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teamleider Vergunningen, Toezicht & Handhaving a.i.

REPORT

Assessment of Wadden Lighthouses

Client: Rijkswaterstaat Corporate Dienst

Reference: BK3248-RHD-XX-XX-RP-S-0001
Status: Final/01
Date: 13 February 2025

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Enhancing Society Together

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DUTCH SUMMARY

De voorliggende notitie beschrijft een controle van de constructieve veiligheid van de vuurtorens van Texel, Ameland en Schiermonnikoog ten aanzien van het vervangen van de huidige radarinstallaties. De opdracht betreft een update van de eerdere beoordeling van de vuurtorens, zoals gepresenteerd in [1], [2], [3], [4], [5]. Daarom moet deze notitie in samenhang met de eerder genoemde documenten worden gelezen. In de initiële beoordeling van de vuurtorens zijn de afmetingen van de nieuwe radarinstallatie gebaseerd op aannames. Aangezien er de nieuwe radarinstallatie sindsdien bekend is geworden, zijn de initiële berekeningen herzien.

In hoofdstuk 2 beschrijven we de aanpak voor de beoordeling. Hoofdstuk 3 behandelt de bijgestelde windbelastingen op de radar, waarbij we rekening houden met de definitieve installatie. In hoofdstuk 4 presenteren we de bijgewerkte resultaten voor de vuurtoren van Texel, vooral met betrekking tot de ankerlengte voor de basis van de stalen kolommen. Hoofdstuk 5 presenteert de conclusies.

De notitie bevat de volgende bijlagen:

- Bijlage A bevat de ontvangen informatie met betrekking tot de definitieve radarantenne.
- Bijlage B bevat de bijgewerkte windbelastingberekeningen.
- Bijlage C bevat de uitwerking van de aanvullende gedetailleerde berekeningen (de ankerlengte voor de basis van de stalen kolommen van de vuurtoren van Texel).

Aanpak

- Gegevens van de definitieve radarinstallatie zijn herzien.
- Windbelastingen op de definitieve radarinstallatie zijn bepaald.
- Structurele beoordelingen zijn uitgevoerd en het FEM-model voor de vuurtoren van Texel is bijgewerkt.

Update windbelasting

- De definitieve radarantenne is kleiner dan aanvankelijk aangenomen, wat leidt tot verminderde windbelastingen.
- Bijgewerkte berekeningen tonen aanzienlijke verminderingen in horizontale kracht en buigmoment.

Controle berekening Texel

- Herziene berekeningen voor de vuurtoren van Texel tonen voldoende capaciteit om de nieuwe radarinstallatie te ondersteunen.
- Aanbevelingen voor boutkwaliteiten en verankeringsdiepte zijn bijgesteld.

Conclusie

- Conclusies t.a.v. constructieve veiligheid voor de vuurtorens van Texel, Ameland en Schiermonnikoog blijven ongewijzigd, met voldoende capaciteit om de nieuwe radarinstallaties te ondersteunen.
- Met betrekking tot de vuurtoren Texel:
    - De bouten van de verbinding bij het bovenste punt van de bogen van het frame moeten 16 x M16 bouten zijn, met een minimale kwaliteit van 8.8. Of de huidige bouten van deze

kwaliteit zijn kan waarschijnlijk worden afgelezen van de boutkoppen. Anderzijds kunnen de bouten een voor een vervangen worden door het juiste exemplaar.

- Aangezien de capaciteit van de ankers tussen de stalen kolommen en de betonnen vloer voldoende is, rekening houdend met de bijgewerkte krachten van de definitieve antenne, kan de aanbeveling met betrekking tot hun diepte worden genegeerd. Wij concluderen dat de verbinding voldoende capaciteit heeft.

1 Introduction

The assignment involves the structural assessment of the replacement of radar installations on lighthouses in Texel (Eierland), Ameland, and Schiermonnikoog (Noordertoren). The lighthouses are shown in Figure 1-1. This document concerns an update to the previous assessment of the lighthouses, as presented in [1], [2], [3], [4], [5]. Thus, this document should be read in conjunction with the previously referenced documents.

Based on the conclusion of the previous assessment [3], which showed that the structure of the Terschelling (Brandaris) lighthouse does not comply with the structural safety requirements, the Terschelling (Brandaris) lighthouse is not included in this updated assessment.

In the initial assessment of the lighthouses, the new radar antenna dimensions have been based on assumptions. Since information has been received with respect to the chosen radar antenna, the initial calculations have been revised.



(a) Texel



(b) Terschelling



(c) Ameland



(d) Schiermonnikoog

Figure 1-1 Lighthouses (source: vuurtorens.org)

1.1 Reading guide

- In Chapter 2 the approach for this assessment is explained.
- In Chapter 3 the update in loads caused by the wind loads on the radar, considering the final antenna, are explained.
- In Chapter 4 the updated results for the Texel lighthouse are presented, mainly with respect to the anchorage length for the base of the steel columns.
- In Chapter 5 the conclusions are shown.

The report contains the following appendices:

- Appendix A contains the information received with respect to the final radar antenna.
- Appendix B contains the updated wind load calculations.
- Appendix C contains the elaboration of the additional detailed calculations (the anchorage length for the base of the steel columns of the Texel lighthouse)

1.2 Applicable documents

[1] Report “Radarinstallaties vuurtorens Waddeneilanden – Uitgangspunten constructieve beoordeling”, Royal HaskoningDHV, d.d. 29 september 2023, reference BI6464-109-VT-WAD-RI-RP-0001

[2] Report “Radarinstallaties vuurtorens Waddeneilanden – Constructieve beoordeling Texel”, Royal HaskoningDHV, d.d. 29 september 2023, reference BI6464-109-VT-WAD-RI-RP-0002

[3] Report “Radarinstallaties vuurtorens Waddeneilanden – Constructieve beoordeling Terschelling”, Royal HaskoningDHV, d.d. 29 september 2023, reference BI6464-109-VT-WAD-RI-RP-0003

[4] Report “Radarinstallaties vuurtorens Waddeneilanden – Constructieve beoordeling Ameland”, Royal HaskoningDHV, d.d. 29 september 2023, reference BI6464-109-VT-WAD-RI-RP-0004

[5] Report “Radarinstallaties vuurtorens Waddeneilanden – Constructieve beoordeling Schiermonnikoog”, Royal HaskoningDHV, d.d. 29 september 2023, reference BI6464-109-VT-WAD-RI-RP-0005

[6] E-mail: “Afmetingen en massa huidige radars”, Leo Smits (Rijkswaterstaat Centrale Informatievoorziening), d.d. 13-02-2023

[7] E-mail: “Controle berekeningen radarinstallaties”, Leo Smits (Rijkswaterstaat Centrale Informatievoorziening), d.d. 22 mei 2024

2 Approach

The approach to the assessment of the lighthouses, concerning the updated information on the radar antenna concerns the following steps:

- Review the supplied data of the final radar installation.
- Determine the wind loads on the final radar installation.
- Perform the assessment of the support structures under the loads on the final radar installation, compared to the loads on the assumed radar installation.
- Adjust the loads in the FEM model of the Texel radar and perform the check of the anchorage length under the new loading conditions.
- Conclude the assessment for lighthouses Texel (Eierland), Ameland, and Schiermonnikoog (Noordertoren).

Note: Lighthouse Terschelling is not included in this updated assessment, based on the initial results of our assessment.

3 Wind force update

In the updated calculations, all the principles that have been included in the initial Basis of Assessment report [1] have been maintained. The only difference concerns the dimensions of the radar antenna, which has an influence on the wind loads transferred to the structure.

3.1 Final radar dimensions

In the initial calculations, data provided by the Rijkswaterstaat [6] was used as a starting point for the calculations, as presented in Table 3-1. The updated data provided by Rijkswaterstaat (see Appendix A and [7]), considering the chosen radar antenna is presented in Table 3-2. As requested by Rijkswaterstaat, for both the assumed and final radar installations, a conservative factor of 1.15 has been used in the area's calculation. Comparing the two tables, it can immediately be observed that the dimensions of the radar assumed in the initial calculations have been conservatively chosen.

Table 3-1 Properties of the assumed radar installation

Totaal weight [kg]	Wind area radar antenna (115%) [m^2]	Wind area radar base (115%) [m^2]	Total wind area (115%) [m^2]	Form
550	4,81	1,77	6,58	Rectangular with round corners

Table 3-2 Properties of the final radar installation

Totaal weight [kg]	Wind area radar antenna (115%) [m^2]	Wind area radar base (115%) [m^2]	Total wind area (115%) [m^2]	Form
374	1,86	0,94	2,80	Obround

3.2 Updated wind load

The wind load on the lighthouse was determined using NEN-EN-1991-1-4 and §4.2 of the Basis of Assessment report [1]. The updates only concern the wind loads on the radar installation. Compared to the initial assessment, the wind load calculation has been updated, considering:

- The final dimensions of the radar antenna and radar base.
- The form factors, considering the actual geometry of the radar antenna and radar base.
    - Since the form of the radar antenna is obround (compared to the initially assumed rectangular with round corners), a reduction of the ψ_r factor is used.
    - In the initial calculations a value of 0.88 is used for ψ_r, while in the final calculations the value is reduced to 0.5.
- The correct lever arm of the bending moment caused by the wind on the radar antenna and radar base.

The table below shows an overview of the wind load calculation for the three considered lighthouses. The extended calculations are shown in Appendix B.

Table 3-3 Wind load final radar antenna

	$C_{f.radar}$	$C_{f.base}$	F_w [kN]	M_w [kNm]
Texel	0.73	0.96	4.51	4.88
Ameland	0.73	0.96	4.85	5.24
Schiermonnikoog	0.73	N.v.t.	2.72	1.63

3.3 Wind load comparison

The updated calculations lead to a significant reduction of both the horizontal force and bending moment caused by the wind on the radar antenna and radar base. The significant reduction is caused by three reasons:

- The considerably smaller dimensions of the final radar antenna and radar base, compared to the assumed dimensions (2,5x smaller radar antenna, and 2x smaller radar base).
- The form of the radar antenna (obround, compared to assumption of rectangular with round corners)
- The form of the radar base (cylindrical, compared to the assumption of rectangular prism).

.

This is shown in the table below, where the initially assumed and the final forces are compared. The updated horizontal force represents up to 25% of the assumed horizontal force, while the updated bending moment represents up to 20% of the assumed bending moment.

Table 3-4 Forces comparison between the initially assumed and final radar

	Fw initial [kN]	Fw final [kN]	Mw initial [kNm]	Mw final [kNm]	Fw reduction	Mw reduction
Texel	18.80	4.51	25.71	4.88	**0.24**	**0.19**
Ameland	20.20	4.85	27.62	5.24	**0.24**	**0.19**
Schiermonnikoog	12.06	2.72	11.27	1.63	**0.23**	**0.14**

4 Texel model update

In the initial assessment of the Texel lighthouse, two critical connections have been addressed:

- The connection at the top of the radar frame → the initial recommendation was to check that the 16 M16 bolts should be of at least the grade 8.8. This recommendation does not change, since the bolt strength of 8.8 is preferable for such a connection. The grade should be readable on the bolt head. If the replacement of the bolts is required, they can be replaced one by one.

- The connection with chemical anchors to the concrete floor → a revised calculation for this connection has been performed, using the updated loads.

The FEM Model used is identical to the one presented in Appendix E of the *"Constructieve beoordeling Texel"* report [2], with the exception of the updated forces caused by the wind on the radar (horizontal force and moment). The axial force and the shear force at the bolted connection, considering the load update, are shown in Figure 4-1 and Figure 4-2.

The results of the updated calculation of the connection with chemical anchors is presented below. The results are based on an anchor drilled and glued 80mm into a concrete floor with a grade of at least C20/25. The extended results can be found in Appendix F.

Table 4-1 Overview of the updated anchorage depth calculation

Tension/bolt [kN]	Shear/bolt [kN]	Tension capacity bolt [kN]	Shear capacity bolt [kN]	Tension + Shear U.C.
6,26	1,47	83,73	50,24	0.49

A significant reduction is observed compared to the initial calculation. A unity check of 0,49 is obtained, assuming an 80mm anchorage depth. In the initial calculation, a unity check of 0,86 has been obtained assuming an 100mm anchorage depth. Based on these updated results, we consider that the capacity of the anchored connection is sufficient to withstand the new radar.



Figure 4-1 Axial force at bolted connection, FEM model considering the updated loads

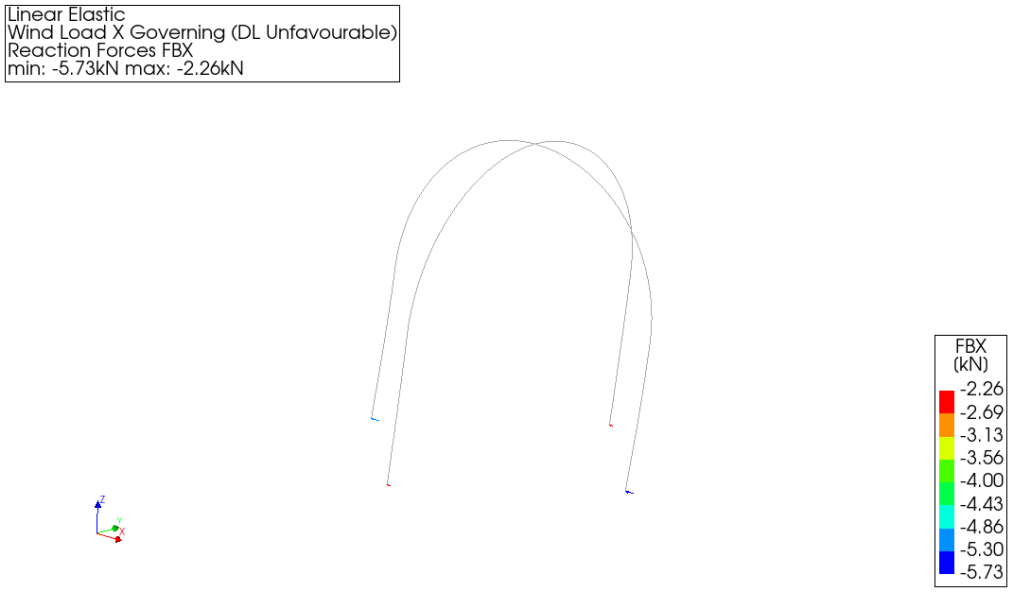


Figure 4-2 Shear force at bolted connection, FEM model considering the updated loads

5 Conclusion

Due to the fact that the final radar antenna is significantly lower in size than the initially assumed radar antenna, it is concluded that the previous assessment, as described in [1], [2], [3], [4], [5], has followed a conservative approach.

We note that the check of the direct connection between the radar antenna/turning unit and the support structure was not part of our assessment. We assume this will be considered as a part of the suppliers engineering related to the execution of the radar replacement.

5.1 Lighthouse Texel

The conclusion on the structural safety of the Texel lighthouse with respect to the replacement of the radar installation remains similar to the one in the *Constructieve beoordeling Texel* report [2][5]. The only difference refers to the Recommendations (Chapter 5.2 of [2] – specifically with respect to the anchorage of the steel columns in the concrete floor). The main points are reiterated below, while the full conclusions and recommendations (except for the difference explained above) should be read as the one in report [2].

- We conclude that the lighthouse meets the structural safety requirements of Besluit bouwwerken leefomgeving and has sufficient capacity to support the new radar installation.

The following recommendation still applies:

- The bolts of the connection at the top intersection of the arcs should be at least 16 x M16 bolts, with a minimum grade of 8.8. Thus, the connection should be checked and, if the bolts are of a lower grade, they should be replaced.

