

Maximum Capability Document

DYNACON, Inc. Job 1171

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Introduction

The purpose of this report is to provide a Maximum Capability Document (MCD) for Woods Hole Oceanographic Institute docking head assembly built under DYNACON Job 1171 in order to specify the Maximum Permissible Tension (MPT) of the system as defined in RVSS Appendix B. The serial number for the docking head is 1171-0101 DH. This report is intended to show the calculated stresses and safety factors at the critical failure points along the load path of the docking head.

Analysis

The results in this report are calculated based on using a Safe Working Load (SWL) of 10,000 lbs (4,535 kg). Two-g acceleration was applied to the SWL with the addition of a docking head weight of 4,000 lbs (1,814 kg) resulting in a design load of 24,000 lbs (10,884 kg). The design load of 24,000 lbs (10,884 kg) will be used to calculate the stresses at critical failure points in the docking head. All calculated stresses based on the above design load were determined to have a minimum factory of safety of 1.5 to the American Standard for Testing and Materials (ASTM) minimum yield for the given materials.

This report will demonstrate that the docking head Maximum Permissible Load is in excess of the customer specified Maximum Allowable Operating Tension (MAOT) of 15,000 lbs (6,803 kg). RVSS Appendix B Standards states that the factor of safety between the yield load and the MAOT is to be no less than 1.5, resulting in a calculated minimum yield load of 22,500 lbs (10,204 kg).

DYNACON, Inc. determined a design load of 24,000 lbs (10,884 kg); which will be used to calculate the stresses at the critical points. The calculated stresses with a minimum factor of safety of 1.5 to ASTM minimum yield for the given materials results in a minimum factor of safety of 2.4 between the yield load and the customer specified MAOT of 15,000 lbs (6,803 kg).

The complete design package for the system is maintained on file at DYNACON, Inc. The calculations used to complete this report are available at DYNACON's facility for on-site inspection.

System Specifications

Safe Working Load

High Speed/Low Torque	5,400 lbs (2,449 kg)
Low Speed/High Torque	10,000 lbs (4,536 kg)
Maximum Line Pull = SWL @ Max Displacement x 1.25	12,500 lbs (5,559 kg)

Lift Winch Line Speed

High Speed/Low Torque	0-112 fpm (0-34 mpm)
Low Speed/High Torque	0-56 fpm (0-17 mpm)

Brake Holding Load

18,000 lbs (8,163 kg) @ Full Drum

Rotation Angles

Sway	±20°
Swing	+40° to -76°
Slew	270°

Lift Winch Drum Capability

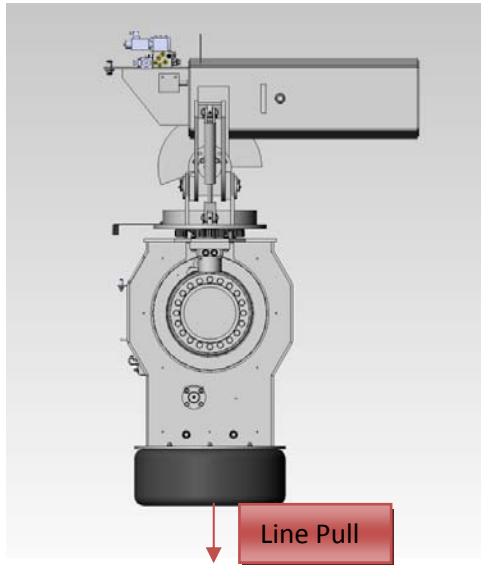
75 ft. of ¾ inch Amsteel – Rope
Provided

Required Power (Customer Supplied)

