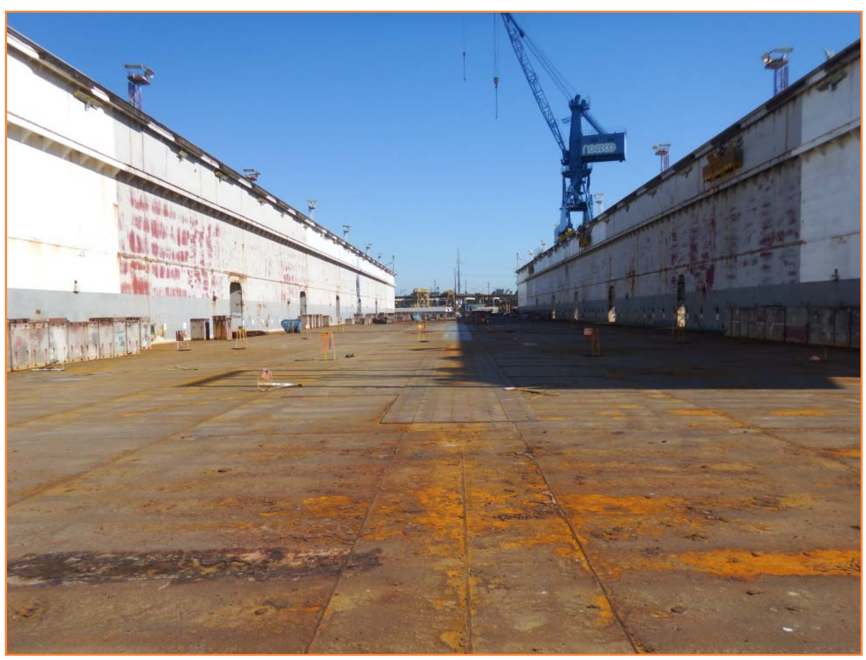
GENERAL DYNAMICS
NASSCO

PONTOON DECK ANALYSIS

Floating Dry Dock "NASSCO BUILDER"

"Revision B"

HEGER DRY DOCK, INC has conducted an engineering analysis of NASSCO's floating dry dock "BUILDER" located in San Diego, California to investigate operational limitations based on various levels of corrosion/degradation in the aging pontoon deck.



HEGER DRY DOCK, INC
Hopkinton, Massachusetts

May 1, 2020
Job# 4274-D

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1.0 Scope of Analysis

At the request of NASSCO San Diego, HEGER DRY DOCK (HDD) has conducted an independent study of both the head pressure and vehicle wheel load capacity of the "NASSCO BUILDER" floating dry dock's pontoon deck.

Based on UT readings provided by NASSCO San Diego it was determined that the area of focus should be considered to be from 50' off centerline to the inboard wing shell. This area of pontoon deck is less susceptible to failure in transverse bending due to its distance from centerline and the design is thus typically controlled by differential head pressure and working vehicle wheel loads.

HDD performed a head pressure and vehicle wheel load analysis on the pontoon deck plate and substructure in the specified area of the dry dock. In order to determine the effect of deck plate deterioration, corrosion values ranging from 0% to 50% were investigated. This range was intended to provide a perspective on the structure's original capacity as well as the effect present or future deterioration has on capacity.

Using the received UT Data in conjunction with the structural calculations, HDD was able to successfully investigate the effect of the reduced plating thickness on the dry dock's operational limitations.

2.0 Description of Dry Dock

The "NASSCO BUILDER" dry dock was originally constructed in 1983 in Japan by Kawasaki. The dock was originally designed as a 584' long by 170.6' wide dock with 24 ballast tanks and a lifting capacity of 25,000 long tons. The dock was designed with a keel line structural capacity of 60 LT/ft.

In 1998, the dry dock was lengthened at NASSCO's shipyard in San Diego, California. The dock was lengthened by cutting off the aft 98' and inserting a new 200' section constructed on site by NASSCO. During the lengthening, the aft 98' of the dock was strengthened by welding doubler plates to the pontoon deck and pontoon bottom along the transverse bulkheads near the dock's centerline. The new 200' section was constructed out of higher strength steel (yield strength of 50 ksi versus the dock's original 36 ksi). The lengthening work resulted in an increased pontoon length of 784' with the aft 298' having a rated keel line structural capacity of 84 LT/ft and forward 486' of original dock structure having a rated keel line structural capacity of 60 LT/ft.

The dock currently maintains an ABS classification and is enrolled in the Navy's MIL-STD certification program. A general arrangement of the dock is attached in Appendix A.

Dock Parameters

Dock Length Overall (w/ Aprons)	820.0’ 249.96 M
Pontoon Length	784.0’ 238.96 M
Pontoon Width	170.6’ 52.00 M
Pontoon Height at CL	17.22’ 5.25 M
Pontoon Height at Wings	16.73’ 5.10 M
Dock Light Weight (from FRR)	17,328 LT
Rated Capacity (18” Freeboard)	35,000 LT

3.0 Pontoon Deck – UT Data

The UT data provided by NASSCO San Diego has been compiled and is provided in Appendix B. The data was recently collected in 2020.

The scope of the analysis focuses on measurements 28-26 on both the port and starboard side. These measurements showed accelerated degradation in comparison to the rest of the structure. Measurements 28-26 on the port and starboard side fall within the span of pontoon deck from 50’ off centerline to the inboard wing shell.

The data in Appendix B has been highlighted according to the percentage of deterioration from the original 16mm plate. The green highlight is representative of 15-20% corrosion, the yellow highlight is representative of 20-25% corrosion, and the red highlight is representative of 25% or greater corrosion. In addition, existing doubler plates are highlighted in blue.

It was observed that in general the plate closest to the inboard wing shell experienced the most deterioration. In addition, it was observed that the majority of the plate deterioration is located on the forward end of the dock between frames 110.5 and 241.5 on the port side, and between frames 60.25 and 241.5 on the starboard side. This is most likely due to vehicle travel patterns and the location of the ramp on the forward end of the dock.

4.0 Pontoon Deck Structure - Description

The area to be analyzed is the section of pontoon deck from 50’ off centerline to the inboard wing shell on both the port and starboard side. This area of the pontoon deck consists of transversely stiffened deck panel supported by girders in the longitudinal direction. The longitudinal girders are supported by bulkheads located every 12-ft along the dock’s length.

The transverse scantling which support the pontoon deck plating has a consistent spacing of 732mm (28.82”) in the area analyzed. The longitudinal girders, however, have two different spacing’s in the area analyzed. The most outboard bay has a longitudinal girder spacing of 2.38M (7.81 feet) with the adjacent bay having a spacing of 3.16M (10.37 ft).

The dimensions of the two pontoon deck plate panels analyzed are sketched below in Image 1 and Image 2.

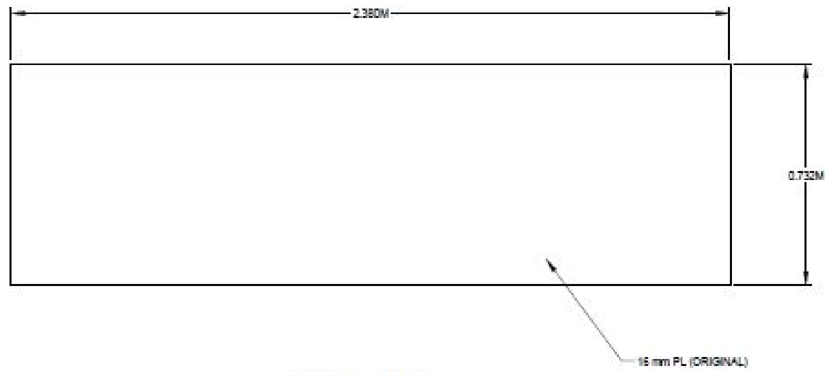


Image 1: Typical Deck Panel in the Dock's Most Outboard Bay (Adjacent to Inner Wingwall)

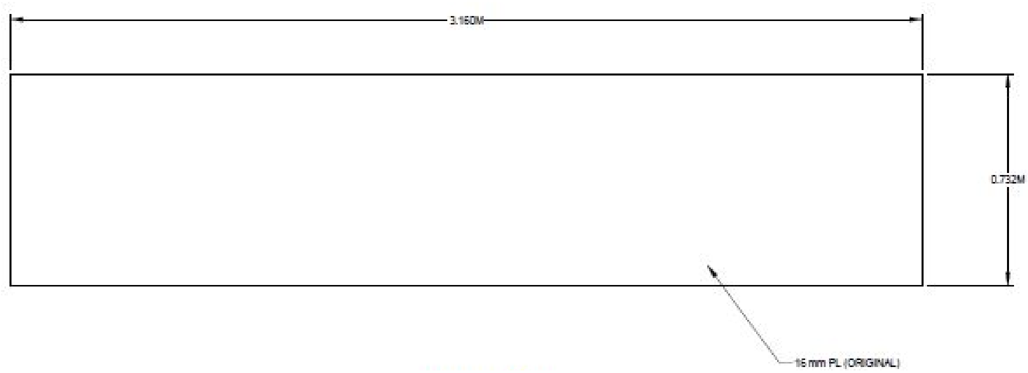


Image 2: Typical Deck Panel in the Dock's Second Most Outboard l Bay

The original plate thickness in the analysis area is 16 mm or 0.629 inches.

The transverse deck stiffeners in the analysis area are Tee sections with 247mm x 9mm web and a 100mm x 15mm flange. A longitudinal section through the typical pontoon deck can be seen below in Image 3.

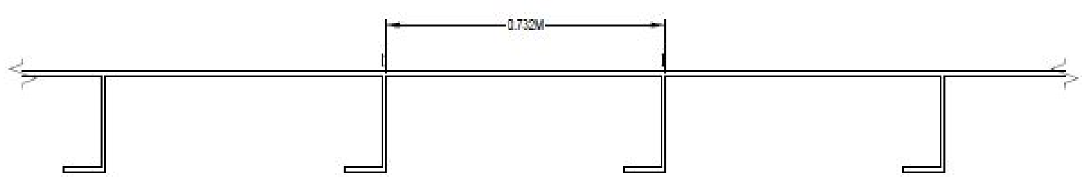


Image 3: Longitudinal Section of Typical Stiffened Pontoon Deck

5.0 ANALYSIS - DIFFERENTIAL HEAD PRESSURE

Based on the original classing of the floating dry dock, the differential head pressure limitation for the pontoon deck is specified to be 34'-5" when lifting a vessel.

