ASSESSMENT OF THE DAMAGE STABILITY 
OF A HEAVY LIFT SHIP TRANSPORTING 
A MODU

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ABSTRACT

In the case of self-propelled semi-submersible heavy lift 
ships, the conventional stability requirements are no longer 
applicable. Considering the MIGHTY SERVANT class of vessels as 
ships of a novel kind, the damage stability criteria are 
adapted and presented in this paper. In order to examine the 
validity of these new criteria, the dry transportation of a 
jack-up respectively semi-submersible drilling rig are checked 
with regard to damage stability. It is shown that in both 
cases the new criteria are easily met.

1 INTRODUCTION

Transportation of floating heavy and bulky objects over sea 
was first effected by simply connecting a tugboat and (wet) 
tow them across the oceans. This method was improved by the introduction of submersible 
barges which were designed to be towed, resulting in improved 
transit speed. The latest improvement was made by the intro-
duction of the semi-submersible self-propelled heavy lift 
vessels. These vessels are unique in design and cannot be re-
garded as a simple barge or a conventional cargo ship. Rules 
of statutory and regulating authorities lag behind. To illus-
trate this, damage stability requirements with respect to load 
line rules were studied and found to be unacceptable for these 
type of vessels.

Safety is increased by addition of buoyant deck cargo. However 
this is not taken into account when calculating the load line 
for these vessels. After several discussions between Dutch 
Shipping Inspection, Lloyd's Register of Shipping and the 
author's company, this aspect was recognized and as such the 
existing rules were adapted.
Applications of the new set of requirements for dry transportation of large mobile offshore drilling units are shown in this paper.

MIGHTY SERVANT 3 en route from the Far East to the North Sea, transporting the largest jack-up rig built to date.
2 DAMAGE STABILITY REQUIREMENTS

2.1 Introduction

Heavy lift ships are designed to carry cargoes on their main deck. Often these are loaded by means of floating on, i.e. the carrier submerges, the cargo is floated over the submerged deck and positioned, after which the carrier starts deballasting and the cargo is lifted out of the water, see figure 2.1.

![Diagram of float-on operation](image)

1. SHIP FULLY SUBMERGED
   - Rig towed over deck
   - Tugger wires connected

2. RIG POSITIONED
   - Tugs disconnected
   - Start deballasting

3. SHIP DEBALLASTED
   - Rig resting on cribbing
   - Start seafastening

Figure 2.1 Float-on operation.

Subsequently, the cargo is secured by seafastenings which are placed around it and welded to the deck, see figure 2.2.

![Diagram of standard seafastening](image)

Figure 2.2 Standard seafastening.
After seafastening, both carrier and cargo can be considered as one combined unit. As such, the buoyancy of the cargo is included in the dynamic stability calculations. Without this cargo buoyancy, countless heavy lift transports executed in the past would not have been possible since the dynamic stability of the carrier alone did not meet the intact stability requirements. (See figure 2.1).

![Dynamic Stability Diagram](image)

Figure 2.3 Dynamic stability with/without cargo buoyancy included.

Generally damage stability is only considered in special cases. One such case is when an approval for sailing with a draft exceeding the load line is required.

### 2.2 B-100 type freeboard

The International Convention on Load Lines, 1966, distinguishes two types of ships, with the following typical characteristics:

**Type A ships:**
1) Designed for transport of fluids.
2) Main deck in principle watertight.
3) Subdivision into many separate tanks.
4) Tanks are generally full in case of damage.

**Type B ships:**
1) All ships that do not have the type A 1) to 4) characteristics.

Depending on the so-called "freeboard-length" of the ship, the corresponding minimum freeboards can be found for both types of ships.

