.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
60	16.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
68.46	18.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
77.36	20.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
86.87	22.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
97.18	24.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
108.68	26.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
122.09	28.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
137.27	30.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
180	32.0	22.12	4.75	4.19	1.33	54.40	0.67	0.83			
Pedestal											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Axial stress	Combined stress	UF	
14.36	4.0	2.46	22.12	257.46	112.86	12.27	3.96	3.96	16.23	0.05	
21.61	6.0	2.46	22.12	386.19	112.86	18.41	3.96	22.37	0.07		
28.96	8.0	2.46	22.12	514.92	112.86	24.55	3.96	28.50	0.09		
36.42	10.0	2.46	22.12	643.66	112.86	30.68	3.96	34.64	0.11		
44.05	12.0	2.46	22.12	772.39	112.86	36.82	3.96	40.78	0.14		
51.89	14.0	2.46	22.12	901.12	112.86	42.96	3.96	46.92	0.16		
60	16.0	2.46	22.12	1029.85	112.86	49.10	3.96	53.05	0.18		
68.46	18.0	2.46	22.12	1158.58	112.86	55.23	3.96	59.19	0.20		
77.36	20.0	2.46	22.12	1287.31	112.86	61.37	3.96	65.32	0.22		
86.87	22.0	2.46	22.12	1416.04	112.86	67.51	3.96	71.46	0.24		
97.18	24.0	2.46	22.12	1544.77	112.86	73.65	3.96	77.60	0.26		
108.68	26.0	2.46	22.12	1673.50	112.86	79.78	3.96	83.74	0.28		
122.09	28.0	2.46	22.12	1802.24	112.86	85.92	3.96	89.88	0.30		
137.27	30.0	2.46	22.12	1930.97	112.86	92.05	3.96	96.01	0.32		
180	32.0	2.46	22.12	2059.70	112.86	98.19	3.96	102.15	0.34		

Crane total											
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Load factor selfweight	Load factor hook load	Maximum utilization					
14.36	4.0	20.0	2.5	2.73	1.22	1.34	1.00				
21.61	6.0	20.0	2.5	2.73	1.22	1.34	1.00				
28.96	8.0	20.0	2.5	2.73	1.22	1.34	1.00				
36.42	10.0	20.0	2.5	2.73	1.22	1.34	1.00				
44.05	12.0	20.0	2.5	2.73	1.22	1.34	1.00				
51.89	14.0	20.0	2.5	2.73	1.22	1.34	1.00				
60	16.0	20.0	2.5	2.73	1.22	1.34	1.00				
68.46	18.0	20.0	2.5	2.73	1.22	1.34	1.00				
77.36	20.0	20.0	2.5	2.73	1.22	1.34	1.00				
86.87	22.0	20.0	2.5	2.73	1.22	1.34	1.00				
97.18	24.0	20.0	2.5	2.73	1.22	1.34	1.00				
108.68	26.0	20.0	2.5	2.73	1.22	1.34	1.00				
122.09	28.0	20.0	2.5	2.73	1.22	1.34	1.00				
137.27	30.0	20.0	2.5	2.73	1.22	1.34	1.00				
180	32.0	20.0	2.5	2.73	1.22	1.34	1.00				
Wire rope 0.160 tonne											
Angle	Radius	Hook load	Running rigging factor for running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope			
14.36	4.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
21.61	6.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
28.96	8.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
36.42	10.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
44.05	12.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
51.89	14.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
60	16.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
68.46	18.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
77.36	20.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
86.87	22.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
97.18	24.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
108.68	26.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
122.09	28.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
137.27	30.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
180	32.0	19.95	4.79	4.36	1.35	54.40	0.61	0.84			
Pedestal											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook								

Pedestal adapter					Slewing bearing 1					Slewing bearing 2																				
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	2.19	2.487	272.18	120.14	12.98	0.87	13.85	0.05	14.36	4.0	2.19	140.20	272.18	25.40	0	2.24	50.78	0.06	14.36	4.0	2.19	2.0	60.93	713.29	239.23	0	2.85	609.80	0.58
21.61	6.0	2.19	2.487	408.26	120.14	19.46	0.87	26.82	0.07	21.61	6.0	2.19	140.20	504.36	46.10	0	2.24	92.15	0.10	21.61	6.0	2.19	3.0	60.93	713.29	239.23	0	2.85	609.80	0.58
28.86	8.0	2.19	2.487	544.35	120.14	25.95	0.87	36.31	0.11	28.86	8.0	2.19	140.20	680.44	66.80	0	2.24	133.53	0.19	28.86	8.0	2.19	4.0	60.93	713.29	239.23	0	2.85	609.80	0.58
36.42	10.0	2.19	2.487	680.44	120.14	32.44	0.87	44.05	0.13	36.42	10.0	2.19	140.20	816.53	87.50	0	2.24	174.90	0.28	36.42	10.0	2.19	5.0	60.93	713.29	239.23	0	2.85	609.80	0.58
44.05	12.0	2.19	2.487	816.53	120.14	38.93	0.87	51.89	0.15	44.05	12.0	2.19	140.20	952.62	108.20	0	2.24	216.28	0.35	44.05	12.0	2.19	6.0	60.93	713.29	239.23	0	2.85	609.80	0.58
51.89	14.0	2.19	2.487	952.62	120.14	45.41	0.87	59.73	0.18	51.89	14.0	2.19	140.20	1088.71	128.89	0	2.24	257.65	0.42	51.89	14.0	2.19	7.0	60.93	713.29	239.23	0	2.85	609.80	0.58
60	16.0	2.19	2.487	1088.71	120.14	51.90	0.87	67.57	0.21	60	16.0	2.19	140.20	1224.79	149.59	0	2.24	299.02	0.47	60	16.0	2.19	8.0	60.93	713.29	239.23	0	2.85	609.80	0.58
68.46	18.0	2.19	2.487	1224.79	120.14	58.39	0.87	75.41	0.24	68.46	18.0	2.19	140.20	1360.88	170.29	0	2.24	340.40	0.52	68.46	18.0	2.19	9.0	60.93	713.29	239.23	0	2.85	609.80	0.58
77.36	20.0	2.19	2.487	1360.88	120.14	64.88	0.87	83.25	0.27	77.36	20.0	2.19	140.20	1496.97	190.99	0	2.24	381.77	0.57	77.36	20.0	2.19	10.0	60.93	713.29	239.23	0	2.85	609.80	0.58
86.87	22.0	2.19	2.487	1496.97	120.14	71.35	0.87	91.09	0.29	86.87	22.0	2.19	140.20	1633.06	211.69	0	2.24	423.15	0.62	86.87	22.0	2.19	11.0	60.93	713.29	239.23	0	2.85	609.80	0.58
97.18	24.0	2.19	2.487	1633.06	120.14	77.85	0.87	98.93	0.30	97.18	24.0	2.19	140.20	1769.15	232.38	0	2.24	464.52	0.65	97.18	24.0	2.19	12.0	60.93	713.29	239.23	0	2.85	609.80	0.58
108.68	26.0	2.19	2.487	1769.15	120.14	84.34	0.87	106.77	0.31	108.68	26.0	2.19	140.20	1905.24	253.08	0	2.24	505.89	0.56	108.68	26.0	2.19	13.0	60.93	713.29	239.23	0	2.85	609.80	0.58
120.99	28.0	2.19	2.487	1905.24	120.14	90.83	0.87	114.61	0.32	120.99	28.0	2.19	140.20	2041.32	273.78	0	2.24	547.27	0.61	120.99	28.0	2.19	14.0	60.93	713.29	239.23	0	2.85	609.80	0.58
139.27	30.0	2.19	2.487	2041.32	120.14	97.31	0.87	122.45	0.33	139.27	30.0	2.19	140.20	2177.41	294.48	0	2.24	588.64	0.65	139.27	30.0	2.19	15.0	60.93	713.29	239.23	0	2.85	609.80	0.58
180	32.0	2.19	2.487	2177.41	120.14	103.80	0.87	130.29	0.35	180	32.0	2.19	140.20	2313.50	315.18	0	2.24	630.02	0.70	180	32.0	2.19	16.0	60.93	713.29	239.23	0	2.85	609.80	0.58

Pedestal adapter					Slewing bearing 1					Slewing bearing 2																				
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	2.46	2.212	257.46	116.46	12.27	0.78	13.05	0.04	14.36	4.0	2.46	136.62	257.46	23.59	0	2.24	47.14	0.05	14.36	4.0	2.46	2.0	57.25	654.43	219.26	0	2.85	558.88	0.62
21.61	6.0	2.46	2.212	386.19	116.46	18.41	0.78	19.19	0.06	21.61	6.0	2.46	136.62	386.19	32.56	0	2.24	86.28	0.10	21.61	6.0	2.46	3.0	57.25	654.43	219.26	0	2.85	558.88	0.62
28.86	8.0	2.46	2.212	514.92	116.46	24.55	0.78	25.32	0.08	28.86	8.0	2.46	136.62	514.92	42.74	0	2.24	125.42	0.14	28.86	8.0	2.46	4.0	57.25	654.43	219.26	0	2.85	558.88	0.62
36.42	10.0	2.46	2.212	643.66	116.46	30.68	0.78	31.46	0.10	36.42	10.0	2.46	136.62	643.66	52.92	0	2.24	164.56	0.18	36.42	10.0	2.46	5.0	57.25	654.43	219.26	0	2.85	558.88	0.62
44.05	12.0	2.46	2.212	772.39	116.46	36.82	0.78	37.60	0.12	44.05	12.0	2.46	136.62	772.39	63.10	0	2.24	203.69	0.23	44.05	12.0	2.46	6.0	57.25	654.43	219.26	0	2.85	558.88	0.62
51.89	14.0	2.46	2.212	901.12	116.46	42.96	0.78	43.73	0.15	51.89	14.0	2.46	136.62	901.12	73.28	0	2.24	242.83	0.27	51.89	14.0	2.46	7.0	57.25	654.43	219.26	0	2.85	558.88	0.62
60	16.0	2.46	2.212	1029.85	116.46	49.10	0.78	49.87	0.17	60	16.0	2.46	136.62	1029.85	83.46	0	2.24	281.97	0.31	60	16.0	2.46	8.0	57.25	654.43	219.26	0	2.85	558.88	0.62
68.46	18.0	2.46	2.212	1158.58	116.46	55.23	0.78	56.01	0.19	68.46	18.0	2.46	136.62	1158.58	93.64	0	2.24	321.11	0.36	68.46	18.0	2.46	9.0	57.25	654.43	219.26	0	2.85	558.88	0.62
77.36	20.0	2.46	2.212	1287.31	116.46	61.37	0.78	62.14	0.21	77.36	20.0	2.46	136.62	1287.31	103.82	0	2.24	360.24	0.40	77.36	20.0	2.46	10.0	57.25	654.43	219.26	0	2.85	558.88	0.62
86.87	22.0	2.46	2.212	1416.04	116.46	67.51	0.78	68.28	0.23	86.87	22.0	2.46	136.62	1416.04	113.99	0	2.24	399.38	0.44	86.87	22.0	2.46	11.0	57.25	654.43	219.26	0	2.85	558.88	0.62
97.18	24.0	2.46	2.212	1544.77	116.46	73.64	0.78	74.42	0.25	97.18	24.0	2.46	136.62	1544.77	124.18	0	2.24	438.52	0.46	97.18	24.0	2.46	12.0	57.25	654.43	219.26	0	2.85	558.88	0.62
108.68	26.0	2.46	2.212	1673.51	116.46	79.78	0.78	80.55	0.27	108.68	26.0	2.46	136.62	1673.51	134.36	0	2.24	477.66	0.53	108.68	26.0	2.46	13.0	57.25	654.43	219.26	0	2.85	558.88	0.62
120.99	28.0	2.46	2.212	1802.24	116.46	85.92	0.78	86.69	0.29	120.99	28.0	2.46	136.62	1802.24	144.55	0	2.24	516.79	0.57	120.99	28.0	2.46	14.0	57.25	654.43	219.26	0	2.85	558.88	0.62
139.27	30.0	2.46	2.212	1930.97	116.46	92.05	0.78	92.83	0.31	139.27	30.0	2.46	136.62	1930.97	154.73	0	2.24	555.93	0.62	139.27	30.0	2.46	15.0	57.25	654.43	219.26	0	2.85	558.88	0.62
180	32.0	2.46	2.212	2059.70	116.46	98.19	0.78	98.97	0.33	180	32.0	2.46	136.62	2059.70	164.91	0	2.24	595.07	0.66	180	32.0	2.46	16.0	57.25	654.43	219.26	0	2.85	558.88	0.62