Since the capacity of the anchors between the steel columns and the concrete floor is sufficient, considering the updated forces of the final antenna, the recommendation regarding their depth can be disregarded. It is concluded that the connection does have sufficient capacity.

5.2 Lighthouse Ameland

The conclusion on the structural safety of the Ameland lighthouse with respect to the replacement of the radar installation remains the same as in the *Constructieve beoordeling Ameland* report [4]. The main points are reiterated below, while the full conclusion should be read as the one in report [4].

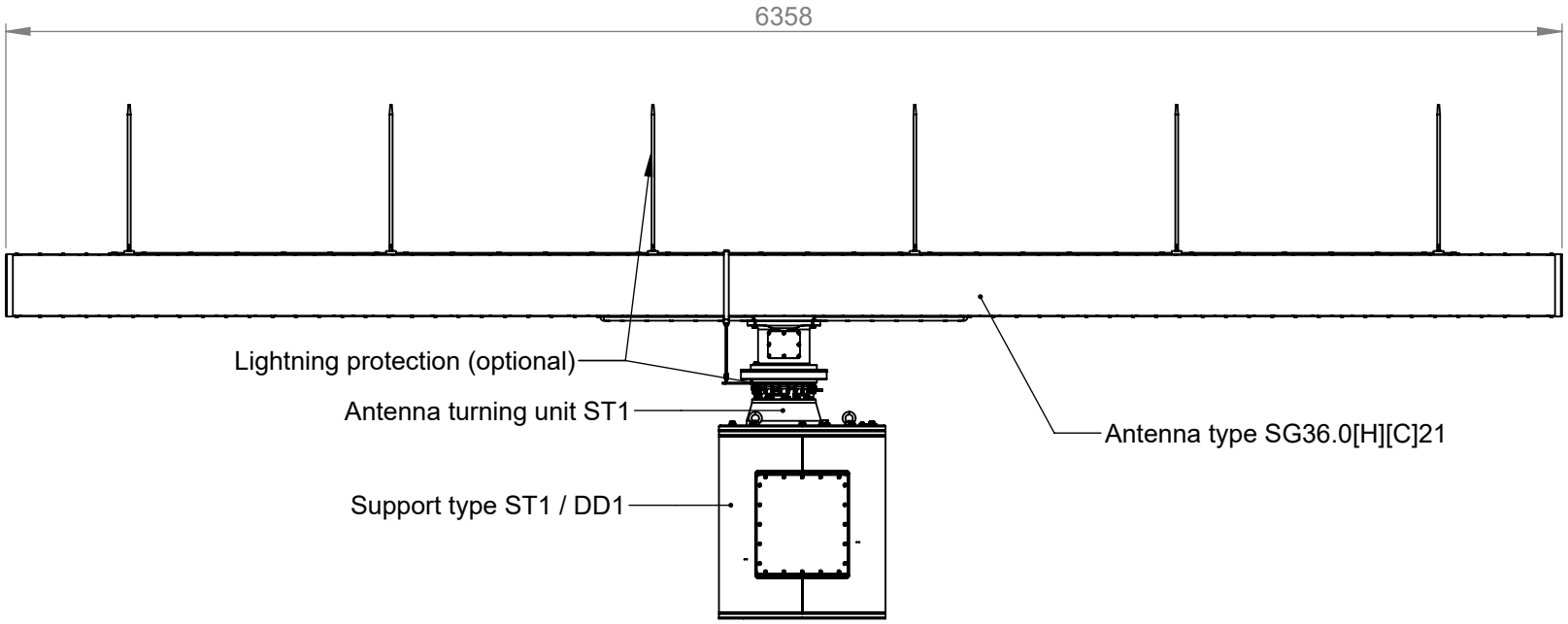
- We conclude that the lighthouse meets the structural safety requirements of Besluit bouwwerken leefomgeving and has sufficient capacity to support the new radar installation.

5.3 Lighthouse Schiermonnikoog

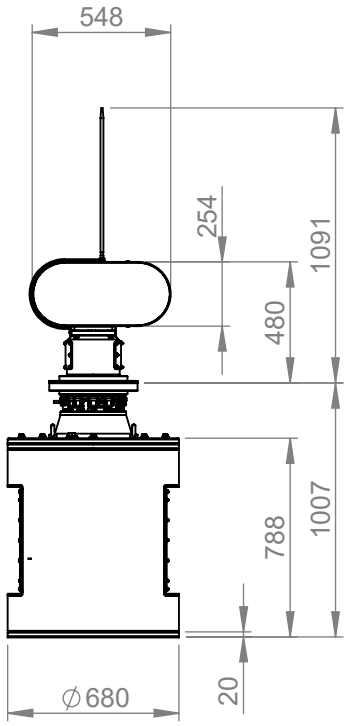
The conclusion on the structural safety of the Schiermonnikoog lighthouse with respect to the replacement of the radar installation remains the same as in the *Constructieve beoordeling Schiermonnikoog* report [5]. The main points are reiterated below, while the full conclusion should be read as the one in report [5].

- We conclude that the lighthouse meets the structural safety requirements of Besluit bouwwerken leefomgeving and has sufficient capacity to support the new radar installation.

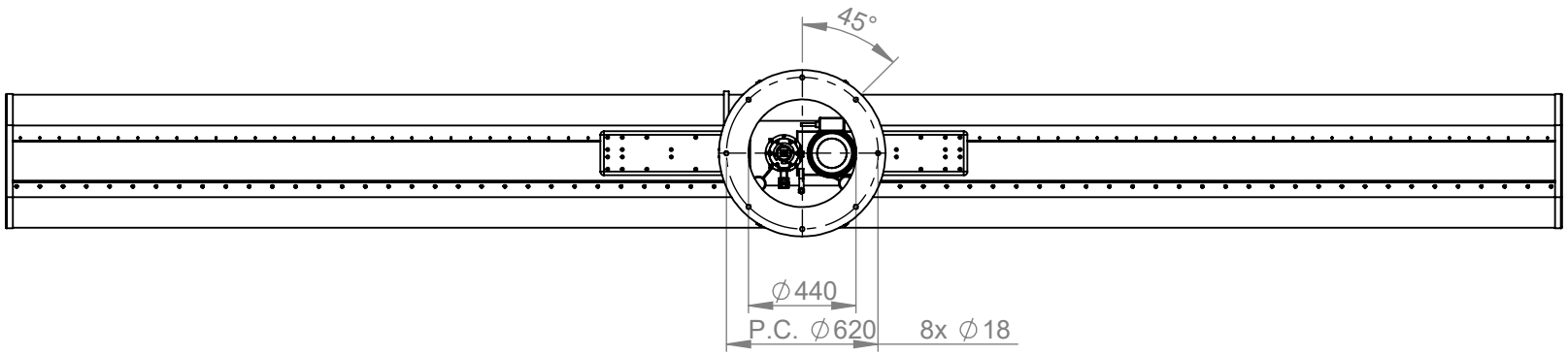
Appendix A – New radar antenna information



Front view



Side view

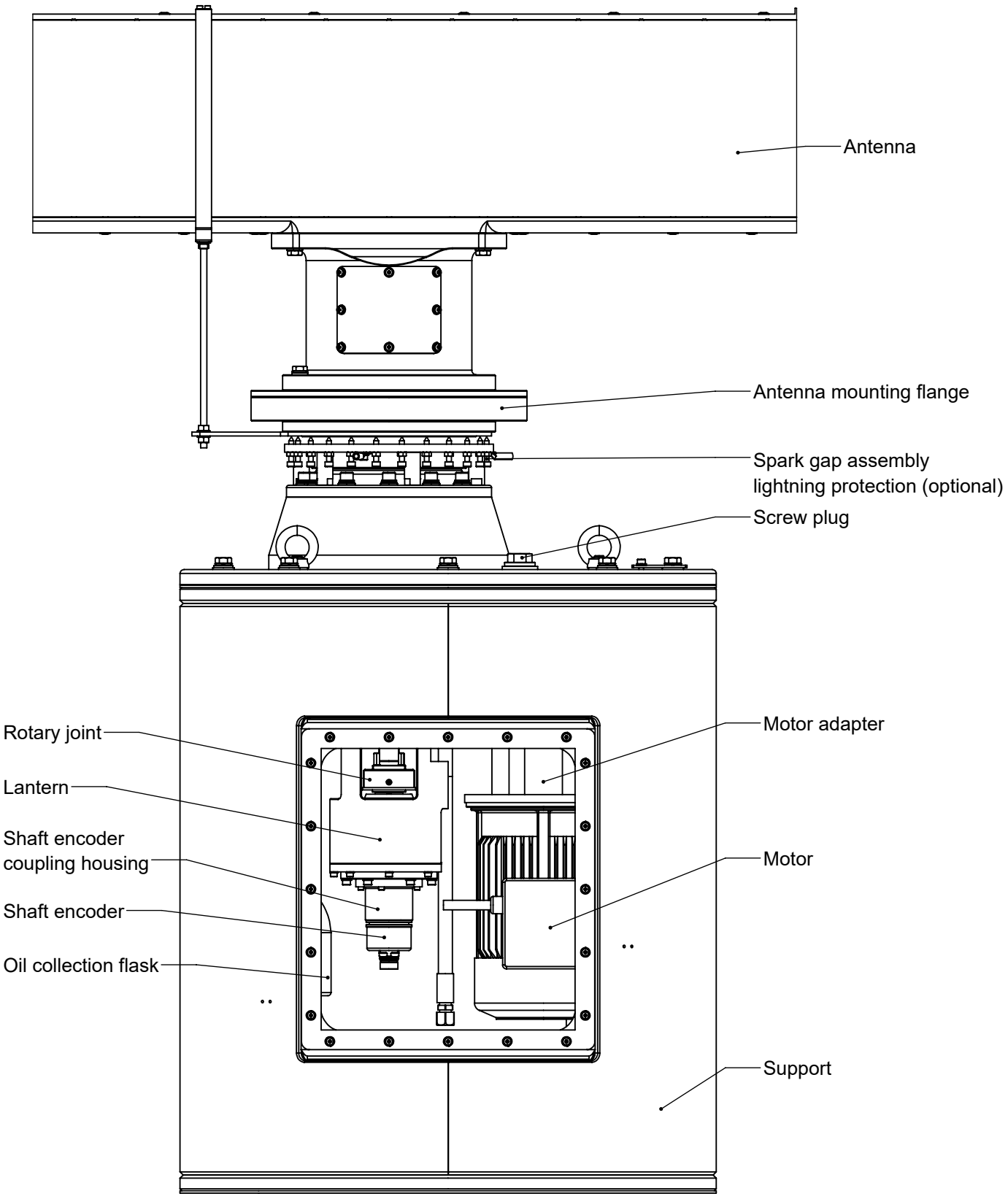


Bottom view

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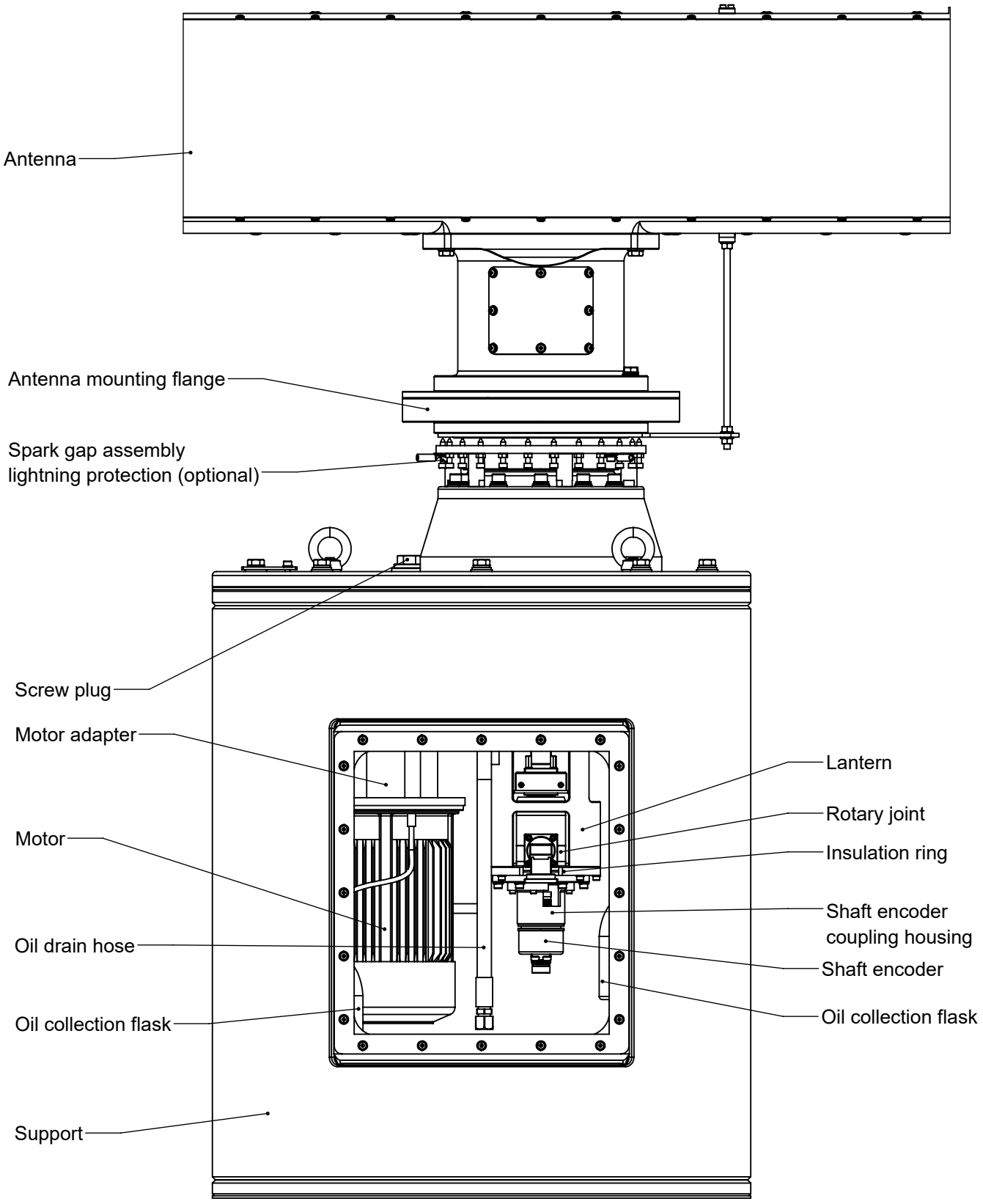
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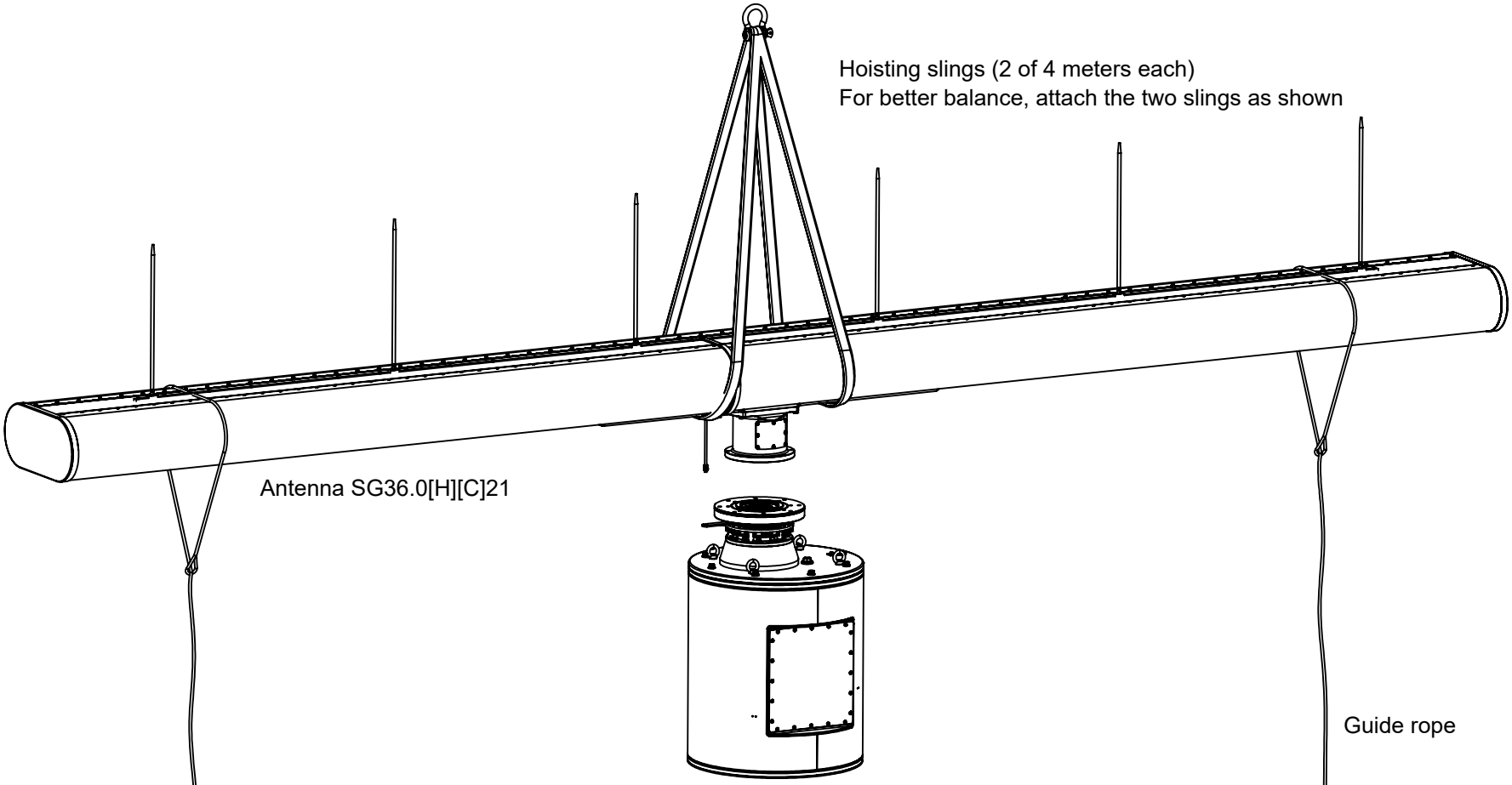
Hatch cover removed for better view