The heavy lift system transport deck of ships. The Load Line B-type freeboard:
1) Freeboard length
2) Sufficient model
3) Hatches are adequately increased draft watertightness
4) Ship can withstand (freeboard design and B-type freeboard)
5) B-type freeboards are acceptable equal

The SERVANT class is a necessarily condition:

### 2.3

The conventional extent of damage 1966 Load Line Condition:

a. Two adjacent cargo areas
b. The vertical section to be equal to the compartment superstructure compartment

c. The transverse inboard from center line to damage of a load line condition

d. No main transverse penetration if the flood compartments located between tanks.

e. If in a transverse penetration not more than 3.05 m in compartments as flooded.
The heavy lift ships of the SERVANT class are designed to transport deck cargoes and as such are regarded as B-type ships. The Load Line Rules however, allow for decrease of B-type freeboard if the following conditions are met:  
1) Freeboard length over 100 meters.  
2) Sufficient measures are taken to protect the crew.  
3) Hatches are strong enough in relation to the increased draft. Special care should be taken to the watertightness and securing of the hatches.  
4) Ship can withstand damage to any one compartment (freeboard decrease of 60% of difference between A and B-type freeboard) or any two adjacent compartments (freeboard decrease of 100% of difference between A and B-type freeboard, i.e. B-100 freeboard) and reaches an acceptable equilibrium.

The SERVANT class vessels satisfy conditions 1) to 3), but not necessarily condition 4), which need some further elaboration.

2.3 B-100 damage stability requirements

The conventional B-100 damage stability requirements as to the extent of damage are as follows (from regulation 27 of the 1966 Load Line Convention):

a. Two adjacent tanks or compartments of the carrier and/or of the cargo are assumed to be damaged.

b. The vertical extent of damage in all cases is assumed to be equal to the depth of the ship at the flooded compartment under consideration. The buoyancy of any superstructure or deckhouse directly above the flooded compartment is to be disregarded.

c. The transverse extent of damage is equal to B/5, measured inboard from the side of the ship perpendicularly to the center line at the level of the summer load waterline. If damage of a lesser extent results in a more severe condition such lesser extent should be assumed.

d. No main transverse bulkhead is assumed damaged except if the flooding of any two adjacent fore and aft compartments is envisaged; in addition the damage may be located between two transverse bulkheads bounding side tanks.

e. If in a transverse bulkhead there are steps or recesses of not more than 3.05 m in length located within the extent of transverse penetration of damage, such transverse bulkheads may be considered intact and the adjacent compartments may be floodable singly. If, however, within the extent of penetration of damage there is a step or recess of more than 3.05 m in length in a transverse bulkhead, the two compartments adjacent to this bulkhead should be considered as flooded.
f. If a double bottom or side tank is divided by a transverse bulkhead located more than 3.05 m from a main transverse bulkhead, the adjacent double bottom or side tank should be considered as flooded. If this side tank has openings into the holds, such holds should also be considered as flooded. This provision is applicable even where such openings are fitted with closing appliances.

In the case of heavy lift ships, objection is made against item c). Since the B-100 freeboard is required for especially large cargoes such as semi-submersible or jack-up drilling rigs, this requirement is not very realistic. After all, the cargo may be protruding the ship's sides in excess of 20 meters, while the vertical distance between the waterline and the bottom of the protruding cargo is relative small, in the order of 2.5-3 meters. Locally the side shell of the carrier is thus well protected by the overhanging cargo since the entry vessel must be either very small or of sufficient size and mass to cause penetration, in spite of the cargo, see figure 2.4.

![Cross-section A-A](image)

**Figure 2.4 Conventional extent of damage.**

Regarding the heavy lift ships of the SERVANT class as "ships of a novel kind" under Article 6 of the International Convention of Load Lines 1966. It was decided by Dutch Shipping Inspection in close co-operation with Lloyd's Register of Shipping and Wijermuller to change item c) in such way that the contour of the cargo are taken into account or:

a. The final waterline, deadrise, heel, opening through.

b. The final waterline, deadrise, heel, opening through.

c. The transverse inboard from the cargo (or carrying vessel) to the cargo is prot 2.5.
c. The transverse extent of damage is equal to B/S, measured inboard from the side of the ship or from the outboard edge of the cargo (on a line normal to the center line of the carrying vessel) over that portion of its length where the cargo is protruding over the carrier's side. See also figure 2.5.

Figure 2.5 More realistic extent of damage.

