NAUTOR SWAN
GLOBAL SERVICE

TECHNICAL ADVICE

Keel disassemble and bolt repair

Swan 57-009

Valkyrie

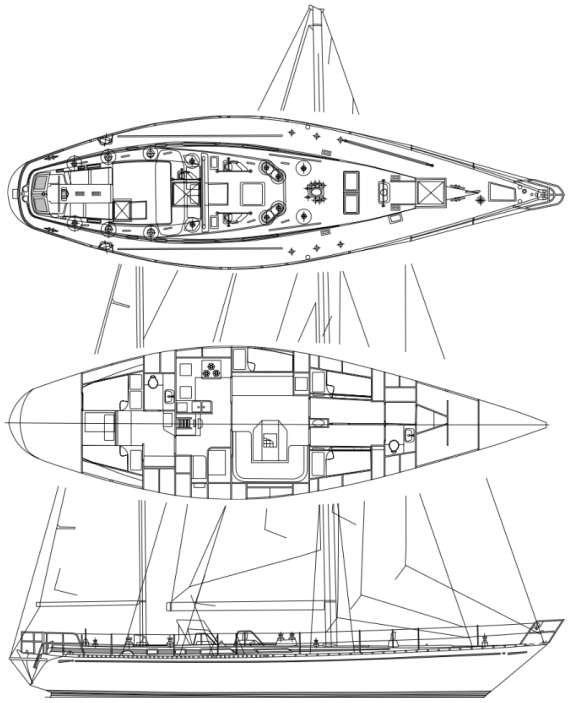
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Yachts involved:

Swan 57 from 001 to 012

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1. TECHNICAL ADVICE DESCRIPTION



BUILDER:	NAUTOR
DELIVERY YEAR:	1977
MODEL:	Swan 57
HULL No:	009
LENGTH OVERALL:	17.50 m
BEAM:	4.83 m
DRAFT:	2.8 m

DESCRIPTION:

This document addresses the request from yacht's owner:

I'm looking for drawings of the keel's internal structure and keel-bolt arrangement and any other technical documentation that may assist with the inspection and repair of the keel's bolts.

INTRODUCTION:

Keel floor damage occurred on one of the 57's in the famous Fastnet 79, and the yacht had to retire.
The yard decided to reinforce all delivered 57's and modified the construction of the 57's in build.

A repair team was sent out to the boats by Gunnar Öst, or an authorized yard did it.

We do not have record of the involved shipyards following Nautor's reinforced instructions.
As a result of the diversity of companies, the finishes of these works may present slight differences.

This yacht 57-009 was delivered in May 1979, before the Fastnet race.

As all Swan 57 S&S produced to that date (summer/fall 1979), after the Fastnet were keel reinforced by Nautor specs, and this must include this yacht, 57-009.

The list of hull numbers involved in this reinforcement is from 001 to 012.

This document is based on the information we have and should be sufficient to understand the design of the keel after the reinforcement; however, small differences may be found.

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INTRODUCTION:

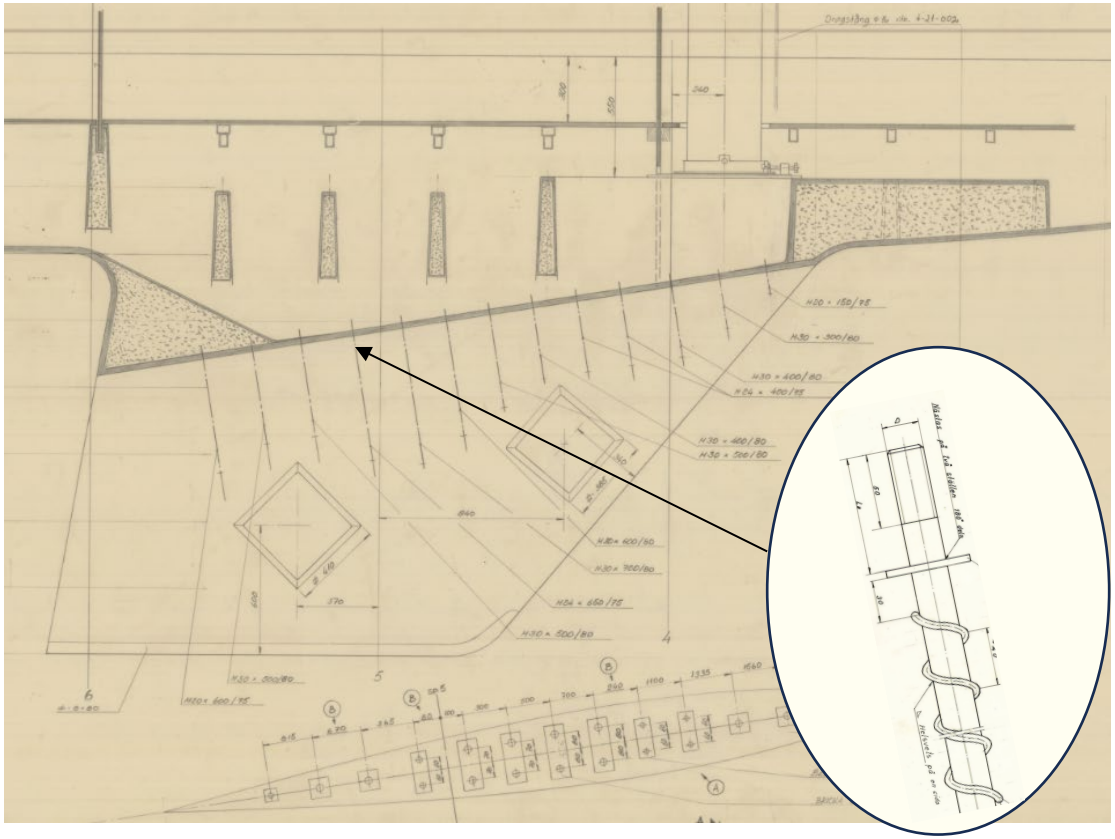
The original keel bolts are 20, 24, and 30 mm in diameter.