Pedestal adapter					Slewing bearing 1					Slewing bearing 2																				
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Radius slew bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	2.73	1.935	245.84	113.56	11.72	0.70	12.42	0.04	14.36	4.0	2.73	133.62	245.84	22.15	0	2.24	44.27	0.05	14.36	4.0	2.73	2.0	54.35	607.95	203.48	0	2.85	518.66	0.58
21.61	6.0	2.73	1.935	368.76	113.56	17.58	0.70	18.28	0.06	21.61	6.0	2.73	133.62	368.76	32.33	0	2.24	81.65	0.09	21.61	6.0	2.73	3.0	54.35	607.95	203.48	0	2.85	518.66	0.58
28.86	8.0	2.73	1.935	491.68	113.56	23.44	0.70	24.14	0.08	28.86	8.0	2.73	133.62	491.68	42.51	0	2.24	119.02	0.13	28.86	8.0	2.73	4.0	54.35	607.95	203.48	0	2.85	518.66	0.58
36.42	10.0	2.73	1.935	614.60	113.56	29.30	0.70	30.00	0.10	36.42	10.0	2.73	133.62	614.60	52.68	0	2.24	156.39	0.17	36.42	10.0	2.73	5.0	54.35	607.95	203.48	0	2.85	518.66	0.58
44.05	12.0	2.73	1.935	737.52	113.56	35.16	0.70	35.86	0.12	44.05	12.0	2.73	133.62	737.52	62.85	0	2.24	193.76	0.22	44.05	12.0	2.73	6.0	54.35	607.95	203.48	0	2.85	518.66	0.58
51.89	14.0	2.73	1.935	860.45	113.56	41.02	0.70	41.72	0.14	51.89	14.0	2.73	133.62	860.45	73.03	0	2.24	231.13	0.26	51.89	14.0	2.73	7.0	54.35	607.95	203.48	0	2.85	518.66	0.58
60	16.0	2.73	1.935	983.37	113.56	46.88	0.70	47.58	0.16	60	16.0	2.73	133.62	983.37	83.20	0</														

Hoist winch							
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	24.9	54.42	27.21	0.73	1.00	1.00
21.61	6.0	24.9	54.42	27.21	0.73	1.00	1.00
28.96	8.0	24.9	54.42	27.21	0.73	1.00	1.00
36.42	10.0	24.9	54.42	27.21	0.73	1.00	1.00
44.05	12.0	24.9	54.42	27.21	0.73	1.00	1.00
51.89	14.0	24.9	54.42	27.21	0.73	1.00	1.00
60	16.0	24.9	54.42	27.21	0.73	1.00	1.00
68.46	18.0	24.9	54.42	27.21	0.73	1.00	1.00
77.36	20.0	24.9	54.42	27.21	0.73	1.00	1.00
86.87	22.0	24.9	54.42	27.21	0.73	1.00	1.00
97.18	24.0	24.9	54.42	27.21	0.73	1.00	1.00
108.68	26.0	24.9	54.42	27.21	0.73	1.00	1.00
122.09	28.0	24.9	54.42	27.21	0.73	1.00	1.00
139.27	30.0	24.9	54.42	27.21	0.73	1.00	1.00
180	32.0	24.9	54.42	27.21	0.73	1.00	1.00

Hoist winch							
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	22.1	54.40	27.20	0.65	1.00	1.00
21.61	6.0	22.1	54.40	27.20	0.65	1.00	1.00
28.96	8.0	22.1	54.40	27.20	0.65	1.00	1.00
36.42	10.0	22.1	54.40	27.20	0.65	1.00	1.00
44.05	12.0	22.1	54.40	27.20	0.65	1.00	1.00
51.89	14.0	22.1	54.40	27.20	0.65	1.00	1.00
60	16.0	22.1	54.40	27.20	0.65	1.00	1.00
68.46	18.0	22.1	54.40	27.20	0.65	1.00	1.00
77.36	20.0	22.1	54.40	27.20	0.65	1.00	1.00
86.87	22.0	22.1	54.40	27.20	0.65	1.00	1.00
97.18	24.0	22.1	54.40	27.20	0.65	1.00	1.00
108.68	26.0	22.1	54.40	27.20	0.65	1.00	1.00
122.09	28.0	22.1	54.40	27.20	0.65	1.00	1.00
139.27	30.0	22.1	54.40	27.20	0.65	1.00	1.00
180	32.0	22.1	54.40	27.20	0.65	1.00	1.00

Hoist winch							
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[T]	[T]
14.36	4.0	20.0	54.40	27.20	0.59	1.00	1.00
21.61	6.0	20.0	54.40	27.20	0.59	1.00	1.00
28.96	8.0	20.0	54.40	27.20	0.59	1.00	1.00
36.42	10.0	20.0	54.40	27.20	0.59	1.00	1.00
44.05	12.0	20.0	54.40	27.20	0.59	1.00	1.00
51.89	14.0	20.0	54.40	27.20	0.59	1.00	1.00
60	16.0	20.0	54.40	27.20	0.59	1.00	1.00
68.46	18.0	20.0	54.40	27.20	0.59	1.00	1.00
77.36	20.0	20.0	54.40	27.20	0.59	1.00	1.00
86.87	22.0	20.0	54.40	27.20	0.59	1.00	1.00
97.18	24.0	20.0	54.40	27.20	0.59	1.00	1.00
108.68	26.0	20.0	54.40	27.20	0.59	1.00	1.00
122.09	28.0	20.0	54.40	27.20	0.59	1.00	1.00
139.27	30.0	20.0	54.40	27.20	0.59	1.00	1.00
180	32.0	20.0	54.40	27.20	0.59	1.00	1.00

Boom																																							
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Section 1				Section 1				Section 1				Total design				web				Flange															
				Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	Bending horizontal at x=1	Bending stress	Shear stress	Von mises	Von mises	Von mises	Von mises	Von mises	Von mises	UF	UF	UF	UF																
[o]	[m]	[T]	[-]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]				
14.36	4.0	24.9	2.19	71.16	80.52	24.87	90.14	168.66	13.29	8.86	219	22.15	37.42	33.25	0.12	0.11																							
21.61	6.0	24.9	2.19	71.16	120.77	24.87	135.21	250.47	19.73	13.16	329	33.22	53.05	46.53	0.17	0.15																							
28.96	8.0	24.9	2.19	71.16	161.03	24.87	180.28	339.19	25.94	17.29	438	44.29	73.5	68.45	0.22	0.19																							
36.42	10.0	24.9	2.19	71.16	201.29	24.87	225.35	403.70	31.81	21.21	548	55.36	98.02	72.68	0.27	0.23																							
44.05	12.0	24.9	2.19	71.16	241.55	24.87	270.42	472.76	37.25	24.83	657	66.44	125.95	85.41	0.31	0.27																							
51.89	14.0	24.9	2.19	71.16	281.81	24.87	315.49	535.01	42.15	28.10	767	77.51	151.95	97.83	0.36	0.31																							
60	16.0	24.9	2.19	71.16	322.07	24.87	360.57	588.87	46.40	30.93	876	88.58	175.15	109.88	0.40	0.35																							
68.46	18.0	24.9	2.19	71.16	362.32	24.87	405.64	632.47	49.83	33.22	986	99.66	198.48	121.50	0.44	0.39																							
77.36	20.0	24.9	2.19	71.16	402.58	24.87	450.71	663.30	52.28	34.85	1095	110.73	217.48	132.62	0.47	0.42																							
86.87	22.0	24.9	2.19	71.16	442.84	24.87	495.78	674.85	53.16	35.64	1205	121.80	232.87	143.17	0.51	0.46																							
97.18	24.0	24.9	2.19	71.16	483.10	24.87	540.85	674.85	53.16	35.64	1314	132.87	250.95	153.07	0.53	0.49																							
108.68	26.0	24.9	2.19	71.16	523.36	24.87	585.92	644.14	50.75	33.84	1424	143.95	264.98	162.25	0.56	0.52																							
122.09	28.0	24.9	2.19	71.16	563.61	24.87	630.99	576.08	45.39	32.26	1533	155.02	273.5	170.62	0.58	0.54																							
139.27	30.0	24.9	2.19	71.16	603.87	24.87	676.06	443.66	34.96	23.30	1643	166.09	282.8	183.71	0.59	0.57																							
180	32.0	24.9	2.19	71.16	644.13	22.12	721.13	0.00	1.74E-15	1.16E-15	1752	177.17	292.3	194.52	0.59	0.59																							

Boom																																							
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Section 1				Section 1				Section 1				Total design				web				Flange															
				Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	Bending horizontal at x=1	Bending stress	Shear stress	Von mises	Von mises	Von mises	Von mises	Von mises	UF	UF	UF	UF																	
[o]	[m]	[T]	[-]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]	[T]	[TM]				
14.36	4.0	22.1	2.46	71.16	80.52	22.12	80.19	154.97	12.21	8.14	206	20.80	35.03	31.28	0.11	0.10																							
21.61	6.0	22.1	2.46	71.16	120.77	22.12	120.29	230.14	18.13	12.09	311	21.92	49.55	43.67	0.16	0.14																							
28.96	8.0	22.1	2.46	71.16	161.03	22.12	160.38	302.48	23.83	15.89	409	23.83	63.86	55.96	0.20	0.18																							
36.42	10.0	22.1	2.46	71.16	201.29	22.12	200.48	370.94	29.23	19.48	514	25.99	77.83	68.08	0.25	0.22																							
44.05	12.0	22.1	2.46	71.16	241.55	22.12	240.57	434.40	34.23	22.82	617	28.39	91.37	79.97	0.29	0.25																							
51.89	14.0	22.1	2.46	71.16	281.81	22.12	280.67	491.60	38.73	25.82	720	30.72	104.35	91.58	0.33	0.29																							
60	16.0	22.1	2.																																				

Pedestal adapter											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]		[°]	[m]
14.36	4.0	2.99	18.22	236.54	111.23	11.28	0.64	11.92	0.04	14.36	4.0
21.61	6.0	2.99	18.22	354.81	111.23	16.91	0.64	17.55	0.06	21.61	6.0
28.96	8.0	2.99	18.22	473.09	111.23	22.55	0.64	23.19	0.08	28.96	8.0
36.42	10.0	2.99	18.22	591.36	111.23	28.19	0.64	28.83	0.10	36.42	10.0
44.05	12.0	2.99	18.22	709.63	111.23	33.83	0.64	34.47	0.11	44.05	12.0
51.89	14.0	2.99	18.22	827.90	111.23	39.47	0.64	40.11	0.13	51.89	14.0
60	16.0	2.99	18.22	946.17	111.23	45.11	0.64	45.74	0.15	60	16.0
68.46	18.0	2.99	18.22	1064.44	111.23	50.74	0.64	51.38	0.17	68.46	18.0
77.36	20.0	2.99	18.22	1182.72	111.23	56.38	0.64	57.02	0.19	77.36	20.0
86.87	22.0	2.99	18.22	1300.99	111.23	62.02	0.64	62.66	0.21	86.87	22.0
97.18	24.0	2.99	18.22	1419.26	111.23	67.66	0.64	68.30	0.23	97.18	24.0
108.68	26.0	2.99	18.22	1537.53	111.23	73.30	0.64	73.94	0.25	108.68	26.0
120.09	28.0	2.99	18.22	1655.80	111.23	78.94	0.64	79.57	0.28	120.09	28.0
132.27	30.0	2.99	18.22	1774.07	111.23	84.57	0.64	85.21	0.30	132.27	30.0
180	32.0	2.99	18.22	1892.35	111.23	90.21	0.64	90.85	0.30	180	32.0