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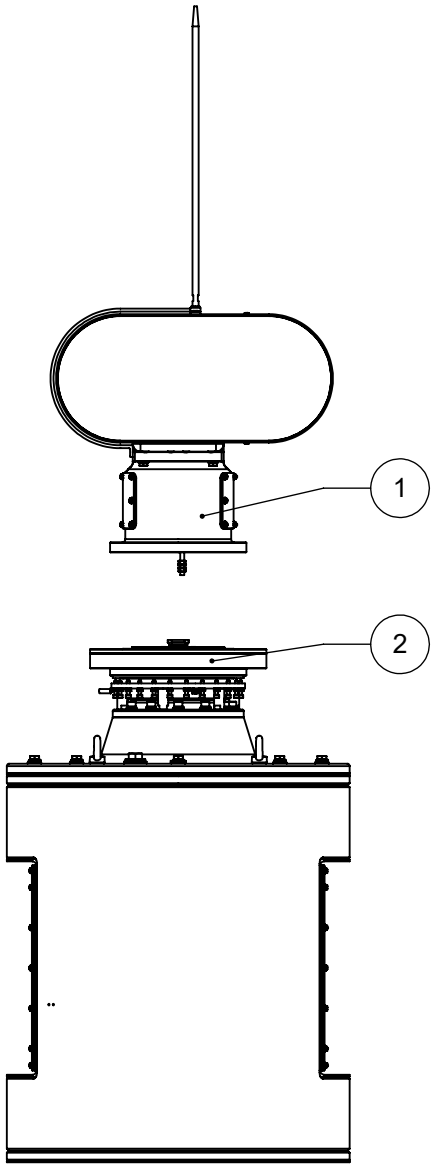
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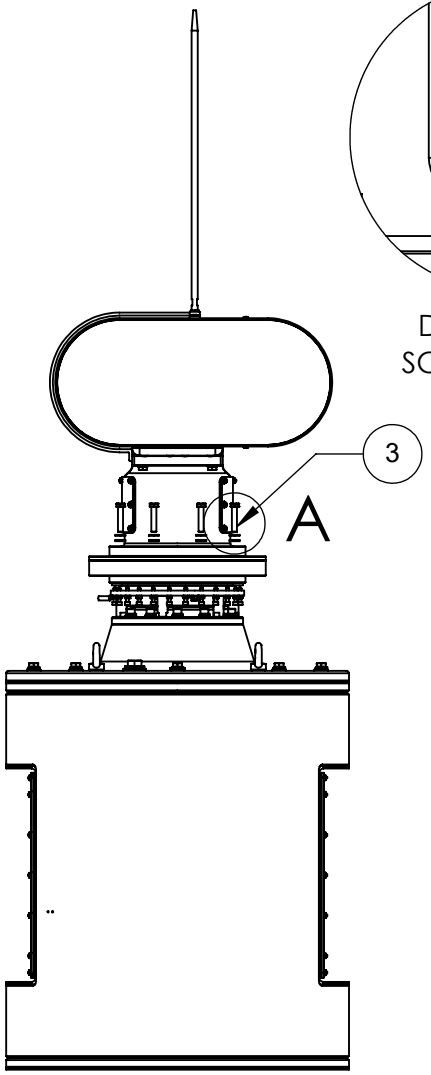
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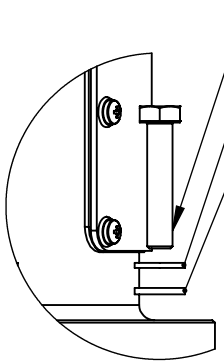
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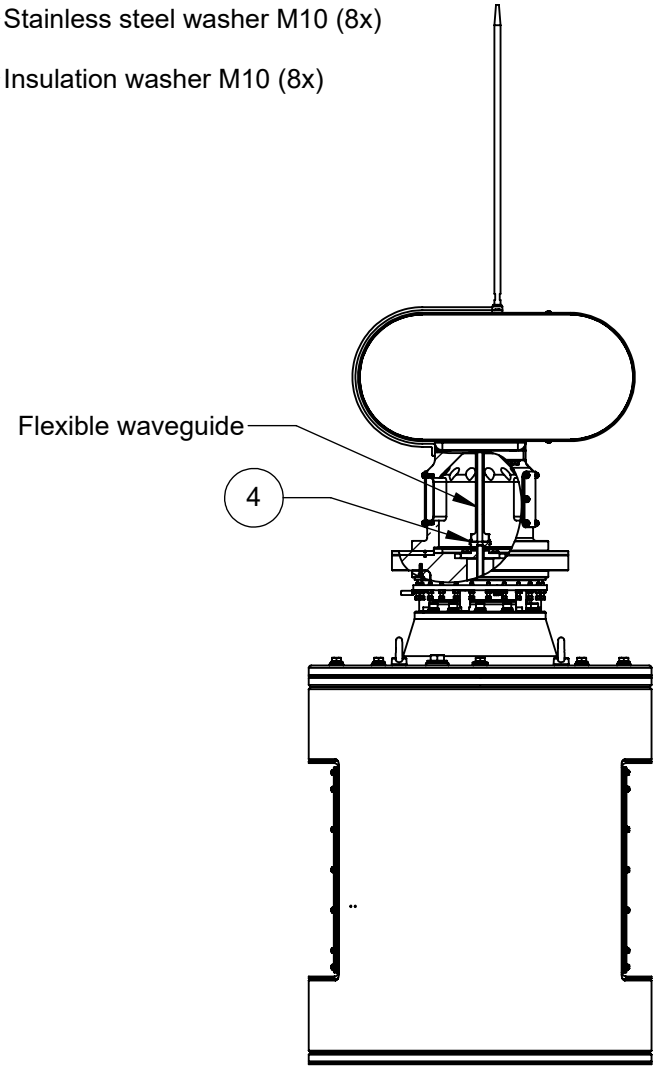
A



B



DETAIL A
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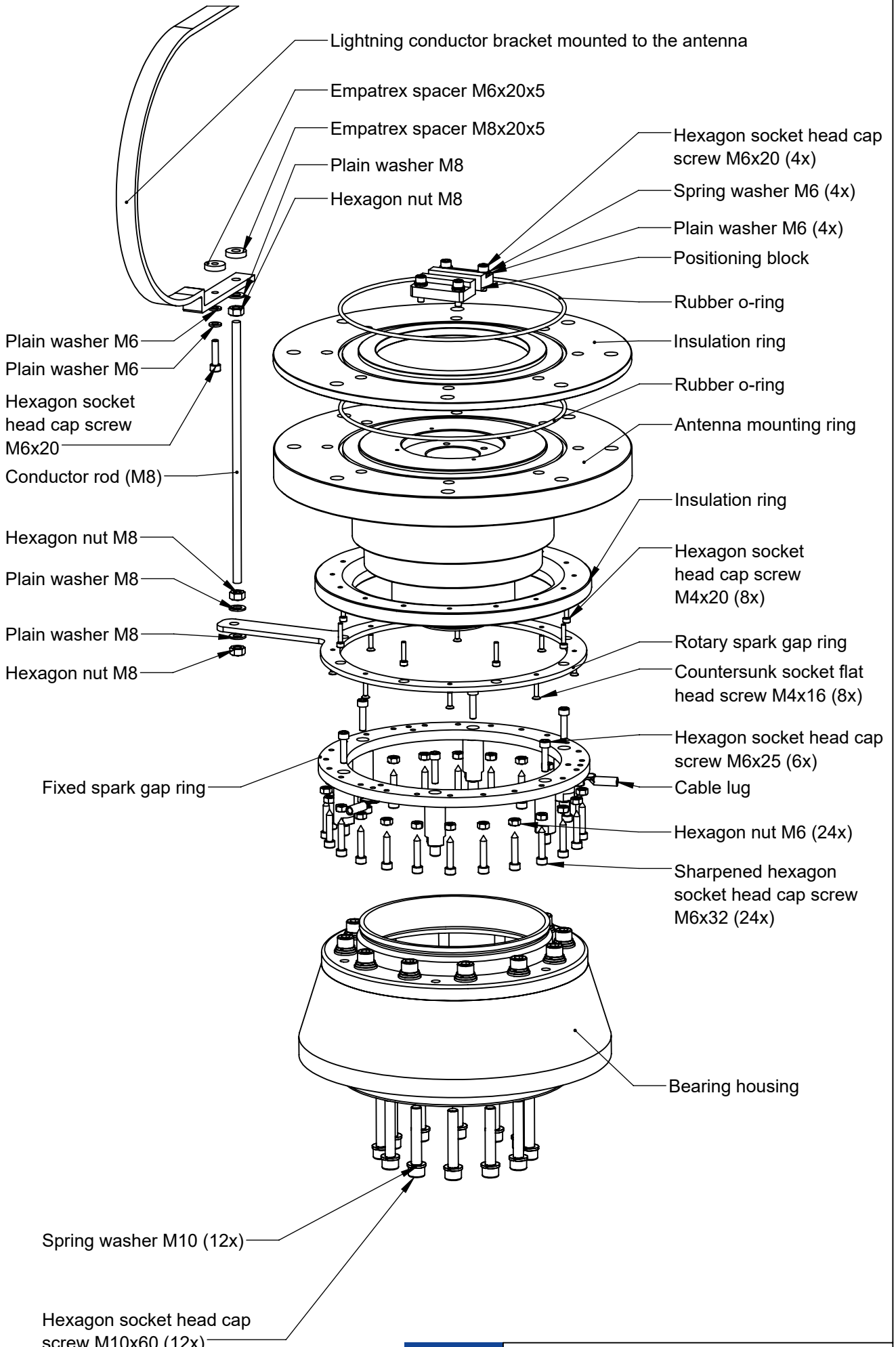