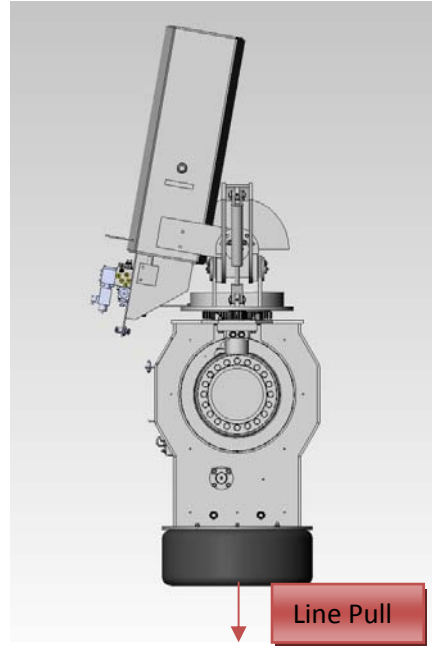
Hydraulic (Open Loop)	24 GPM Flow @ 3,550 psi
Electrical	24 VDC

Docking Head Worst Case Operating Scenarios

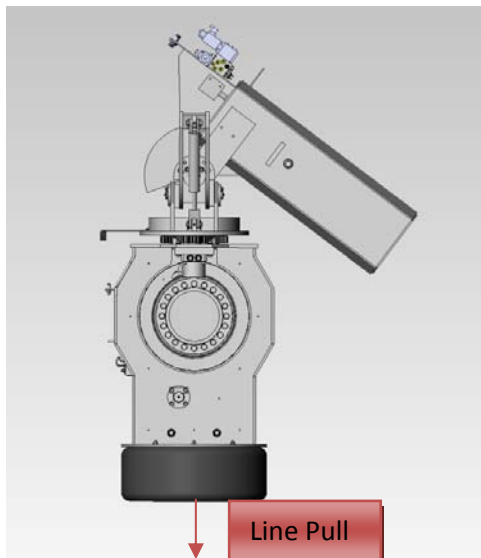
The critical failure points were analyzed based on the worst case operating scenarios. The highest stresses from each of the scenarios were used to calculate the lowest factor of safety.



A) Docking Head 90°



B) Fully Overboard: -76°



C) Fully Inboard: 40°

Figure 1; A) Docking head in normal operating scenario, B) Docking head in most extreme overboard operating scenario, C) Docking head in most extreme inboard operating scenario.

Material Properties

All materials used in the load path are produced to ASTM standards and the allowable stresses are calculated based on DNV Standard No. 2.22, "Lifting Appliances," Oct. 2008 for materials. The materials used in the docking head are shown below in Table 1.

Table 1. Material Properties and Specified Stresses

Material	ASTM Minimum Specified Yield Strength (psi)	*DNV Minimum Allowable Yield Strength (psi)	*DNV Minimum Allowable Shear Strength (psi)
ASTM A36 Plate	36000	24000	14400
ASTM A564 Type 630, 17-4 PH Stainless Bar, Condition H1150	105000	70000	42000
ASTM A 276 Type 304 Stainless Bar	30000	20000	12000
E71T-1 Coated Welding Rod Filler Metal	57000	38000	17100
ASTM A-354, Grade BD, SAE Grade 8 Bolt Material	-	20,350 lbs /Bolt** (Clamp Load)	See Note***
DIN 933 Grade 8.8 Bolt Material	-	27,470 lbs /Bolt** (Clamp Load)	See Note***

* DNV Minimum Allowable Yield Strength is calculated by ASTM Minimum Yield Strength / 1.5. The DNV Minimum Allowable Shear Strength is calculated by ASTM Minimum Yield Strength / 2.5.

**The clamp loads for the bolts in this document are based on 75% of the minimum specified proof loads for each grade and size.

***Note: Shear strength for bolts used in the docking head was not considered. Bolts are analyzed using a Slip Critical Analysis. A coefficient of friction of .11 is used to determine the joint strength. With the bolts torqued to values in Table 1, the frictional force between the bolted surfaces will resist the translational motion and the bolts will not be loaded in shear.

Component Ratings

The components (listed in Table 2) were analyzed to the listed rating of the bearing. This does not include any safety factors that the manufacturer applied to the components.

Table 2. System Component Ratings

Component	Bearing Rating
O&K F34 Bearing	91,125 lbs (Static) [405 kN]
Kaydon MTE-210T Slew Bearing	86,700 lbs (Tension)

Docking Head Critical Load Path Descriptions

The docking head was analyzed using the design load of 24,000 lbs (10,884 kg). The critical load path points of failure are shown in Table 3. The location of each failure point is shown in Figures 2-11 (see Appendix A).