The differential head pressure capacity of the pontoon deck for various levels of plating corrosion was determined using the ABS Design Guide 2020 "Rules for Building and Classing Steel Floating Dry Docks". Both the capacity of the deck plating as well as the associated stiffeners or scantlings was investigated.

The capacity of the longitudinal girders, which support the transverse scantling was checked but the dock's overall capacity for head pressure was found to be controlled by the strength of the plating or transverse stiffeners.

5.1 Plating Analysis

In order to determine the differential head pressure capacity of the pontoon deck plate, the Part 3, Chapter 2, Section 3-3.1 in the ABS "Rules for Building and Classing Steel Floating Dry Docks was used as a guideline. The allowable head for various corrosion levels of the original plate were calculated, ranging from 0-50%. The resulting allowable head was tabulated and the graph can be found below in Figure 1. The supporting calculations can be found in Appendix C.

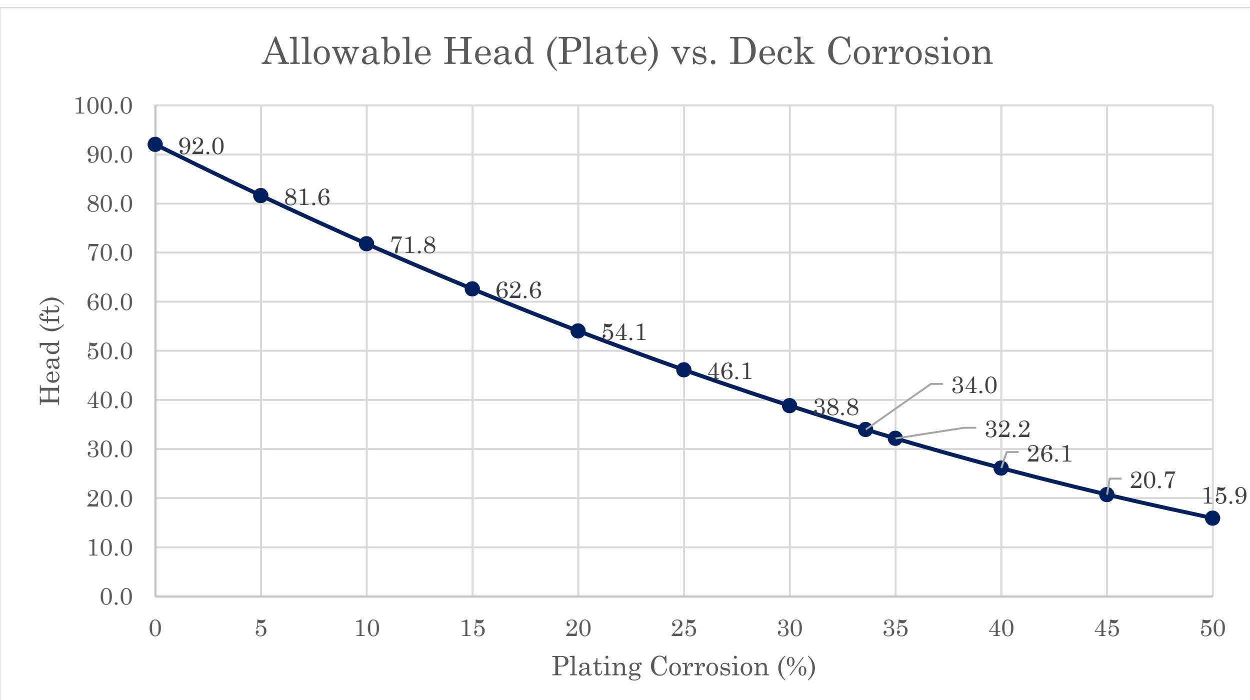


Figure 1: Plating - Allowable Differential Head Pressure vs. Corrosion

Figure 1 shows the dock's differential head pressure limitation of 34.42-ft requires a downgrade of capacity when plating corrosion levels exceed approximately 33% or thickness reduces beyond 0.415 inches.

5.2 Transverse Stiffener Analysis

In order to determine the adequacy of the transverse pontoon deck stiffeners, ABS "Rules for Building and Classing Steel Floating Dry Docks" Part 3, Chapter 2, Section 3-3.3 was used as a guideline.

The section modulus of the stiffener was calculated assuming a gross section comprised of deck plate as well as associated stiffener. In this case, the effective width of deck plate was assumed to be the spacing between adjacent stiffeners. The assumed effective section is sketched below in Image 4.

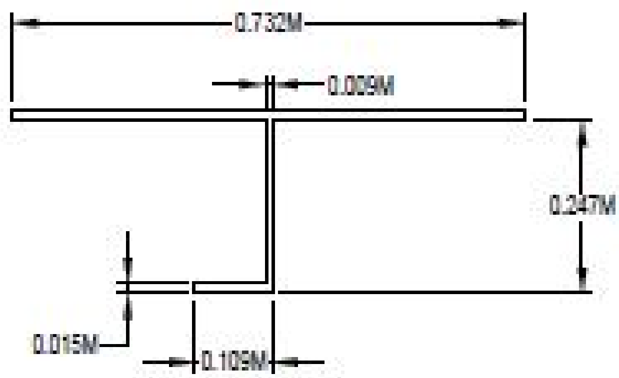


Image 4: Total Gross Section at Each Stiffener

Similarly to the deck plating analysis, various corrosion levels of the original 16 mm deck plate were investigated in the analysis, again ranging from 0-50% corrosion. For the purpose of analysis, a corrosion level of 10% was applied to the thickness of the stiffener flange and web. The graph of allowable head vs. the percent corrosion can be found below in Figure 2. The supporting calculations can be found in Appendix C.

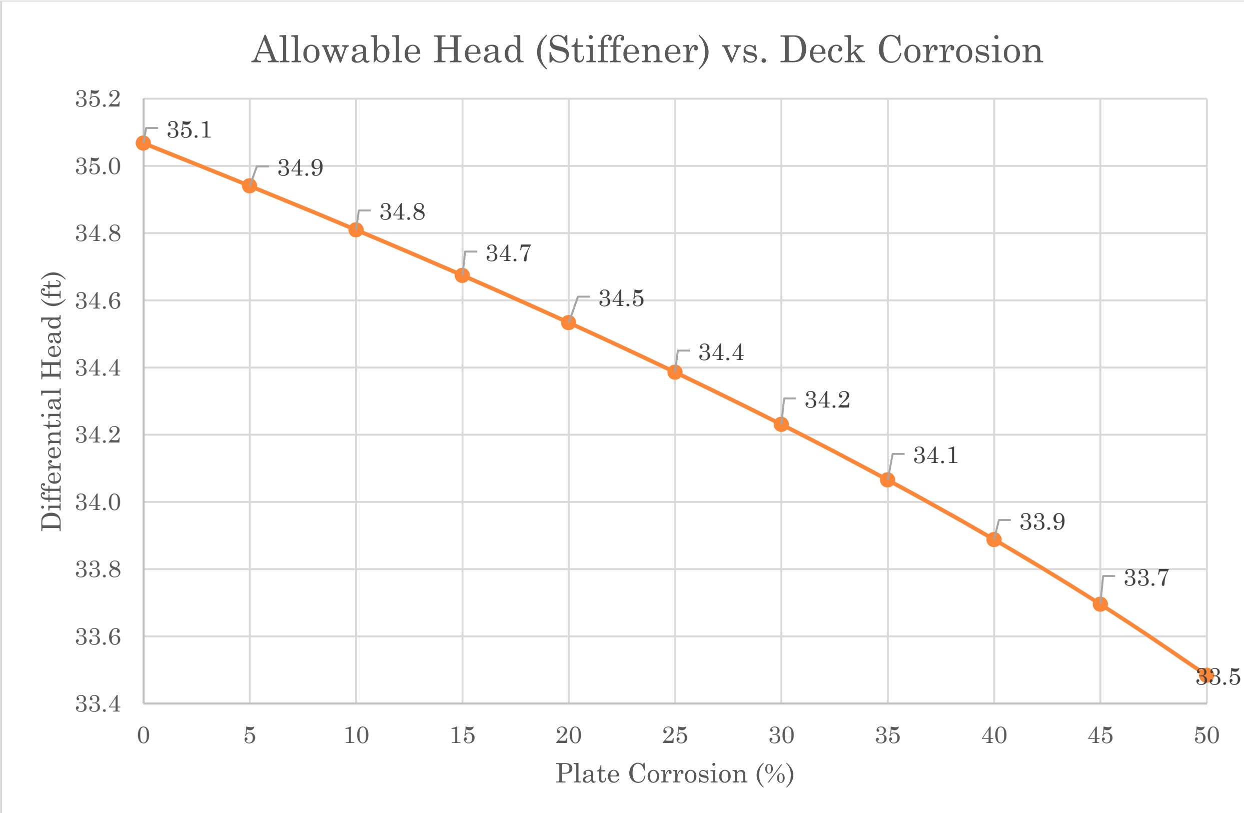


Figure 2: Transverse Stiffener - Allowable Differential Head Pressure vs Plating Corrosion

Figure 2 shows the dock's differential head pressure limitation of 34.42-ft requires a downgrade of capacity when plating corrosion levels exceed approximately 25% or thickness reduces beyond 0.472 inches.

5.3. Summary

Figure 3 shows allowable differential head pressure for the pontoon deck as an overlay of the limitation for the plating and transverse stiffener. Points on the graph that fall below the lowest line for a given corrosion percentage are considered acceptable.

Figure 3 shows that the dock's differential head pressure limitation is controlled by the strength of the transverse Tee stiffener until corrosion levels in the dock's original 16mm (0.629") pontoon deck plate reaches about 33% degradation (0.422"). The head pressure limitation is controlled by the strength of the plating at corrosion levels beyond 33%.