C

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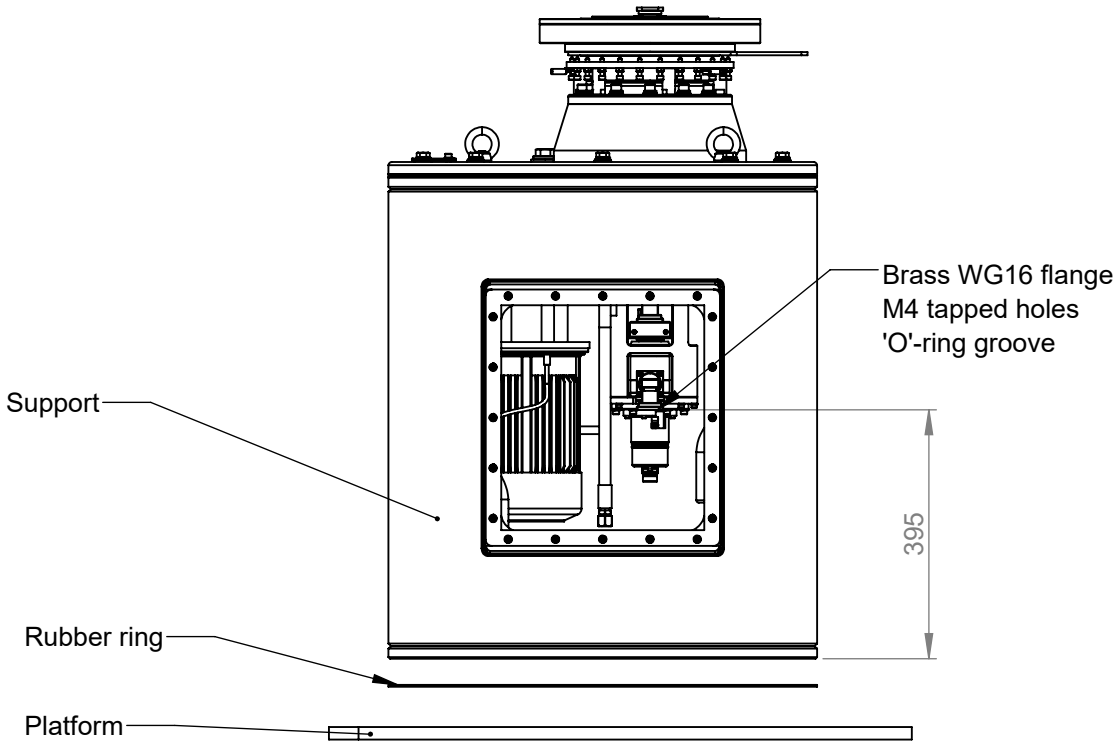
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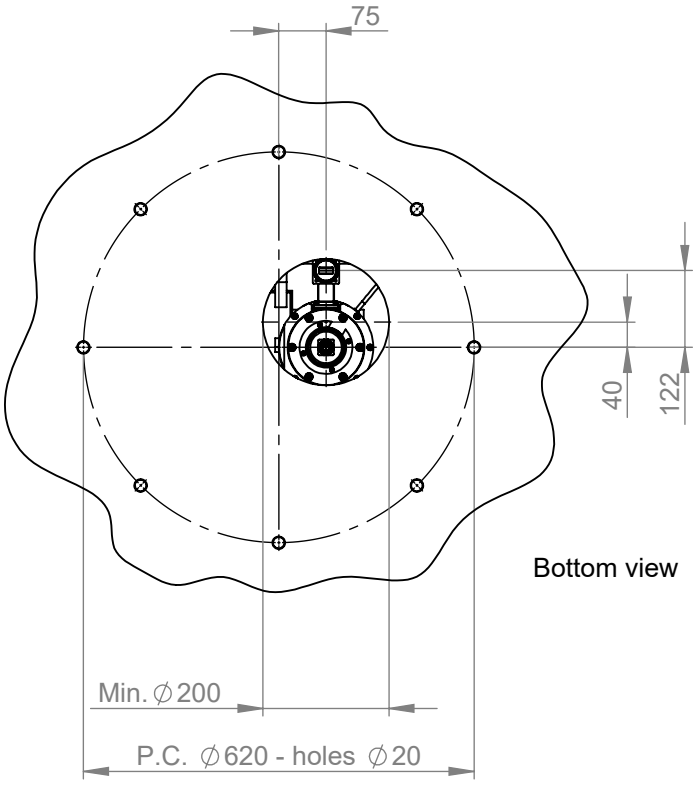
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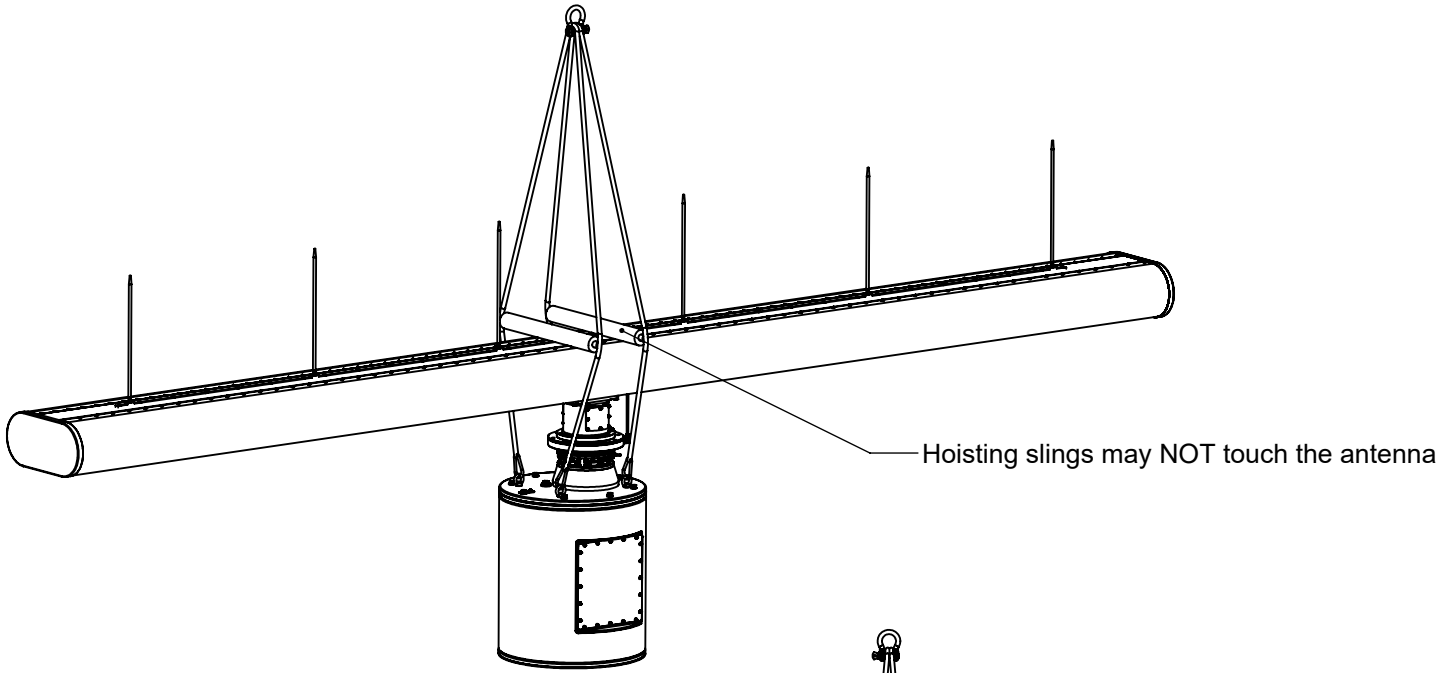
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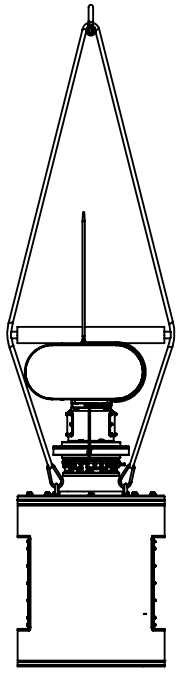
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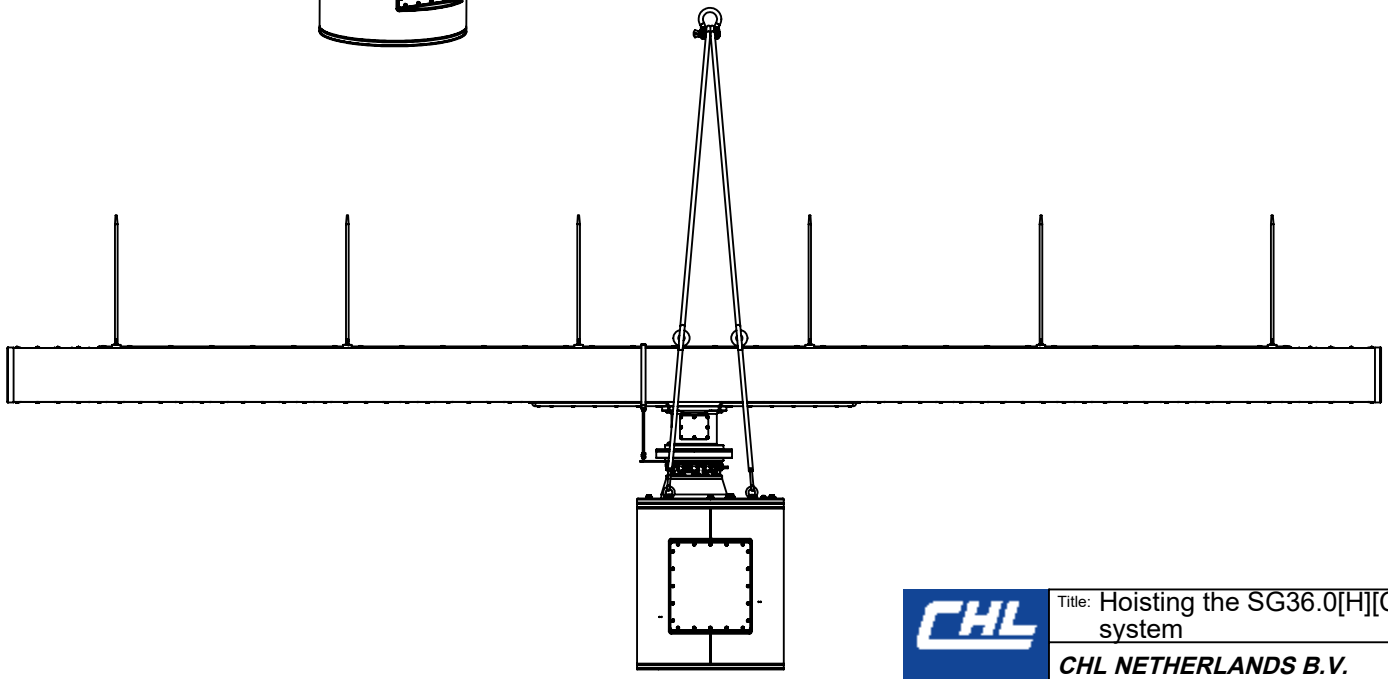
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Sheet:	1 of 1
Drawing number:	C2017096-07





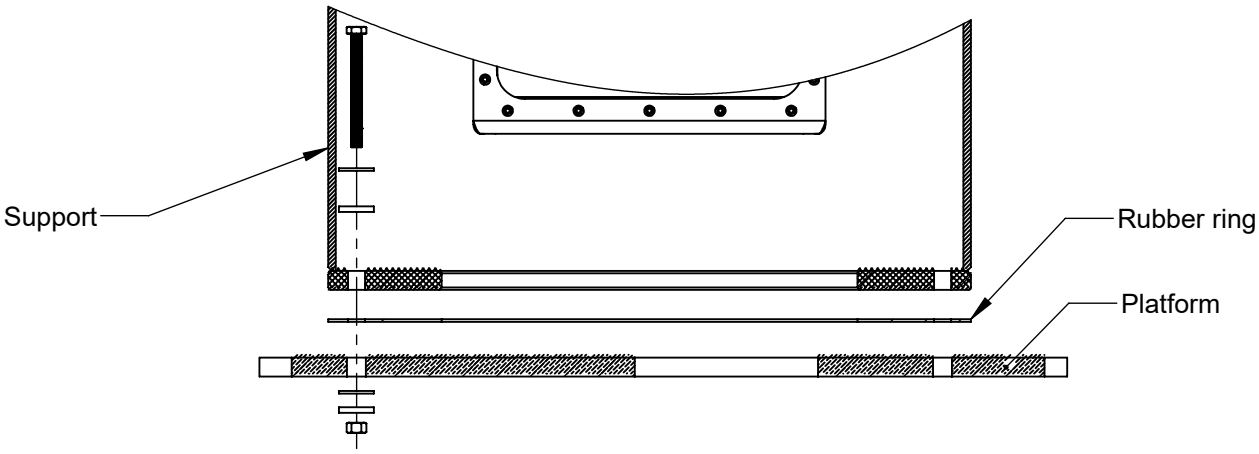


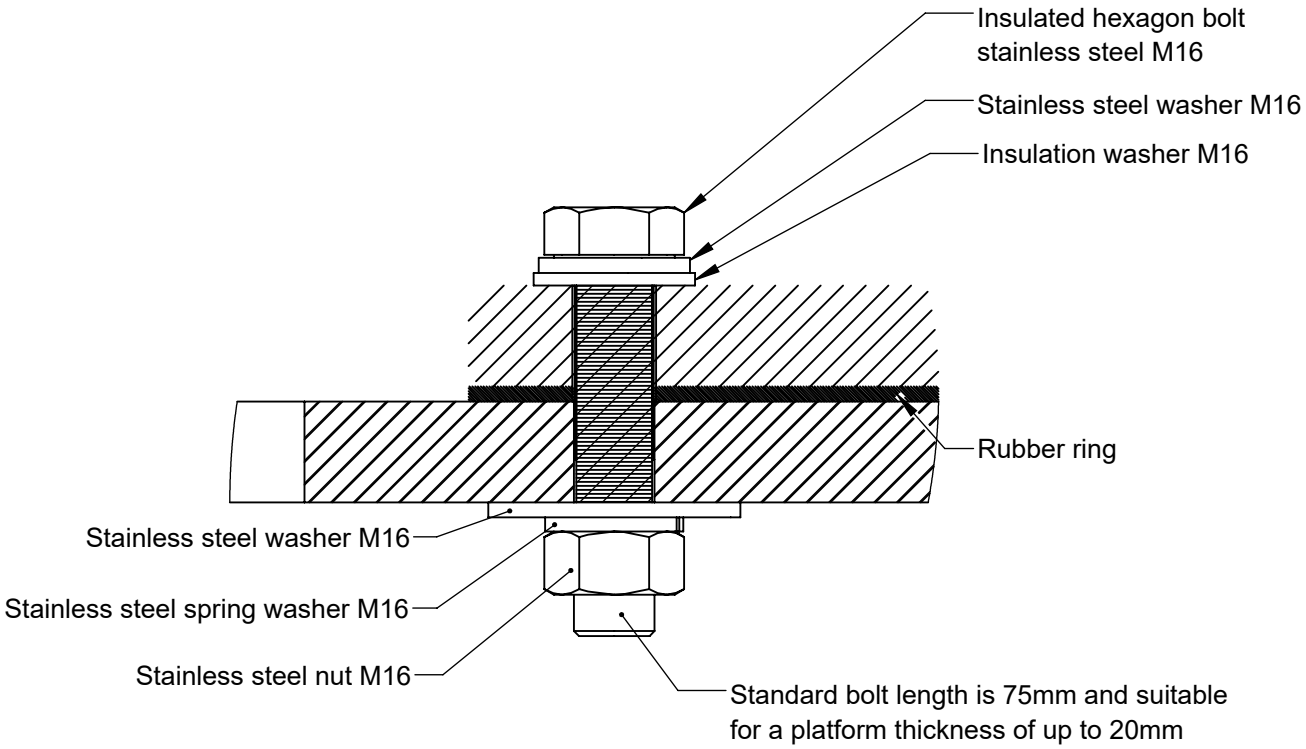
Title: Hoisting the SG36.0[H][C]21 antenna system

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Issue:	A
Issue date:	24-01-2018
Sheet:	1 of 1
Drawing number:	C2017096-08