Table 3. Locations of Critical Failure Points along the Critical Load Path

Location	Fig.	Drawing Ref. #	Description	Mode of Failure
1	2	1171-6004-17	Locking Pin	Shear of pin
2	2	1171-6007-31 Rev. A	Stab Frame Weldment	Bending of beam
3	2	1171-6007-31 Rev. A	Hanging Strap Weld to Stab Frame	Weld shear
4	2	1171-6007-35	Hanging Strap	Hanging strap in bending
5	2	1171-6007-35	Hanging Strap	Pin tear out of hole
6	2	1171-6007-35	Hanging Strap	Normal tear out of hole
7	3	1171-6004-05	Swing Pivot Pin	Shear of pin
8	4	1171-6007-13	Swing Brake Side Plate	Pin tear out of hole
9	4	1171-6007-13	Swing Brake Side Plate	Normal tear out of hole
10	4	1171-6007-10	Side Plate Weld to Pivot Frame	Weld shear
11	5	1171-6007-10	Pivot Frame Weldment	Sway side plate in bending
12	5	1171-6007-11	Sway Side Plate	Pin tear out of hole
13	5	1171-6007-11	Sway Side Plate	Normal tear out of hole
14	6	1171-6004-04	Sway Pivot Pin	Shear of Pin
15	7	1171-6007-01	Sway Frame Weldment	Side plate in bending
16	7	1171-6007-03	Slew Frame Side Plate	Pin tear out of hole
17	7	1171-6007-03	Slew Frame Side Plate	Normal tear out of hole
18	7	1171-6007-03	Slew Frame Side Plate	Shear of side plate
19	7	1171-6007-03	Slew Frame Side Plate	Normal tear out of side plate
20	7	1171-6007-01	Side Plate Weld to Bearing Mount Plate	Weld shear
21	8	1171-6001-01 Rev. A	Top Bolts to Slew Ring	Bolt clamp load exceeded
22	9	1171-6001-01 Rev. A	Slew Bearing	Tension rating exceeded
23	10	1171-6001-01 Rev. A	Bottom Bolts to Slew Ring	Bolt clamp load exceeded
24	11	1171-6006-10	Lift Frame Weldment	Stress at gearbox mount side plate to bearing mount plate
25	11	1171-6006-10	Lift Frame Weldment	Weld shear gearbox mount weld to bearing mount plate
26	11	1171-6006-10	Lift Frame Weldment	Bending of gearbox mount side plate at drum centerline
27	11	1171-6006-01 Rev. A	Gearbox Bearing Rating	Bearing rating exceeded
28	11	1171-6006-10	Lift Frame Weldment	Gearbox adapter plate to gearbox mount weld shear
29	11	1171-6006-01 Rev. A	Gearbox Mount Bolts	Torsion on bolts due to clamp load exceeded

Docking Head Calculated Stresses, Strengths, and Safety Factors

The calculated stresses and strengths at the given locations and factors of safety were calculated based on the allowable values in Tables 1 and 2, and are shown in Tables 4 and 5.