The dock's design differential head pressure limitation of 34.42-ft requires a downgrade of capacity when deck plating corrosion levels exceed approximately 20% or thickness reduces beyond 0.500 inches.

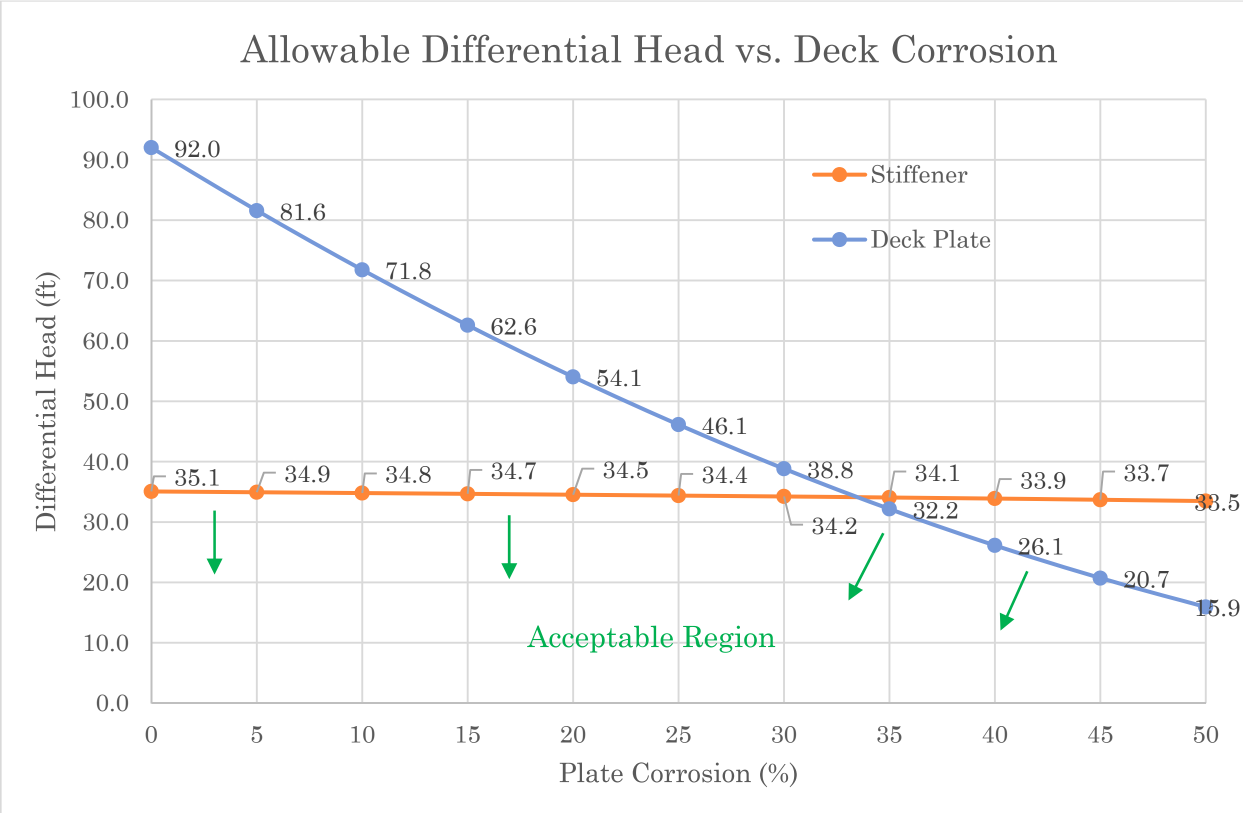


Figure 3: Allowable Differential Head Pressure vs Deck Plating Corrosion

6.0 Analysis - Vehicle Wheel Loads

Due to the relative location of the section of pontoon deck being analyzed, the capacity of the pontoon deck structure to support vehicle traffic is an important consideration. While there is a vessel in the dock, vehicle traffic is forced to frequent the perimeter of the pontoon deck and thus causing increased mechanical deterioration. The traffic also causes frequent isolated loading of the deck plating and transverse stiffeners.

In order to determine the vehicle wheel load capacity of the pontoon deck in the analysis area, the ABS "Rules for Building and Classing Steel Barges" Part 3, Chapter 2, Section 3-17 was utilized as a guideline for evaluating the strength of the plating. The AISC "Steel Construction Manual" was used as a guideline for determining the flexural strength of the transverse stiffener in support of the applied wheel loading.

Since the calculations require wheel/axle dimensions and orientation, a standard AASHTO HS-20 loading was investigated in the analysis as a generalized approach. The HS-20 loading is shown in Image 5. Given the HS-20 footprint, an allowable axle load was determined for pontoon deck plating corrosion levels, again ranging from 0% to 50%.

The layout of the assumed HS-20 axle footprint on the larger pontoon deck panel is shown in Image 6. A similar layout of the HS-20 axle footprint positioned directly over the dock's transverse stiffener is shown in Image 7. The larger pontoon deck panel and transverse stiffener span (3.16M) were specifically investigated in the analysis.

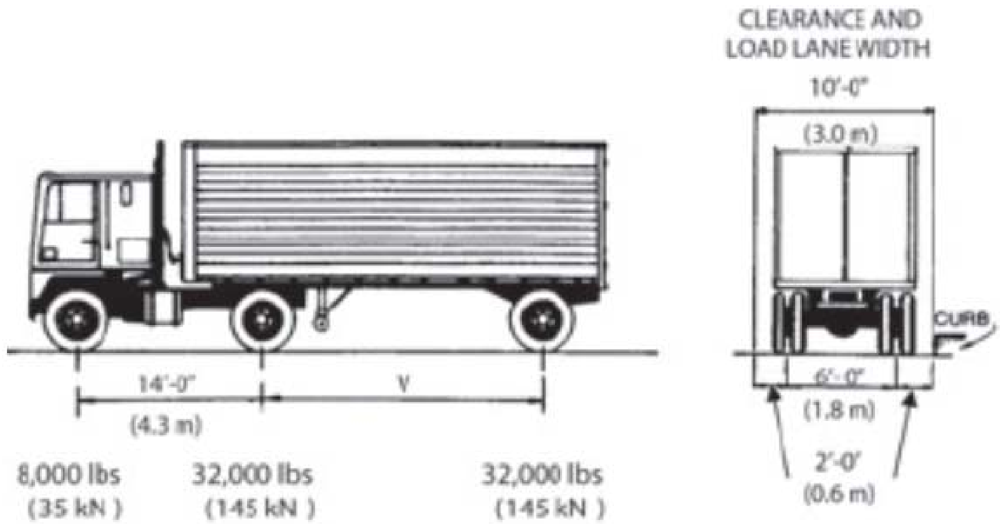


Image 5: ASSTHO HS-20 Loading Sketch

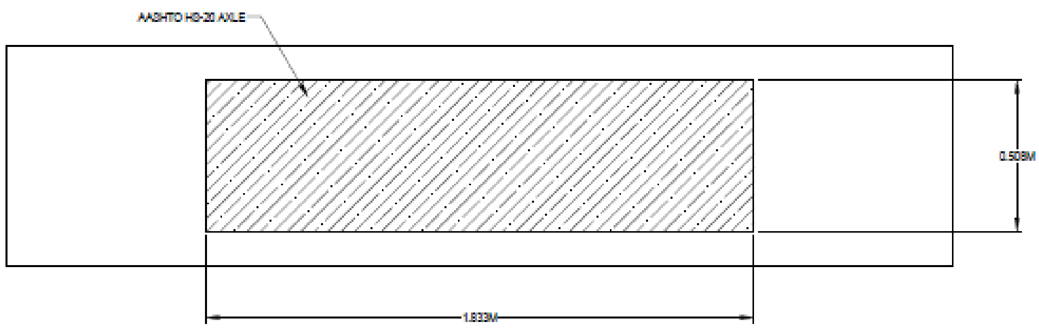


Image 6: HS-20 axle on 3.16M long deck panel

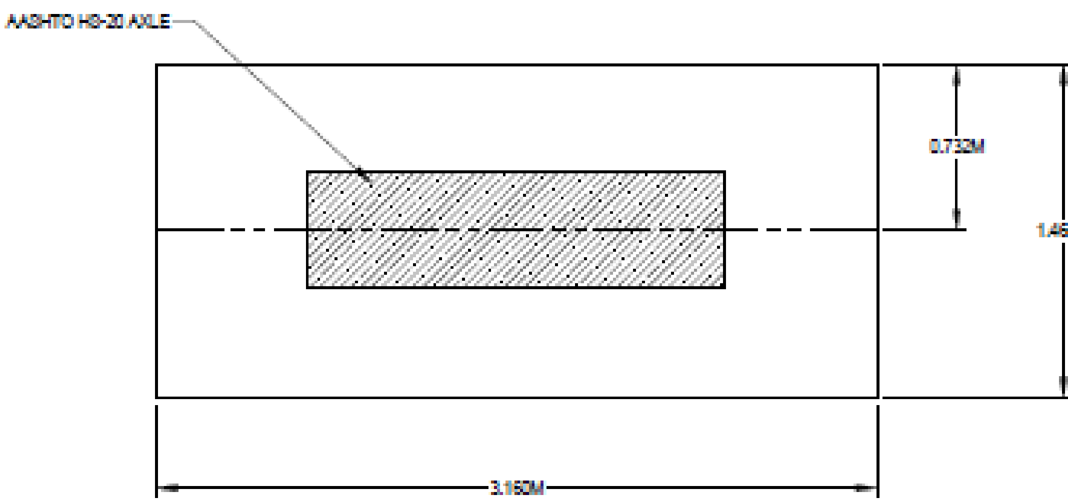


Image 7: HS-20 axle on transverse scantling

Figure 4 shows the maximum HS-20 axle load that can be driven in the analyzed zone given various levels of corrosion in dock's original 16mm (0.629") plating. Points on the graph that fall below the lowest line for a given corrosion percentage are considered acceptable.

Figure 4 shows the strength of the stiffener governs the limit until corrosion levels of 10%. Corrosion levels exceeding 10% or thickness reduced beyond 0.567" are controlled by the strength of the plating.