After the flooding, due to the damage as described above, the vessel should be afloat in a stable condition. This condition should be defined as follows:

a. The final waterline after flooding, taking into account sinkage, heel and trim is to be below the lower edge of any opening through which progressive flooding may take place. Such openings should include air pipes and those which are closed by means of watertight doors or covers, and may exclude those openings closed by means of manhole covers and flush scuttles, cargo hatch covers, weathertight doors which are secured closed while at sea and so logged, remotely operated sliding watertight doors, and side scuttles of the non-opening type.

b. If pipes, ducts or tunnels are situated within the assumed extent of penetration of damage, arrangements should be made so that flooding cannot thereby extend beyond the limits assumed for the calculations of the damaged conditions.
3.1 Introduction

The new damage stability requirements are applied for two dry transports:
- transport of a large jack-up rig from the Far East to the North Sea (executed in summer 1986);
- transport feasibility study of a large semi-submersible drilling rig.

Both units did have such a weight/vertical center of gravity combination that, in order to improve the stability, an increased draft was necessary. For the semi-submersible rig, an increase of width by means of blister tanks was considered.

3.2 Transport of a large jack-up rig

In the summer of 1986, the heaviest jack-up rig ever built was dry transported from the Far East to the North Sea. For a stowage plan and rig particulars, see Appendix I. During the engineering phase it was decided to improve the dynamic stability by increasing the displacement to its B-100 load line maximum. This meant that all double bottom tanks could be ballasted, resulting in a lower vertical center of gravity and an increased GM. Furthermore, the dynamic stability curve improved, because the buoyant overhang immersed at smaller inclination angles, thus providing a contribution to the righting moment, see figure 3.1.
The damage should not be immersed, an excepted.

Stabilization is calculated in the dynamic calculation by the least 50 mm in the longitudinal fit of the angles of heel.

For an angle of water damaging and

For a dry

Near East to the

Submersible

Center of gravity

Submersible rig, was considered.

Rig

The ever built was the Sea. For a

During the dynamic

The B-100 load

The tanks could be

The gravity and

The addition curve

To the

Figure 3.1 Comparison dynamic stability 3 load lines.

In order to obtain approval for the B-100 load line, the damage stability was calculated according to the new set of requirements.

The tank arrangement of the ship plus cargo is given in figure 3.2. The penetration depth (R/5 = 8 m) is also plotted in this figure.

Note that the leg wells are simplified by squares with the same area. The spudcan bottoms are assumed to be flat.

The damage stability calculations are performed using the Wijsmuller Transport B.V. inhouse computer program, developed by "Wolfson Unit MTIA", University of Southampton.

For damages on the ship, the added weight method is used. For the intact condition, all wingtanks are empty. If damaged, the
tanks are assumed to flood completely i.e. the maximum weight is added. However, the maximum free surface correction is taken into account.

For damages on the rig, the lost buoyancy method is used. From the hydrostatic model of the ship plus the rig the damaged tanks of the rig are substracted, giving a new (damaged) model.

![Diagram of tank subdivision](image)

**Figure 3.2** Subdivision of tanks and transverse extent of damage.

With the new hydrostatic model and the new displacement (intact displacement plus added weight of damaged tanks) the righting lever curve is calculated:

\[ GZ = KN - KG' \times \sin \phi \] (m), see figure 3.3.

where KG' is the vertical center of gravity, corrected for the free surface effects. The model is free to trim.

![Diagram of dynamic stability](image)

**Figure 3.3** Nomenclature dynamic stability.

In total, 8 damages are given.

<table>
<thead>
<tr>
<th>Dam. Case</th>
<th>Ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

From the table a worst case, with NO of the tanks damaged, is given.

Regarding dynamic calculations, however, the GZ is easily calculated.

In case of a larger damage, the trim of the ship increases.

The maximum angle of list was calculated to be 20°.

It is required to assess the stability of the ship for all possible flooding of the tanks. In the most one tank damage was considered. Calculations gave a trim angle of 20°.

The buoyancy force was calculated for the upturning moment around the center of gravity. The uplifting moment was determined. Hence no lift-off was possible.
In total, 8 damage cases are considered. A summary of the results is given in the following table.