The top of the bolt has a 50 mm threaded section, below which is an unthreaded 30 mm section leading to a 5 x 60 x 60 mm plate that is welded to the bolt and seats on the upper surface of the lead keel.

The overall length of the bolt varies depending on its location, being shorter towards the bow and in the areas where it meets the pockets for adjusting the keel weight.

The portion of the bolt embedded in the lead has a welded spiral for better anchoring. The lower end of the bolt is finished with an 8 x 70 x 70 mm plate secured by a nut; this assembly is also fixed with spot welds.

The plates used beneath the tightening nuts are 8mm thick, AISI 316.

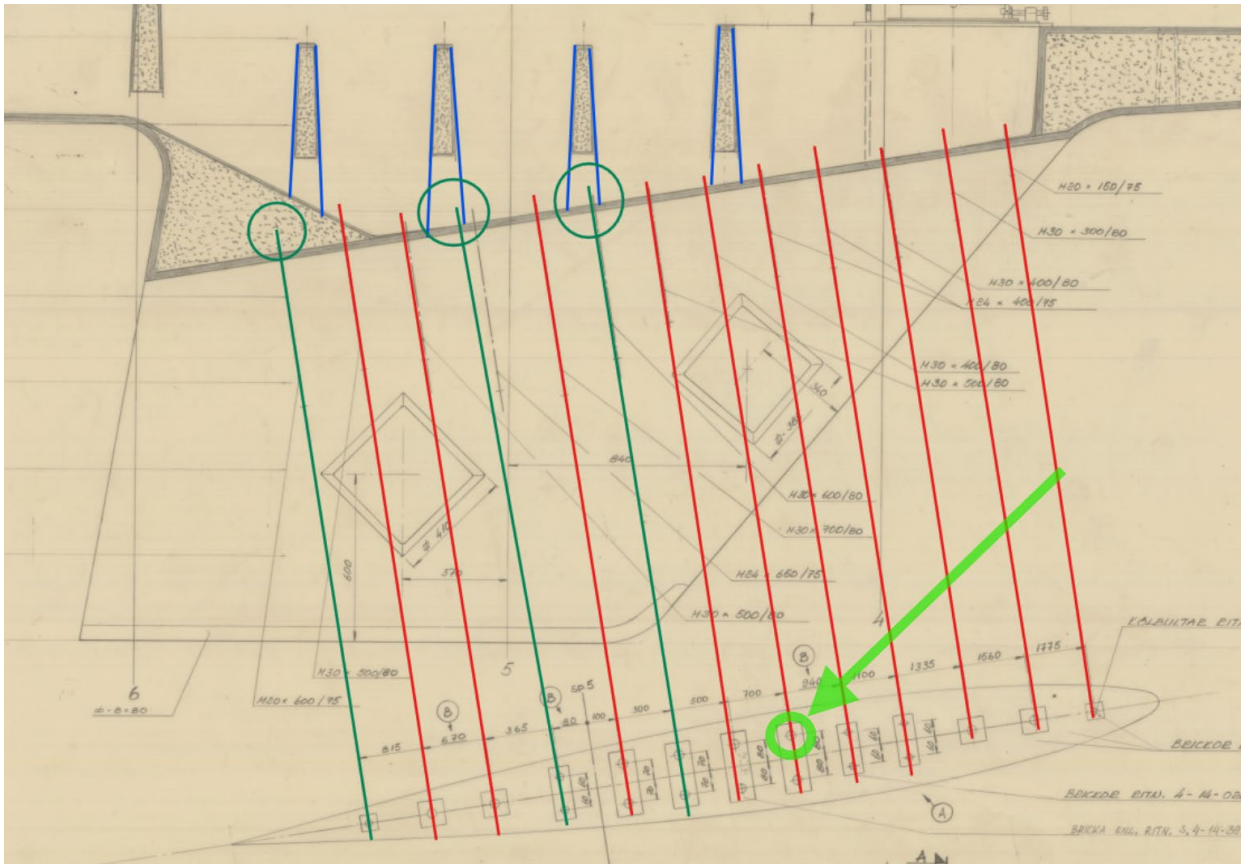


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ANALYSIS:

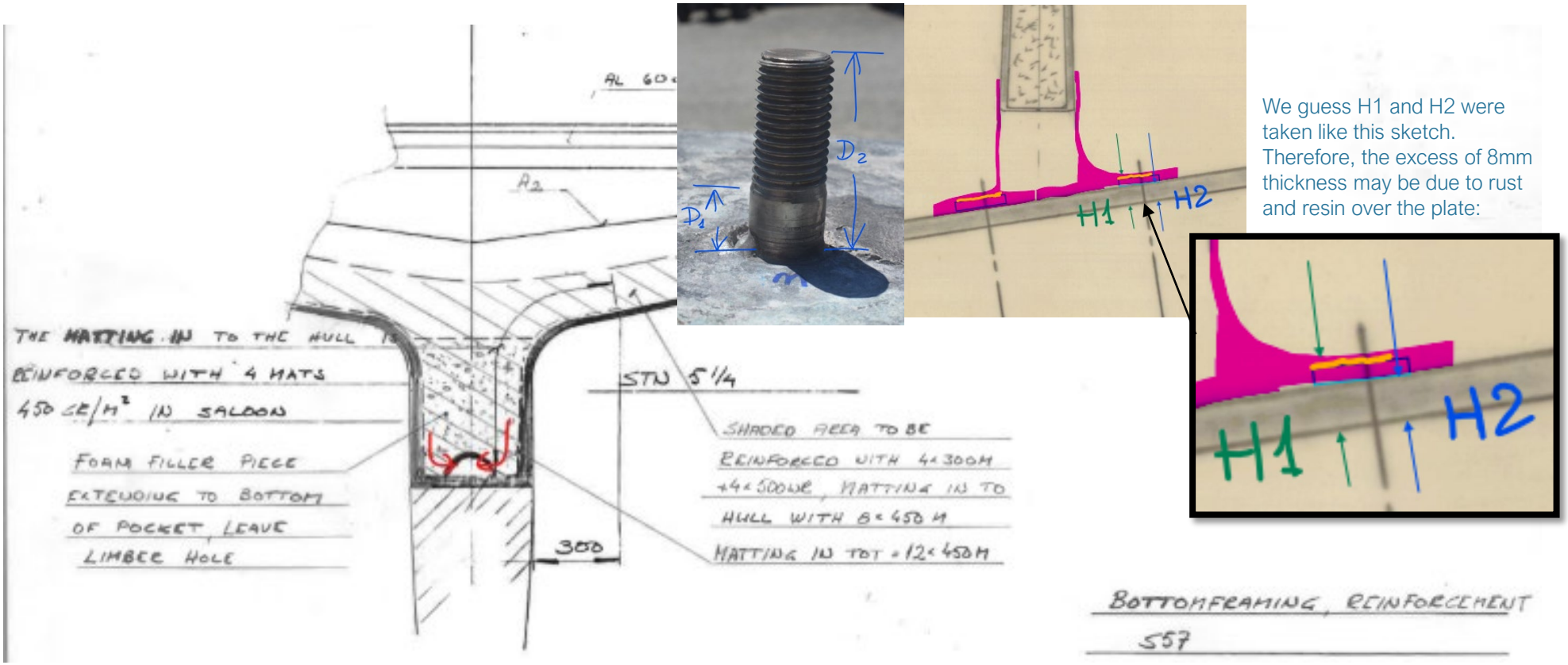
After inspecting the keel, significant corrosion was observed on bolt #8 (green arrow), in addition to other bolts with damaged threads.

Bolts #12 + #13, #18 + #17, and #20 (green lines) are hidden by the fiberglass reinforcement applied after the 1979 Fastnet repair.
Access to these bolts was required, and it is recommended to leave a small access window after the keel is repaired for future torque checks.



ANALYSIS :

After removing and cleaning the keel, measurements were taken of:



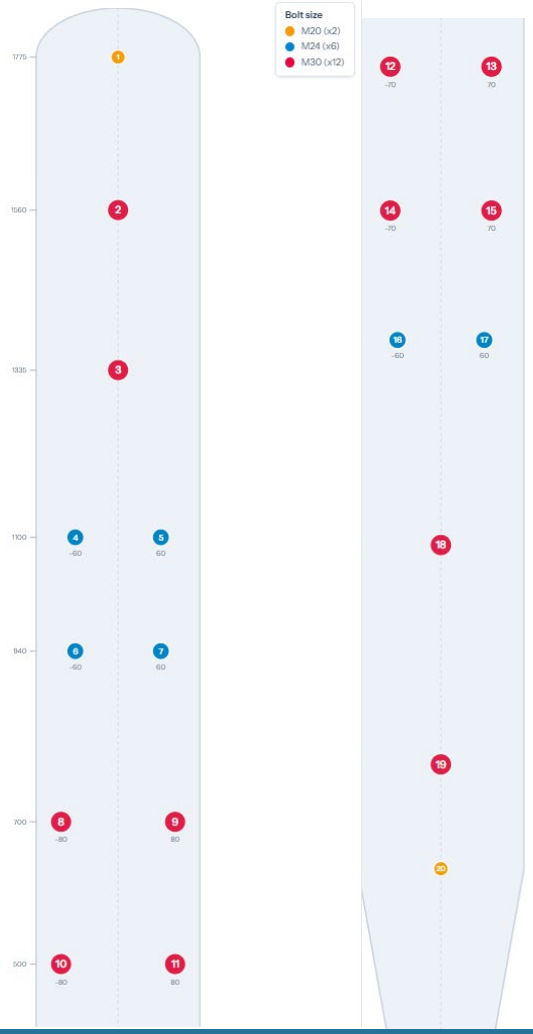
We guess H1 and H2 were taken like this sketch. Therefore, the excess of 8mm thickness may be due to rust and resin over the plate:

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ANALYSIS :

The theoretical thickness, calculated from measurements H1 and H2, is typically above 8 mm due to rolling residue.