For reference, the standard HS-20 axle load is 32 kips. Corrosion levels exceeding 30% or thickness reduced beyond 0.441" can no longer support the conventional HS-20 loading.

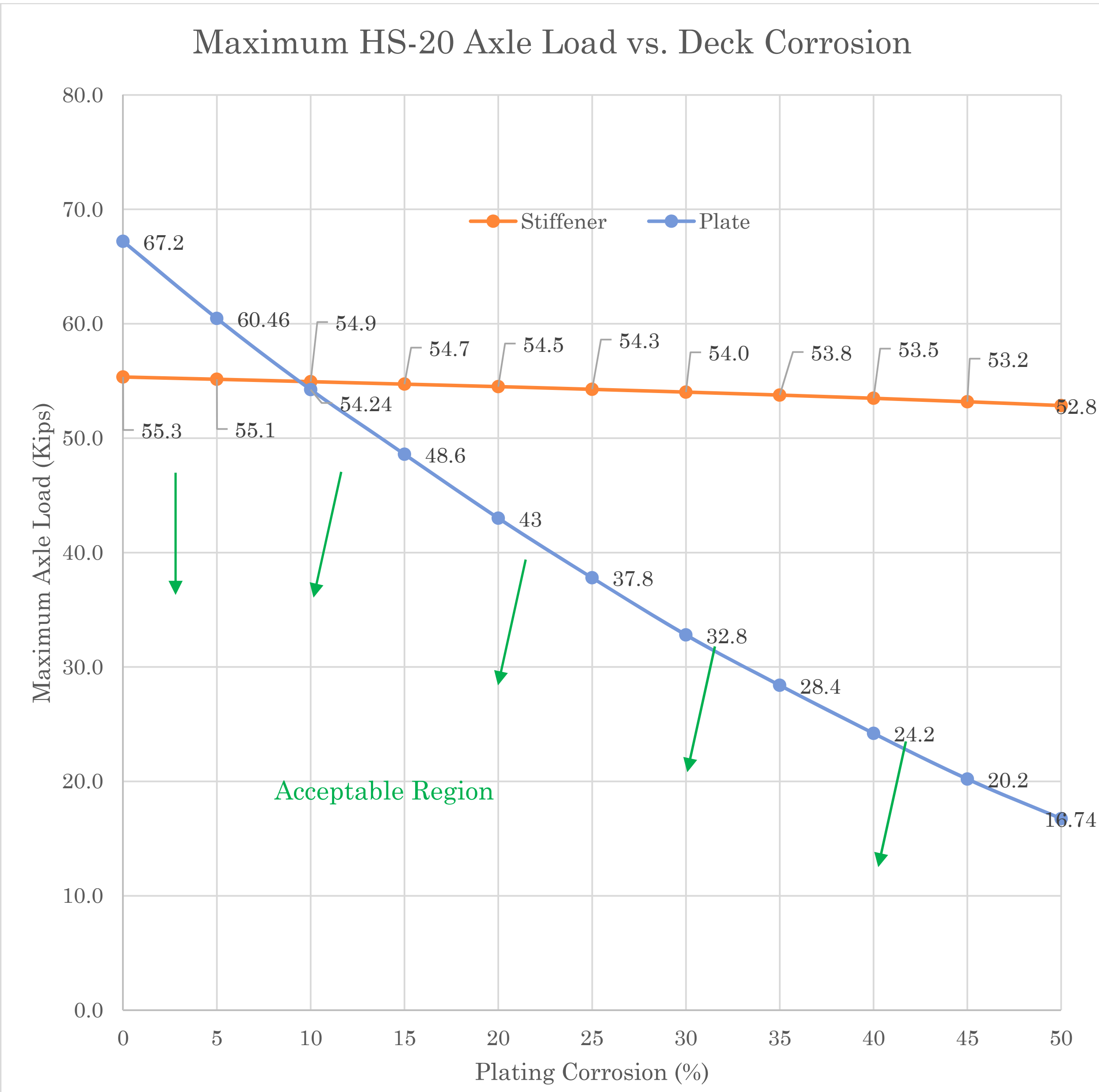


Figure 4: HS-20 axle on transverse scantling

7.0 Pontoon Deck Repairs – Description

Based on the UT readings provided in Appendix B it was determined that the majority of the pontoon deck's high corrosion zones (25% and greater loss of thickness) are located in the vehicular driving lanes towards the inshore end of the dock. This area were determined to be from the inboard wing shell extending into the dock 20-ft, on both the port and starboard side.

In order to repair the deteriorating plating, it was determined that installing a system of doubler plates on top of the existing plating provided an adequate solution for maintaining the dock's current operating limitations. In April 2020, HEGER DRY DOCK designed and provided a detailed pontoon deck repair plan for installing 5/8" thick doublers in the aforementioned areas of plating diminution.

The system of doubler plates on both the port and starboard side is a series of individual panels of various sizes designed to fit within the area requiring repair. The labeling of the individual plates uses transverse and longitudinal labels, effectively creating a grid for the doubler system. The doubler panels are designed with a slot configuration aligning with the pontoon deck's substructure for proper attachment and effectiveness.

All of the panel locations, labels, dimensions, and slot locations can be found in the HDD drawing package for the pontoon deck doubler repair.

8.0 Analysis – Pontoon Deck Repairs

The bending and shear capacity of the combined section, including the added doubler plates, was determined for both the typical transverse and longitudinal scantlings. All calculations were done in accordance with AISC Steel Construction Manual, 15th Edition. Calculations were based on the tributary area and effective span for the typical transverse and longitudinal members. All calculations assume corrosion levels of the structure, as provided below, which account for some potential future corrosion. Future inspection of the dock should monitor the level of surveyed corrosion against the corrosion levels assumed in the calculations.

- Doubler Plating = 25% loss of thickness
- Original Pontoon Deck Plating = 35% loss of thickness
- Scantling Flanges and Webs = 7% loss of thickness

The calculated bending and shear capacities of the combined sections were used to determine differential head pressure capacities for the repaired pontoon deck structure. The maximum allowable head pressure on the repaired pontoon deck structure was determined to be 34.4-ft as controlled by the transverse scantling design.

To ensure that the doubler plates establish an effective connection with the original deck plate and dock structure below, the plates are specified to be welded to the pontoon deck at the allocated slots which align with the substructure below. In order to achieve an adequate structural connection, the slots were located with a maximum center to center spacing of

250mm (9.84"). The length of slot was governed by the required strength of the weld. The associated calculations for this determination can be found in Appendix E.

9.0 Conclusions and Recommendations

Based on ABS design guidelines, it was determined that the pontoon deck structure cannot safety support the dock's design differential head pressure capacity if the pontoon deck plating degrades beyond 25% or 0.472". The differential head pressure capacity of the pontoon deck structure quickly degrades when plating degradation exceeds 35% or 0.409". Refer to Figure 3 for more information.

In order to portray the pontoon deck's ability to support vehicles loads in a general metric, the AASHTO HS-20 axle was used as a basis for all calculations. If the pontoon deck plating degrades beyond 30% or 0.441", the structure can no longer support the conventional HS-20 axle loading of 32 kips. Refer to Figure 4 for more information. Note that some vehicles utilized in support of ship repair activities may have an axle load greater than 32 kips and thus require a more stringent corrosion limitation to be driven on the dock without overloading the structure.

In review of the most current thickness measurements of the dock's pontoon deck plating (provided in Appendix B) it was determined that there are areas of the dock which exceed 25% corrosion and therefore require repair if the dock is to maintain its current operational limitations.

The majority of the pontoon deck's high corrosion zones (25% and greater loss of thickness) are located in the vehicular driving lanes towards the inshore end of the dock. This area was determined to be from the inboard wing shell extending into the dock 20-ft, on both the port and starboard side. In order to repair the deteriorating structure, it was determined that installing a system of doubler plates on top of the existing plating provided an adequate solution for maintaining the dock's current operational limitations. A detailed repair plan for installing 5/8" thick doubler plates was developed by HDD in a separate design drawing package.

Based on a structural analysis of the repaired pontoon deck, HDD recommends the following operational limitations following repair:

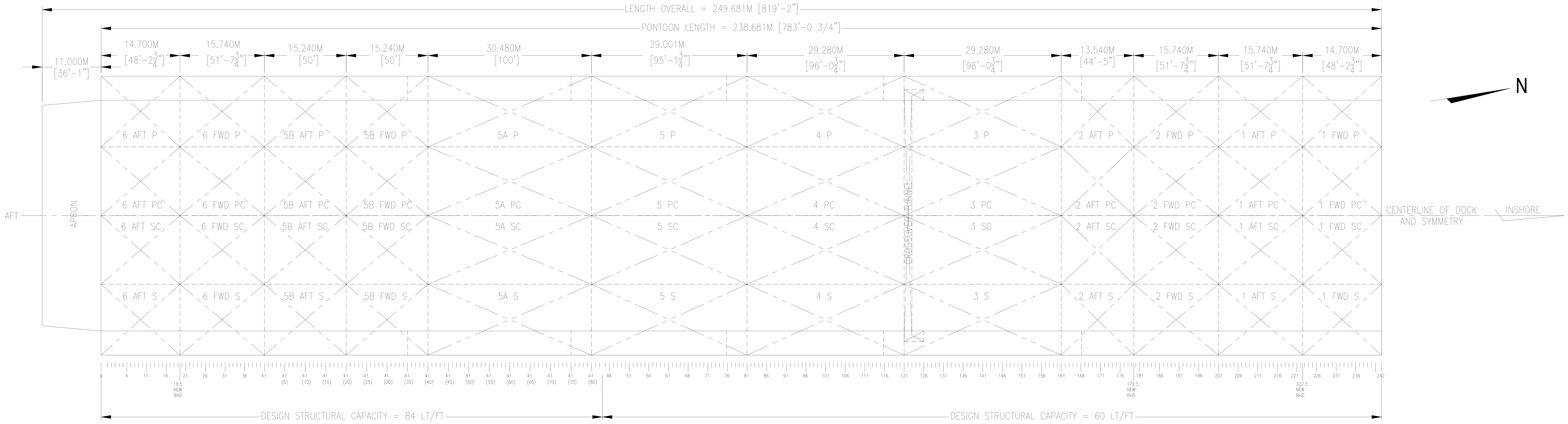
1. Maximum external differential head should be limited to 34.4 ft when lifting a vessel
2. Maximum axle load of 37.8 kips or 18.9 Tons.