<table>
<thead>
<tr>
<th>DAM. CASE</th>
<th>SHIP RIG</th>
<th>LIST</th>
<th>TRIM* (Deg)</th>
<th>** MAX. RANGE (m)</th>
<th>GM' (m)</th>
<th>MEETS REQ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(-)</td>
</tr>
<tr>
<td>1 2 2</td>
<td>8.0</td>
<td>-3.01</td>
<td>44.0</td>
<td>3.35</td>
<td>1.70</td>
<td>Yes</td>
</tr>
<tr>
<td>2 2 4</td>
<td>8.0</td>
<td>-1.00</td>
<td>42.0</td>
<td>3.35</td>
<td>1.72</td>
<td>Yes</td>
</tr>
<tr>
<td>3 1 3</td>
<td>6.6</td>
<td>.01</td>
<td>37.9</td>
<td>2.70</td>
<td>1.73</td>
<td>Yes</td>
</tr>
<tr>
<td>4 3 0</td>
<td>6.7</td>
<td>.08</td>
<td>35.3</td>
<td>2.10</td>
<td>1.77</td>
<td>Yes</td>
</tr>
<tr>
<td>5 - 3</td>
<td>0 .72</td>
<td>.72</td>
<td>32.3</td>
<td>.75</td>
<td>1.62</td>
<td>Yes</td>
</tr>
<tr>
<td>6 - 3</td>
<td>0 .72</td>
<td>.72</td>
<td>30.0</td>
<td>.46</td>
<td>1.62</td>
<td>Yes</td>
</tr>
<tr>
<td>7 1 3</td>
<td>6.7</td>
<td>2.05</td>
<td>32.3</td>
<td>1.47</td>
<td>1.67</td>
<td>Yes</td>
</tr>
<tr>
<td>8 2 2</td>
<td>7.3</td>
<td>3.04</td>
<td>39.7</td>
<td>2.70</td>
<td>1.66</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* = trim by stern
** Residual range beyond equilibrium

From the table above it follows that damage case no. 1 is the worst case, with regard to the list after flooding. Regarding dynamic stability, damage case no. 6 is the worst. However, the GZ-curve still meets the minimum requirements easily.

In case of a large angle of heel, cargo buoyancy can cause the cargo to be "lifted-off" the carrier.

The maximum angle of heel after damage occurs for case 1, having a value of 8 degrees.

It is required that lift-off should not occur before an angle of 20° (residual range) plus the angle of heel after damaging and flooding of the carrier and cargo. In the most onerous case the total range amounts to 28° heel. Calculations gave the following results: (see also figure 3.4).

The buoyancy force B is calculated as 12,000 T. Lift-off will occur if the uplifting moment is larger than the downturning moment around the point of rotation R.

Uplifting moment = 12,000 * 43 = 516,000 Tm
Downturning moment = 20,100 * 30.5 = 613,050 Tm

Hence no lift-off will occur.
The transverse force with a list of 28 degrees equals $G_t - B_t$

\[
B_t = 12,000 \times \sin 28 = 5,633 \text{ T}
\]

\[
G_t = 20,100 \times \sin 28 = 9,436 \text{ T}
\]

Hence the extreme transverse force is approx. 3,800 T. Since the seasterning arrangement is designed for an extreme load of 8,300 T and above this friction may be approximated at 0.2 \* 20,100 = 4,020 T, no shifting of the cargo is expected.

Above calculations were checked by Lloyd's Register of Shipping and approved after which Dutch Shipping Inspection issued the B-100 load line certificate. The transport was successfully executed.

### 3.3 Transport of a large semi-submersible drilling rig

A feasibility study on the dry transport of a large semi-submersible drilling rig showed that in order to improve both initial and dynamic stability, the beam of the carrier must be increased by means of blister tanks and the B-100 displacement was required. For a stowage plan and rig particulars, see Appendix II.

Analogous to the jack-up case, damage stability calculations were made in order to get approval for the B-100 load line.

The tank arrangement of the ship plus cargo is given in figure 3.5 in which also the penetration depth of 8 m is plotted.
Figure 3.5 Subdivisions of tanks and transverse extent of damage.

In total, 8 damage cases are considered. A summary of the results is given in the following table.