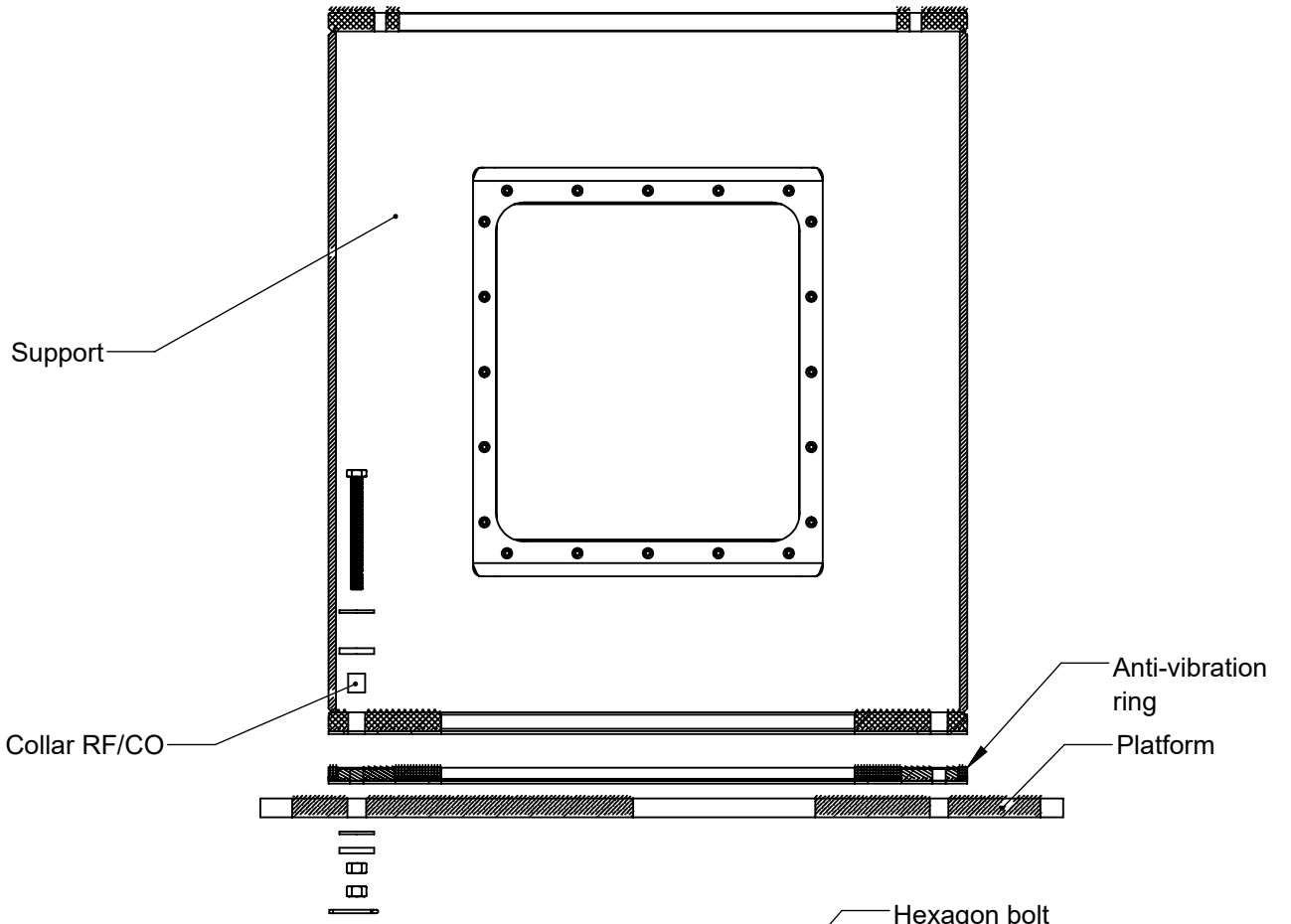


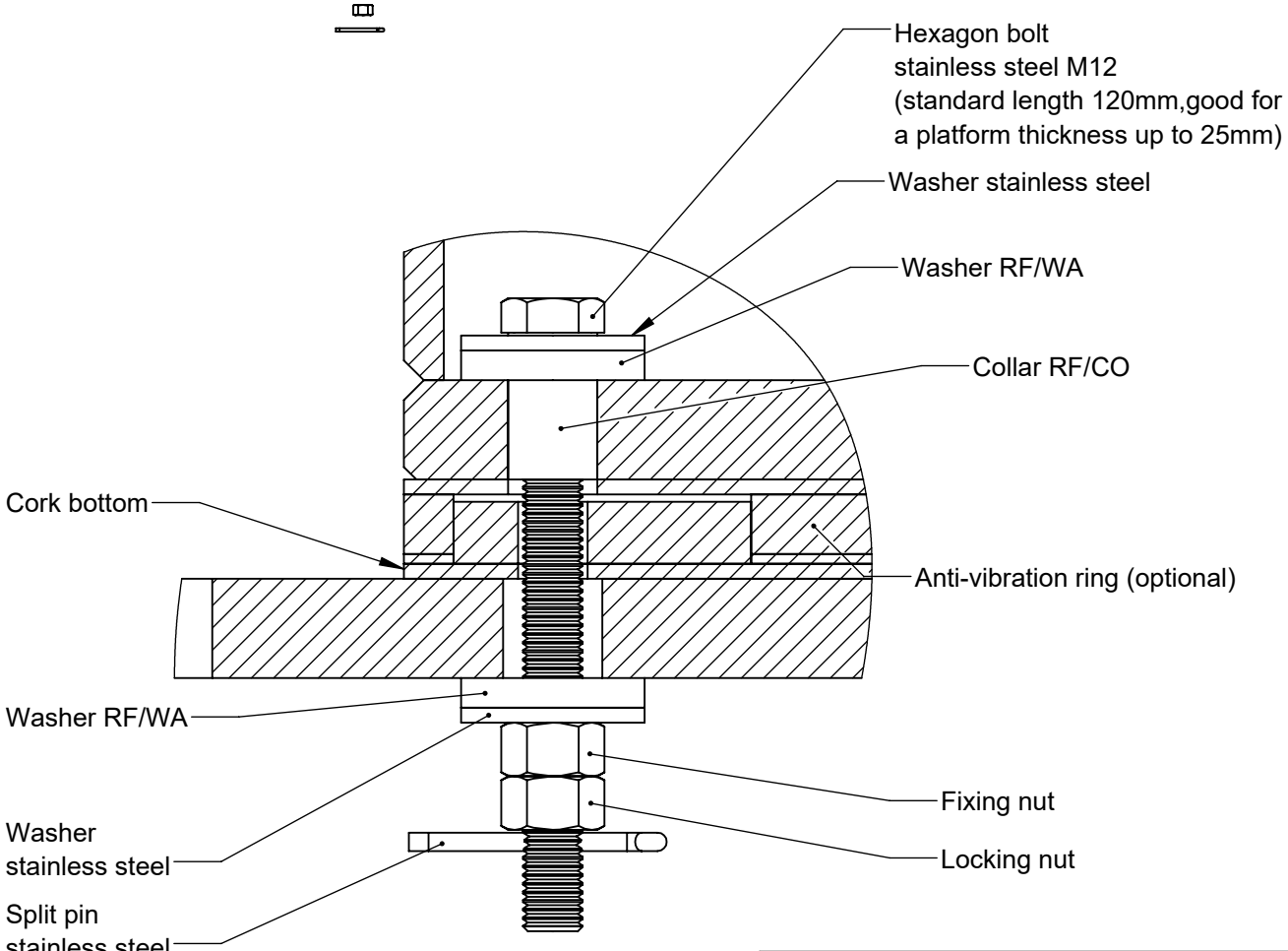


All dimensions in millimeters

Title:	Mounting the antenna system
CHL NETHERLANDS B.V. Katwijk-The Netherlands	Issue: A
	Issue date: 31-01-2018
	Sheet: 1 of 1
	Drawing number: C2017096-09

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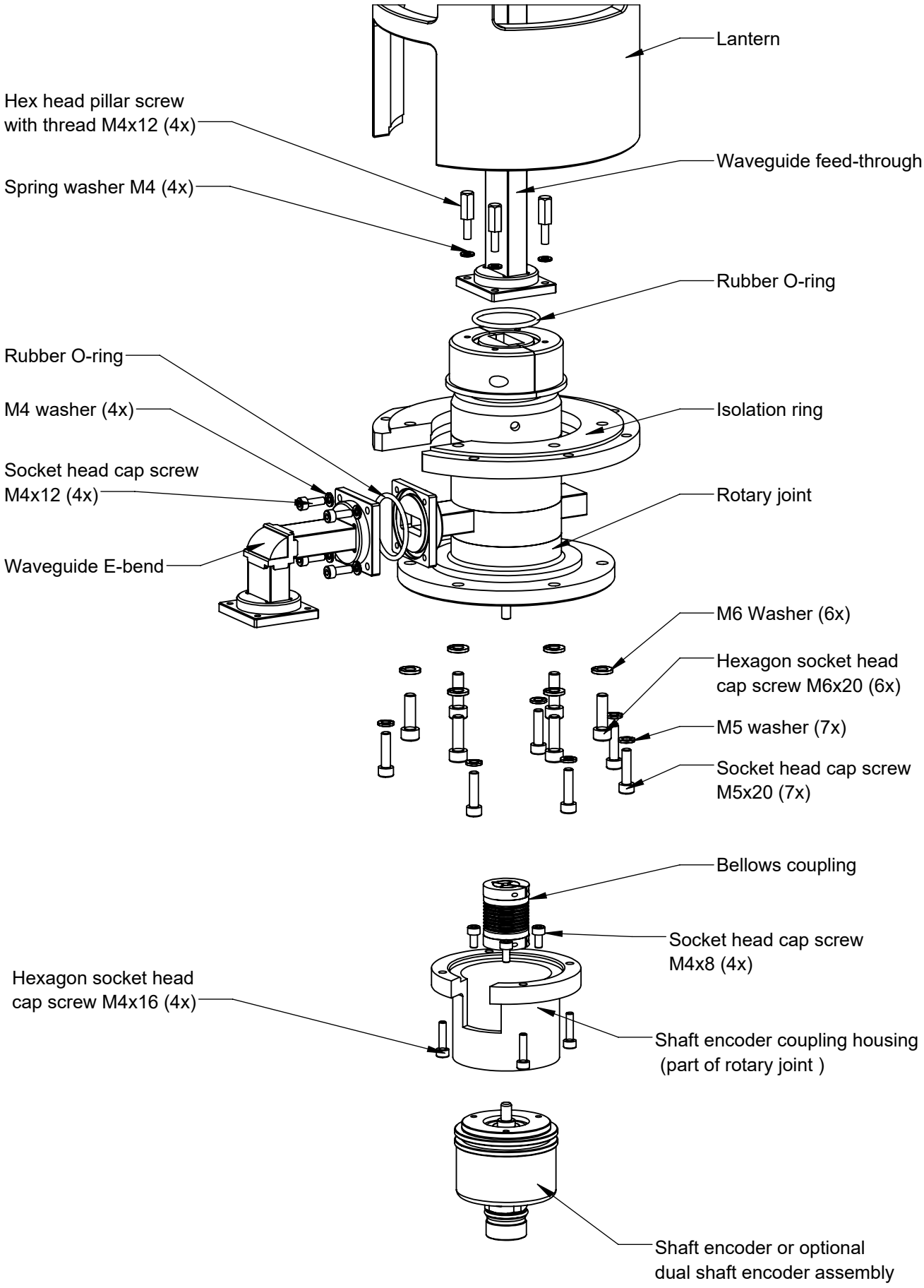




All dimensions in millimeters

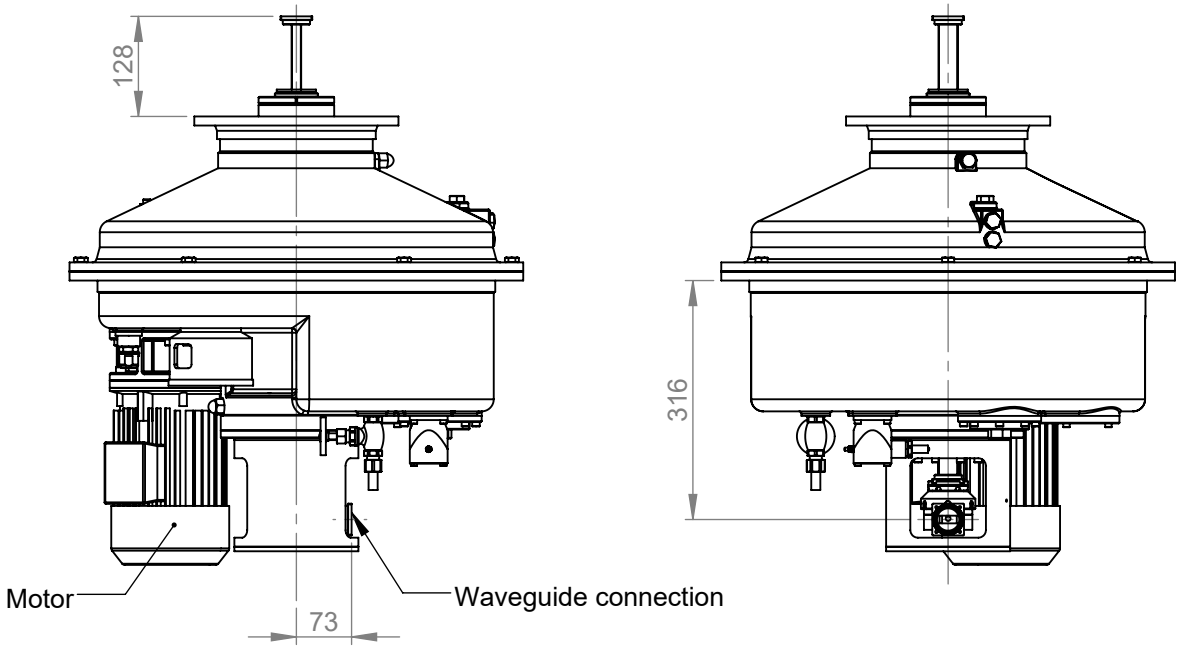
Title:	Mounting the antenna system with an anti-vibration ring
CHL NETHERLANDS B.V.	
Katwijk-The Netherlands	
Issue:	A
Issue date:	31-01-2018
Sheet:	1 of 1
Drawing number:	C2017096-10

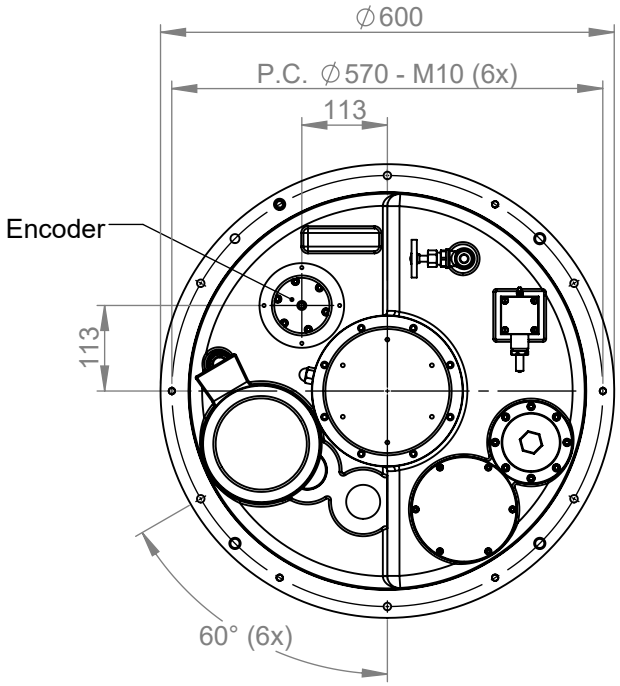
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CHL	Title: Shaft encoder and rotary joint	
CHL NETHERLANDS B.V. Katwijk-The Netherlands		Issue: A Issue date: 29-1-2018 Sheet: 1 of 1 Drawing number: C2017096-11

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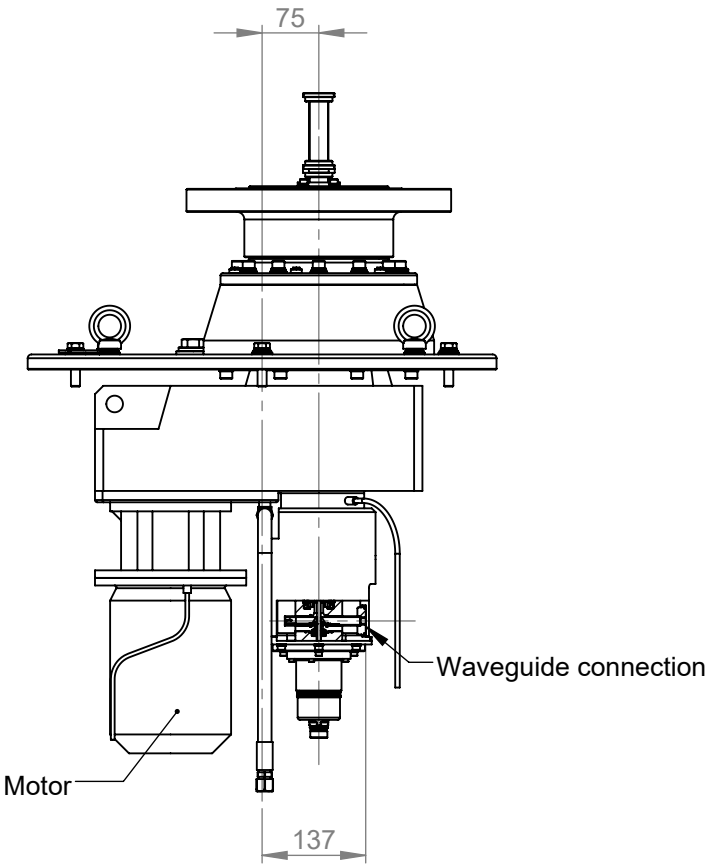
ALL DIMENSIONS IN MILLIMETERS