Table 4. Calculated Stresses and Safety Factors per Materials Used

Location	Material	Allowable Stress	Calculated Stress	Factor of Safety
1	304 Stainless Bar	12,000 psi (shear)	9,340 psi	1.28
2	A36 Plate	24,000 psi	9,618 psi	2.50
3	E71T-1 Welding Rod	17,100 psi (shear)	3,755 psi	4.55
4	A36 Plate	24,000 psi	17,363 psi	1.38
5	A36 Plate	24,000 psi	4,000 psi	6.00
6	A36 Plate	24,000 psi	8,535 psi	2.81
7	304 Stainless Bar	12,000 psi (shear)	3,820 psi	3.14
8	A36 Plate	24,000 psi	1,896 psi	12.66
9	A36 Plate	24,000 psi	6,154 psi	3.90
10	E71T-1 Welding Rod	17,100 psi (shear)	2,263 psi	7.56
11	A36 Plate	24,000 psi	11,784 psi	2.04
12	A36 Plate	24,000 psi	2,667 psi	9.00
13	A36 Plate	24,000 psi	5,755 psi	4.17
14	304 Stainless Bar	12,000 psi (shear)	3,820 psi	3.14
15	A36 Plate	24,000 psi	12,081 psi	1.99
16	A36 Plate	24,000 psi	3,118 psi	7.70
17	A36 Plate	24,000 psi	5,565 psi	4.31
18	A36 Plate	24,000 psi	1,100 psi	21.82
19	A36 Plate	24,000 psi	2,000 psi	12.00
20	E71T-1 Welding Rod	17,100 psi (shear)	2,381 psi	7.18
24	A36 Plate	24,000 psi	9,948 psi	2.41
25	E71T-1 Welding Rod	17,100 psi (shear)	13,111 psi	1.30
26	A36 Plate	24,000 psi	17,349 psi	1.38
28	E71T-1 Welding Rod	17,100 psi (shear)	2,930 psi	5.84

Table 5. Calculated Loads per Bolt Rating

Location	Component	Allowable Strength	Calculated Strength	Factor of Safety
21	SAE Grade 8 Bolt Mat.	20,350 lbs / Bolt	1,500 lbs / Bolt	13.50
22	Slew Bearing Tension	86,700 lbs	24,000 lbs	3.61
23	SAE Grade 8 Bolt Mat.	20,350 lbs / Bolt	1,200 lbs / Bolt	16.96

Table 6. Calculated Loads per Component Rating

Location	Component	Allowable Load	Calculated Load	Factor of Safety
27	O&K F34 Gearbox	91,125 lbs Static	72,000 lbs Static	1.27
29	DIN 933 Grade 8.8 Bolt Material	60,434 lbs – Based on Slip-Critical Bolt Force	32,755 lbs	1.85

Conclusions

The analysis of the critical load path shows the docking head has a suitable safety factor for the Maximum Allowable Operating Tension as stated by the customer.

Appendix A

Figures 2-11 show the locations of the critical failure points along the load path.