Slewing bearing 1											
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load FA	Horiz. sector load FR	Lever arm effect	Bolt stress	UF	Angle	Radius
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[-]	[MPa]		[°]	[m]
14.36	4.0	2.99	131.29	236.54	21.00	0	2.24	41.98	0.05	14.36	4.0
21.61	6.0	2.99	131.29	354.81	38.99	0	2.24	77.99	0.09	21.61	6.0
28.96	8.0	2.99	131.29	473.09	56.98	0	2.24	113.89	0.13	28.96	8.0
36.42	10.0	2.99	131.29	591.36	74.96	0	2.24	149.85	0.17	36.42	10.0
44.05	12.0	2.99	131.29	709.63	92.95	0	2.24	185.81	0.21	44.05	12.0
51.89	14.0	2.99	131.29	827.90	110.94	0	2.24	221.76	0.25	51.89	14.0
60	16.0	2.99	131.29	946.17	128.93	0	2.24	257.72	0.29	60	16.0
68.46	18.0	2.99	131.29	1064.44	146.92	0	2.24	293.68	0.33	68.46	18.0
77.36	20.0	2.99	131.29	1182.72	164.91	0	2.24	329.64	0.37	77.36	20.0
86.87	22.0	2.99	131.29	1300.99	182.89	0	2.24	365.59	0.41	86.87	22.0
97.18	24.0	2.99	131.29	1419.26	200.88	0	2.24	401.55	0.45	97.18	24.0
108.68	26.0	2.99	131.29	1537.53	218.87	0	2.24	437.51	0.48	108.68	26.0
120.09	28.0	2.99	131.29	1655.80	236.86	0	2.24	473.47	0.52	120.09	28.0
132.27	30.0	2.99	131.29	1774.07	254.85	0	2.24	509.42	0.55	132.27	30.0
180	32.0	2.99	131.29	1892.35	272.84	0	2.24	545.38	0.61	180	32.0

Slewing bearing 2											
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load FA	Horiz. sector load FR	Lever arm effect	Bolt stress	UF	Angle	Radius
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[-]	[MPa]		[°]	[m]
14.36	4.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	14.36	4.0
21.61	6.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	21.61	6.0
28.96	8.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	28.96	8.0
36.42	10.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	36.42	10.0
44.05	12.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	44.05	12.0
51.89	14.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	51.89	14.0
60	16.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	60	16.0
68.46	18.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	68.46	18.0
77.36	20.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	77.36	20.0
86.87	22.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	86.87	22.0
97.18	24.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	97.18	24.0
108.68	26.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	108.68	26.0
120.09	28.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	120.09	28.0
132.27	30.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	132.27	30.0
180	16.0	2.99	52.02	570.76	190.86	0	2.85	486.48	0.54	180	16.0

Pedestal adapter											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]		[°]	[m]
14.36	4.0	3.24	16.78	228.81	109.30	10.91	0.59	11.50	0.04	14.36	4.0
21.61	6.0	3.24	16.78	343.21	109.30	16.36	0.59	12.95	0.06	21.61	6.0
28.96	8.0	3.24	16.78	457.62	109.30	21.82	0.59	14.40	0.07	28.96	8.0
36.42	10.0	3.24	16.78	572.02	109.30	27.27	0.59	15.86	0.09	36.42	10.0
44.05	12.0	3.24	16.78	686.43	109.30	32.72	0.59	17.31	0.11	44.05	12.0
51.89	14.0	3.24	16.78	800.83	109.30	38.18	0.59	18.77	0.13	51.89	14.0
60	16.0	3.24	16.78	915.23	109.30	43.63	0.59	20.22	0.15	60	16.0
68.46	18.0	3.24	16.78	1029.64	109.30	49.09	0.59	21.67	0.16	68.46	18.0
77.36	20.0	3.24	16.78	1144.04	109.30	54.54	0.59	23.13	0.18	77.36	20.0
86.87	22.0	3.24	16.78	1258.45	109.30	59.99	0.59	24.58	0.20	86.87	22.0
97.18	24.0	3.24	16.78	1372.85	109.30	65.45	0.59	26.03	0.22	97.18	24.0
108.68	26.0	3.24	16.78	1487.26	109.30	70.90	0.59	27.49	0.24	108.68	26.0
120.09	28.0	3.24	16.78	1601.66	109.30	76.35	0.59	28.94	0.26	120.09	28.0
132.27	30.0	3.24	16.78	1716.06	109.30	81.81	0.59	30.40	0.27	132.27	30.0
180	32.0	3.24	16.78	1830.47	109.30	87.26	0.59	31.85	0.29	180	32.0

Slewing bearing 1											
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load FA	Horiz. sector load FR	Lever arm effect	Bolt stress	UF	Angle	Radius
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[-]	[MPa]		[°]	[m]
14.36	4.0	3.24	129.36	228.81	20.04	0	2.24	40.07	0.04	14.36	4.0
21.61	6.0	3.24	129.36	343.21	37.44	0	2.24	74.85	0.08	21.61	6.0
28.96	8.0	3.24	129.36	457.62	54.84	0	2.24	109.63	0.12	28.96	8.0
36.42	10.0	3.24	129.36	572.02	72.24	0	2.24	144.41	0.16	36.42	10.0
44.05	12.0	3.24	129.36	686.43	89.64	0	2.24	179.19	0.20	44.05	12.0
51.89	14.0	3.24	129.36	800.83	107.04	0	2.24	213.98	0.24	51.89	14.0
60	16.0	3.24	129.36	915.23	124.44	0	2.24	248.76	0.28	60	16.0
68.46	18.0	3.24	129.36	1029.64	141.84	0	2.24	283.54	0.32	68.46	18.0
77.36	20.0	3.24	129.36	1144.04	159.24	0	2.24	318.32	0.35	77.36	20.0
86.87	22.0	3.24	129.36	1258.45	176.65	0	2.24	353.10	0.38	86.87	22.0
97.18	24.0	3.24	129.36	1372.85	194.05	0	2.24	387.88	0.42	97.18	24.0
108.68	26.0	3.24	129.36	1487.26	211.45	0	2.24	422.66	0.45	108.68	26.0
120.09	28.0	3.24	129.36	1601.66	228.85	0	2.24	457.45	0.51	120.09	28.0
132.27	30.0	3.24	129.36	1716.06	246.25	0	2.24	492.23	0.51	132.27	30.0
180	32.0	3.24	129.36	1830.47	263.65	0	2.24	527.01	0.59	180	32.0

Slewing bearing 2											
Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load FA	Horiz. sector load FR	Lever arm effect	Bolt stress	UF	Angle	Radius
[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[-]	[MPa]		[°]	[m]
14.36	4.0	3.24	50.09	539.82	180.36	0	2.85	459.72	0.51	14.36	4.0
21.61	6.0	3.24	50.09	539.82	180.36	0	2.85	459.72	0.51	21.61	6.0
28.96	8.0	3.24	50.09	539.82	180.36	0	2.85	459.72	0.51	28.96	8.0
36.42	10.0	3.24	50.09	539.82	180.36	0	2.85	459.72	0.51	36.42	10.0
44.05	12.0	3.24	50.09	539.82	180.36	0	2.85	459.72	0.51	44.05	12.0
51.89	14.0	3.24	50.09	539.82	180.36	0					

Hoist winch			Dynamic			Hoist		
Angle	Radius	Hook load	Dynamic hook load	load in hoist	winch	Static UF	Dynamic UF	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[0.54]	[0.54]	[1.00]
14.36	4.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
21.61	6.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
28.96	8.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
36.42	10.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
44.05	12.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
51.89	14.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
60	16.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
68.46	18.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
77.36	20.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
86.87	22.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
97.18	24.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
108.68	26.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
122.09	28.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
139.27	30.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00
180	32.0	18.2	54.42	27.21	27.21	0.54	0.54	1.00

Hoist winch			Dynamic			Hoist		
Angle	Radius	Hook load	Dynamic hook load	load in hoist	winch	Static UF	Dynamic UF	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[0.49]	[0.49]	[1.00]
14.36	4.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
21.61	6.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
28.96	8.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
36.42	10.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
44.05	12.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
51.89	14.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
60	16.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
68.46	18.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
77.36	20.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
86.87	22.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
97.18	24.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
108.68	26.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
122.09	28.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
139.27	30.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00
180	32.0	16.8	54.40	27.20	27.20	0.49	0.49	1.00

Hoist winch			Dynamic			Hoist		
Angle	Radius	Hook load	Dynamic hook load	load in hoist	winch	Static UF	Dynamic UF	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[0.46]	[0.46]	[1.00]
14.36	4.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
21.61	6.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
28.96	8.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
36.42	10.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
44.05	12.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
51.89	14.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
60	16.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
68.46	18.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
77.36	20.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
86.87	22.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
97.18	24.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
108.68	26.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
122.09	28.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
139.27	30.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00
180	32.0	15.6	54.40	27.20	27.20	0.46	0.46	1.00

Boom			Section 1			Section 1			Section 1			Section 1			Section 1			Section 1			Section 1			Section 1		
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	load horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises	Flange	UF Web	UF Flange								
[o]	[m]	[T]	[-]	[T]	[Tm]	[T]	[Tm]	[Tm]	[MPa]	[MPa]	[Tm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[0.10]	[0.10]								
14.36	4.0	18.2	2.99	71.16	80.52	18.22	66.04	135.51	10.68	7.12	187	18.88	6.81	31.65	28.49	0.09	0.09									
21.61	6.0	18.2	2.99	71.16	120.77	18.22	99.06	200.25	15.86	10.57	280	28.32	6.81	44.59	39.61	0.14	0.13									
28.96	8.0	18.2	2.99	71.16	161.03	18.22	132.08	264.50	20.84	13.89	373	37.76	6.81	57.35	50.65	0.18	0.16									
36.42	10.0	18.2	2.99	71.16	201.29	18.22	165.11	324.76	25.96	17.04	467	47.20	6.81	69.83	61.55	0.22	0.20									
44.05	12.0	18.2	2.99	71.16	241.55	18.22	198.13	379.86	29.59	19.95	560	56.64	6.81	81.99	72.25	0.26	0.23									
51.89	14.0	18.2	2.99	71.16	281.81	18.22	231.15	429.87	33.87	22.58	654	66.08	6.81	93.57	82.72	0.30	0.26									
60	16.0	18.2	2.99	71.16	322.07	18.22	264.17	473.15	37.28	24.85	747	75.52	6.81	104.63	92.90	0.33	0.30									
68.46	18.0	18.2	2.99	71.16	362.32	18.22	297.19	508.18	40.04	26.69	840	84.96	6.81	115.03	102.76	0.37	0.33									
77.36	20.0	18.2	2.99	71.16	402.58	18.22	330.21	545.31	42.01	28.00	934	94.40	6.81	124.65	112.23	0.40	0.36									
86.87	22.0	18.2	2.99	71.16	443.10	18.22	363.23	584.26	42.71	28.67	1027	103.84	6.81	133.37	121.27	0.43	0.39									
97.18	24.0	18.2	2.99	71.16	483.10	18.22	397.25	624.97	42.78	28.67	1120	113.28	6.81	141.05	129.82	0.45	0.41									
108.68	26.0	18.2	2.99	71.16	523.36	18.22	429.28	665.85	42.78	27.19	1214	122.72	6.81	147.54	137.82	0.47	0.44									
122.09	28.0	18.2	2.99	71.16	563.61	18.22	462.50	706.87	42.78	26.31	1307	132.16	6.81	152.69	145.21	0.49	0.46									
139.27	30.0	18.2	2.99	71.16	603.87	18.22	495.32	747.52	42.78	24.93	1400	141.60	6.81	156.18	151.91	0.50	0.48									
180	32.0	18.2	2.99	71.16	644.13	16.72	528.34	787.52	42.78	23.55	1494	151.04	6.81	157.85	157.85	0.50	0.50									