Table: Summary of results (semi-submersible rig)

<table>
<thead>
<tr>
<th>NO OF TANKS DAMAGED</th>
<th>EQUILIBRIUM</th>
<th>DYNAMIC STABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LIST</td>
<td>TRIM*</td>
</tr>
<tr>
<td></td>
<td>(Deg)</td>
<td>(m)</td>
</tr>
<tr>
<td>DAM. CASE</td>
<td>SHIP RIG</td>
<td></td>
</tr>
<tr>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>1 2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>2 2</td>
<td>2</td>
<td>-</td>
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<tr>
<td>3 2</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>4 2</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>5 2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6 2</td>
<td>4</td>
<td>9.0</td>
</tr>
<tr>
<td>7 2</td>
<td>4</td>
<td>9.0</td>
</tr>
<tr>
<td>8 2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

** + = trim by stern
** Residual range beyond equilibrium

From the table above it follows that condition 7 is the worst case, regarding the list after flooding and the dynamic stability. However, the GZ-curve still easily meets the minimum requirements.
The floaters are divided into separate tanks. Openings in the
tank bulkheads are not very likely. The tanks are only
accessible from the column.
Therefore no progressive flooding after damaging is expected.

In case of a large angle of heel, cargo buoyancy may cause the
cargo to be "lifted-off" the carrier.

The maximum angle of heel after damage occurs under condition 7,
and amounts to 9°.

It is required that lift-off should not occur before an angle
of 20° (residual range) plus the angle of heel after damaging
and flooding of the carrier and cargo.
In the most onerous case the total range amounts to 29° heel.
Calculations gave the following results: (see also figure
3.6).

![Diagram](image)

**Figure 3.6 Check lift-off.**

The buoyancy force B is calculated as 11,234 T. Lift-off will
occur if the uplifting moment is larger than the downturning
moment about the point of rotation R.

Uplifting moment  = 11,234 * 47.81 = 537,142 Tm
Downturning moment  = 22,200 * 32.0 = 710,400 Tm

Hence the resulting downturning moment of the rig implies that
no lift-off will occur.

Transverse force

\[ G_t = 22,200 \times \sin \theta \]

\[ B_t = 11,234 \times \sin \theta \]

Hence the extreme lift-off is

Since the seafast extreme load of 6000 approximated at 0°
will not give any
shift of cargo is

Above calculation of

Buoyant cargo is not
vessels in such a
when calculating
Load Line Rules we
account. Furthermore
provides protection.
Therefore, the are
taken from the ship
If the penetration
ship plus overhang
requirements are

Because of the overhang
such that either the
intact, resulting
the overhang is in
stability, or a cell
equilibrium and sail

In the worst damage
is expected.

Heavy lift transport
unique in a lot of
often not applicable
are necessary.
Presently, this is
the common goal of
(classification as
transport companies
solutions for judge
adapting the tradition
suit these type of
Transverse force of cargo at a list of 29° equals \( G_L - B_L \)

\[
G_L = 22,200 \times \sin 29 = 10,763 \text{ T}
\]

\[
B_L = 11,234 \times \sin 29 = 5,446 \text{ T}
\]

Hence the extreme transverse force is approx 5,320 T.

Since the seastaying arrangement is designed to withstand an extreme load of 6,400 T and above, this friction may be approximated at 0.2 \( \times \) 22,200 = 4,440 T, this transverse force will not give any problems in view of the seastayings. No shift of cargo is anticipated.

Above calculations were checked and approved by Lloyd's Register of Shipping. The transport however did not materialize.

4 CONCLUSIONS

Buoyant cargo is secured onto the main deck of heavy lift vessels in such a way that its buoyancy can be taken into account when calculating the range of intact stability. As such, the Load Line Rules were adapted to take this buoyancy into account. Furthermore, it was recognized that cargo overhang provides protection to the carrier in case of a collision. Therefore, the assumed penetration depth \( (B/5) \) should not be taken from the ship's sides, but should include this overhang. If the penetration depth of 8 meters follows the contours of the ship plus overhanging cargo, the adapted B-100 damage stability requirements are easily met.

Because of the overhang, the damage after collision is always such that either the overhang is damaged while the carrier is intact, resulting in no list, or the carrier is damaged while the overhang is intact and thus providing all the large angle stability, or a combination of both. In all three cases, a safe equilibrium and sufficient residual dynamic stability is found.

In the worst damage cases, no lift-off nor shifting of the cargo is expected.

Heavy lift transmits such as the ones described above are unique in a lot of ways. Standard rules and regulations are often not applicable in these cases and special considerations are necessary.