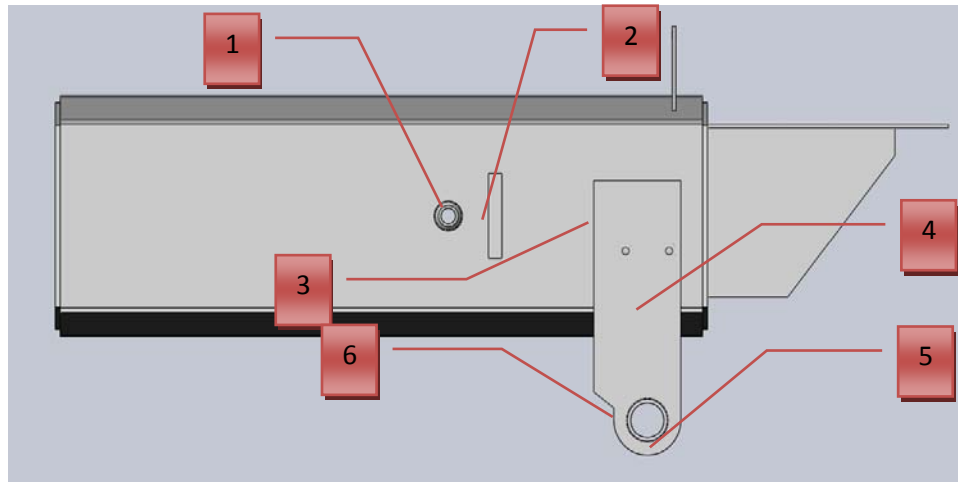


Figure 2. Docking Head Stab Frame Critical Failure Points

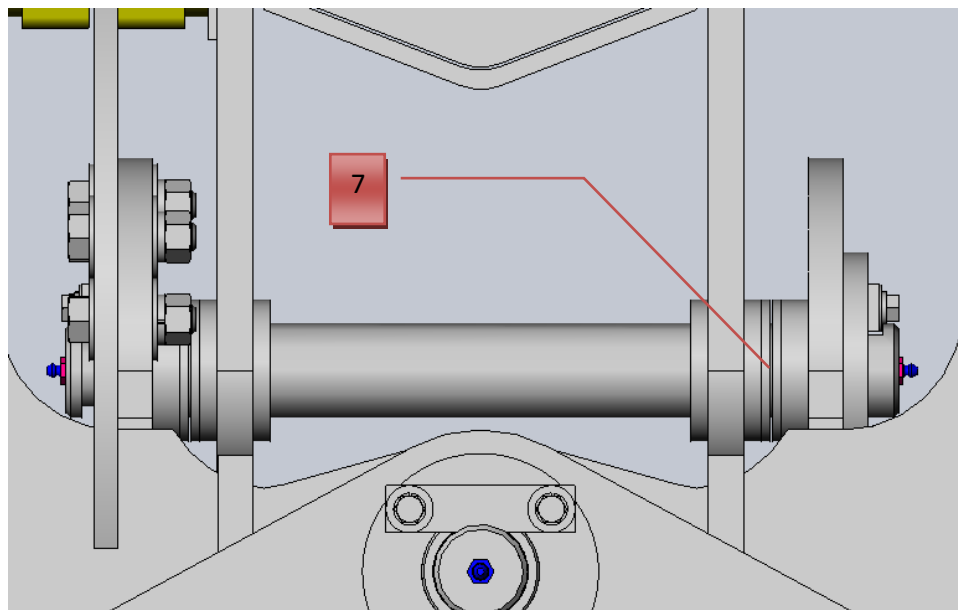


Figure 2. Docking Head Swing Pin Critical Failure Point

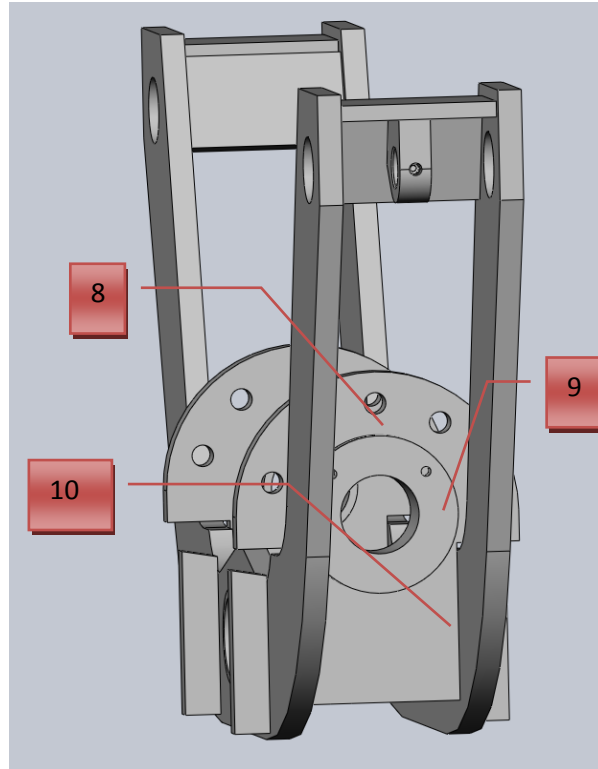