However, the plates at bolts #8 and #9 must be carefully examined because, if the measurement is accurate, they may need to be replaced due to corrosion.
I recommend removing all plates for analysis, reconditioning, or replacement before reinstalling them and re-rolling the reinforcements on the bulkheads.



Keel Bolt Measurement Worksheet

D2 = total bolt height (head to tip, above the lead) · D1 = height from the lead to the start of the threads · H2 = bottom of plate · H1 = top of plate · Plate thickness = H1 minus H2. All measurements in mm. Rows shaded amber have a plate thickness that differs sharply from another bolt at the same station — worth double-checking that bolt's H1/H2 measurements.

Bolt #	D2 — Total bolt height (mm)	D1 — Lead to thread (mm)	H2 — Bottom of plate (mm)	H1 — Top of plate (mm)	Plate thickness — calc. (mm)
1	74.3	25	41.85	51.05	**9.2**
2	79.7	30	31.24	41.83	**10.59**
3	76.25	25	32.02	44.3	**12.28**
4	73.23	22	31.08	46.55	**15.47**
5	71.23	23	31.06	45.88	**14.82**
6	72.2	21	32.62	52.5	**19.88**
7	68.81	19.5	32.08	51.77	**19.69**
8	78.12	29	32.52	36.04	**3.52** QUESTIONABLE
9	76.14	30	23.23	33.52	**10.29** QUESTIONABLE
10	75.13	23	27.49	37.8	**10.31**
11	73.23	26	25.68	35.31	**9.63**
12	75.82	26	23.49	37.94	**14.45**
13	76.12	28	23.13	34.8	**11.67**
14	77.61	25	23.37	37.88	**14.51** QUESTIONABLE
15	78.81	29	26.23	35.75	**9.52** QUESTIONABLE
16	75.73	24.5	20.84	32.33	**11.49**
17	69.62	19	20.41	33.17	**12.76**
18	74.86	21.5	17.29	30.12	**12.83**
19	71.59	17	25.48	34.05	**8.57**
20	74.25	24	41.53	51.03	**9.5**

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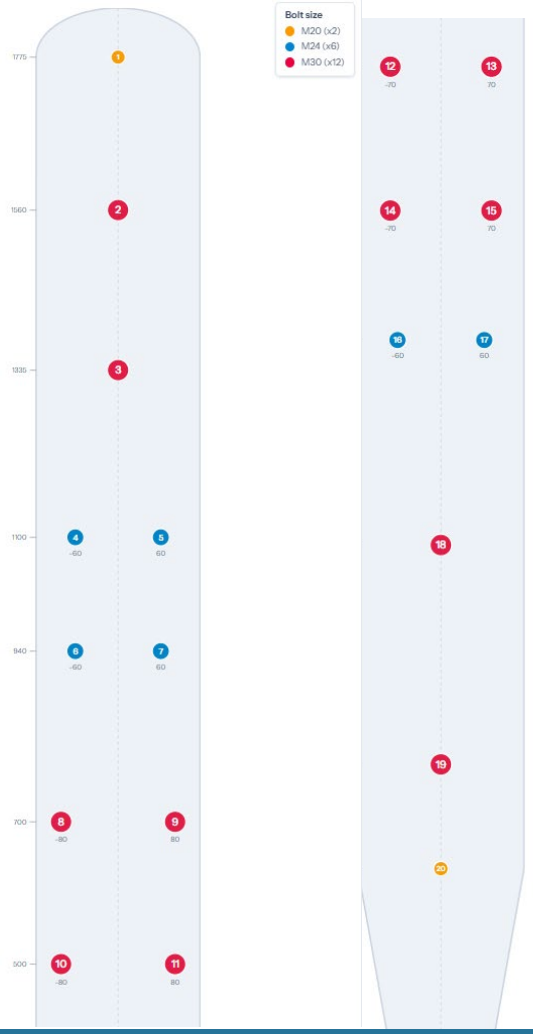
ANALYSIS :

Taking these measurements into account, the available thread for tightening the nuts is another important aspect to consider.

For bolts #6 and #7, the calculation gives us only 19 mm and 17 mm respectively, which is insufficient to safely tighten the nuts to the correct torque. Maybe because the thickness of plate + rolling residue.

This is another reason why it is very important to remove all the plates and recheck them after cleaning them or fabricating new ones if necessary.

If, despite this, the available thread is still insufficient, then a bolt extension should be installed, which I describe later in Appendix 1, at the end of this document.