NOTE: Any area of pontoon deck not captured by the doubler repair plan and having corrosion exceeding 25% is recommended to be repaired by insert plating.

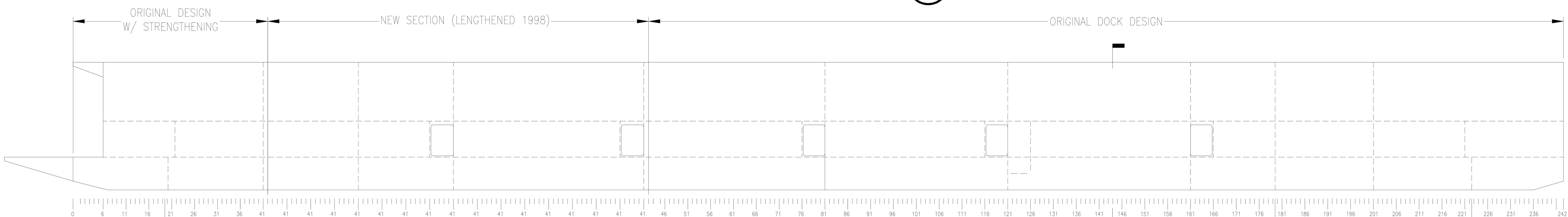
Please contact us with any questions or comments regarding this report,

HEGER DRY DOCK
2020

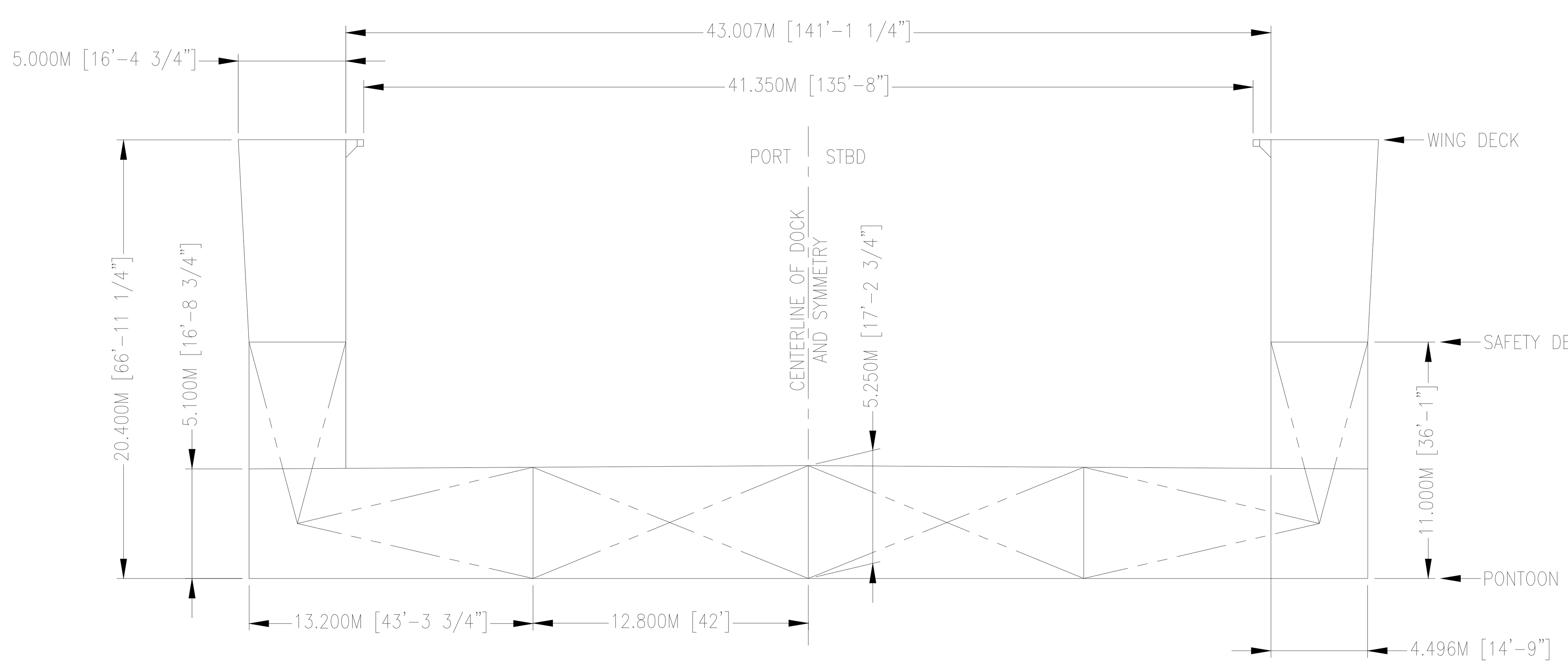
Appendix A – General Arrangement



PLAN VIEW C1
SCALE 1 : 400



PROFILE VIEW B1
SCALE 1 : 400



SECTION A1
SCALE 1 : 200 A-001

GENERAL

DELIVERED	11/18/83
SHIPYARD	KAWASAKI HEAVY INDUSTRIES, LTD., SAKAIDE WORKS, JAPAN
LENGTHENED	5/10/98 TO 11/30/98
SHIPYARD	NATIONAL STEEL AND SHIPBUILDING COMPANY
CLASSIFICATION –	✠ABS A1 FLOATING DRY DOCK
DOCK WEIGHT	17,328 LT
VCG	25.03 FT

LIFTING CAPACITY

NAVY CERTIFIED RATED CAPACITY (18 INCHES FREEBOARD)	35,000 LT
BUOYANT CAPACITY	48.3 LT/FT
ABS RATED LIFTING CAPACITY (12 INCHES FREEBOARD)	37,000 LT

1 : 400 0 5.0 10.000 20.000M
1 : 200 0 5.000 10.000M

HEGER DRY DOCK, Inc.
DRY DOCK ENGINEERS
DESIGN, INSPECTION AND CERTIFICATION
77 MAIN STREET, SUITE 9
HOPKINTON, MA 01748
(508) 429-1800

PRELIMINARY
NOT FOR CONSTRUCTION

DES — DRW JJB CHK —
CHIEF ENG. PREMAL SHAH
DATE: 02-26-2020

CLIENT NAME AND ADDRESS: NASSCO SAN DIEG, CA
PROJECT TITLE: ANALYSIS OF FDD "BUILDER" PONTOON DECK
DRAWING TITLE: GENERAL ARRANGEMENT

SCALE: AS NOTED
PROJECT NO.: 4274-D
CONSTR. CONTR. NO.:
SHEET 1 OF ##
G-001

Appendix B – Pontoon Deck UT Measurements

HEGER DRY DOCK, Inc.
HOPKINTON, MASSACHUSETTS

Done By : **P.Trudeau**
Checked By : **P.SHAH**
Date : **4/14/2020**
Job No : **4274-D**

Client : NASSCO San Diego
ıbject : Pontoon Deck Analysis of Builder FDD "Rev A"