Figure 3. Docking Head Pivot Frame Swing Critical Failure Points

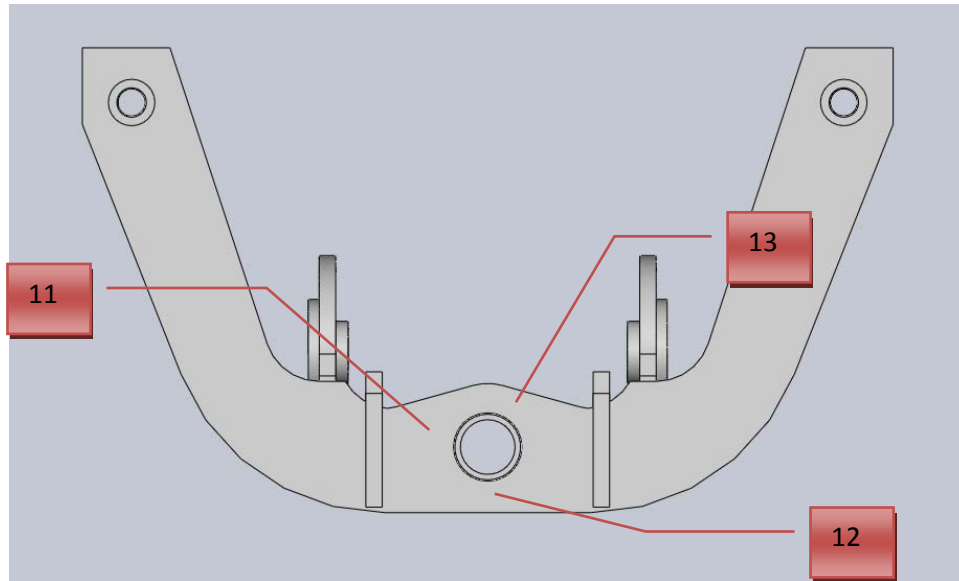


Figure 4. Docking Head Pivot Frame Sway Critical Failure Points

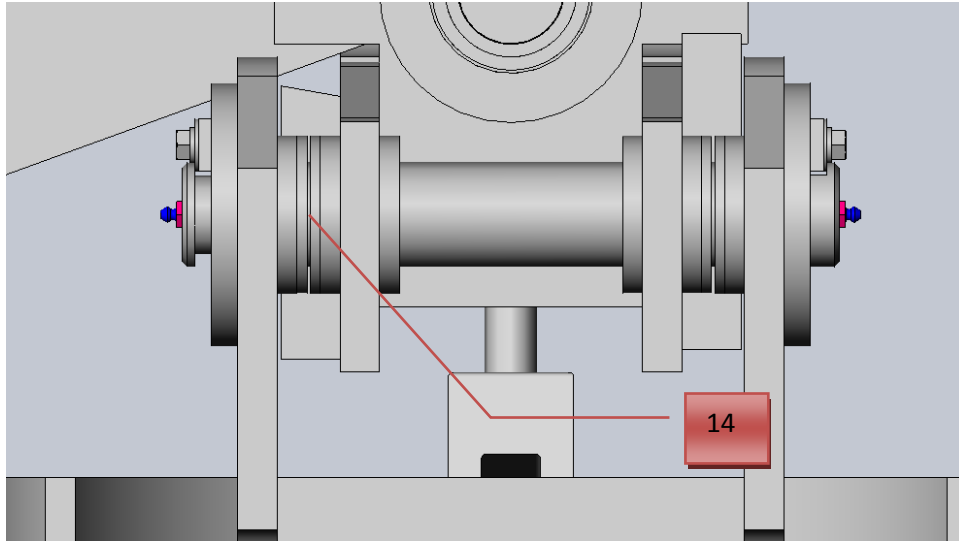


Figure 5. Docking Head Sway Pin Critical Failure Point