Boom			Section 1			Section 1			Section 1			Section 1			Section 1			Section 1			Section 1		
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web	Torsion flange	load horizontal at x=x1	Bending stress	Shear stress	Von mises	Von mises	Flange	UF Web	UF Flange					
[o]	[m]	[T]	[-]	[T]	[Tm]	[T]	[Tm]	[Tm]	[MPa]	[MPa]	[Tm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[0.10]	[0.10]					
14.36	4.0	16.8	3.24	71.16	80.52	16.78	60.81	128.32	10.11	6.74	180	18.17	6.69	30.41	27.47	0.09	0.09						
21.61	6.0	16.8	3.24	71.16	120.77	16.78	81.22	190.56	15.01	10.01	270	27.26	6.69	42.76	38.12	0.14	0.12						
28.96	8.0	16.8	3.24	71.16	161.03	16.78	101.62	250.46	19.73	13.16	359	36.34	6.69	54.96	48.69	0.18	0.16						
36.42	10.0	16.8	3.24	71.16	201.29	16.78	121.23	307.14	24.20	16.13	449	45.43	6.69	66.88	59.14	0.21	0.19						
44.05	12.0	16.8	3.24	71.16	241.55	16.78	141.55	359.69	28.34	18.89	539	54.52	6.69	78.46	69.40	0.25	0.22						
51.89	14.0	16.8	3.24	71.16	281.81	16.78	161.58	407.05	32.07	21.38	629	63.60	6.69	89.59	79.45	0.29	0.25						
60	16.0	16.8	3.24	71.16	322.07	16.78	181.25	448.83	35.30	23.53	719	72.69	6.69	100.20	89.23	0.32	0.28						
68.46	18.0	16.8	3.24	71.16	362.32	16.78	200.65	481.20	37.92	25.28	809	81.77	6.69	110.17	98.70	0.35	0.31						
77.36	20.0	16.8	3.24	71.16	402.58	16.78	219.58	504.81	39.78	26.52	899	87.96	6.69	119.42	107.82	0.38	0.34						
86.87	22.0	16.8	3.24	71.16	443.10	16.78	238.46	516.57	40.70	27.13	988	90.95	6.69	127.83	116.53	0.41	0.37						
97.18	24.0	16.8	3.24	71.16	483.10	16.78	256.87	516.57	40.44	26.94	1078	100.03	6.69	135.27	124.79	0.43	0.40						
108.68	26.0	16.8	3.24	71.16	523.36	16.78	273.56	493.08	38.61	26.56	1168	118.12	6.69	141.60	132.53	0.45	0.42						
122.09	28.0	16.8	3.24	71.16	563.61	16.78	290.68	438.30	34.53	23.02	1258	127.20	6.69	146.65	139.70	0.47	0.45						
139.27	30.0	16.8	3.24	71.16	603.87	16.78	307.55	337.55	26.60	17.73	1348	136.29	6.69	150.22	146.24	0.48	0.47						
180	32.0	16.8	3.24	71.16	644.13	16.78	324	0.00	1.74E-15	1.16E-15	1438	145.37	6.69	152.06	152.06	0.48	0.48						

C.5.4 Calculations for each component for $H_s = 4.5 - 5.5m$ with two falls

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor selfweight	Load factor hook	Load factor lead	Maximum utilization
[°]	[m]	[T]	[H]	[-]	[-]	[-]	[-]	[-]	
14.36	4.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
21.61	6.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
28.96	8.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
36.42	10.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
44.05	12.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
51.89	14.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
60	16.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
68.46	18.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
77.36	20.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
86.87	22.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
97.18	24.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
108.68	26.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
122.09	28.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
139.27	30.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00
180	32.0	14.2	4.5	3.84	1.22	1.22	1.34	1.34	1.00

Wire rope 0.160 tonne									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope	
[°]	[m]	[T]	Static DF	Dynamic DF	Static UF	Dynamic UF	Static UF	Dynamic UF	
14.36	4.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
21.61	6.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
28.96	8.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
36.42	10.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
44.05	12.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
51.89	14.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
60	16.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
68.46	18.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
77.36	20.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
86.87	22.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
97.18	24.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
108.68	26.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
122.09	28.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
139.27	30.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	
180	32.0	14.18	4.91	4.38	0.46	0.87	0.41	0.87	

Pedestal									
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	
14.36	4.0	4.28	12.71	207.00	103.44	9.87	3.63	13.49	0.04
21.61	6.0	4.28	12.71	310.50	103.44	14.80	3.63	18.43	0.06
28.96	8.0	4.28	12.71	413.99	103.44	19.74	3.63	23.36	0.08
36.42	10.0	4.28	12.71	517.49	103.44	24.67	3.63	28.30	0.11
44.05	12.0	4.28	12.71	620.99	103.44	29.60	3.63	33.23	0.14
51.89	14.0	4.28	12.71	724.49	103.44	34.54	3.63	38.16	0.17
60	16.0	4.28	12.71	827.99	103.44	39.47	3.63	43.09	0.20
68.46	18.0	4.28	12.71	931.49	103.44	44.41	3.63	48.02	0.23
77.36	20.0	4.28	12.71	1034.99	103.44	49.34	3.63	52.95	0.26
86.87	22.0	4.28	12.71	1138.49	103.44	54.27	3.63	57.88	0.29
97.18	24.0	4.28	12.71	1241.99	103.44	59.20	3.63	62.81	0.32
108.68	26.0	4.28	12.71	1345.49	103.44	64.14	3.63	67.74	0.35
122.09	28.0	4.28	12.71	1448.98	103.44	69.08	3.63	72.67	0.38
139.27	30.0	4.28	12.71	1552.48	103.44	74.01	3.63	77.60	0.41
180	32.0	4.28	12.71	1655.98	103.44	78.94	3.63	82.53	0.44

Crane total									
Angle	Radius	Hook load	Significant wave height	Dynamic amplifying factor (DAF)	Load factor	Load factor selfweight	Load factor hook	Load factor lead	Maximum utilization
[°]	[m]	[T]	[H]	[-]	[-]	[-]	[-]	[-]	
14.36	4.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
21.61	6.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
28.96	8.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
36.42	10.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
44.05	12.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
51.89	14.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
60	16.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
68.46	18.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
77.36	20.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
86.87	22.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
97.18	24.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
108.68	26.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
122.09	28.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
139.27	30.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88
180	32.0	11.65	4.97	5.16	1.35	1.35	54.38	0.38	0.88

Wire rope 0.160 tonne									
Angle	Radius	Hook load	Running rigging	Load reference factor for running rigging	Running rigging	Dynamic load	Hoist rope	Hoist rope	
[°]	[m]	[T]	Static DF	Dynamic DF	Static UF	Dynamic UF	Static UF	Dynamic UF	
14.36	4.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
21.61	6.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
28.96	8.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
36.42	10.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
44.05	12.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
51.89	14.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
60	16.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
68.46	18.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
77.36	20.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
86.87	22.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
97.18	24.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
108.68	26.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
122.09	28.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
139.27	30.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	
180	32.0	11.65	4.97	5.16	0.38	0.88	0.41	0.88	

Pedestal									
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]	
14.36	4.0	4.67	11.65	201.36	102.39	9.60	3.59	13.19	0.04
21.61	6.0	4.67	11.65	302.04	102.39	14.40	3.59	17.99	0.06
28.96	8.0	4.67	11.65	402.72	102.39	19.20	3.59	22.79	0.08
36.42	10.0	4.67	11.65	503.39	102.39	24.00	3.59	27.59	0.10
44.05	12.0	4.67	11.65	604.07	102.39	28.80	3.59	32.39	0.12
51.89	14.0	4.67	11.65	704.75	102.39	33.60	3.59	37.19	0.14
60	16.0	4.67	11.65	805.43	102.39	38.40	3.59	41.99	0.16
68.46	18.0	4.67	11.65	906.11	102.39	43.20	3.59	46.79	0.18
77.36	20.0	4.67	11.65	1006.79	102.39	48.00	3.59	51.59	0.20
86.87	22.0	4.67	11.65	1107.47	102.39	52.80	3.59	56.39	0.22
97.18	24.0	4.67	11.65	1208.15	102.39	57.60	3.59	61.19	0.24
108.68	26.0	4.67	11.65	1308.82	102.39	62.40	3.59	65.99	0.26
122.09	28.0	4.67	11.65	1409.50	102.39	67.19	3.59	70.79	0.28
139.27	30.0	4.67	11.65	1510.18	102.39	71.99	3.59	75.59	0.30
180	32.0	4.67	11.65	1610.86	102.39	76.79	3.59	80.39	0.32

Pedestal adapter										Sewing bearing 1										Sewing bearing 2													
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	4.57	11.65	201.36	102.44	9.60	0.41	10.01	0.03	14.36	4.0	3.84	125.89	214.91	18.33	0	2.24	36.63	0.04	14.36	4.0	2.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
21.61	6.0	4.67	11.65	302.04	102.44	14.40	0.41	16.81	0.05	21.61	6.0	3.84	125.89	322.36	34.67	0	2.24	69.30	0.08	21.61	6.0	3.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
28.96	8.0	4.67	11.65	402.72	102.44	19.20	0.41	19.61	0.07	28.96	8.0	3.84	125.89	429.82	51.01	0	2.24	101.97	0.15	28.96	8.0	4.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
36.42	10.0	4.67	11.65	503.39	102.44	24.00	0.41	24.41	0.08	36.42	10.0	3.84	125.89	537.27	67.36	0	2.24	134.64	0.15	36.42	10.0	5.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
44.05	12.0	4.67	11.65	604.07	102.44	28.80	0.41	29.21	0.10	44.05	12.0	3.84	125.89	644.73	83.70	0	2.24	167.31	0.19	44.05	12.0	6.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
51.89	14.0	4.67	11.65	704.75	102.44	33.60	0.41	34.01	0.11	51.89	14.0	3.84	125.89	752.18	100.04	0	2.24	199.98	0.22	51.89	14.0	7.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
60	16.0	4.67	11.65	805.43	102.44	38.40	0.41	38.81	0.12	60	16.0	3.84	125.89	859.64	116.39	0	2.24	232.65	0.26	60	16.0	8.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
68.46	18.0	4.67	11.65	906.11	102.44	43.20	0.41	43.60	0.14	68.46	18.0	3.84	125.89	967.09	132.73	0	2.24	265.32	0.33	68.46	18.0	9.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
77.36	20.0	4.67	11.65	1006.79	102.44	48.00	0.41	48.20	0.16	77.36	20.0	3.84	125.89	1074.55	149.07	0	2.24	297.98	0.37	77.36	20.0	10.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
86.87	22.0	4.67	11.65	1107.47	102.44	52.80	0.41	53.20	0.18	86.87	22.0	3.84	125.89	1182.00	165.41	0	2.24	330.65	0.40	86.87	22.0	11.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
97.18	24.0	4.67	11.65	1208.15	102.44	57.59	0.41	58.00	0.19	97.18	24.0	3.84	125.89	1289.46	181.76	0	2.24	363.32	0.44	97.18	24.0	12.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
108.68	26.0	4.67	11.65	1308.82	102.44	62.39	0.41	62.80	0.21	108.68	26.0	3.84	125.89	1396.91	198.10	0	2.24	395.99	0.48	108.68	26.0	13.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
122.09	28.0	4.67	11.65	1409.50	102.44	67.19	0.41	67.60	0.22	122.09	28.0	3.84	125.89	1504.37	214.44	0	2.24	428.66	0.48	122.09	28.0	14.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
139.27	30.0	4.67	11.65	1510.18	102.44	71.99	0.41	72.40	0.24	139.27	30.0	3.84	125.89	1611.82	230.79	0	2.24	461.33	0.51	139.27	30.0	15.0	46.61	484.22	161.49	0	2.85	364.72	0.41				
180	32.0	4.67	11.65	1610.86	102.44	76.79	0.41	77.20	0.26	180	32.0	3.84	125.89	1719.28	247.13	0	2.24	494.00	0.55	180	32.0	16.0	46.61	484.22	161.49	0	2.85	364.72	0.41				