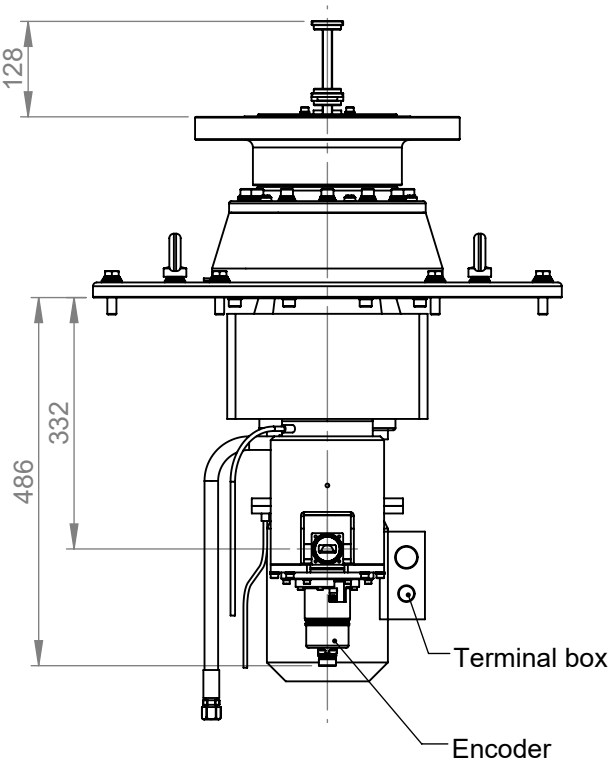
Title: Sketch of ATU type 5 interfaces

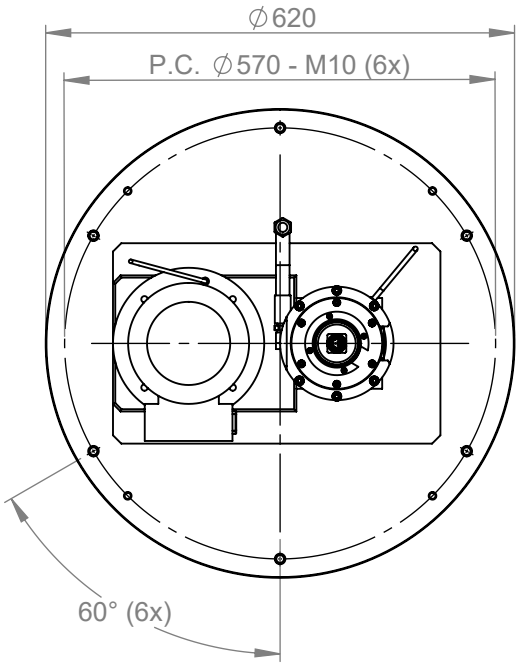
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Issue:	-
Issue date:	2017-03-06
Sheet:	1 of 2
Drawing number:	N/A







	Title: Sketch of ATU ST1-F20-MP5 interfaces	
CHL NETHERLANDS B.V. Katwijk-The Netherlands	Issue:	-
	Issue date:	2017-03-06
	Sheet:	2 of 2
	Drawing number:	N/A

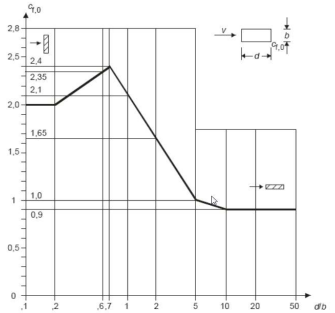
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Appendix B – Wind load calculation

Wind loading on final radar

Afmetingen radar:

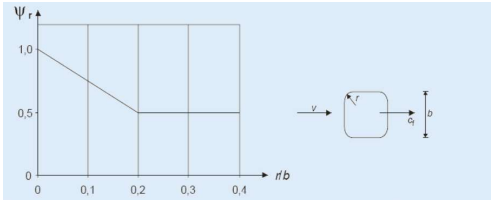
A	1.86	m^2	according to antenna outline system type; 15% increase
d	0.55	m	according to antenna outline system type
b	0.25	m	according to antenna outline system type
r	0.13	m	according to antenna outline system type
l	6.36	m	according to antenna outline system type
r/b	0.50		
d/b	2.16		
c_f	0.73		= $c_{f,0} * \psi_r * \psi_\lambda$
$c_{f,0}$	1.65		Zie figuur 7.23 NEN-EN-1991-1-4
ψ_r	0.50		Zie figuur 7.24 NEN-EN-1991-1-4
ψ_λ	0.88		Zie figuur 7.36 NEN-EN-1991-1-4
λ	50.1		Zie tabel 7.16 NEN-EN-1991-1-4
φ	1		Zie formule 7.28 NEN-EN 1991-1-4



Figuur 7.23 — Krachtcoëfficiënt $c_{f,0}$ voor rechthoekige doorsneden met scherpe hoeken en zonder eindeffecten

Afmetingen onderstel:

A	0.94	m^2	according to antenna outline system type; 15% increase
d	0.68	m	according to antenna outline system type
b	0.68	m	according to antenna outline system type
r/b	0.34	m	according to antenna outline system type
l	1.20	m	according to antenna outline system type (conservative assumption)
r/b	0.50		
d/b	1		
c_f	0.96		= $c_{f,0} * \psi_r * \psi_\lambda$
$c_{f,0}$	2.10		Zie figuur 7.23 NEN-EN-1991-1-4
ψ_r	0.50		Zie figuur 7.24 NEN-EN-1991-1-4
ψ_λ	0.91		Zie figuur 7.36 NEN-EN-1991-1-4
λ	70		Zie tabel 7.16 NEN-EN-1991-1-4
φ	1		Zie formule 7.28 NEN-EN 1991-1-4



Figuur 7.24 — Reductiefactor ψ_r voor een vierkante dwarsdoorsnede met afgeronde hoeken

Instead of calculating a circular section, we opted for a square section with rounded edges (conservative approach)

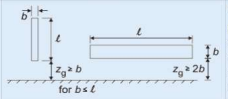
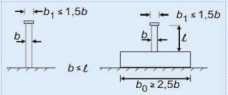
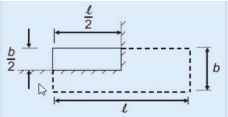
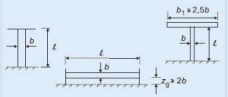
L	1.4		arm for the radar antenna
L2	0.6		arm for the radar antenna without base

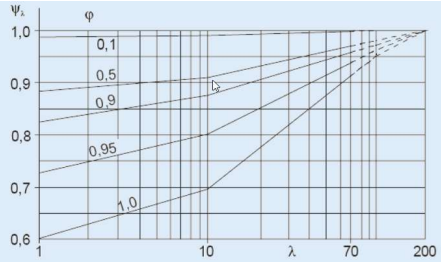
		Radar		Onderstel		**Totaal**	
	q_p	F_{w_radar}	M_{w_radar}	F_w	M_w	**F_w**	**M_w**
	(kN/m^2)	(kN)	(kNm)	(kN)	(kNm)	**(kN)**	**(kNm)**
Texel	2.01	2.71	3.79	1.80	1.08	**4.51**	**4.88**
Terschelling **	2.14	3.46	2.08	2.30	1.38	**3.46**	**2.08**
Ameland	2.16	2.91	4.08	1.94	1.16	**4.85**	**5.24**
Schiermonnikoog **	2.02	2.72	1.63	1.81	1.09	**2.72**	**1.63**

** In Terschelling en Schiermonnikoog bevindt het onderstel zich binnen de koepel van het lichthuis en vangt derhalve geen wind.

Inclusief factor $c_s c_d = 1,2$

Tabel 7.16 — Aanbevolen waarden van λ voor cilinders, veelhoekige doorsneden, rechthoekige doorsneden, constructiedoorsneden met scherpe hoeken en vakwerkconstructies

Nr.	Positie van de constructie, wind normaal op het vlak van de pagina	Effectieve slankheid λ
1		Voor veelhoekige, rechthoekige doorsneden met scherpe hoeken en vakwerkconstructies: voor $\ell \geq 50$ m: neem de kleinste van $\lambda = 1,4\ \ell/b$ of $\lambda = 70$, voor $\ell < 15$ m: neem de kleinste van $\lambda = 2\ \ell/b$ of $\lambda = 70$. Voor cirkelvormige cilinders: voor $\ell \geq 50$ m: neem de kleinste van $\lambda = 0,7\ \ell/b$ of $\lambda = 70$, voor $\ell < 15$ m: neem de kleinste van $\lambda = \ell/b$ of $\lambda = 70$.
2		
3		Voor tussenliggende waarden van ℓ behoort lineair te zijn geïnterpoleerd.
4		voor $\ell \geq 50$ m: neem de grootste waarde van $\lambda = 0,7\ \ell/b$ of $\lambda = 70$; voor $\ell < 15$ m: neem de grootste waarde van $\lambda = \ell/b$ of $\lambda = 70$. Voor tussenliggende waarden van ℓ behoort lineair te zijn geïnterpoleerd.



Figuur 7.36 — Indicatieve waarden van de eindeffectfactor ψ_λ als functie van volheidsgraden φ versus slankheid λ

Date 2/14/2025

Reference BK3248-RHD-XX-XX-RP-S-0001

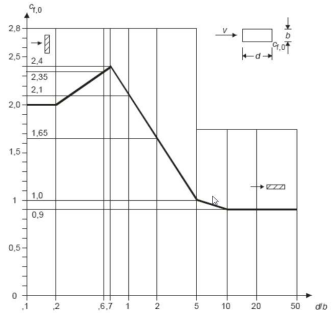
Wind loading on initially assumed radar

Afmetingen radar:

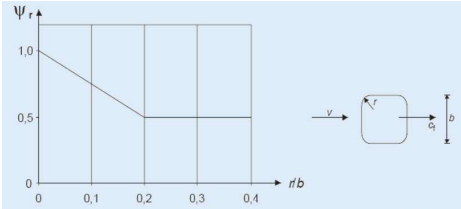
A	4.81	m^2	= 1,15 * 4,18m^2; Indicated value
d	0.93	m	= 2 * b; estimated value
b	0.47	m	
l	10.28	m	=22 * b; estimated value
r/b	0.05		Indicated value
c_f	1.24		= $c_{f,0}$ * ψ_r * ψ_λ
$c_{f,0}$	1.65		Zie figuur 7.23 NEN-EN-1991-1-4
ψ_r	0.88		Zie figuur 7.24 NEN-EN-1991-1-4
ψ_λ	0.86		Zie figuur 7.36 NEN-EN-1991-1-4
λ	44		Zie tabel 7.16 NEN-EN-1991-1-4
φ	1		Zie formule 7.28 NEN-EN 1991-1-4

Afmetingen onderstel:

A	1.77	m^2	= 1,15 * 1,54m^2; Indicated value
d	1.88	m	= b; estimated value
b	1.88	m	
l	0.94	m	=0,5 * b; estimated value
r/b	0.00		Estimated value
c_f	1.91		= $c_{f,0}$ * ψ_r * ψ_λ
$c_{f,0}$	2.10		Zie figuur 7.23 NEN-EN-1991-1-4
ψ_r	1.00		Zie figuur 7.24 NEN-EN-1991-1-4
ψ_λ	0.91		Zie figuur 7.36 NEN-EN-1991-1-4
λ	70		Zie tabel 7.16 NEN-EN-1991-1-4
φ	1		Zie formule 7.28 NEN-EN 1991-1-4

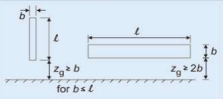
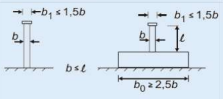
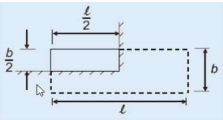
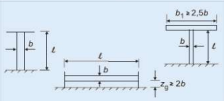


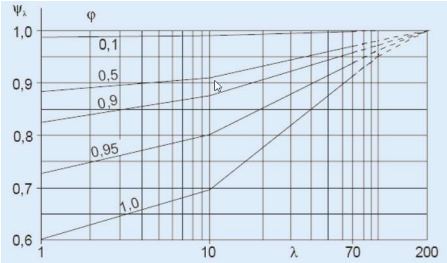
Figuur 7.23 — Krachtcoëfficiënt $c_{f,0}$ voor rechthoekige doorsneden met scherpe hoeken en zonder eindeffecten



Figuur 7.24 — Reductiefactor ψ_r voor een vierkante dwarsdoorsnede met afgeronde hoeken

Tabel 7.16 — Aanbevolen waarden van λ voor cilinders, veelhoekige doorsneden, rechthoekige doorsneden, constructiedoorsneden met scherpe hoeken en vakwerkconstructies

Nr.	Positie van de constructie, wind normaal op het vlak van de pagina	Effectieve slankheid λ
1		Voor veelhoekige, rechthoekige doorsneden met scherpe hoeken en vakwerkconstructies: voor $\ell \geq 50$ m: neem de kleinste van $\lambda = 1{,}4\ \ell/b$ of $\lambda = 70$, voor $\ell < 15$ m: neem de kleinste van $\lambda = 2\ \ell/b$ of $\lambda = 70$. Voor cirkelvormige cilinders: voor $\ell \geq 50$ m: neem de kleinste van $\lambda = 0{,}7\ \ell/b$ of $\lambda = 70$, voor $\ell < 15$ m: neem de kleinste van $\lambda = \ell/b$ of $\lambda = 70$.
2		
3		Voor tussenliggende waarden van ℓ behoort lineair te zijn geïnterpoleerd.
4		voor $\ell \geq 50$ m: neem de grootste waarde van $\lambda = 0{,}7\ \ell/b$ of $\lambda = 70$; voor $\ell < 15$ m: neem de grootste waarde van $\lambda = \ell/b$ of $\lambda = 70$. Voor tussenliggende waarden van ℓ behoort lineair te zijn geïnterpoleerd.



Figuur 7.36 — Indicatieve waarden van de eindeffectfactor ψ_λ als functie van volheidsgraden φ versus slankheid λ

		Radar		Onderstel		Totaal	
	q_p (kN/m^2)	F_{w_radar} (kN)	M_{w_radar*} (kNm)	F_w (kN)	M_w (kNm)	F_w (kN)	M_w (kNm)
Texel	2.01	12.00	11.22	6.80	3.20	18.80	25.71
Terschelling **	2.14	15.33	14.33	8.69	4.09	15.33	14.33
Ameland	2.16	12.89	12.05	7.31	3.44	20.20	27.62
Schiermonnikoog **	2.02	12.06	11.27	6.84	3.22	12.06	11.27

* Aanname arm = 2 x hoogte radar (b)

** In Terschelling en Schiermonnikoog bevindt het onderstel zich binnen de koepel van het lichthuis en vangt derhalve geen wind.