	METRIC	Bolt #	D2 — Total bolt height (mm)	D1 — Lead to thread (mm)	H2 — Bottom of plate (mm)	H1 — Top of plate (mm)	Plate thickness — calc. (mm)	Available to thread the nut (mm)
SINGLE	20	1	74,3	25	41,85	51,05	9,2	23,25
SINGLE	30	2	79,7	30	31,24	41,83	10,59	37,87
SINGLE	30	3	76,25	25	32,02	44,3	12,28	31,95
PAIR	24	4	73,23	22	31,08	46,55	15,47	26,68
	24	5	71,23	23	31,06	45,88	14,82	25,35
PAIR	24	6	72,2	21	32,62	52,5	19,88	19,7
	24	7	68,81	10,5	32,08	51,77	19,69	17,04
PAIR	30	8	78,12	29	32,52	36,04	**3,52**	42,08
	30	9	76,14	30	23,23	33,52	**10,29**	42,62
PAIR	30	10	75,13	23	27,49	37,8	10,31	37,33
	30	11	73,23	26	25,68	35,31	9,63	37,92
PAIR	30	12	75,82	26	23,49	37,94	14,45	37,88
	30	13	76,12	28	23,13	34,8	11,67	41,32
PAIR	30	14	77,61	25	23,37	37,88	14,51	39,73
	30	15	78,81	29	26,23	35,75	9,52	43,06
PAIR	24	16	75,73	24,5	20,84	32,33	11,49	43,4
	24	17	69,62	19	20,41	33,17	12,76	36,45
SINGLE	30	18	74,86	21,5	17,29	30,12	12,83	44,74
SINGLE	30	19	71,59	17	25,48	34,05	8,57	37,54
SINGLE	20	20	74,25	24	41,53	51,03	9,5	23,22

PROCEDURE:

Next, we will describe the recommended actions to take, bolt by bolt.

#1 (M20)
Nothing to do but clean better the thread.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
74.3 mm	**25 mm**	**51.05 mm**	**41.85 mm**	**9.2 mm**

D2 is the bolt's total height, from the head/tip down to the top of the lead. **D1** is the height from the lead up to where the threads start. **H1** is how deep the hole in the hull is where the bolt sits. **H2** is the thickness from the bottom of the keelson to the bottom of the internal plate. **Plate thickness** is calculated as H1 minus H2.







PROCEDURE:

#2 (M30)
Nothing to do but clean better the thread.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
79.7 mm	**30 mm**	**41.83 mm**	**31.24 mm**	**10.59 mm**

D2 is the bolt's total height, from the head/tip down to the top of the lead. **D1** is the height from the lead up to where the threads start. **H1** is how deep the hole in the hull is where the bolt sits. **H2** is the thickness from the bottom of the keelson to the bottom of the internal plate. **Plate thickness** is calculated as H1 minus H2.





PROCEDURE:

#3 (M30)
Nothing to do but clean better the thread.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
76.25 mm	**25 mm**	**44.3 mm**	**32.02 mm**	**12.28 mm**

D2 is the bolt's total height, from the head/tip down to the top of the lead. **D1** is the height from the lead up to where the threads start. **H1** is how deep the hole in the hull is where the bolt sits. **H2** is the thickness from the bottom of the keelson to the bottom of the internal plate. **Plate thickness** is calculated as H1 minus H2.



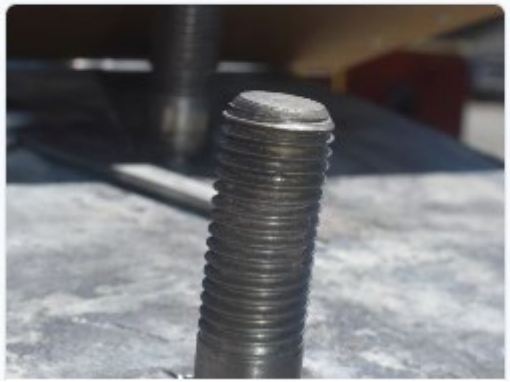


PROCEDURE:

#4 & #5 (M24)
Nothing to do but clean better the thread.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
73.23 mm	22 mm	46.55 mm	31.08 mm	15.47 mm
71.23 mm	23 mm	45.88 mm	31.06 mm	14.82 mm







Add a note...

#5

PROCEDURE:

#6 & #7 (M24)
Nothing to do but check the thickness of plate + rolling residue.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
72.2 mm	21 mm	52.5 mm	32.62 mm	19.88 mm
68.81 mm	19.5 mm	51.77 mm	32.08 mm	19.69 mm







Add a note...

#7

PROCEDURE:

#8 & #9 (M30)
Install a bolt extension, a sort of prosthesis that rebuilds the bolt, according to the procedure explained in Appendix 1 at the end of this document.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
78.12 mm	29 mm	36.04 mm	32.52 mm	3.52 mm
76.14 mm	30 mm	33.52 mm	23.23 mm	10.29 mm







Add a note... #9

PROCEDURE:

#10 & #11 (M30)
Nothing to do on #10 but the #11 must be machined on place. If after this action, the thread is no working well, then same procedure in Appendix 1.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
75.13 mm	23 mm	37.8 mm	27.49 mm	10.31 mm
D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
73.23 mm	26 mm	35.31 mm	25.68 mm	9.63 mm







Add a note... #11

PROCEDURE:

#12 & #13 (M30)
The #12 must be machined on place. The #13 nothing to do.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
75.82 mm	26 mm	37.94 mm	23.49 mm	14.45 mm
76.12 mm	28 mm	34.8 mm	23.13 mm	11.67 mm







Add a note...