		PORT								CL	STBD							
Ft. from AP	**Frame**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**C.L.**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
784	**241.5**	0.450	0.556	0.598	0.552	0.596	0.608	624.000	0.698	0.696	0.672	0.610	0.534	0.620	0.578	xx	xx	0.458
764	**234.25**	0.404	0.526	0.588	0.614	0.604	0.610	0.614	0.608	0.610	0.620	0.620	0.620	0.614	0.622	xx	xx	0.458
744	**226.75**	0.418	0.516	0.610	0.598	0.618	0.608	0.618	0.618	0.622	0.622	0.624	0.616	0.614	0.614	0.602	0.604	0.420
724	**218.5**	0.478	0.450	0.620	0.614	0.614	0.616	0.620	0.614	0.590	0.614	0.618	0.610	0.600	0.604	0.604	0.614	0.406
704	**209.5**	0.452	0.556	0.614	0.610	0.620	0.574	0.582	0.624	0.610	0.600	0.612	0.614	0.610	0.608	0.592	0.568	0.396
684	**201.5**	0.480	0.570	0.608	0.612	0.614	0.614	0.616	0.614	0.582	0.594	0.584	0.614	0.600	0.606	0.596	0.596	0.410
664	**193.25**	0.474	0.586	0.612	0.614	0.618	0.574	0.612	0.616	0.594	0.608	0.602	0.602	0.608	0.610	0.594	0.410	0.440
644	**184.5**	0.520	0.510	0.598	0.610	0.614	0.616	0.612	0.614	0.606	0.612	0.620	0.620	0.612	0.612	0.604	0.412	0.426
624	**176.5**	0.464	0.544	0.576	0.564	0.582	0.540	0.546	0.596	0.506	0.586	0.606	0.590	0.574	0.558	0.582	0.470	0.424
604	**168.25**	0.460	0.460	0.544	0.568	0.588	0.600	0.608	0.604	0.556	0.598	0.586	0.596	0.614	0.602	0.594	0.594	0.500
584	**159.5**	0.470	0.574	0.572	0.584	0.592	0.546	0.578	0.576	0.520	0.632	0.608	0.590	0.560	0.564	0.552	0.386	0.434
564	**151.5**	0.528	0.590	0.592	0.604	0.560	0.582	0.562	0.618	0.554	0.614	0.528	0.580	0.588	0.594	0.600	0.446	0.466
544	**143.25**	0.458	0.594	0.610	0.572	0.576	0.604	0.596	0.580	0.574	0.616	0.616	0.600	0.608	0.584	0.604	0.432	0.470
524	**135.25**	0.498	0.592	0.600	0.604	0.544	0.554	0.576	0.594	0.488	0.596	0.510	0.564	0.526	0.526	0.532	0.428	0.480
504	**126.5**	0.504	0.594	0.616	0.566	0.602	0.594	0.586	0.610	0.552	0.586	0.498	0.600	0.594	0.598	0.582	0.494	0.364
484	**118.25**	0.462	0.580	0.592	0.584	0.576	0.622	0.600	0.600	0.564	0.582	0.594	0.602	0.606	0.578	0.542	0.396	0.394
464	**110.5**	0.462	0.548	0.600	0.582	0.604	0.596	0.590	0.602	0.528	0.500	0.620	0.612	0.526	0.560	0.566	0.566	0.456
444	**101.5**	0.574	0.582	0.592	0.570	0.590	0.606	0.614	0.600	0.574	0.612	0.596	0.598	0.598	0.498	0.592	0.500	0.460
424	**93.5**	0.580	0.604	0.558	0.560	0.600	0.614	0.604	0.604	0.550	0.618	0.620	0.614	0.540	0.554	0.552	0.500	0.472
404	**85.75**	0.568	0.620	0.570	0.596	0.600	0.628	0.614	0.624	0.552	0.584	0.580	0.614	0.562	0.514	0.584	0.564	0.510
384	**76.5**	0.598	0.610	0.594	0.564	0.584	0.584	0.618	0.606	0.552	0.570	0.560	0.548	0.566	0.528	0.516	0.462	0.410
364	**68.5**	0.594	0.592	0.594	0.582	0.568	0.614	0.588	0.562	0.552	0.586	0.620	0.602	0.564	0.560	0.532	0.556	0.486
344	**60.25**	0.592	0.592	0.600	0.596	0.600	0.586	0.600	0.614	0.536	0.556	0.614	0.506	0.590	0.586	0.580	0.392	0.492
324	**52.5**	0.598	0.600	0.608	0.590	0.600	0.624	0.620	0.626	0.590	0.594	0.516	0.610	0.559	0.506	0.604	0.536	0.446
304	**43.5**	0.622	0.626	0.632	0.640	0.644	0.600	0.644	0.636	0.640	0.626	0.630	0.610	0.586	0.648	0.630	0.616	0.496
284	**41(74.50)**	0.632	0.632	0.630	0.634	0.646	0.650	0.648	0.650	0.640	0.616	0.614	0.650	0.650	0.646	0.618	0.634	0.554
264	**41(66.25)**	0.634	0.636	0.630	0.646	0.648	0.648	0.644	0.650	0.638	0.644	0.644	0.650	0.652	0.646	0.632	0.632	0.572
244	**41(58.25)**	0.628	0.628	0.636	0.642	0.650	0.648	0.652	0.644	0.638	0.646	0.590	0.642	0.652	0.644	0.642	0.638	0.552
224	**41(50.25)**	0.632	0.630	0.638	0.636	0.646	0.650	0.654	0.646	0.636	0.630	0.652	0.648	0.652	0.638	0.642	0.610	0.586
204	**41(42.25)**	0.636	0.638	0.632	0.652	0.652	0.642	0.590	0.638	0.638	0.648	0.652	0.652	0.652	0.636	0.636	0.630	0.534
184	**41(34.25)**	0.638	0.640	0.638	0.652	0.648	0.640	0.610	0.644	0.638	0.646	0.646	0.654	0.654	0.632	0.636	0.640	0.612
164	**41(26.25)**	0.638	0.640	0.620	0.648	0.644	0.652	0.642	0.642	0.638	0.646	0.646	0.654	0.654	0.648	0.634	0.640	0.608
144	**41(18.25)**	0.646	0.634	0.636	0.644	0.650	0.644	0.650	0.648	0.632	0.628	0.650	0.644	0.642	0.624	0.626	0.628	0.604
124	**41(10.25)**	0.610	0.632	0.640	0.640	0.642	0.646	0.640	0.642	0.608	0.616	0.630	0.650	0.648	0.642	0.632	0.612	0.570
104	**41(2.5)**	0.564	0.600	0.610	0.604	0.612	0.614	0.618	0.620	0.440	0.594	0.594	0.618	0.616	0.594	0.480	0.528	0.530
84	**34.75**	0.610	0.616	0.596	0.614	0.596	0.612	0.616	0.610	0.440	0.610	0.620	0.606	0.616	0.612	0.602	0.432	0.538
64	**26.25**	0.618	0.612	0.582	0.612	0.600	0.616	0.608	0.620	0.440	0.612	0.562	0.564	0.602	0.614	0.582	0.536	0.524
44	**18.5**	0.556	0.604	0.570	0.606	0.600	0.582	0.588	0.618	0.440	0.612	0.564	0.612	0.592	0.596	0.612	0.492	0.478
24	**9.75**	0.614	0.606	0.598	0.614	0.616	0.616	0.560	0.612	0.440	0.622	0.628	0.620	0.508	0.616	0.578	0.592	0.528
4	**1.5**	0.604	0.612	0.590	0.612	0.618	0.612	0.612	0.622	0.440	0.618	0.614	0.614	0.604	0.592	0.604	0.614	0.604

Original Thickness: 0.629 in

Key:

% Corr	Reading
< 15	>0.535
15-20	0.535 - 0.504
20-25	0.504 - 0.472
>25	<0.472
Doubler PL	

Note:

Each individual data point is representative of a 8'x20' section of pontoon deck plate.

Appendix C – Pontoon Deck Head Pressure Calculations

HEGER DRY DOCK, Inc.

HOPKINTON, MASSACHUSETTS

Done By : **P.Trudeau**
Checked By : **P.SHAH**
Date : **2/25/2020**
Job No : **4274-D**

Client : NASSCO San Diego
Subject : Pontoon Deck Analysis of Builder FDD

Deck Plating Head Capacity

1 Buckling

The structural panels and members are to be adequately stiffened to prevent buckling. It may be required that calculations be submitted in support of resistance to buckling for any part of the vessel's structure.

3 Tank and Shell Scantlings

3.1 Plating

Plating is to be of the thickness obtained from the following equation.

$$t = \frac{s\sqrt{h}}{283} + 2.30 \text{ mm}$$

$$t = \frac{s\sqrt{h}}{511} + 0.09 \text{ in.}$$

where

s = spacing of stiffeners, in mm (in.)

h = for ballast tanks, the greatest of the following distances, in m (ft), from the lower edge of the plate:

i) To a point located at two-thirds of the distance from the top of the tank to the top of the overflow. As an alternative, the maximum differential head in service may be used, provided hydrostatic data is submitted to show the differential head based on the highest levels to which water will rise on each side of the structure in service. Where the head is obtained using the maximum differential head in service, data on operating the dry dock within such design limits are to be included in the operating manual.

ii) 2.5 m (8.2 ft)

= for all other tanks, the greatest of the following distances, in m (ft), from the lower edge of the plate:

i) To a point located two-thirds of the distance from the top of the tank to the top of the overflow

ii) To the maximum immersion waterline, for wing wall and pontoon plating

iii) 2.5 m (8.2 ft)

= for void spaces and cofferdams, the greater of the following distances, in m (ft), from the lower edge of the plate:

i) To the maximum immersion waterline, for wing wall and pontoon plating

ii) 2.5 m (8.2 ft)

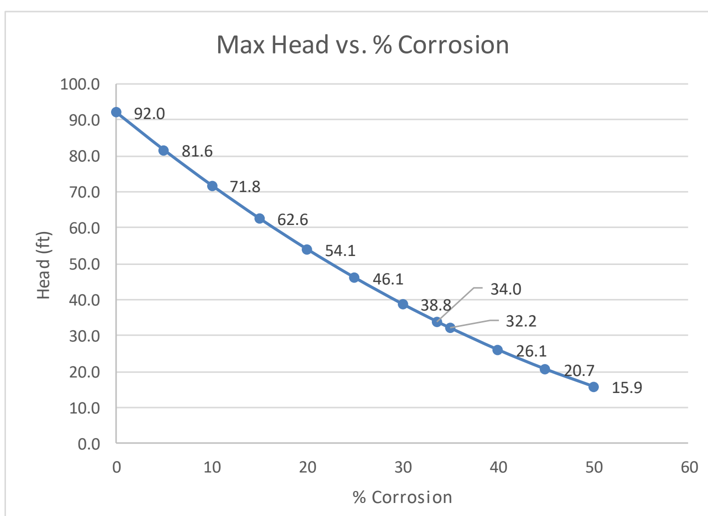
The thickness is not to be less than 6.5 mm (1/4 in.). Special consideration is to be given to the required plating thickness where it forms the boundary of an air cushion.

Deck Characteristics

s = 732 mm (Stiff Spacing)
h = X m (Effective head)
t = X mm (Plate Thickness)

ABS Rules for Building and Classing Steel Floating Dry Docks Jan. 2020
[Part 3, Chapter 2, Section 3.3.1]

Corr %	t (mm)	t (in)	h (m)
0	16	0.630	28.1
5	15.2	0.598	24.9
10	14.4	0.567	21.9
15	13.6	0.535	19.1
20	12.8	0.504	16.5
25	12	0.472	14.1
30	11.2	0.441	11.8
33.6	10.63	0.418	10.4
35	10.4	0.409	9.8
40	9.6	0.378	8.0
45	8.8	0.346	6.3
50	8	0.315	4.9



HEGER DRY DOCK, Inc.

HOPKINTON, MASSACHUSETTS

Done By :	P.Trudeau
Checked By :	P.SHAH
Date :	2/25/2020
Job No :	4274-D

Client : NASSCO San Diego

Subject : Pontoon Deck Analysis of Builder FDD

Stiffener Head Capacity

3.3 Stiffeners

Each stiffener, in association with the plating to which it is attached, is to have section modulus, SM, not less than obtained from the following equation:

$$SM = 6.75hs\ell^2 \quad cm^3$$

$$SM = 0.0035hs\ell^2 \quad in^3$$

where

h = for ballast tanks, the greatest of the following distances, in m (ft), from the middle of ℓ:

- *i)* To a point located at two-thirds of the distance from the top of the tank to the top of the overflow. As an alternative, the maximum differential head in service may be used, provided hydrostatic data is submitted to show the differential head based on the highest levels to which water will rise on each side of the structure in service. Where the head is obtained using the maximum differential head in service, data on operating the dry dock within such design limits are to be included in the operating manual.
- *ii)* 2.5 m (8.2 ft)

= for all other tanks, the greatest of the following distances, in m (ft), from the middle of ℓ:

- *i)* To a point located two-thirds of the distance from the top of the tank to the top of the overflow
- *ii)* To the maximum immersion waterline, for wing wall and pontoon plating
- *iii)* 2.5 m (8.2 ft)

= for void spaces, the distance, in m (ft), from the middle of l to the maximum immersion waterline for wing wall and pontoon stiffeners, but not less than 2.5 m (8.2 ft) for wing wall, pontoon, and bulkhead stiffeners.

s = spacing of the stiffeners, in m (ft)

ℓ = span, in m (ft), between effective supporting members. Where brackets complying with 3-2-3/9 TABLE 1 are fitted at bulkheads, decks, or shell and intersect the stiffeners at about 45 degrees, the span ℓ may be measured to a point 25% of the extent of the bracket beyond the bracket toe.