Presently, this is well recognized within the industry and with the common goal of safe transports in mind, all parties involved (classification and statutory authorities, warranty surveyors, transport companies) can work out reliable (and realistic) solutions for judging the safety of these transports. As such, adapting the traditional damage stability requirements to better suit these type of heavy lift vessels is a good example.
APPENDIX I

Damage stability calculations of heavy lift ship transporting a jack-up rig

The principal particulars of the rig are:

a. Dimensions:

<table>
<thead>
<tr>
<th>Platform</th>
<th>Length</th>
<th>84.00 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breadth</td>
<td>90.00 m</td>
</tr>
<tr>
<td></td>
<td>Depth</td>
<td>9.50 m</td>
</tr>
<tr>
<td>Draft at loading/unloading</td>
<td>4.05 m</td>
<td></td>
</tr>
<tr>
<td>Plane shape</td>
<td>Modified triangular with leg wells in the three corners</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Legs</th>
<th>Type</th>
<th>Triangular lattice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>3</td>
</tr>
<tr>
<td>Longitudinal centers</td>
<td>56.80 m</td>
<td></td>
</tr>
<tr>
<td>Transverse centers</td>
<td>66.00 m</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>156.80 m</td>
<td></td>
</tr>
<tr>
<td>Chord diameter</td>
<td>1.00 m</td>
<td></td>
</tr>
<tr>
<td>Chord centers</td>
<td>12.00 m</td>
<td></td>
</tr>
</tbody>
</table>

Legs are completely retractable flush with the platform bottom when they are fully elevated.

b. Weight and center of gravity:

<table>
<thead>
<tr>
<th>WEIGHT (T)</th>
<th>VCG (m)</th>
<th>LCG (m)</th>
<th>TCG (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIGHT WEIGHT</td>
<td>19.100</td>
<td>28.50</td>
<td></td>
</tr>
<tr>
<td>VARIABLE LOAD</td>
<td>1.000</td>
<td>6.50</td>
<td></td>
</tr>
<tr>
<td>TOTAL WEIGHT</td>
<td>20.100</td>
<td>27.40</td>
<td>32.85</td>
</tr>
</tbody>
</table>

For a stowage arrangement and results of damage stability calculations, see following pages.
Ship transporting a triangular lattice structure in the three
APPENDIX II

Damage stability calculations of heavy lift ship transporting semi-submersible rig

The principal particulars of the rig are:

a. Dimensions:

<table>
<thead>
<tr>
<th>Rig</th>
<th>Length</th>
<th>97.50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breadth</td>
<td>72.50 m</td>
</tr>
<tr>
<td></td>
<td>Height</td>
<td>38.80 m</td>
</tr>
<tr>
<td>Distance between floaters</td>
<td>39.50 m</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floaters</th>
<th>Length</th>
<th>97.50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breadth</td>
<td>72.50 m</td>
</tr>
<tr>
<td></td>
<td>Depth</td>
<td>8.50 m</td>
</tr>
<tr>
<td></td>
<td>Bilge radius</td>
<td>1.60 m</td>
</tr>
<tr>
<td></td>
<td>Draft at loading/unloading</td>
<td>7.80 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
</tr>
<tr>
<td>Diameter outer columns</td>
</tr>
<tr>
<td>Diameter inner columns</td>
</tr>
</tbody>
</table>

b. Weight and center of gravity:

<table>
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<tr>
<th></th>
<th>WEIGHT (T)</th>
<th>VCG (m)</th>
<th>LCG (m)</th>
<th>TCG (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIG</td>
<td>19.600</td>
<td>28.90</td>
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<tr>
<td>CHAINS</td>
<td>2.420</td>
<td>6.60</td>
<td></td>
<td></td>
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<tr>
<td>ANCHORS</td>
<td>180</td>
<td>11.00</td>
<td></td>
<td></td>
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<td>TOTAL</td>
<td>22.200</td>
<td>26.30</td>
<td>48.75</td>
<td>0.00</td>
</tr>
</tbody>
</table>

For a stowage arrangement and results of damage stability calculations, see following pages.
STOWAGE PLAN
LARGE SEMI-SUB
ON MIGHTY SERVANT 3

LCG
(m)

TCG
(m)

48.75
0.00

damage stability