Pedestal adapter										Sewing bearing 1										Sewing bearing 2													
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	4.28	12.71	207.00	103.85	9.67	0.45	10.31	0.03	14.36	4.0	4.28	123.91	207.00	17.35	0	2.24	34.66	0.04	14.36	4.0	2.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
21.61	6.0	4.28	12.71	310.50	103.85	14.40	0.45	15.25	0.05	21.61	6.0	4.28	123.91	310.50	33.09	0	2.24	66.15	0.11	21.61	6.0	3.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
28.96	8.0	4.28	12.71	413.99	103.85	19.20	0.45	20.18	0.07	28.96	8.0	4.28	123.91	413.99	48.83	0	2.24	97.61	0.17	28.96	8.0	4.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
36.42	10.0	4.28	12.71	517.49	103.85	24.00	0.45	25.12	0.08	36.42	10.0	4.28	123.91	517.49	64.57	0	2.24	129.08	0.16	36.42	10.0	5.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
44.05	12.0	4.28	12.71	620.99	103.85	28.80	0.45	30.05	0.10	44.05	12.0	4.28	123.91	620.99	80.31	0	2.24	160.54	0.14	44.05	12.0	6.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
51.89	14.0	4.28	12.71	724.49	103.85	34.54	0.45	34.98	0.12	51.89	14.0	4.28	123.91	724.49	96.06	0	2.24	192.01	0.21	51.89	14.0	7.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
60	16.0	4.28	12.71	827.99	103.85	39.47	0.45	39.92	0.13	60	16.0	4.28	123.91	827.99	111.80	0	2.24	223.48	0.25	60	16.0	8.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
68.46	18.0	4.28	12.71	931.49	103.85	44.34	0.45	44.85	0.15	68.46	18.0	4.28	123.91	931.49	127.54	0	2.24	254.94	0.28	68.46	18.0	9.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
77.36	20.0	4.28	12.71	1034.99	103.85	49.24	0.45	49.79	0.17	77.36	20.0	4.28	123.91	1034.99	143.28	0	2.24	286.41	0.32	77.36	20.0	10.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
86.87	22.0	4.28	12.71	1138.48	103.85	54.17	0.45	54.72	0.18	86.87	22.0	4.28	123.91	1138.48	159.02	0	2.24	317.87	0.35	86.87	22.0	11.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
97.18	24.0	4.28	12.71	1241.98	103.85	59.21	0.45	59.65	0.20	97.18	24.0	4.28	123.91	1241.98	174.76	0	2.24	349.34	0.35	97.18	24.0	12.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
108.68	26.0	4.28	12.71	1345.48	103.85	64.24	0.45	64.59	0.21	108.68	26.0	4.28	123.91	1345.48	190.50	0	2.24	380.81	0.35	108.68	26.0	13.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
122.09	28.0	4.28	12.71	1448.98	103.85	69.08	0.45	69.52	0.23	122.09	28.0	4.28	123.91	1448.98	206.25	0	2.24	412.27	0.46	122.09	28.0	14.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
139.27	30.0	4.28	12.71	1552.48	103.85	74.01	0.45	74.46	0.25	139.27	30.0	4.28	123.91	1552.48	221.99	0	2.24	443.74	0.49	139.27	30.0	15.0	44.64	452.57	150.74	0	2.85	384.24	0.43				
180	32.0	4.28	12.71	1655.98	103.85	78.94	0.45	79.39	0.26	180	32.0	4.28	123.91	1655.98	237.73	0	2.24	475.20	0.53	180	32.0	16.0	44.64	452.57	150.74	0	2.85	384.24	0.43				

Pedestal adapter										Sewing bearing 1										Sewing bearing 2													
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz. sector load	Vertical sector load	Horz. sector load	Lever arm effect	Bolt stress	UF
14.36	4.0	4.57	11.65	201.36	102.44	9.60	0.41	10.01	0.03	14.36	4.0	4.57	122.50	201.36	16.65	0	2.24	33.29	0.04	14.36	4.0	2.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
21.61	6.0	4.67	11.65	302.04	102.44	14.40	0.41	16.81	0.05	21.61	6.0	4.67	122.50	302.04	31.96	0	2.24	63.89	0.07	21.61	6.0	3.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
28.96	8.0	4.67	11.65	402.72	102.44	19.20	0.41	19.61	0.07	28.96	8.0	4.67	122.50	402.72	47.28	0	2.24	94.50	0.11	28.96	8.0	4.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
36.42	10.0	4.67	11.65	503.39	102.44	24.00	0.41	24.41	0.08	36.42	10.0	4.67	122.50	503.39	62.59	0	2.24	125.11	0.14	36.42	10.0	5.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
44.05	12.0	4.67	11.65	604.07	102.44	28.80	0.41	29.21	0.10	44.05	12.0	4.67	122.50	604.07	77.90	0	2.24	155.72	0.17	44.05	12.0	6.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
51.89	14.0	4.67	11.65	704.75	102.44	33.60	0.41	34.01	0.11	51.89	14.0	4.67	122.50	704.75	93.21	0	2.24	186.33	0.21	51.89	14.0	7.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
60	16.0	4.67	11.65	805.43	102.44	38.40	0.41	38.81	0.12	60	16.0	4.67	122.50	805.43	108.53	0	2.24	216.94	0.24	60	16.0	8.0	43.23	430.02	143.09	0	2.85	364.72	0.41				
68.46	18.0	4.67	11.65	906.11	102.44	43.20	0.41	43.60	0.14	68.46	18.0	4.6																					

Hoist winch									
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Static UF	Dynamic UF	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[0.42]	[1.00]	[0.42]	[1.00]
14.36	4.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
21.61	6.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
28.96	8.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
36.42	10.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
44.05	12.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
51.89	14.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
60	16.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
68.46	18.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
77.36	20.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
86.87	22.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
97.18	24.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
108.68	26.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
122.09	28.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
139.27	30.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00
180	32.0	14.2	54.40	27.20	0.42	1.00	0.42	1.00	1.00

Boom																		
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Section 1		Section 1		Section 1		Total design load at x=x1	Bending stress	Shear stress	web		Flange		UF Web	UF Flange
				Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web				Torsion flange	Bending stress	Von mises	Von mises		
[o]	[m]	[T]	[-]	[T]	[Tm]	[T]	[Tm]	[Tm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[0.09]	[0.08]
14.36	4.0	14.2	3.84	71.16	80.52	14.18	51.41	115.39	9.08	6.06	16.90	6.48	28.18	25.62	35.44	0.13	0.11	
21.61	6.0	14.2	3.84	71.16	120.77	14.18	102.82	173.36	13.50	9.00	25.35	6.48	39.49	35.44	45.19	0.16	0.14	
28.96	8.0	14.2	3.84	71.16	161.03	14.18	127.42	225.52	17.75	11.83	33.80	6.48	50.66	45.19	54.82	0.20	0.17	
36.42	10.0	14.2	3.84	71.16	201.29	14.18	154.23	276.60	21.76	14.51	41.8	6.48	61.60	54.82	64.30	0.23	0.21	
44.05	12.0	14.2	3.84	71.16	241.55	14.18	184.55	323.45	25.49	16.99	50.1	6.48	72.23	64.30	73.59	0.26	0.23	
51.89	14.0	14.2	3.84	71.16	282.81	14.18	219.94	366.04	28.84	19.23	58.5	6.48	82.47	73.59	82.64	0.29	0.26	
60	16.0	14.2	3.84	71.16	322.07	14.18	259.65	402.58	31.74	21.16	66.8	6.48	92.25	82.64	91.43	0.32	0.29	
68.46	18.0	14.2	3.84	71.16	362.32	14.18	302.32	432.72	34.10	22.73	75.2	6.48	101.47	91.43	99.90	0.35	0.32	
77.36	20.0	14.2	3.84	71.16	402.58	14.18	348.44	456.52	35.77	23.85	84.49	6.48	110.06	99.90	108.03	0.38	0.34	
86.87	22.0	14.2	3.84	71.16	442.84	14.18	398.47	473.10	36.60	24.25	91.9	6.48	117.91	108.03	115.75	0.40	0.37	
97.18	24.0	14.2	3.84	71.16	483.10	14.18	450.71	482.57	36.37	24.25	101.39	6.48	124.91	115.75	123.03	0.42	0.39	
108.68	26.0	14.2	3.84	71.16	523.36	14.18	504.18	494.34	34.72	23.15	108.84	6.48	130.94	123.03	129.82	0.43	0.41	
122.09	28.0	14.2	3.84	71.16	563.61	14.18	559.88	503.54	23.92	15.94	117.0	6.48	135.87	129.82	136.05	0.44	0.43	
139.27	30.0	14.2	3.84	71.16	603.87	14.18	603.87	503.54	0.00	1.74E-15	123.9	6.48	139.51	136.05	141.66	0.45	0.43	
180	32.0	14.2	3.84	71.16	644.13	14.18	644.13	503.54	0.00	1.74E-15	137	6.48	141.66	141.66	141.66	0.45	0.43	

Hoist winch									
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Static UF	Dynamic UF	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[0.37]	[1.00]	[0.37]	[1.00]
14.36	4.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
21.61	6.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
28.96	8.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
36.42	10.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
44.05	12.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
51.89	14.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
60	16.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
68.46	18.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
77.36	20.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
86.87	22.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
97.18	24.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
108.68	26.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
122.09	28.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
139.27	30.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00
180	32.0	12.7	54.35	27.17	0.37	1.00	0.37	1.00	1.00

Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Section 1		Section 1		Section 1		Total design load at x=x1	Bending stress	Shear stress	web		Flange		UF Web	UF Flange
				Shear boom	Moment horizontal	Shear boom	Moment horizontal	Torsion	Torsion web				Torsion flange	Bending stress	Von mises	Von mises		
[o]	[m]	[T]	[-]	[T]	[Tm]	[T]	[Tm]	[Tm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[0.09]	[0.08]	
14.36	4.0	12.7	4.28	71.16	80.52	12.71	46.06	108.03	8.51	5.67	16.17	6.36	26.92	24.58	33.92	0.12	0.11	
21.61	6.0	12.7	4.28	71.16	120.77	12.71	69.09	160.43	12.64	8.43	24.26	6.36	37.64	33.92	43.20	0.15	0.14	
28.96	8.0	12.7	4.28	71.16	161.03	12.71	92.12	210.86	16.61	11.08	32.35	6.36	48.23	43.20	52.37	0.19	0.17	
36.42	10.0	12.7	4.28	71.16	201.29	12.71	115.15	258.58	20.37	13.58	40.43	6.36	58.60	52.37	61.40	0.22	0.20	
44.05	12.0	12.7	4.28	71.16	241.55	12.71	141.55	302.82	23.86	15.91	48.50	6.36	68.70	61.40	70.26	0.25	0.22	
51.89	14.0	12.7	4.28	71.16	282.81	12.71	161.21	342.70	27.00	18.00	56.61	6.36	78.43	70.26	80.96	0.28	0.25	
60	16.0	12.7	4.28	71.16	322.07	12.71	180.24	377.19	29.72	19.81	64.0	6.36	87.74	78.90	87.30	0.31	0.28	
68.46	18.0	12.7	4.28	71.16	362.32	12.71	207.27	405.12	31.49	21.28	72.78	6.36	96.54	87.30	95.41	0.33	0.30	
77.36	20.0	12.7	4.28	71.16	402.58	12.71	230.30	428.58	32.80	22.32	80.87	6.36	104.75	95.41	103.19	0.35	0.32	
86.87	22.0	12.7	4.28	71.16	442.84	12.71	253.33	443.90	34.27	22.84	88.95	6.36	112.28	103.19	109.19	0.36	0.33	
97.18	24.0	12.7	4.28	71.16	483.10	12.71	276.36	453.10	34.05	22.70	96.0	6.36	119.03	109.19	116.62	0.38	0.35	
108.68	26.0	12.7	4.28	71.16	523.36	12.71	299.39	452.80	32.51	21.67	104.00	6.36	124.89	116.62	124.19	0.40	0.38	
122.09	28.0	12.7	4.28	71.16	563.61	12.71	322.42	453.61	29.07	19.38	113.21	6.36	129.74	124.19	130.25	0.41	0.40	
139.27	30.0	12.7	4.28	71.16	603.87	12.71	345.45	453.61	22.39	14.93	121.30	6.36	133.42	130.25	135.42	0.43	0.42	
180	32.0	12.7	4.28	71.16	644.13	12.71	368.48	453.61	0.00	1.74E-15	128.0	6.36	135.74	135.74	135.74	0.43	0.43	