Special consideration is to be given to the scantlings of stiffeners supporting plating which forms the boundary of an air cushion.

Deck/Stiffener Characteristics

s =	0.732	mm	(Stiffener Spacing)
h =	10.69	m	(Effective head)
L =	3.16	m	(Stiffener Span)
SM (min) =	527.50	cm^3	

Allowable head on stiff (no plate assumed) = 10.7 m

35.1 ft

% Corr PL	SM (min) in^3	SM (min) cm^3	Head m	Head ft
0	32.19	527.50	10.69	35.1
5	32.07	525.59	10.65	34.9
10	31.95	523.62	10.61	34.8
15	31.83	521.58	10.57	34.7
20	31.70	519.46	10.53	34.5
25	31.56	517.25	10.48	34.4
30	31.42	514.91	10.44	34.2
35	31.27	512.42	10.39	34.1
40	31.11	509.75	10.33	33.9
45	30.93	506.86	10.27	33.7
50	30.74	503.68	10.21	33.5

HEGER DRY DOCK, Inc.

HOPKINTON, MASSACHUSETTS

Done By : **P.Trudeau**
Checked By : **P. SHAH**
Date : **2/25/2020**
Job No : **4274-D**

Client : NASSCO San Diego
Subject : Pontoon Deck Analysis of Builder FDD

Stiffener Head Capacity

3.3 Stiffeners

Each stiffener, in association with the plating to which it is attached, is to have section modulus, SM, not less than obtained from the following equation:

$SM = 6.75hs\ell^2$ cm^3

$SM = 0.0035hs\ell^2$ in^3

where

h = for ballast tanks, the greatest of the following distances, in m (ft), from the middle of ℓ:

- *i)* To a point located at two-thirds of the distance from the top of the tank to the top of the overflow. As an alternative, the maximum differential head in service may be used, provided hydrostatic data is submitted to show the differential head based on the highest levels to which water will rise on each side of the structure in service. Where the head is obtained using the maximum differential head in service, data on operating the dry dock within such design limits are to be included in the operating manual.
- *ii)* 2.5 m (8.2 ft)

= for all other tanks, the greatest of the following distances, in m (ft), from the middle of ℓ:

- *i)* To a point located two-thirds of the distance from the top of the tank to the top of the overflow
- *ii)* To the maximum immersion waterline, for wing wall and pontoon plating
- *iii)* 2.5 m (8.2 ft)

= for void spaces, the distance, in m (ft), from the middle of l to the maximum immersion waterline for wing wall and pontoon stiffeners, but not less than 2.5 m (8.2 ft) for wing wall, pontoon, and bulkhead stiffeners.

s = spacing of the stiffeners, in m (ft)

ℓ = span, in m (ft), between effective supporting members. Where brackets complying with 3-2-3/9 TABLE 1 are fitted at bulkheads, decks, or shell and intersect the stiffeners at about 45 degrees, the spanℓ may be measured to a point 25% of the extent of the bracket beyond the bracket toe.

Special consideration is to be given to the scantlings of stiffeners supporting plating which forms the boundary of an air cushion.

Deck/Stiffener Characteristics

s =	0.732 mm	(Stiffener Spacing)
h =	18.85 m	(Effective head)
L =	2.38 m	(Stiffener Span)
SM (min) =	527.50 cm^3	

Allowable head on stiff (no plate assumed) = 18.85 m
61.82 ft

% Corr PL	SM (min) in^3	SM (min) cm^3	Head m	Head ft
0	32.2	527.5	18.85	61.8
5	32.1	525.6	18.78	61.6
10	32.0	523.6	18.71	61.4
15	31.8	521.6	18.64	61.1
20	31.7	519.5	18.56	60.9
25	31.6	517.2	18.48	60.6
30	31.4	514.9	18.40	60.3
35	31.3	512.4	18.31	60.1
40	31.1	509.8	18.21	59.7
45	30.9	506.9	18.11	59.4
50	30.7	503.7	18.00	59.0

Appendix D – Pontoon Deck Vehicle Wheel Load Calculations

Deck Plate

Tire Capacity, W =	67,158 lbs	33.58 tons
Plate Pressure =	46.5 psi	
Tire Width, a =	72.15 in	(HS 20)
Hence, Tire Contact Length, b =	20.00 in	

Plate Check - ABS Rules for Steel Barges (2015) - Part 3, Chapter 2, Section 3, Item 17

Tire Load located anywhere on pontoon deck plate

17 Vehicle Loading *(2014)*

Where provision is to be made for the operation or stowage of vehicles having rubber tires, and after all other requirements are met, the thickness of deck plating is to be not less than obtained from the following equation:

$t = 25.2Kn\sqrt{CW}$ mm $\qquad$ $t = Kn\sqrt{CW}$ in.

where

K = $[21.99 + 0.316(a/s)^2 - 5.328(a/s) + 2.6(a/s)(b/s) - 0.895(b/s)^2 - 7.624(b/s)]10^{-2}$, derived from the curves indicated in 3-2-3/Figure 1

n = 1.0 where $\ell/s \geq 2.0$ and 0.85 where ℓ/s =1.0, for intermediate values of ℓ/s, n is to be obtained by interpolation.

C = 1.5 for wheel loads of vehicles stowed at sea and 1.1 for vehicles operating in port

W = static wheel load, in tonnes (tons)

a = wheel imprint dimension, in mm (in.), parallel to the longer edge, ℓ, of the plate panel

b = wheel imprint dimension, in mm (in.), perpendicular to the longer edge, ℓ, of the plate panel

s = spacing of the deck beams or deck longitudinals, in mm (in)

ℓ = length of the plate panel, in mm (in.)

For wheel loading, the strength deck plating thickness is not to be less than 10% greater than required by the above equation and the platform deck plating thickness is to be not less than 90% of that required by the above equation.

Where the wheels are close together, special consideration will be given to the use of a combined imprint and load. Where the intended operation is such that only the larger dimension of the wheel imprint is perpendicular to the longer edge of the plate panel, b, above may be taken as the larger wheel imprint dimension, in which case, a is to be the lesser wheel imprint dimension.

s =	29 in	C =	1.10
l =	124 in	K =	0.0942
l/s =	4.32		
n =	1.00 (l/s > 2)	t =	0.57 in

Minimum Deck Plate thickness required = 1.1*t =	0.630 in		
Actual Deck Plate thickness =	0.630 in	OK	
Allowable Corrosion =	0%		0.00 in Corr Allowed

Deck Plate

Tire Capacity, W =	35,082 lbs	17.54 tons
Plate Pressure =	60.5 psi	
Tire Width, a =	29.00 in	(HS 20)
Hence, Tire Contact Length, b =	20.00 in	

Plate Check - ABS Rules for Steel Barges (2015) - Part 3, Chapter 2, Section 3, Item 17

Tire Load located anywhere on pontoon deck plate

17 Vehicle Loading *(2014)*

Where provision is to be made for the operation or stowage of vehicles having rubber tires, and after all other requirements are met, the thickness of deck plating is to be not less than obtained from the following equation:

$t = 25.2Kn\sqrt{CW}$ mm $\qquad t = Kn\sqrt{CW}$ in.

where

K = $[21.99 + 0.316(a/s)^2 - 5.328(a/s) + 2.6(a/s)(b/s) - 0.895(b/s)^2 - 7.624(b/s)]10^{-2}$, derived from the curves indicated in 3-2-3/Figure 1

n = 1.0 where $\ell/s \geq 2.0$ and 0.85 where ℓ/s =1.0, for intermediate values of ℓ/s, n is to be obtained by interpolation.

C = 1.5 for wheel loads of vehicles stowed at sea and 1.1 for vehicles operating in port

W = static wheel load, in tonnes (tons)

a = wheel imprint dimension, in mm (in.), parallel to the longer edge, ℓ, of the plate panel

b = wheel imprint dimension, in mm (in.), perpendicular to the longer edge, ℓ, of the plate panel

s = spacing of the deck beams or deck longitudinals, in mm (in)

ℓ = length of the plate panel, in mm (in.)

For wheel loading, the strength deck plating thickness is not to be less than 10% greater than required by the above equation and the platform deck plating thickness is to be not less than 90% of that required by the above equation.