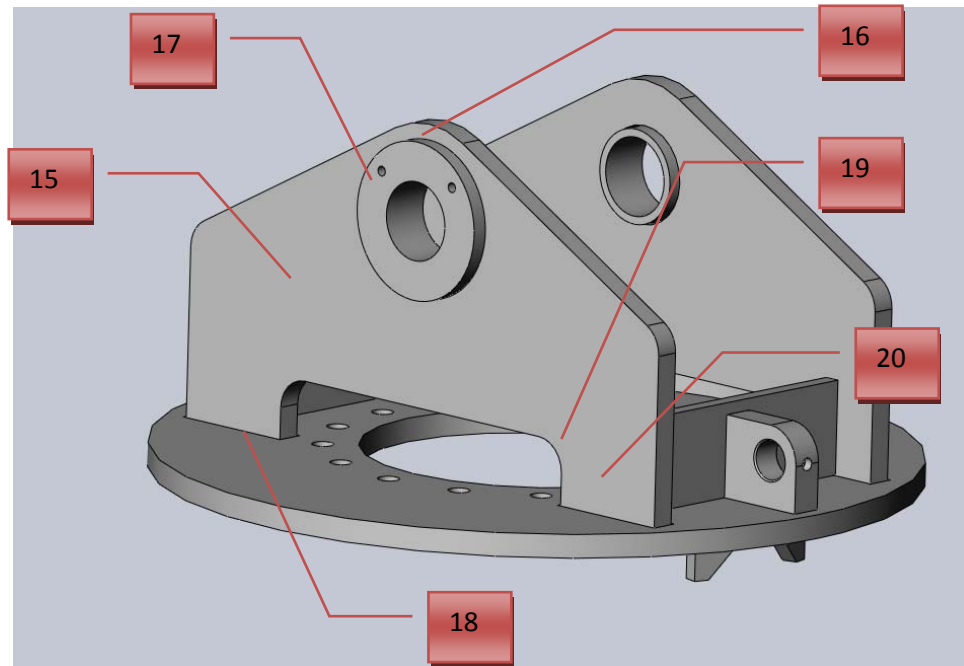


Figure 6. Docking Head Slew Frame Critical Failure Points

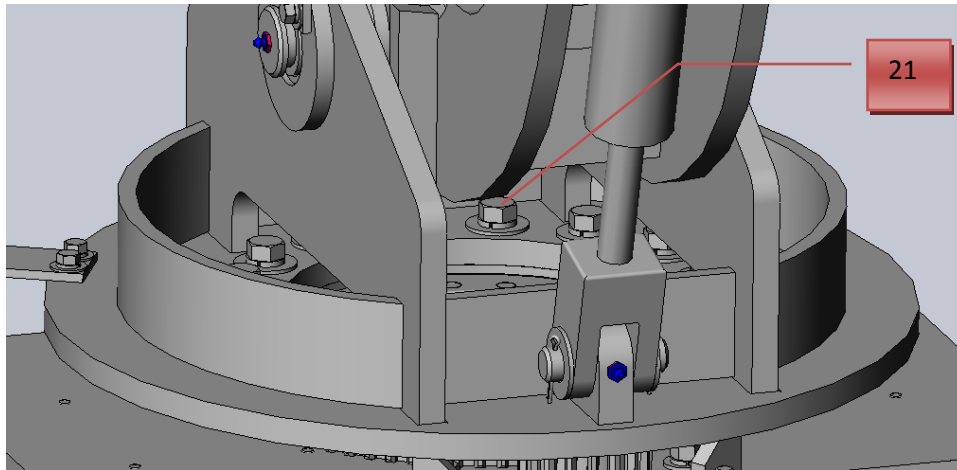


Figure 7. Docking Head Slew Bearing Outer Bolts Critical Failure Points

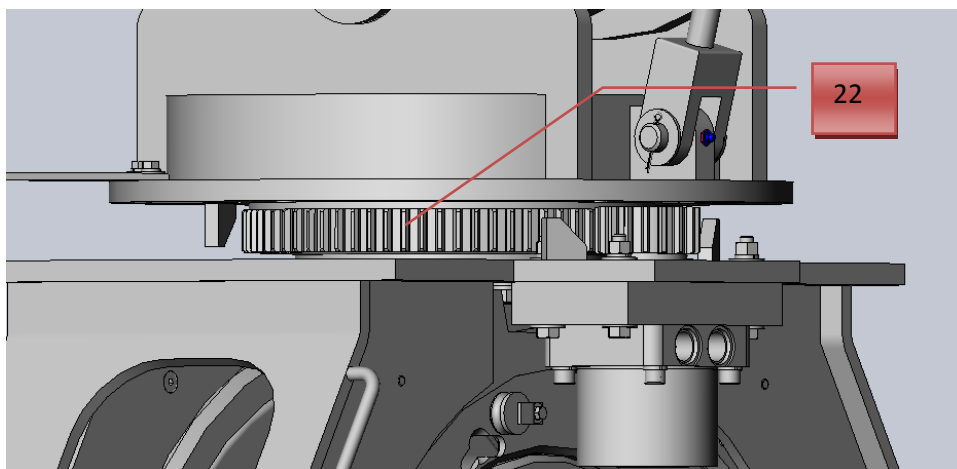