Hoist winch									
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Static UF	Dynamic UF	Hoist winch	Hoist winch
[o]	[m]	[T]	[T]	[T]	[T]	[0.34]	[1.00]	[0.34]	[1.00]
14.36	4.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
21.61	6.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
28.96	8.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
36.42	10.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
44.05	12.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
51.89	14.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
60	16.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
68.46	18.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
77.36	20.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
86.87	22.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
97.18	24.0	11.7	54.38	27.19	0.34	1.00	0.34	1.00	1.00
108.68	26.0	11.7</							

C.5.5 Calculations for each component for $H_s = 6m$ with two falls

Frame total											
Angle	Radius	Hook load	Significant wave height	Dynamic		Load factor	Load factor hook	Maximum utilization			
				amplifying factor (DAF)	Φ						
14.36	4.0	10.8	6	5.03	1.22	1.34	1.00				
21.61	6.0	10.8	6	5.03	1.22	1.34	1.00				
28.96	8.0	10.8	6	5.03	1.22	1.34	1.00				
36.42	10.0	10.8	6	5.03	1.22	1.34	1.00				
44.05	12.0	10.8	6	5.03	1.22	1.34	1.00				
51.89	14.0	10.8	6	5.03	1.22	1.34	1.00				
60	16.0	10.8	6	5.03	1.22	1.34	1.00				
68.46	18.0	10.8	6	5.03	1.22	1.34	1.00				
77.36	20.0	10.8	6	5.03	1.22	1.34	1.00				
86.87	22.0	10.8	6	5.03	1.22	1.34	1.00				
97.12	24.0	10.8	6	5.03	1.22	1.34	1.00				
108.18	26.0	10.8	6	5.03	1.22	1.34	1.00				
122.09	28.0	10.8	6	5.03	1.22	1.34	1.00				
139.27	30.0	10.8	6	5.03	1.22	1.34	1.00				
180	32.0	10.8	6	5.03	1.22	1.34	1.00				

Wire rope 0-160 (zome)											
Angle	Radius	Hook load	Static DF	Running rigging	Load reference factor for running rigging	Dynamic DF	Dynamic load	Static UF	Dynamic UF		
										14.36	4.0
21.61	6.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
28.96	8.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
36.42	10.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
44.05	12.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
51.89	14.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
60	16.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
68.46	18.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
77.36	20.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
86.87	22.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
97.12	24.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
108.18	26.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
122.09	28.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
139.27	30.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			
180	32.0	10.82	4.99	5.25	1.96	54.39	0.36	0.89			

Pedestal											
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF		
										14.36	4.0
21.61	6.0	5.03	10.82	295.36	101.56	14.08	3.56	17.64	0.06		
28.96	8.0	5.03	10.82	393.81	101.56	18.77	3.56	22.33	0.07		
36.42	10.0	5.03	10.82	492.26	101.56	23.47	3.56	27.03	0.09		
44.05	12.0	5.03	10.82	590.71	101.56	28.16	3.56	31.72	0.11		
51.89	14.0	5.03	10.82	689.16	101.56	32.85	3.56	36.41	0.12		
60	16.0	5.03	10.82	787.61	101.56	37.55	3.56	41.11	0.14		
68.46	18.0	5.03	10.82	886.07	101.56	42.24	3.56	45.80	0.15		
77.36	20.0	5.03	10.82	984.52	101.56	46.93	3.56	50.49	0.17		
86.87	22.0	5.03	10.82	1082.97	101.56	51.63	3.56	55.19	0.18		
97.12	24.0	5.03	10.82	1181.42	101.56	56.32	3.56	59.88	0.20		
108.18	26.0	5.03	10.82	1279.87	101.56	61.02	3.56	64.57	0.21		
122.09	28.0	5.03	10.82	1378.33	101.56	65.71	3.56	69.27	0.23		
139.27	30.0	5.03	10.82	1476.78	101.56	70.40	3.56	73.96	0.25		
180	32.0	5.03	10.82	1575.23	101.56	75.09	3.56	78.65	0.26		

Pedestal adapter										Stewing bearing 1										Stewing bearing 2										
Angle	Radius	Dynamic amplifying factor (DAF)	Hook load	Bending moment	Axial force	Bending stress	Axial stress	Combined stress	UF	Angle	Radius	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- ontal sector load	Lever arm effect	Bolt stress	UF	Angle	Radius	Radius slewing bearing 2	Dynamic amplifying factor (DAF)	Vertical load	Bending Moment	Vertical sector load	Horz- ontal sector load	Lever arm effect	Bolt stress	UF
[°]	[m]	[-]	[T]	[TM]	[T]	[MPa]	[MPa]	[MPa]		[°]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[-]	[MPa]		[°]	[m]	[m]	[-]	[T]	[TM]	[kN]	[kN]	[-]	[MPa]	
14,36	4,0	5,03	10,82	196,90	101,32	9,39	0,38	9,77	0,03	14,36	4,0	5,03	121,38	196,90	16,10	0	2,24	32,19	0,04	14,36	4,0	2,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
21,61	6,0	5,03	10,82	295,36	101,32	14,08	0,38	14,46	0,05	21,61	6,0	5,03	121,38	295,36	31,08	0	2,24	62,12	0,07	21,61	4,0	3,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
28,96	8,0	5,03	10,82	393,81	101,32	18,77	0,38	19,15	0,06	28,96	8,0	5,03	121,38	393,81	46,05	0	2,24	92,05	0,10	28,96	4,0	4,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
36,42	10,0	5,03	10,82	492,26	101,32	23,47	0,38	23,85	0,08	36,42	10,0	5,03	121,38	492,26	61,02	0	2,24	121,98	0,14	36,42	5,0	5,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
44,05	12,0	5,03	10,82	590,71	101,32	28,16	0,38	28,54	0,09	44,05	12,0	5,03	121,38	590,71	76,00	0	2,24	151,91	0,17	44,05	6,0	6,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
51,89	14,0	5,03	10,82	689,16	101,32	32,85	0,38	33,23	0,11	51,89	14,0	5,03	121,38	689,16	90,97	0	2,24	181,84	0,20	51,89	7,0	7,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
60	16,0	5,03	10,82	787,61	101,32	37,55	0,38	37,93	0,13	60	16,0	5,03	121,38	787,61	105,94	0	2,24	211,78	0,24	60	8,0	8,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
68,46	18,0	5,03	10,82	886,07	101,32	42,24	0,38	42,62	0,14	68,46	18,0	5,03	121,38	886,07	120,92	0	2,24	241,71	0,27	68,46	10,0	9,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
77,36	20,0	5,03	10,82	984,52	101,32	46,93	0,38	47,31	0,16	77,36	20,0	5,03	121,38	984,52	135,89	0	2,24	271,64	0,30	77,36	11,0	10,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
86,87	22,0	5,03	10,82	1082,97	101,32	51,63	0,38	52,01	0,17	86,87	22,0	5,03	121,38	1082,97	150,87	0	2,24	301,57	0,37	86,87	12,0	11,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
97,18	24,0	5,03	10,82	1181,42	101,32	56,32	0,38	56,70	0,19	97,18	24,0	5,03	121,38	1181,42	165,84	0	2,24	331,50	0,40	97,18	13,0	12,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
108,68	26,0	5,03	10,82	1279,87	101,32	61,01	0,38	61,39	0,20	108,68	26,0	5,03	121,38	1279,87	180,81	0	2,24	361,43	0,43	108,68	14,0	13,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
122,09	28,0	5,03	10,82	1378,33	101,32	65,71	0,38	66,09	0,22	122,09	28,0	5,03	121,38	1378,33	195,79	0	2,24	391,37	0,45	122,09	15,0	14,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
139,27	30,0	5,03	10,82	1476,78	101,32	70,40	0,38	70,78	0,23	139,27	30,0	5,03	121,38	1476,78	210,76	0	2,24	421,30	0,47	139,27	16,0	15,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39
180	32,0	5,03	10,82	1575,23	101,32	75,09	0,38	75,47	0,25	180	32,0	5,03	121,38	1575,23	225,74	0	2,24	451,23	0,50	180	18,0	16,0	5,03	42,11	412,20	137,04	0	2,85	349,31	0,39

Hoist winch										
Angle	Radius	Hook load	Dynamic hook load	Dynamic load in hoist	Hoist winch	Hoist winch	Static UF	Dynamic UF		
[°]	[m]	[T]	[T]	[T]	[T]	[T]				
14,36	4,0	10,8	54,39	27,20	0,32	1,00				
21,61	6,0	10,8	54,39	27,20	0,32	1,00				
28,96	8,0	10,8	54,39	27,20	0,32	1,00				
36,42	10,0	10,8	54,39	27,20	0,32	1,00				
44,05	12,0	10,8	54,39	27,20	0,32	1,00				
51,89	14,0	10,8	54,39	27,20	0,32	1,00				
60	16,0	10,8	54,39	27,20	0,32	1,00				
68,46	18,0	10,8	54,39	27,20	0,32	1,00				
77,36	20,0	10,8	54,39	27,20	0,32	1,00				
86,87	22,0	10,8	54,39	27,20	0,32	1,00				
97,18	24,0	10,8	54,39	27,20	0,32	1,00				
108,68	26,0	10,8	54,39	27,20	0,32	1,00				
122,09	28,0	10,8	54,39	27,20	0,32	1,00				
139,27	30,0	10,8	54,39	27,20	0,32	1,00				
180	32,0	10,8	54,39	27,20	0,32	1,00				

Boom																		
Angle	Radius	Hook load	Dynamic amplifying factor (DAF)	Section 1				Torsion web	Torsion flange	Bending horizontal at x=1	Web				Flange		UF Web	UF Flange
				Shear boom	Moment horizontal	Shear boom	Moment horizontal				Torsion	Torsion	Bending stress	Shear stress	Von mises	Von mises		
[°]	[m]	[T]	[]	[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]		
14,36	4,0	10,8	5,03	71,16	80,52	10,82	39,23	98,64	7,77	5,18	151	15,25	6,20	25,32	23,25	0,08	0,07	
21,61	6,0	10,8	5,03	71,16	120,77	10,82	58,85	146,49	11,54	7,69	226	22,87	6,20	25,32	31,98	0,11	0,10	
28,96	8,0	10,8	5,03	71,16	161,03	10,82	78,47	192,53	15,17	10,11	302	30,50	6,20	25,32	40,65	0,14	0,13	
36,42	10,0	10,8	5,03	71,16	201,29	10,82	98,08	236,51	18,60	12,40	377	38,12	6,20	25,32	49,25	0,17	0,16	
44,05	12,0	10,8	5,03	71,16	241,55	10,82	117,70	276,51	21,79	14,52	452	45,74	6,20	25,32	57,72	0,20	0,19	
51,89	14,0	10,8	5,03	71,16	281,81	10,82	137,32	312,91	24,66	16,44	528	53,37	6,20	25,32	66,02	0,23	0,21	
60	16,0	10,8	5,03	71,16	322,07	10,82	156,94	344,42	27,14	18,09	603	60,99	6,20	25,32	74,14	0,26	0,24	
68,46	18,0	10,8	5,03	71,16	362,32	10,82	176,55	369,92	29,15	19,43	679	68,62	6,20	25,32	82,04	0,29	0,26	
77,36	20,0	10,8	5,03	71,16	402,58	10,82	196,17	388,06	30,58	20,38	754	76,24	6,20	25,32	90,26	0,31	0,29	
86,87	22,0	10,8	5,03	71,16	442,84	10,82	215,79	397,10	31,29	20,73	829	83,87	6,20	25,32	97,99	0,34	0,31	
97,18	24,0	10,8	5,03	71,16	483,10	10,82	235,40	394,58	31,68	20,73	905	91,49	6,20	25,32	104,08	0,36	0,33	
108,68	26,0	10,8	5,03	71,16	523,36	10,82	255,02	376,74	29,68	19,79	980	99,11	6,20	25,32	110,75	0,37	0,35	
122,09	28,0	10,8	5,03	71,16	563,61	10,82	274,64	336,93	26,55	17,70	1056	106,74	6,20	25,32	117,03	0,39	0,37	
139,27	30,0	10,8	5,03	71,16	603,87	10,82	294,25	294,25	20,45	13,63	1131	114,36	6,20	25,32	122,85	0,40	0,39	
180	32,0	10,8	5,03	71,16	644,13	10,82	313,87	0,00	1,74E-15	1,16E-15	1206	121,99	6,20	25,32	128,19	0,41	0,41	