#13

PROCEDURE:

#14 & #15 (M30)
The #14 must be machined on place. The #15 nothing to do.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
77.61 mm	25 mm	37.88 mm	23.37 mm	14.51 mm
78.81 mm	29 mm	35.75 mm	26.23 mm	9.52 mm







Add a note...

#15

PROCEDURE:

#16 & #17 (M24)
The #16 must be machined on place. The #15 nothing to do.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
75.73 mm	24.5 mm	32.33 mm	20.84 mm	11.49 mm
D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
69.62 mm	19 mm	33.17 mm	20.41 mm	12.76 mm







Add a note...

#17

PROCEDURE:

#18 (M30)
Must be machined on place.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
74.86 mm	**21.5 mm**	**30.12 mm**	**17.29 mm**	**12.83 mm**

D2 is the bolt's total height, from the head/tip down to the top of the lead. **D1** is the height from the lead up to where the threads start. **H1** is how deep the hole in the hull is where the bolt sits. **H2** is the thickness from the bottom of the keelson to the bottom of the internal plate. **Plate thickness** is calculated as H1 minus H2.







PROCEDURE:

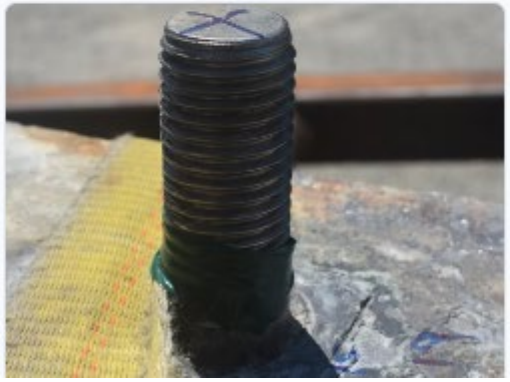
#19 (M30)
Must be machined on place. If after this action, the thread is no working well, then same procedure in Appendix 1.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
71.59 mm	**17 mm**	**34.05 mm**	**25.48 mm**	**8.57 mm**

D2 is the bolt's total height, from the head/tip down to the top of the lead. **D1** is the height from the lead up to where the threads start. **H1** is how deep the hole in the hull is where the bolt sits. **H2** is the thickness from the bottom of the keelson to the bottom of the internal plate. **Plate thickness** is calculated as H1 minus H2.







PROCEDURE:

#20 (M20)
Nothing to do.

Bolt dimensions

D2 — Total bolt height	D1 — Lead to thread	H1 — Hull hole depth	H2 — Keelson to plate	Plate thickness (calc.)
74.25 mm	**24 mm**	**51.03 mm**	**41.53 mm**	**9.5 mm**

D2 is the bolt's total height, from the head/tip down to the top of the lead. **D1** is the height from the lead up to where the threads start. **H1** is how deep the hole in the hull is where the bolt sits. **H2** is the thickness from the bottom of the keelson to the bottom of the internal plate. **Plate thickness** is calculated as H1 minus H2.







4. APPENDIX 1

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DESCRIPTION:

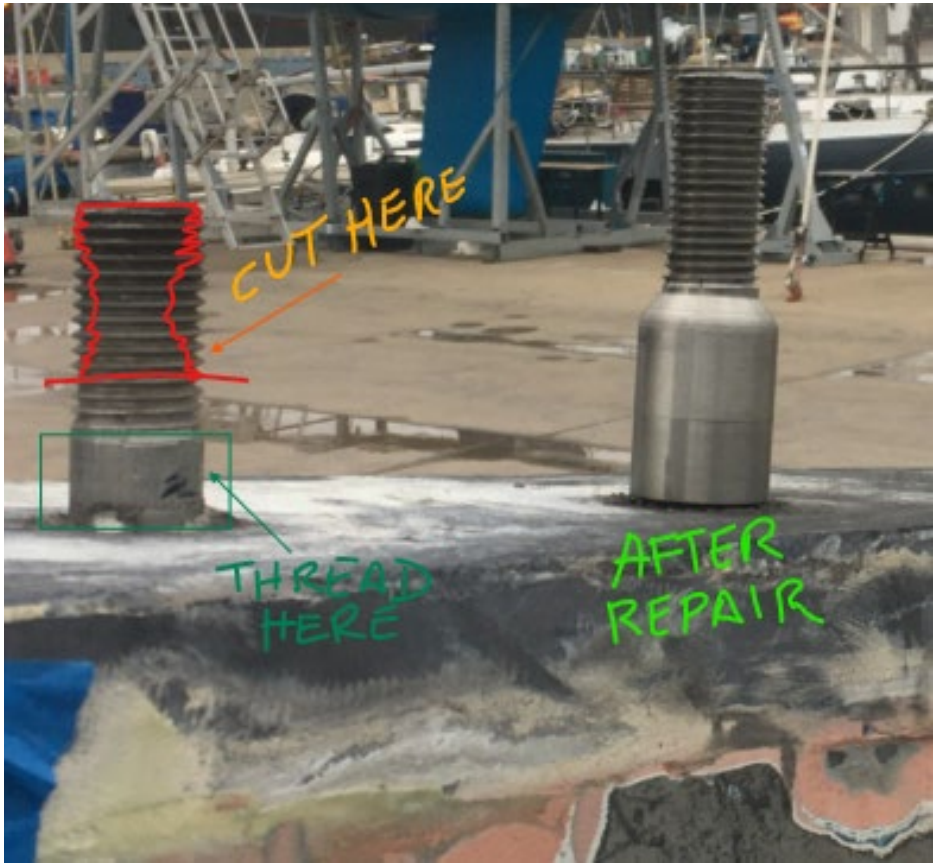
This Appendix cover the solution to fix a corroded or damaged bolt doing a bolt extension, a sort of prosthesis that rebuilds the bolt.