Figure 8. Docking Head Slew Bearing Critical Failure Point

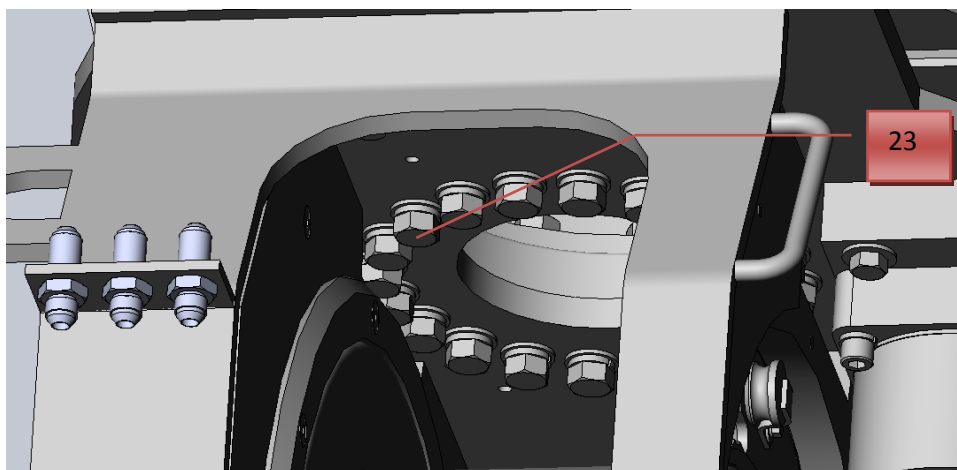


Figure 9. Docking Head Slew Bearing Inner Bolts Critical Failure Points

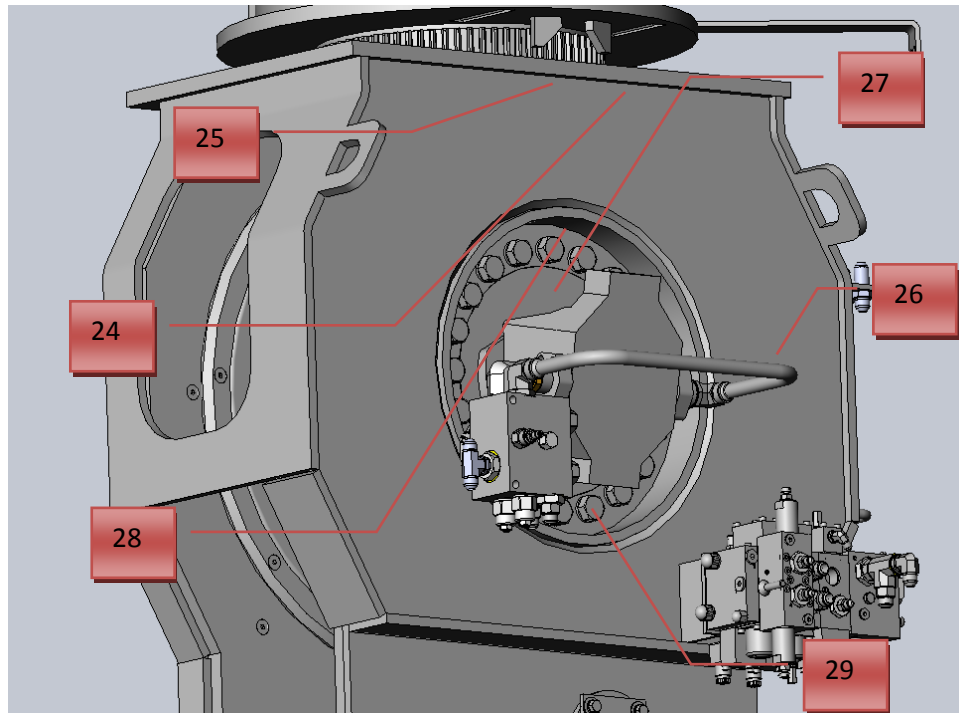


Figure 10. Docking Head Winch Frame Critical Failure Points