Section 2										Section 3													
Self weight only	Self weight only	Hook load only	Hook load only	Torsion	Torsion	Torsion	Torsion	Torsion	Torsion	TOTAL DESIGN	WEB	FLANGE	UF	UF	Self weight only	Self weight only	Hook load only	Hook load only	TOTAL DESIGN	Bending	Shear	Von mises	UF
Shear boom	Moment horizontal	Shear boom	Moment horizontal	web	flange	horizontal at x=x1	stress	stress	Von mises	Von mises	Von mises	Von mises	Section 2	Section 2	Shear boom	Moment horizontal	Shear boom	Moment horizontal	horizontal at x=x1	stress	stress	Von mises	Section 3
[T]	[TM]	[T]	[TM]	[MPa]	[MPa]	[TM]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]			[T]	[TM]	[T]	[TM]	[TM]	[MPa]	[MPa]	[MPa]	
30.33	27.01	10.82	23.00	398.64	12.53	8.35	7.49	3.68	24.41	18.28	0.08	0.06			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	36.24	10.82	34.50	146.49	18.61	12.41	10.63	3.68	35.26	25.81	0.11	0.08			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	45.46	10.82	46.00	192.53	24.46	16.31	13.76	3.68	45.81	33.19	0.15	0.11			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	54.69	10.82	57.50	236.11	29.99	20.00	16.90	3.68	55.88	40.28	0.18	0.13			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	63.92	10.82	69.00	276.51	35.13	23.42	20.03	3.68	65.30	46.98	0.21	0.15			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	73.15	10.82	80.50	312.91	39.75	26.50	23.17	3.68	73.90	53.17	0.24	0.17			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	82.38	10.82	92.00	344.42	43.75	29.17	26.30	3.68	81.49	58.75	0.26	0.19			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	91.61	10.82	103.50	369.92	46.99	31.33	29.43	3.68	87.87	63.57	0.28	0.20			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	100.84	10.82	115.00	388.06	49.30	32.86	32.57	3.68	92.76	67.48	0.30	0.22			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	110.07	10.82	126.50	397.10	50.44	33.63	35.70	3.68	95.84	70.31	0.31	0.22			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	119.30	10.82	137.99	394.58	50.12	33.42	38.84	3.68	96.67	71.82	0.31	0.23			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	128.53	10.82	149.49	376.74	47.86	31.91	41.97	3.68	94.63	71.68	0.30	0.23			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	137.76	10.82	160.99	336.93	42.80	28.53	45.11	3.68	88.75	69.44	0.28	0.22			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	146.98	10.82	172.49	259.49	32.96	21.98	48.24	3.68	77.17	64.38	0.25	0.21			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18
30.33	156.21	10.82	183.99	0.00	2.80E-15	1.87E-15	51.38	3.68	55.05	55.05	0.18	0.18			15.99	119.77	10.82	16.235	364	54.15	2.44	56.59	0.18

Section 4		Section 1		Section 1		Section 1		Section 1		Section 1		Section 4	
Self weight only	Self weight only	Hook load only	Hook load only	Total weight	Bending load horizontal at x=1	Bending stress	Shear stress	Von mises	UF				
[T]	[TM]	[T]	[TM]	[TM]	[TM]	[MPa]	[MPa]	[MPa]					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					
1,29	0,42	10,82	5,41	8	1,59	1,44	3,03	0,01					

Velocity check				VH/VS	
Minimum steady hosting velocity	Maximum steady hosting velocity	VH (m/s)	VS (m/s)		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		
0,10	2,30	0,36	0,36		


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'HS=4
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ActiveCell.FormulaR1C1 = "5"
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Sheets("Utilizations").Range("I5").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E3")
Sheets("Utilizations").Range("I6").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E4")
Sheets("Utilizations").Range("I7").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E5")
Sheets("Utilizations").Range("I8").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E6")
Sheets("Utilizations").Range("I9").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E7")
Sheets("Utilizations").Range("I10").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E8")
Sheets("Utilizations").Range("I11").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E9")
Sheets("Utilizations").Range("I12").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E10")
Sheets("Utilizations").Range("I13").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E11")
Sheets("Utilizations").Range("I14").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E12")
Sheets("Utilizations").Range("I15").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E13")
Sheets("Utilizations").Range("I16").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E14")
Sheets("Utilizations").Range("I17").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E15")
Sheets("Utilizations").Range("I18").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E16")
Sheets("Utilizations").Range("I19").GoalSeek Goal:=1, ChangingCell:=Sheets("Calculations").Range("E17")
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D Appendix D: Bolt

From [26]

ROCKSIDE
EXPORT LIMITED


PROPERTIES OF GRADE 10.9 BOLT & NUT (ISO)

BOLT SIZE	PITCH	STRESS AREA MM2	BOLT/STUD/SCREW ISO 898-1 Gr. 10.9						NUT ISO 898-2 Gr. 10		
			PROOF STRESS N/MM2	PROOF LOAD KN	TENSILE STRESS N/MM2	TORQUE* N-m	HARDNESS HRC	ELONGATION# %	PROOF STRESS N/MM2	PROOF LOAD KN	HARDNESS HRC
M6	1	20.1	830	16.7	1,040.0	13.4	32-39	9.0	1050	20.9	28-38
M8	1.25	36.6	830	30.4	1,040.0	32.6	32-39	9.0	1060	38.1	28-38
M10	1.5	58.8	830	48.8	1,040.0	65.5	32-39	9.0	1060	61.7	28-38
M12	1.75	84.3	830	70.0	1,040.0	112.7	32-39	9.0	1050	88.5	28-38
M14	2.0	115.0	830	95.5	1,040.0	179.4	32-39	9.0	1050	120.8	28-38
M16	2.0	157.0	830	130.3	1,040.0	279.9	32-39	9.0	1060	166.4	28-38
M18	2.5	192.0	830	159.4	1,040.0	385.1	32-39	9.0	1060	203.5	28-38
M20	2.5	245.0	830	203.4	1,040.0	546.0	32-39	9.0	1060	259.7	28-38
M22	2.5	303.0	830	251.5	1,040.0	742.8	32-39	9.0	1060	321.2	28-38
M24	3.0	353.0	830	293.0	1,040.0	944.0	32-39	9.0	1060	374.2	28-38
M27	3.0	459.0	830	381.0	1,040.0	1,381	32-39	9.0	1060	486.5	28-38
M30	3.5	561.0	830	465.6	1,040.0	1,875	32-39	9.0	1060	594.7	28-38
M33	3.5	694.0	830	576.0	1,040.0	2,552	32-39	9.0	1060	735.6	28-38
M36	4.0	817.0	830	678.1	1,040.0	3,277	32-39	9.0	1060	866.0	28-38
M39	4.0	976.0	830	810.1	1,040.0	4,241	32-39	9.0	1060	1,034.6	28-38
M42	4.5	1,120.0	830	929.6	1,040.0	5,242	32-39	9.0	1060	1,187.2	28-38
M45	4.5	1,310.0									
M48	5.0	1,470.0									
M52	5.0	1,760.0									
M56	5.5	2,030.0									
M60	5.5	2,360.0									
M64	6.0	2,680.0									
M68	6.0	3,060.0									
M72	6.0	3,460.0									

DIMENSIONS	NORMAL HEX	NORMAL HEX
MARKINGS	'RS' 'M' '10.9'	'RS' '10'
CARBON	0.15-0.35	-0.58
MANAGENESE	0.7-	VD.30-
SULPHUR	-0.035	-0.058
SILICON		
CHROMIUM		
MOLYDENUM		
NICKLE		
VANADIUM		
BORON	-0.003	
PHOSPHOROUS	-0.035	-0.046
MATERIAL	Carbon with add Eg B, Mn or Cr Quenched & tempered	Medium Carbon or Alloy Steel

NOTES:

Left hand side of '-' is minimum value
 Right hand side of '-' is maximum value
 Eg. 0.5 - 0.7 min. is 0.5 and max is 0.7
 Eg. -0.8 max is 0.8 no minimum value
 Eg. 2.0- min. is 2.0 no maximum value

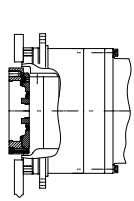
* Torque value based on 75% of proof load and finish as recieved steel

While every care has been taken in preparation of the information, the company accepts no liability for any loss or damage either direct or consequential. Please refer Original standards for details.

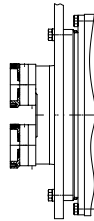
E Appendix E: Hoist winch

From [27]

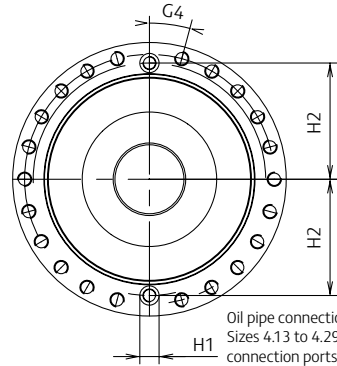
Technical Data



Integrated drive unit



Drive unit with spur gear



Oil pipe connection ports
 Sizes 4.13 to 4.29: the oil pipe connection ports are on the gear mounting flange.
 Sizes 4.31 and above: the oil pipe connection is on the gearbox face.