PROCEDURE:

The bolt must be machined again, including the unthreaded section until the lead.
The goal is to obtain at least 30mm (32-35mm is recommended) of new thread on which to screw a new piece.
This new piece has an internal M30 female thread along its lower end for 35mm approx, and then tapers down to form an extension of the M30 bolt.

Nuts will be screwed onto this extension to apply the necessary torque to secure the keel once it is assembled.
The corroded section of the original bolt must be cut off to allow this piece thread into the new M30 thread x 32mm high.

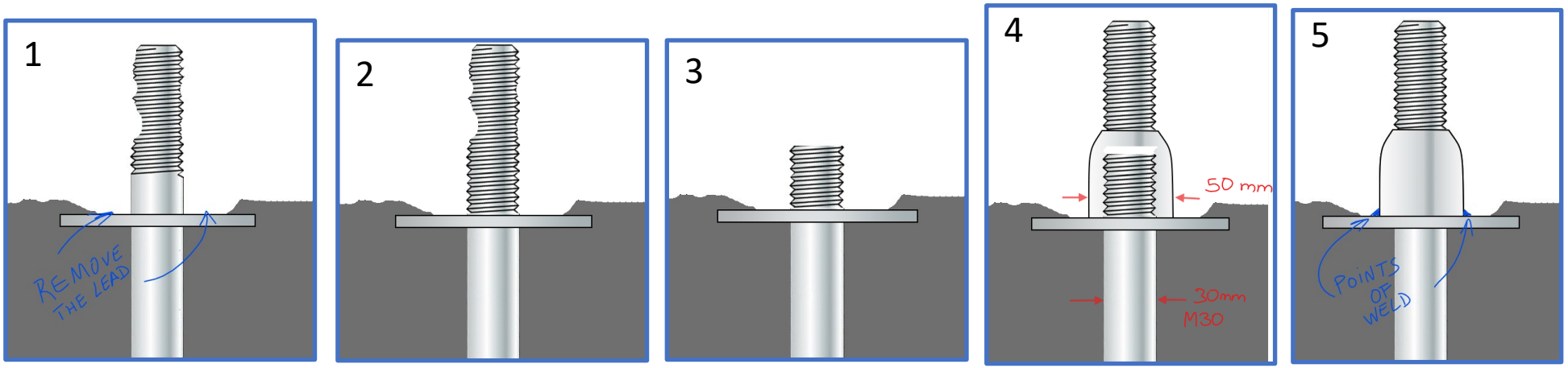
If there is not enough height for the new thread, the lead at the base can be removed until the plate with the bolt welded on is reached, and the new piece can be threaded up to the plate, applying 2 points of solder at the end to help the nut-locking compound not to loosen.



PROCEDURE:

1) Remove the lead around the bolt until the plate.
2) The bolt must be machined again, including the unthreaded section until the lead. The goal is to obtain at least 30mm (32-35mm is recommended) of new thread on which to screw a new piece.
3) Cut enough rusty/corroded bolt to allow thread the new piece.
4) This new piece is AISI 316 grade 70 and has an internal M30 female thread along its lower end for 35mm heigh approx, and 50mm diameter, and then tapers down to form an extension of the M30 bolt.
5) Applying 2 points of solder at the end to help the nut-locking compound not to loosen.

It will be necessary to drill bigger holes on the hull to allow insert this new pieces of 50mm diameter versus the M30 bolt, where is needed.



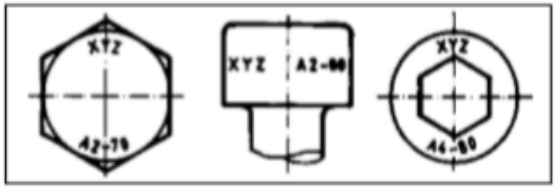
ADITIONAL NOTES:

A galled nut may be impossible to remove, heating not recommended due to the adjacent laminate. A nut splitter may be the only remedy.
For AISI 316 bolts the risk of galling is reduced if harder steel nuts are used. The nuts need to have a Brinell hardness at least 50 units higher than for the bolts, i.e. HB > 200. Use A4 - 70.

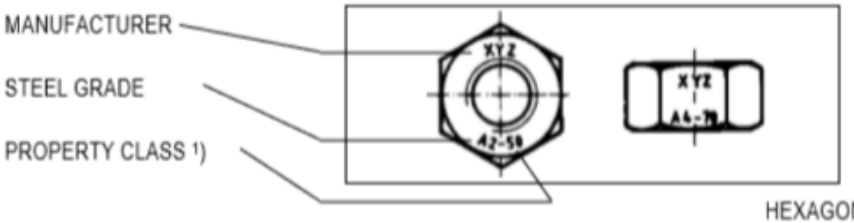
When installing the nuts it is necessary to first check that they easily can be screwed to the bottom of the threads, i.e. without tools. Stiff threads need to be cleaned with a re-threading die.
It is worthwhile to lubricate the threads, then 2/3 of the dry thread torque is sufficient. Sikaflex is a good thread lubricant, pls note graphite based grease must NOT be used, causes corrosion on the stainless.
It is very important that the keel plank slot around each bolt is completely filled with mastic right down to the lead. No water pockets allowed, they cause invisible crevice corrosion.