Where the wheels are close together, special consideration will be given to the use of a combined imprint and load. Where the intended operation is such that only the larger dimension of the wheel imprint is perpendicular to the longer edge of the plate panel, b, above may be taken as the larger wheel imprint dimension, in which case, a is to be the lesser wheel imprint dimension.

s =	29 in	C =	1.10
l =	124 in	K =	0.1304
l/s =	4.32		
n =	1.00 (l/s > 2)	t =	0.57 in

Minimum Deck Plate thickness required = 1.1*t =	0.630 in	
Actual Deck Plate thickness =	0.630 in	OK
Allowable Corrosion =	0%	0.00 in Corr Allowed

HEGER DRY DOCK, Inc.
HOPKINTON, MASSACHUSETTS

Done By : P.Trudeau
Checked By : P. SHAH
Date : 2/25/2020
Job No : 4274-D

Client : NASSCO San Diego
Subject : Pontoon Deck Analysis of Builder FDD

Pontoon Deck Stiffener (247x9; 100x15)

			Original (in)	Corr. %	Used dim. (in)
Flg t =	0.59	in	0.59	10%	0.53
Flg L =	3.94	in	3.94		3.94
Stiffener Height =	9.72	in	9.72		9.72
Web Thickness =	0.35	in	0.35	10%	0.32
Plate t =			0.63	0%	0.63
Eff. Plate width =			40.00	t	25.20

I of Stiffener on Plate

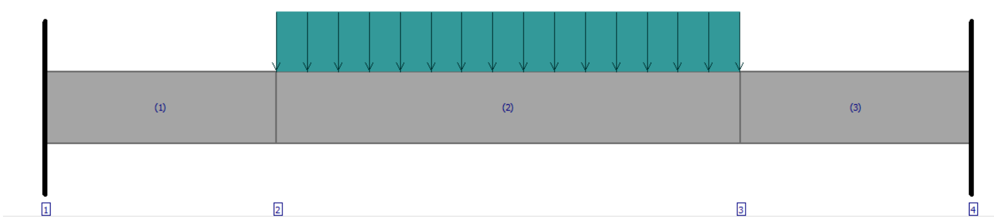
Item	Area	Arm	Area*Arm	Dist.	Area*D^2	I (Initial)
Stiffener Web	3.10	5.49	17.00	-3.39	35.61	27.09
Stiff Flg	2.09	10.62	22.21	-8.52	151.78	0.07
Plate	15.88	0.32	5.00	1.78	50.53	0.53
Totals	21.07		44.22		237.92	27.68

Neutral Axis = 2.10 in
Depth of section = 10.35 in

I (Total) = 265.60 in^4
S_{top} = 126.54 in^3
S_{Bot} = 32.19 in^3

f_b = Allowable Bending Stress = 20.40 ksi (AISC)
Min. Section Modulus = SM = 32.19 in^3
Max. Allowable BM = SM*f_b = 656.68 kip-in

f_v = Allowable Shear Stress = 13.60 ksi (AISC)
Available Shear Area = A = 3.30 in^2
Max. Allowable Shear = A*f_v = 44.85 kips



Stiffener Length = 124.41 in
Sitffener Spacing = 28.82 in

Bending

Allowable Load on Stiff @ midpoint = 55.35 kips

27.67 tons

Shear

Allowable Load @ stiff midpoint = 90.43 kips

45.22 tons

Appendix E – Doubler Plate Calculations

Done By: **M. Naylor**
Checked By: **P. Shah**
Date: **4/28/2020**
Job No: **4274-D**

Client: **NASSCO - San Diego**
Subject: **Doubler Plate Design for BUILDER**

Original Dimensions

Original Pontoon Deck Plate, t =	16 mm	0.630 in
Web Height, hw =	247 mm	9.72 in
Web Thickness, tw =	9 mm	0.354 in
Flange Width, bf =	100 mm	3.94 in
Flange Thickness, tf =	15 mm	0.591 in
Doubler Plate Thickness, dp =	15 mm	0.591 in
Stiffener Spacing, s =	732 mm	28.819 in
Stiffener Span, l =	3.16 M	10.37 ft
Tributary Area =	24.90 ft^2	

Assumed Dimensions for Calculation

	Original Thinkness	Corrosion	Assumed Thickness
Doubler Plate	0.591 in	25%	0.443 in
Pontoon Deck Plate	0.630 in	35%	0.409 in
Web Plate	0.354 in	7%	0.330 in
Flange Plate	0.591 in	7%	0.549 in

Effective width of Doubler Plate, be_1 =	50.0 *t	22.15 in	Min(50*t,s)
Effective width of Pontoon Deck Plate, be_2 =	50.0 *t	20.47 in	Min(50*t,s)

Calculated Section Properties

Top of Doubler Plate referenced as datum for calculation

I of Stiffener Connected to Plate						
Item	Area	Arm	Area*Arm	Dist.	Area*D^2	I (Initial)
Doubler Plate	9.81	0.22	2.17	1.87	34.47	0.16
Plate	8.38	0.65	5.43	1.45	17.58	0.12
Web	3.20	5.71	18.31	-3.62	41.96	25.25
Flange	2.16	10.85	23.46	-8.76	165.75	0.05
Totals	23.56		49.38		259.76	25.58

Section Height =	11.13 In.
Neutral Axis =	2.10 In.
Moment of Inertia, $I_{x\text{-}x}$ (Total) =	285 $In.^4$
S_{min} =	31.6 $In.^3$
Shear Area =	3.67 $In.^2$

HEGER DRY DOCK, Inc.

HOPKINTON, MASSACHUSETTS

Done By:	M. Naylor
Checked By:	P. Shah
Date:	4/28/2020
Job No:	4274-D

Client: NASSCO - San Diego

Subject: Doubler Plate Design for BUILDER

Section Capacity

Yield Point, Fy =	36.0	ksi		
Allowable Bending Stress, fb =	21.6	ksi		
Allowable Shear Stress, fv =	14.4	ksi		
Section Moment Capacity =	682.6	k-in		
Maximum Load Across Span, w =	0.441	k/in	[Bending Moment Limit]	
Section Shear Capacity =	52.8	k		
Maximum Load Across Span, w =	0.849	k/in	[Shear Limit]	
Beam Loading Capacity, w =	0.441	k/in		
Maximum Load Across Span =	54.9	kips		
Equivalent Head Pressure =	**34.5**	**ft**		

Horizontal Shear Flow thru Doubler

Doubler Plate Q =	18.4	$In.^3$		
Section Moment of Inertia, I =	285	$In.^4$		
Maximum Applied Shear, V =	27.4	kips		
Applied Shear Flow in Doubler =	1.77	k/in	[VQ/I]	
Center to Center Spacing of Weld Slots (Max) =	250	mm		9.84 in
Required Total Shear Flow =	17.40	kips		
Length of Double Sided Fillet Wel Along Slot =	100	mm		3.94 in
Required Weld Strength =	2.21	k/in		
Required Weld Size =	0.15	in		3 /16

HEGER DRY DOCK, Inc.

HOPKINTON, MASSACHUSETTS

Done By: **M. Naylor**
Checked By: **P. Shah**
Date: **4/28/2020**
Job No: **4274-D**

Client: **NASSCO - San Diego**
Subject: **Doubler Plate Design for BUILDER**

Original Dimensions

Original Pontoon Deck Plate, t =	16 mm	0.630 in
Web Height, hw =	597 mm	23.50 in
Web Thickness, tw =	14 mm	0.551 in
Flange Width, bf =	125 mm	4.92 in
Flange Thickness, tf =	18 mm	0.709 in
Doubler Plate Thickness, dp =	15 mm	0.591 in
Stiffener Spacing, s =	3160 mm	124.409 in
Stiffener Span, l =	3.66 M	12.01 ft
Tributary Area =	124.49 ft^2	

Assumed Dimensions for Calculation

	Original Thinkness	Corrosion	Assumed Thickness
Doubler Plate	0.591 in	25%	0.443 in
Pontoon Deck Plate	0.630 in	35%	0.409 in
Web Plate	0.551 in	7%	0.513 in
Flange Plate	0.709 in	7%	0.659 in

Effective width of Doubler Plate, be_1 =	50.0 *t	22.15 in	Min(50*t,s)
Effective width of Pontoon Deck Plate, be_2 =	50.0 *t	20.47 in	Min(50*t,s)

Calculated Section Properties

Top of Doubler Plate referenced as datum for calculation

I of Stiffener Connected to Plate						
Item	Area	Arm	Area*Arm	Dist.	Area*D^2	I (Initial)
Doubler Plate	9.81	0.22	2.17	6.93	471.37	0.16
Plate	8.38	0.65	5.43	6.51	354.82	0.12
Web	12.05	12.60	151.86	-5.45	357.94	554.65
Flange	3.24	24.69	80.07	-17.53	996.93	0.12
Totals	33.48		239.52		2181.06	555.04

Section Height =	25.02 In.
Neutral Axis =	7.15 In.
Moment of Inertia, $I_{x\text{-}x}$ (Total) =	2,736 $In.^4$
S_{plate} =	382.5 $In.^3$
S_{flange} =	153.2 $In.^3$
Shear Area =	12.82 $In.^2$

HEGER DRY DOCK, Inc.

HOPKINTON, MASSACHUSETTS

Done By:	**M. Naylor**
Checked By:	**P. Shah**
Date:	**4/28/2020**
Job No:	**4274-D**

Client: **NASSCO - San Diego**

Subject: **Doubler Plate Design for BUILDER**

Section Capacity

Plate Yield Point, Fyp =	36.0	ksi	[Mild Steel]
Allowable Bending Stress, fb =	21.6	ksi	
Allowable Shear Stress, fv =	14.4	ksi	
Stiffener Yield Point, Fys =	51.0	ksi	[HSS Steel]
Allowable Bending Stress, fb =	30.6	ksi	
Allowable Shear Stress, fv =	20.4	ksi	
Section Moment Capacity (Plate) =	8,261	k-in	[Mild Steel]
Section Moment Capacity (Stiffener) =	4,687	k-in	[HSS Steel]
Controlling Moment Capacity =	4,687	k-in	
Maximum Load Across Span, w =	2.258	k/in	[Bending Moment Limit]
Section Shear Capacity =	261.6	k	[HSS Steel]
Maximum Load Across Span, w =	3.631	k/in	[Shear Limit]
Beam Loading Capacity, w =	2.258	k/in	
Maximum Load Across Span =	325.3	kips	
Equivalent Head Pressure =	40.9	ft	
Design Head Pressure =	**34.5**	**ft**	[Controlled by Transverse Scantling]
Maximum Load Across Span =	274.7	kips	

Horizontal Shear Flow thru Doubler

Doubler Plate Q =	68.0	$In.^3$	
Section Moment of Inertia, I =	2,736	$In.^4$	
Maximum Applied Shear, V =	137.4	kips	
Applied Shear Flow in Doubler =	3.41	k/in	[VQ/I]
Center to Center Spacing of Weld Slots =	244	mm	9.61 in
Required Total Shear Flow =	32.8	kips	
Length of Double Sided Fillet Wel Along Slot =	125	mm	4.92 in
Required Weld Strength =	3.33	k/in	
Required Weld Size =	0.22	in	4 /16