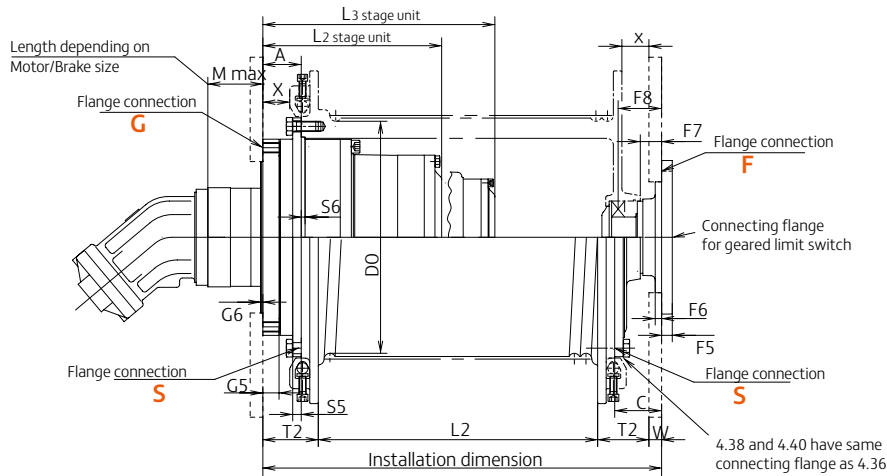
Type	Nominal gearbox ratings			Max input speed	D O approx	G Flange connection – Gear unit to frame Bolts class 10.9						S Flange connection – Gear unit to drum Bolts class 8.8						F F 1 location
	T _{dyn} max l ≤ 70 l > 70	T _{stat} max l ≤ 70 l > 70	Typical line pull F _{nom} (kN)			n _{max} (rpm)	ca.	G 1 location ∅	G 2 pcd ∅ ± 0,2	G 3 outer ∅	G 4 fixing ∅	G 5	G 6	S 1 location ∅	S 2 pcd ∅ ± 0,2	S 3 outer ∅	S 4 fixing ∅	
ZHP	1.650	2.650	17	180	125	145	167	30° 12 * M 10	16	5	145	185	203	30° 12 * ∅ 11	10	9	120	
	1.750	2.800	18															
4.15	4.000	6.400	33	260	155	185	213	20° 16 * M 12	24	5	225	245	265	20° 18 * ∅ 11	10	9	150	
	4.150	6.650	34															
4.19	7.000	11.200	46	300	190	225	255	20° 16 * M 16	25	5	265	290	310	15° 24 * ∅ 14	12	9	175	
	7.300	11.700	48															
4.20	11.200	18.000	67	340	200	255	285	20° 16 * M 16	25	5	295	320	340	15° 24 * ∅ 14	12	9	175	
	11.600	18.500	69															
4.22	18.800	30.000	95	390	230	280	315	15° 22 * M 16	25	5	330	360	390	20° 18 * ∅ 18	16	9	200	
	19.400	31.000	98															
4.24	25.000	40.000	116	440	270	320	355	15° 22 * M 16	25	5	370	400	430	15° 24 * ∅ 18	16	9	200	
	25.500	41.000	119															
4.25	35.000	56.000	143	480	300	350	385	15° 22 * M 20	30	5	400	440	480	18 * ∅ 22	20	9	230	
	36.000	57.500	147															
4.26	47.000	75.000	180	520	330	390	425	15° 22 * M 20	30	5	440	480	520	15° 24 * ∅ 22	20	9	260	
	48.000	77.000	184															
4.27	61.000	97.500	213	570	355	420	460	15° 22 * M 24	38	5	470	520	560	20° 18 * ∅ 26	24	9	260	
	63.000	101.000	220															
4.29	102.000	163.000	304	670	430	480	530	15° 22 * M 24	38	5	550	590	630	15° 24 * ∅ 26	24	9	300	
	105.000	168.000	313															
4.31	150.000	240.000	395	770	515	565	615	15° 24 * M 30	47	5	640	690	750	15° 24 * ∅ 33	30	9	325	
	155.000	248.000	408															
4.32	229.000	366.500	549	830	580	630	680	15° 24 * M 30	47	5	700	755	815	15° 24 * ∅ 33	30	9	325	
	236.000	377.500	566															
4.33	300.000	480.000	637	930	670	720	770	12° 30 * M 30	47	5	790	840	890	12° 30 * ∅ 33	30	9	375	
	311.000	497.500	660															
4.34	392.000	627.000	760	1.030	720	770	820	10° 36 * M 30	47	5	850	900	950	10° 36 * ∅ 33	30	9	375	
	406.000	649.500	787															
4.36	623.000	997.000	1.038	1.200	840	900	960	10° 36 * M 36	56	5	1.000	1.055	1.120	10° 36 * ∅ 39	36	9	430	
	644.000	1.030.500	1.073															
4.38	1.050.000	1.680.000	1.450	1.360	1.060	1.140	1.210	# 10° 36 * M 30	78	26	1.240	1.320	1.390	# 10° 36 * ∅ 33	45	13	600	
	1.100.000	1.760.000	1.520															
4.40	1.400.000	2.240.000	1.820	1.530	1.160	1.240	1.310	# 10° 36 * M 30	78	26	1.340	1.420	1.490	# 10° 36 * ∅ 33	45	13	600	
	1.500.000	2.400.000	1.950															
4.44	2.400.000	3.840.000	2.540	1.800	1.250	1.350	1.441	# 7,5° 48 * M 30	105	25	1.630	1.725	1.820	# 7,5° 48 * M 33	55	25	750	
	2.500.000	4.000.000	2.650															

Depending on motor and brake arrangement: 2000...5000 rpm

Rating according to FEM section I

Drive unit class M5
 Load condition L 2 (P = const./ n_{ab} = 15 rpm)
 Running time class T5
 # With clamping sleeves

ZOLLERN have a policy of continuous product improvement, and detail may be changed without notice.



Flange Connection – End support bearing to frame – Bolts class 8.8										Assembly length = L2 + 2 • T2 + W depending on design										Type	
F 2 pcd	F 3 outer	F 4 fixing	F 5	F 6	F 7	F 8	H 1	H 2	A	C	M _{max}	T 1 min.		T 2	W approx frame thickness	L x min.		ZHP	EG		
± 0,2	∅	60° 6 • ∅					∅					2-stages	3-stages		2-stages	3-stages					
140	160	60° 6 • ∅ 9	12	8	20	36	–	–	40	55	130	165	–	70	10	170	–	10	4.13		
175	200	60° 6 • ∅ 11	15	8	25	50	26	93,5	55	70	140	185	255	85	15	225	295	15	4.15		
200	225	60° 6 • ∅ 11	15	10	30	64	26	111	60	75	170	190	290	95	15	245	340	15	4.19		
200	225	60° 6 • ∅ 11	15	10	30	64	26	117	60	75	140	225	295	95	15	270	350	15	4.20		
230	260	60° 6 • ∅ 14	18	12	35	71	26	132	60	75	170	245	345	100	15	300	410	15	4.22		
230	260	60° 6 • ∅ 14	18	12	35	71	26	152	60	80	170	270	405	100	20	325	460	20	4.24		
260	290	60° 6 • ∅ 18	18	15	40	78	30	168	75	95	160	270	395	120	20	350	480	20	4.25		
310	360	60° 6 • ∅ 22	25	15	50	92	30	184	75	95	210	305	445	120	20	375	510	20	4.26		
310	360	60° 6 • ∅ 22	25	15	50	92	30	195,5	90	110	200	325	455	140	20	420	560	20	4.27		
350	400	60° 6 • ∅ 22	30	15	50	104	30	233	90	115	200	370	520	145	25	465	620	25	4.29		
375	425	60° 6 • ∅ 26	35	15	70	134	–	235	110	140	200	375	540	180	30	515	685	30	4.31		
375	425	60° 6 • ∅ 26	35	15	70	134	–	268	110	140	150	465	695	180	30	590	815	30	4.32		
435	500	60° 6 • ∅ 33	40	15	80	144	–	298	110	160	150	470	720	180	40	675	925	40	4.33		
435	500	60° 6 • ∅ 33	40	15	80	144	–	335	120	160	140	495	760	200	40	700	975	40	4.34		
490	550	60° 6 • ∅ 33	40	15	90	180	–	385	120	190	110	685	970	240	50	875	1.160	50	4.36		
680	750	30° 12 • ∅ 33	50	20	80	180	–	460/497	130	170	–	960	1.320	230	60	1.195	1.555	50	4.38		
680	750	30° 12 • ∅ 33	50	20	80	180	–	460/545	130	170	–	1.235	1.650	195	60	1.320	1.735	50	4.40		
850	950	15° 24 • ∅ 33	60	25	110	230	–	675/675	115	210	–	–	1.750	220	80	–	1.690	70	4.44		

F Appendix F: Wire rope

From [28]

CASAR EUROLIFT / Rotation-Resistant Ropes // Drehungsfreie Seile

Nominal Diameter // Nenn-durchmesser				Minimum Breaking Force // Mindestbruchkraft							
				Weight // Gewicht		1960 N/mm ²				2160 N/mm ²	
mm	inch	kg/m	lb/ft	kN	t [metric]	lbs	t [2000 lbs]	kN	t [metric]	lbs	t [2000 lbs]
10		0,50	0,33	89,6	9,14	20.143	10,07	97,4	9,93	21.896	10,95
11	7/16	0,61	0,41	108,8	11,09	24.459	12,23	118,4	12,07	26.617	13,31
12		0,73	0,49	130,8	13,34	29.405	14,70	139,9	14,27	31.451	15,73
13	1/2	0,81	0,54	146,4	14,93	32.912	16,46	161,4	16,46	36.284	18,14
14		0,84	0,57	152,7	15,57	34.328	17,16	165,4	16,87	37.183	18,59
15		0,97	0,65	179,1	18,26	40.263	20,13	190,9	19,47	42.916	21,46
16	5/8	1,12	0,75	204,0	20,80	45.861	22,93	219,5	22,38	49.346	24,67
17		1,28	0,86	230,6	23,51	51.841	25,92	249,1	25,40	56.000	28,00
18		1,43	0,96	257,9	26,30	57.978	28,99	280,6	28,61	63.081	31,54
19	3/4	1,61	1,08	293,9	29,97	66.071	33,04	317,5	32,38	71.377	35,69
20		1,79	1,20	329,0	33,55	73.962	36,98	352,8	35,98	79.313	39,66
21		2,01	1,35	362,2	36,93	81.426	40,71	391,7	39,94	88.058	44,03
22		2,19	1,47	396,1	40,39	89.047	44,52	430,9	43,94	96.870	48,44
23	7/8	2,42	1,62	441,4	45,01	99.231	49,62	472,0	48,13	106.110	53,05
24		2,47	1,66	450,4	45,93	101.254	50,63	481,6	49,11	108.268	54,13
25		2,64	1,78	471,8	48,11	106.065	53,03	513,2	52,33	115.372	57,69
26		2,89	1,94	524,3	53,46	117.867	58,93	564,1	57,52	126.815	63,41
27		3,07	2,06	567,9	57,91	127.669	63,83	609,4	62,14	136.999	68,50
28	1	3,17	2,13	586,2	59,78	131.783	65,89	629,0	64,14	141.405	70,70
29		3,35	2,25	614,9	62,70	138.235	69,12	657,4	67,04	147.789	73,89
30		3,64	2,44	654,2	66,71	147.070	73,53	711,7	72,57	159.996	80,00
31		3,91	2,63	712,9	72,70	160.266	80,13	765,6	78,07	172.114	86,06
32	1 1/8	4,09	2,75	742,4	75,70	166.898	83,45	797,3	81,30	179.240	89,62
33		4,19	2,82	754,6	76,95	169.641	84,82	821,0	83,72	184.568	92,28
34		4,48	3,01	817,4	83,35	183.759	91,88	877,9	89,52	197.360	98,68
35		4,83	3,25	869,7	88,69	195.516	97,76	958,4	97,73	215.457	107,73
36	1 1/4	5,12	3,44	930,0	94,83	209.072	104,54	1.002,8	102,26	225.438	112,72
37		5,47	3,68	992,8	101,24	223.190	111,60	1.094,1	111,57	245.963	122,98
38		5,76	3,87	1.045,0	106,56	234.925	117,46	1.130,9	115,32	254.236	127,12
39	1 3/8	6,16	4,14	1.107,3	112,91	248.931	124,47	1.198,4	122,20	269.411	134,71
40		6,51	4,38	1.185,0	120,84	266.399	133,20	1.262,3	128,72	283.776	141,89
41	1 1/2	7,21	4,84	1.319,0	134,50	296.523	148,26	1.412,2	144,01	317.475	158,74
42		8,04	5,40	1.462,0	149,08	328.671	164,34	1.560,4	159,12	350.792	175,40
43	1 5/8	8,41	5,65	1.556,1	158,68	349.825	174,91	1.610,4	164,22	362.032	181,02
44		8,85	5,94	1.611,2	164,30	362.212	181,11	1.667,4	170,03	374.846	187,42
45		9,71	6,52	1.767,0	180,19	397.237	198,62	1.823,0	185,90	409.827	204,91
46	1 3/4	9,75	6,55	1.803,4	183,90	405.420	202,71	1.861,3	189,80	418.437	209,22
47		10,68	7,18	1.935,0	197,32	435.005	217,50	1.989,7	202,90	447.302	223,65
48	1 7/8	11,58	7,78	2.113,3	215,50	475.089	237,54	2.187,0	223,01	491.657	245,83
49		12,50	8,40	2.272,8	231,76	510.946	255,47	2.504,7	255,41	563.079	281,54
50	2	13,04	8,77	2.346,1	239,24	527.424	263,71	2.585,5	263,65	581.243	290,62
51		14,18	9,53	2.500,0	254,93	562.022	281,01	2.750,0	280,42	618.224	309,11
52	2 1/8	14,69	9,87	2.651,2	270,35	596.013	298,01	2.921,7	297,93	656.824	328,41
53		15,75	10,58	2.851,2	290,74	640.975	320,49	3.142,2	320,42	706.395	353,20
54	2 1/4	16,32	10,97	2.953,9	301,22	664.063	332,03	3.255,4	331,96	731.843	365,92
55		16,83	11,31	3.058,5	311,88	687.578	343,79	3.370,6	343,71	757.741	378,87
56		18,01	12,10	3.273,1	333,77	735.822	367,91	3.607,1	367,83	810.908	405,45

Special constructions and diameters available – please contact us directly. // Sonderausführungen möglich – bitte sprechen Sie uns an.

// 03.2019