Electrical resistivity for AISI 316 is 44 times higher than for copper. This needs to be considered if making electrical connections were stainless bolts are part of a circuit.
The bolts are cast into the lead keel and can not be removed. The lead shrinks during cooling, and this grips the bolts tightly.

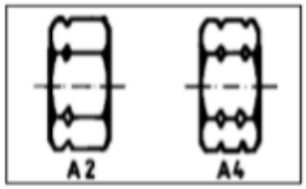
AISI 316 fasteners are marked A4, and available in three Classes: 50, 70, and 80, and these numbers are shown on their heads and nuts.
Marking A1 or A2 means AISI 303 or 304, having lower corrosion resistance, these should be avoided.



HEXAGON HEAD BOLT SOCKET CAPSCREW



HEXAGON NUT



ADITIONAL NOTES:

AISI 316 is fine if no welding is done, but for welding the AISI 316 L Grade is recommended. ”L” means low carbon content, and this is necessary for avoiding carbide precipitation, or ”weld decay” which causes invisible intracrystalline cracks and may lead to sudden failure.
The nuts should be of minimum Class A4-70 if they are of AISI 316 (nonmagnetic) or alternatively of a stronger steel.

Greased and ungreased threads require different torques, and this results in two torque recommendations.
The nuts should be reliably locked, either with an additional lock nut, or in some other way, for example a thin washer with the edge bent up. The old models have the keel bolts matted over, but this is not necessary if the nuts are reliably locked.

Recommended keel bolt torques:

AISI 316 (metric)

Spanner size	dry threads	greased
M20 30 mm	146 Nm	99 Nm
M24 36 mm	252 Nm	172 Nm
M30 46 mm	504 Nm	343 Nm

AISI 316 (imperial)

Wrench size	dry threads	greased
M20 1-3/16”	108 lbf.ft	73 lbf.ft
M24 1-27/64”	186 lbf.ft	127 lbf.ft
M30 1-13/16”	372 lbf.ft	253 lbf.ft

3. NSGS SERVICES

Nautor Swan Global Service offers a personalized service from a dedicated team committed to giving the best care for every Swan. The team has unrivalled understanding of the technical specifications and requirements of your Swan, providing quality workmanship, whatever the yacht's age or condition with the flexibility to work around the world.
If you're planning service, upgrades, refit or repair work, make the Nautor Swan Global Service your first port of call.

Maintenance
Proper certified maintenance will prolong the life of your yacht, maximise the pleasure of your ownership and enhance her long-term value. Our maintenance program will always ensure she will be fully ready for each season and provide reliable service and enjoyment wherever your cruising takes you.

Refit
Nautor Swan Global Service offers personalized project analysis based on each Swan owner's needs. The team has managed and delivered a large number of refit projects of various magnitude and complexity and it is this experience, coupled with Nautor's exclusive product knowledge, that make the service truly unique.

Yacht Care / Guardiennage
From yacht cleaning to onboard provisioning, carrying out general maintenance and yacht care - Owners will only need to think about their next anchorage.

Racing Assistance
Nautor Swan Global Service is present at the most iconic regattas around the world available to assist preparing your yacht to maximise her potential and to provide ongoing support and service during the event. For the ClubSwan OD fleet, a special race preparation program and dedicated team is available.



WITH MORE THAN 50 YEARS OF BOATBUILDING AND HERITAGE PROUD

Spare Parts Supply
Nautor maintains a complete inventory of approved spare parts which are required for every day maintenance of your Swan, as well as most custom components that Swan owners will not find elsewhere. No matter where you are in the world, Nautor Swan Global Service will coordinate delivery and installation if you need it.

Technical Advice, Surveys and Certificates
Nautor maintains an extensive library of original drawings, specifications, records and samples for each boat built to date. The team is ready to provide technical advice for any upgrade or modification needed, taking advantage of the know-how and workmanship based in Finland..

Restoration
Nautor is proud of its legacy supporting the restoration of cherished classic Swans.

Worldwide Assistance
Through the regional Nautor Swan Authorized Service Centres located in key yachting hubs and also with a dedicated mobile team available to travel to your boat. Nautor Swan Global Service is ready to service your Swan in any part of the world.

4. CONTACTS

Disclaimer For Technical Advice

The information provided in this Technical Advice is free of charge and offer only as consultancy inside the post sales service that Nautor's Swan Global Service offer to the Swan owners.
This information is not intended as a substitute for a proper Technical and Engineering Consultancy, Report, Survey, and repair plans that NSGS offer as service. Please ask for this services if need it.
The statements, analysis or calculations you received is based on the information received from the owner or person that place the request and the info available on the Nautor's Swan archive and shall be used as general information only within stated limitations and with opinion given in good faith as far as seen at the time of the request.
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