Inclusief factor $c_s c_d$ = 1,2

Date 2/14/2025

Reference BK3248-RHD-XX-XX-RP-S-0001

Appendix C – Plate anchorage calculation

Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Texel Anchors - Final Antenna	Date:	06-02-2025
Fastening Point:			

Specifier's comments:

1 Anchor Design

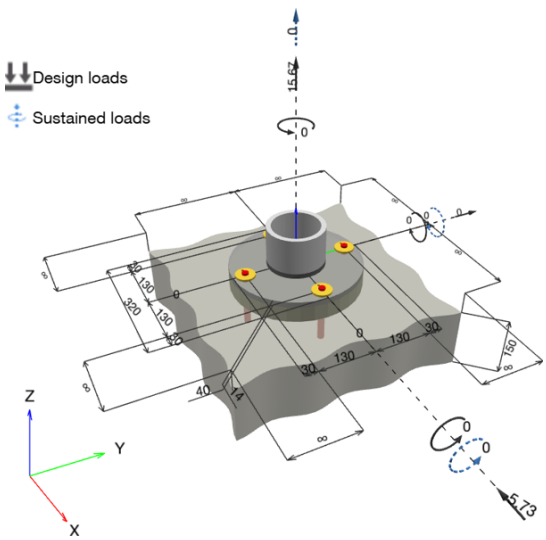
1.1 Input data



Anchor type and size:	**HIT-HY 200-A V3 + HAS-U 8.8 M16**
Return period (service life in years):	50
Item number:	2223835 HAS-U 8.8 M16x190 (insert) / 2378172 HIT-HY 200-A V3 (mortar)
Hilti Filling Set or any suitable annular gap filling solution	
Effective embedment depth:	$h_{ef,opti}$ = 80.0 mm ($h_{ef,limit}$ = 114.0 mm)
Material:	8.8
Approval No.:	ETA 19/0601
Issued I Valid:	29-01-2024 | -
Proof:	SOFA based on EN 1992-4, Chemical
Stand-off installation:	grouted standoff; restraint level (baseplate): 2.00; e_b = 40.0 mm; t = 14.0 mm grout compressive strength = 40.00 N/mm^2
Baseplate^{CBFEM}:	l_x x l_y x t = 320.0 mm x 320.0 mm x 14.0 mm;
Profile:	Pipe, 139,7 x 12; (L x W x T) = 139.7 mm x 139.7 mm x 12.0 mm
Base material:	cracked concrete, C20/25, $f_{c,cyl}$ = 20.00 N/mm^2; h =150.0 mm, Temp. short/long: 40/24 °C, User-defined partial material safety factor γ_c = 1.500
Installation:	**Hammer drilled hole, Installation condition: Dry**
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm) no longitudinal edge reinforcement Reinforcement to control splitting acc. to EN 1992-4, 7.2.1.7 (2) b) 2) present

^{CBFEM} - The anchor calculation is based on a component-based Finite Element Method (CBFEM)

Geometry [mm] & Loading [kN, kNm]



Input data and results must be checked for conformity with the existing conditions and for plausibility!
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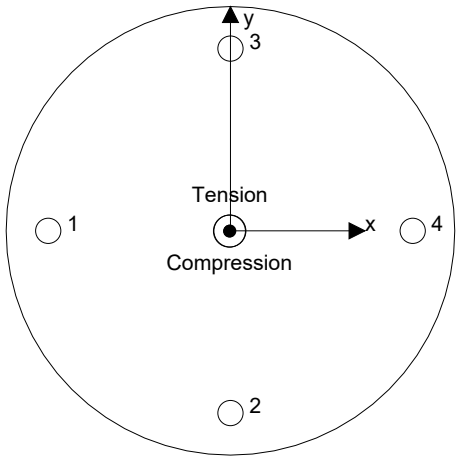
1.1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = 15.670; V_x = -5.730; V_y = 0.000; M_x = 0.000; M_y = 0.000; M_z = 0.000; N_{sus} = 0.000; $M_{x,sus}$ = 0.000; $M_{y,sus}$ = 0.000;	no	no	49

1.2 Load case/Resulting anchor forces

Anchor reactions [kN]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	6.197	1.400	-1.400	-0.000
2	6.259	1.432	-1.432	0.037
3	6.239	1.432	-1.432	-0.037
4	6.122	1.466	-1.466	-0.000



Resulting tension force in (x/y)=(-0.4/-0.1): 24.817 [kN]
Resulting compression force in (x/y)=(-0.7/-0.2): 10.167 [kN]

Anchor forces are calculated based on a component-based Finite Element Method (CBFEM)

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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Company:		Page:	3
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Texel Anchors - Final Antenna	Date:	06-02-2025
Fastening Point:			

1.3 Tension load EN 1992-4, Section 7.2.1

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	6.259	83.733	8	OK
Combined pullout-concrete cone failure**	24.817	80.141	31	OK
Concrete Breakout failure**	24.817	51.690	49	OK
Splitting failure**	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

1.3.1 Steel failure

$$N_{Ed} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$$ EN 1992-4, Table 7.1

$N_{Rk,s}$ [kN]	γ_{Ms}	$N_{Rd,s}$ [kN]	N_{Ed} [kN]
125.600	1.500	83.733	6.259

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.3.2 Combined pullout-concrete cone failure

$N_{Ed} \le N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$ EN 1992-4, Table 7.1

$N_{Rk,p} = N^0_{Rk,p} \cdot \frac{A_{p,N}}{A^0_{p,N}} \cdot \psi_{g,Np} \cdot \psi_{s,Np} \cdot \psi_{re,Np} \cdot \psi_{ec1,Np} \cdot \psi_{ec2,Np}$ EN 1992-4, Eq. (7.13)

$N^0_{Rk,p} = \psi_{sus} \cdot \tau_{Rk} \cdot \pi \cdot d \cdot h_{ef}$ EN 1992-4, Eq. (7.14)

$\psi_{sus} = 1$ EN 1992-4, Eq. (7.14a)

$s_{cr,Np} = 7.3 \cdot d \cdot \sqrt{\psi_{sus} \cdot \tau_{Rk}} \le 3 \cdot h_{ef}$ EN 1992-4, Eq. (7.15)

$\psi_{g,Np} = \psi^0_{g,Np} - \left(\frac{s}{s_{cr,Np}}\right)^{0,5} \cdot \left(\psi^0_{g,Np} - 1\right) \ge 1.00$ EN 1992-4, Eq. (7.17)

$\psi^0_{g,Np} = \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,c}}\right)^{1,5} \ge 1.00$ EN 1992-4, Eq. (7.18)

$\tau_{Rk,c} = \frac{k_3}{\pi \cdot d} \cdot \sqrt{h_{ef} \cdot f_{ck}}$ EN 1992-4, Eq. (7.19)

$\psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \le 1.00$ EN 1992-4, Eq. (7.20)

$\psi_{ec1,Np} = \frac{1}{1 + \left(\frac{2 \cdot e_{c1,N}}{s_{cr,Np}}\right)} \le 1.00$ EN 1992-4, Eq. (7.21)

$\psi_{ec2,Np} = \frac{1}{1 + \left(\frac{2 \cdot e_{c2,N}}{s_{cr,Np}}\right)} \le 1.00$ EN 1992-4, Eq. (7.21)

$A_{p,N}$ [mm²]	$A^0_{p,N}$ [mm²]	$\tau_{Rk,ucr,20}$ [N/mm²]	$s_{cr,Np}$ [mm]	$c_{cr,Np}$ [mm]	c_{min} [mm]	$f_{c,cyl}$ [N/mm²]
182,000	57,600	18.00	240.0	120.0	∞	20.00

ψ_c	$\tau_{Rk,cr}$ [N/mm²]	k_3	$\tau_{Rk,c}$ [N/mm²]	$\psi^0_{g,Np}$	$\psi_{g,Np}$
1.000	9.50	7.700	6.13	1.000	1.000

$e_{c1,N}$ [mm]	$\psi_{ec1,Np}$	$e_{c2,N}$ [mm]	$\psi_{ec2,Np}$	$\psi_{s,Np}$	$\psi_{re,Np}$
0.4	0.997	0.1	0.999	1.000	1.000

ψ^0_{sus}	α_{sus}	ψ_{sus}
0.800	0.000	1.000

$N^0_{Rk,p}$ [kN]	$N_{Rk,p}$ [kN]	γ_{Mp}	$N_{Rd,p}$ [kN]	N_{Ed} [kN]
38.202	120.211	1.500	80.141	24.817

Group anchor ID
1-4

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.3.3 Concrete Breakout failure

$N_{Ed} \le N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}}$ EN 1992-4, Table 7.1

$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{M,N}$ EN 1992-4, Eq. (7.1)

$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1,5}$ EN 1992-4, Eq. (7.2)

$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$ EN 1992-4, Eq. (7.3)

$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \le 1.00$ EN 1992-4, Eq. (7.4)

$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{N,1}}{s_{cr,N}}\right)} \le 1.00$ EN 1992-4, Eq. (7.6)

$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{N,2}}{s_{cr,N}}\right)} \le 1.00$ EN 1992-4, Eq. (7.6)

$\psi_{M,N} = 1$ EN 1992-4, Eq. (7.7)

$A_{c,N}$ [mm²]	$A^0_{c,N}$ [mm²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	$f_{c,cyl}$ [N/mm²]
182,000	57,600	120.0	240.0	20.00

$e_{c1,N}$ [mm]	$\psi_{ec1,N}$	$e_{c2,N}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	z [mm]
0.4	0.997	0.1	0.999	1.000	1.000	0.4

$\psi_{M,N}$	k_1	$N^0_{Rk,c}$ [kN]	γ_{Mc}	$N_{Rd,c}$ [kN]	N_{Ed} [kN]
1.000	7.700	24.640	1.500	51.690	24.817

Group anchor ID
1-4

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.4 Shear load EN 1992-4, Section 7.2.2

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel failure (without lever arm)*	1.466	50.240	3	OK
Steel failure (with lever arm)*	1.466	7.183	21	OK
Pryout failure**	5.730	103.807	6	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (relevant anchors)
When the input edge distance is set to "infinity", edge breakout verification is not performed in that direction

1.4.1 Steel failure (without lever arm)

$V_{Ed} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}}$ EN 1992-4, Table 7.2

$V_{Rk,s} = k_7 \cdot V^0_{Rk,s}$ EN 1992-4, Eq. (7.35)

$V^0_{Rk,s}$ [kN]	k_7	$V_{Rk,s}$ [kN]	γ_{Ms}	$V_{Rd,s}$ [kN]	V_{Ed} [kN]
62.800	1.000	62.800	1.250	50.240	1.466

1.4.2 Steel failure (with lever arm)

$V_{Ed} \leq V_{Rd,s,M} = \frac{V_{Rk,s,M}}{\gamma_{Ms}}$ EN 1992-4, Table 7.2

$V_{Rk,s,M} = \frac{\alpha_M \cdot M_{Rk,s}}{l_a}$ EN 1992-4, Eq. 7.37

$M_{Rk,s} = M^0_{Rk,s} \cdot \left(1 - \frac{N_{Ed}}{N_{Rd,s}}\right)$ EN 1992-4, Eq. 7.38

$l_a = e_c + \frac{t}{2} + a_3$ EN 1992-4, Eq. 6.2

l [mm]	α_M
55.0	2.00

$N_{Ed} / N_{Rd,s}$	$1 - N_{Ed} / N_{Rd,s}$	$M^0_{Rk,s}$ [kNm]	$M_{Rk,s} = M^0_{Rk,s} (1 - N_{Ed}/ N_{Rd,s})$ [kNm]
0.073	0.927	0.266	0.247

$V^M_{Rk,s} = \alpha_M * M_{Rk,s} / l$ [kN]	γ_{Ms}	$V^M_{Rd,s}$ [kN]	V_{Ed} [kN]
8.979	1.250	7.183	1.466

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.4.3 Pryout failure (concrete cone relevant)

$V_{Ed} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc,p}}$ EN 1992-4, Table 7.2

$V_{Rk,cp} = k_8 \cdot \min \{N_{Rk,c}; N_{Rk,p}\}$ EN 1992-4, Eq. (7.39c)

$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec1,N} \cdot \psi_{ec2,N} \cdot \psi_{M,N}$ EN 1992-4, Eq. (7.1)

$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1,5}$ EN 1992-4, Eq. (7.2)

$A^0_{c,N} = s_{cr,N} \cdot s_{cr,N}$ EN 1992-4, Eq. (7.3)

$\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leq 1.00$ EN 1992-4, Eq. (7.4)

$\psi_{ec1,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{V,1}}{s_{cr,N}}\right)} \leq 1.00$ EN 1992-4, Eq. (7.6)

$\psi_{ec2,N} = \frac{1}{1 + \left(\frac{2 \cdot e_{V,2}}{s_{cr,N}}\right)} \leq 1.00$ EN 1992-4, Eq. (7.6)

$\psi_{M,N} = 1$ EN 1992-4, Eq. (7.7)

$A_{c,N}$ [mm²]	$A^0_{c,N}$ [mm²]	$c_{cr,N}$ [mm]	$s_{cr,N}$ [mm]	k_8	$f_{c,cyl}$ [N/mm²]
182,000	57,600	120.0	240.0	2.000	20.00

$e_{c1,V}$ [mm]	$\psi_{ec1,N}$	$e_{c2,V}$ [mm]	$\psi_{ec2,N}$	$\psi_{s,N}$	$\psi_{re,N}$	$\psi_{M,N}$
0.0	1.000	0.0	1.000	1.000	1.000	1.000

k_1	$N^0_{Rk,c}$ [kN]	$\gamma_{Mc,p}$	$V_{Rd,cp}$ [kN]	V_{Ed} [kN]
7.700	24.640	1.500	103.807	5.730

Group anchor ID
1-4

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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1.5 Combined tension and shear loads (EN 1992-4, Section 7.2.3)

Steel failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.075	0.029	2.000	1	OK

$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$

Concrete failure

β_N	β_V	α	Utilization $\beta_{N,V}$ [%]	Status
0.480	0.055	1.500	35	OK

$\beta_N^\alpha + \beta_V^\alpha \leq 1.0$

1.6 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates as per current regulations (ETAG 001/Annex C, EOTA TR029, etc.). This means load re-distribution on the anchors due to elastic deformations of the baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate based on the assumptions explained above. The proof if the rigid base plate assumption is valid is not carried out by PROFIS Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- The equations presented in this report are based on metric units. When inputs are displayed in imperial units, the user should be aware that the equations remain in their metric format.
- Checking the transfer of loads into the base material is required in accordance with EN 1992-4, Annex A!
- The design is only valid if the clearance hole in the fixture is not larger than the value given in Table 6.1 of EN 1992-4! For larger diameters of the clearance hole see section 6.2.2 of EN 1992-4!
- The accessory list in this report is for the information of the user only. In any case, the instructions for use provided with the product have to be followed to ensure a proper installation.
- For the determination of the $\psi_{re,v}$ (concrete edge failure) the minimum concrete cover defined in the design settings is used as the concrete cover of the edge reinforcement.
- Please note that this design utilizes user defined material safety factor values that differ from the default values recommended in EN1992-4. Partial Safety factor value: $\gamma_c = 1.500$
- Drilled hole cleaning must be performed according to instructions for use (blow twice with oil-free compressed air (min. 6 bar), brush twice, blow twice with oil-free compressed air (min. 6 bar)).
- Characteristic bond resistances depend on short- and long-term temperatures.
- Edge reinforcement is not required to avoid splitting failure
- Design is only valid if hole is filled to remove clearance, clearance as per EN 1992-4 Table 6.1
- Load transfer from supplementary reinforcement to the structural member shall be verified by the responsible structural engineer.
- With supplementary reinforcement and post-installed anchors, please ensure that in the jobsite the rebars are not drilled through.
- The anchor design methods in PROFIS Engineering require rigid baseplates, as per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means that the baseplate should be sufficiently rigid to prevent load re-distribution to the anchors due to elastic/plastic displacements. The user accepts that the baseplate is considered close to rigid by engineering judgment."
- The characteristic bond resistances depend on the return period (service life in years): 50

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1.7 Installation data

Baseplate, steel: S 235; E = 210,000.00 N/mm^2; f_{yk} = 235.00 N/mm^2

Profile: Pipe, 139,7 x 12; (L x W x T) = 139.7 mm x 139.7 mm x 12.0 mm

Hole diameter in the fixture: d_f = 18.0 mm

Plate thickness (input): 14.0 mm

Drilling method: Hammer drilled

Cleaning: Compressed air cleaning of the drilled hole according to instructions for use is required

Anchor type and size: HIT-HY 200-A V3 + HAS-U 8.8 M16

Item number: 2223835 HAS-U 8.8 M16x190 (insert) / 2378172 HIT-HY 200-A V3 (mortar)

Maximum installation torque: 80 Nm

Hole diameter in the base material: 18.0 mm

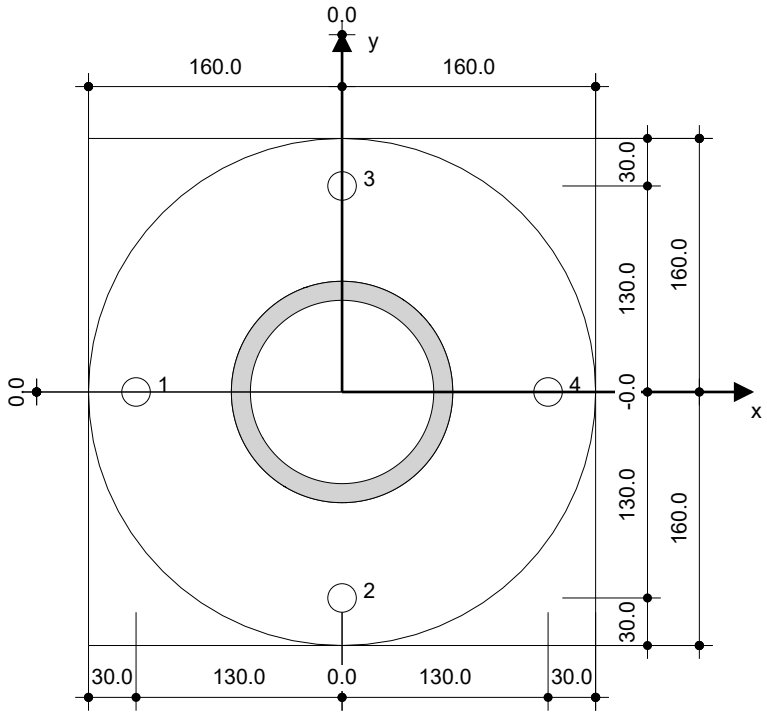
Hole depth in the base material: 80.0 mm

Minimum thickness of the base material: 116.0 mm

Hilti HAS-U 8.8 threaded rod with HIT-HY 200-A V3 injection mortar with 80 mm embedment hef, M16, Steel galvanized, Hammer drilling installation per ETA 19/0601, with annular gaps filled with Hilti Filling Set or any suitable gap solutions

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Compressed air with required accessories to blow from the bottom of the hole • Proper diameter wire brush	• Dispenser including cassette and mixer • For deep installations, a piston plug is necessary • Torque wrench



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-130.0	0.0	-	-	-	-
2	0.0	-130.0	-	-	-	-
3	0.0	130.0	-	-	-	-
4	130.0	-0.0	-	-	-	-

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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Company:		Page:	10
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Texel Anchors - Final Antenna	Date:	06-02-2025
Fastening Point:			

2 Baseplate design

2.1 Input data

Baseplate:	Shape: Circular l_x x l_y x t = 320.0 mm x 1,000.0 mm x 14.0 mm Calculation: CBFEM Material: S 235; F_y = 235.00 N/mm²; ε_{lim} = 5.00%
Anchor type and size:	HIT-HY 200-A V3 + HAS-U 8.8 M16, h_{ef} = 80.0 mm
Anchor stiffness:	The anchor is modelled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.
Design method:	EN based design using component-based FEM
Stand-off installation:	e_b = 40.0 mm (Stand-off with grouting); t = 14.0 mm
Profile:	139,7 x 12; (L x W x T x FT) = 139.7 mm x 139.7 mm x 12.0 mm x - Material: S 235; F_y = 235.00 N/mm²; ε_{lim} = 5.00% Eccentricity x: 0.0 mm Eccentricity y: -0.0 mm
Base material:	Cracked concrete; C20/25; $f_{c,cyl}$ = 20.00 N/mm²; h = 150.0 mm; E = 30,000.00 N/mm²; G = 12,500.00 N/mm²; v = 0.20
Welds (profile to baseplate):	Type of redistribution: Plastic Material: S 235
Mesh size:	Number of elements on edge: 8 Min. size of element: 10.0 mm Max size of element: 50.0 mm

2.2 Summary

	Description	Profile		Baseplate		
		σ_{Ed} [N/mm²]	ε_{Pl} [%]	σ_{Ed} [N/mm²]	ε_{Pl} [%]	Hole bearing [%]
1	Combination 1	36.05	0.00	25.36	0.00	2

2.3 Baseplate plate classification

Results below are displayed for the decisive load combinations: Combination 1

Anchor tension forces	Equivalent rigid baseplate (CBFEM)	Component-based Finite Element Method (CBFEM) baseplate
Anchor 1	3.928 kN	6.197 kN
Anchor 2	3.918 kN	6.259 kN
Anchor 3	3.918 kN	6.239 kN
Anchor 4	3.906 kN	6.122 kN

User accepted to consider the selected baseplate as rigid by his/her engineering judgement. This means the anchor design guidelines can be applied.

2.4 Profile/Stiffeners/Plate

Profile and stiffeners are verified at the level of the steel to concrete connection. The connection design does not replace the steel design for critical cross sections, which should be performed outside of PROFIS Engineering.

2.4.1 Equivalent stress and plastic strain

Limit state criteria as per EN1993-1-5 Annex C.8, (1) 2.

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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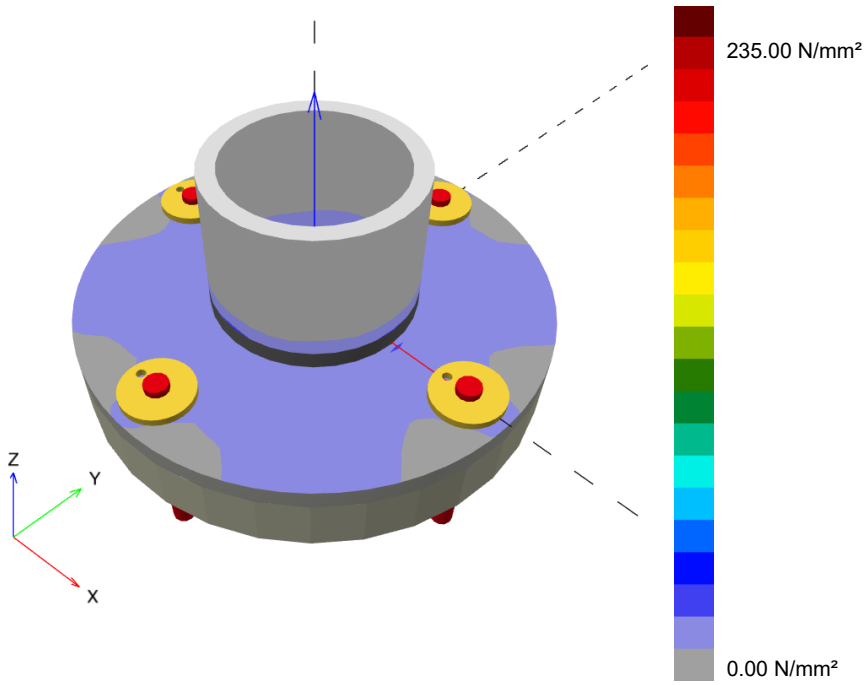
Company:		Page:	11
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Texel Anchors - Final Antenna	Date:	06-02-2025
Fastening Point:			

Results

Part	Load combination	Material	σ_{Ed} [N/mm²]	ε_{Pl} [%]	f_y [N/mm²]	γ_{M0}	f_y/γ_{M0} [N/mm²]	ε_{lim} [%]	Status
Plate	Combination 1	S 235	25.36	0.00	235.00	1.00	235.00	5.00	OK
Profile	Combination 1	S 235	36.05	0.00	235.00	1.00	235.00	5.00	OK

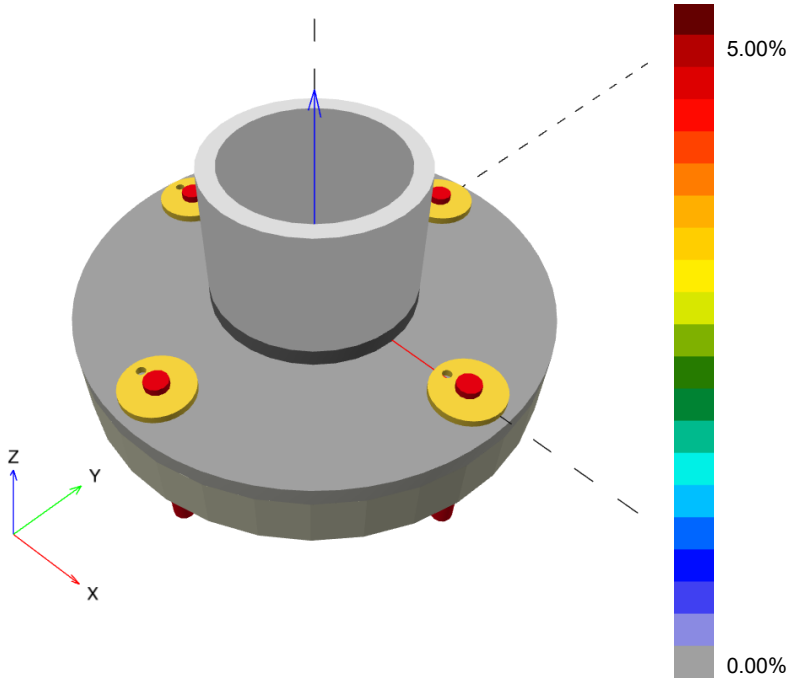
2.4.1.1 Equivalent stress

Results below are displayed for the decisive load combination: 1 - Combination 1



2.4.1.2 Plastic strain

Results below are displayed for the decisive load combination: 1 - Combination 1



2.4.2 Hole bearing

Decisive load combination: 1 - Combination 1

Plate hole bearing resistance, EN1993-1 - 8 section 3.6.1:

Equations

$$F_{b,Rd} = \frac{k_1 \, a_b \, f_u \, d \, t}{\gamma_{M2}}$$

$$\text{Utilisation} = \frac{V_{Ed}}{F_{b,Rd}}$$

Variables

	k_1	a_b	f_u [N/mm²]	d [mm]	t [mm]	γ_{M2}
Anchor 1	2.50	1.00	360.00	16.0	14.0	1.25
Anchor 2	2.50	1.00	360.00	16.0	14.0	1.25
Anchor 3	2.50	1.00	360.00	16.0	14.0	1.25
Anchor 4	2.50	0.56	360.00	16.0	14.0	1.25

Results

	V_{Ed} [kN]	$F_{b,Rd}$ [kN]	Utilisation [%]	Status
Anchor 1	1.400	161.280	1	OK
Anchor 2	1.432	161.280	1	OK
Anchor 3	1.432	161.280	1	OK
Anchor 4	1.466	89.600	2	OK

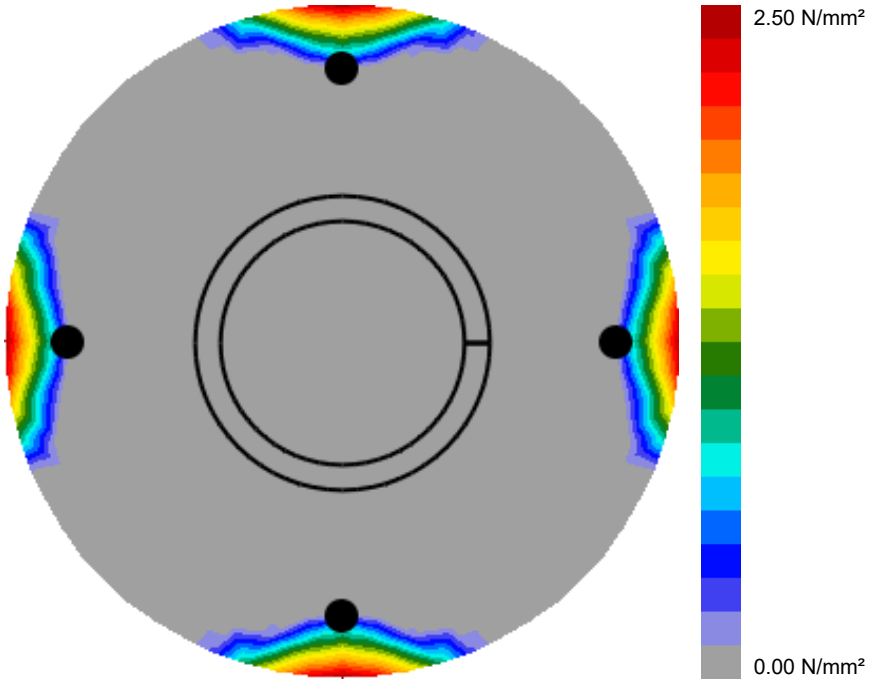
Input data and results must be checked for conformity with the existing conditions and for plausibility!
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2.5 Concrete

Decisive load combination: 1 - Combination 1

According to EN1992-1-1 section 6.7(4), the concrete should have sufficient reinforcement to take into account the tensile forces that develop due to the fixture attachment. The definition of the reinforcement in the concrete is not within the scope of PROFIS Engineering.

2.5.1 Compression in concrete under the baseplate



2.5.2 Note: In case no external compression loads are applied to the baseplate, compressions in concrete under the plate, per EN1993-1-8 section 6.7 and EN1992-1, are not performed.

2.6 Symbol explanation

a_b	Factor
d	Nominal diameter of the bolt
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
f_u	Ultimate strength
f_y	Yield strength
γ_{M0}	Steel safety factor gamma M0
γ_{M2}	Steel safety factor gamma M2
k_1	Factor for edge distance and bolt spacing perpendicular to the direction of load transfer - EN 1993-1-8 - Table 3.4
σ_{Ed}	Equivalent stress
t	Thickness of the baseplate
V_{Ed}	Anchor shear force

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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2.7 Warnings

- By using the CBFEM calculation functionality of PROFIS Engineering you may act outside the applicable design codes and your specified baseplate may not behave rigidly. Please, have the results validated by a professional designer and/or structural engineer to ensure suitability and adequacy for your specific jurisdiction and project requirements.
- The anchor is modelled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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3 Summary of results

Design of the baseplate, anchor, welds and other elements are based on CBFEM (component based finite element method) and Eurocode regulations.

	Load combination	Max. utilisation	Status
Anchors	Combination 1	49%	OK
Baseplate	Combination 1	11%	OK
Profile	Combination 1	16%	OK

Fastening meets the design criteria!

Input data and results must be checked for conformity with the existing conditions and for plausibility!
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4 Remarks; Your Cooperation Duties

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