NAVAL GROUP

POWER AT SEA

SHIPYARD ASPECT ON NAVAL SHIP STABILITY FROM THEORY TO OPERATIONS

G. LE FRAPPER

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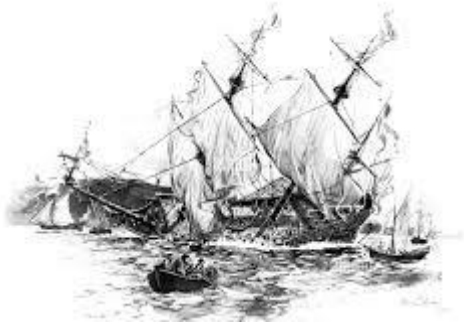
ASSOCIATION TECHNIQUE MARITIME ET AERONAUTIQUE
ATMA

INTRODUCTION

Shipyard are sometimes between regulations, customers requirements and end-user needs.



Especially for stability purposes:

- Theoretical displacements
- Experiment at the end of construction to validate hypothesis
- Needs onboard differ from what's is required by society rules etc…

And sometimes there is no issue at all: for example, Vasa sank because the King requires too many cannon on upper Decks.

SUMMARY

No pretention to present all subjects but focus on 3:

1. Loading conditions: from theory to operation
2. Documentation: from regulations to on-board use
3. Inclining test: the final cleaver

LOADING CONDITIONS

WEIGHT REPORT - DEFINITION

Lightship:

All equipment onboard: and mandatory for operations (including piping fluids at operating levels).

Deadweight:

All moving equipment (including crew and crew effects, stores consumables, etc.).

Extract from BV NR 483 Pt B, Ch 1, Sec 2:

5.1.1 The lightship is a ship complete in all respects, but without consumables, stores, and crew and effects, and without any liquids on board except for machinery and piping fluids, such as lubricant and hydraulic, which are at operating levels.

WEIGHT REPORT – LOADING CASE

Deadweight

Spare parts, Ammunitions: Quantity depends on customer's activity and habits.

Special forces boat used as safety boat?

For analysis of daily ship loading during operations: not easy for the crew to assess displacement variations when equipment is in the lightship.

Extract from BV NR 483 Pt B, Ch 1, Sec 2:

Table 2 : Definition

Components	Full load condition
Lighship	100%
Crew with luggage	100%
External personnel with equipment	100%
Ship logistic material	100%
Foods	100%
Ammunition	100%
Helicopters with their logistic	100%
Fuels (propulsion, auxiliaries, helicopters,...)	100%
Lubricant storage	100%
Other consumable materials	100%
Drinking water	100%
Drinking water	100%
Industrial waters	100%
Grey and black waters	0%
Ballast waters	0%
Stabilizing tanks	p. level
Non consumables and pumping residues	100%
Miscellaneous	100%

EXAMPLE: DAVIT

What is the center of gravity in theoretical loading cases for these types of installations?

Example of an embarkation unloaded by a crane, what CDG to take: resting position or operating position which is the most critical but no « every time use » position.

WEIGHT REPORT – LOADING CASE

Deadweight

Beyond theory: complete filling of tanks, spare parts and ammunition magazines throughout the ship, including the passageways could be an operational case (in times of crisis or war) outside theory and without compliance with regulatory criteria

- on-board modifications are the responsibility of the crew
- the only limit not to be exceeded is the maximum draft allowed by the study

Extract from BV NR 483 Pt B, Ch 1, Sec 2:

Table 2 : Definition of loading cases (% of mass or specified maximum loads)

Components	Full load condition	Operational load condition	Minimum operational condition	Comments
Lightship	100%	100%	100%	See [3.1.1]
Crew with luggage	100%	100%	100%	
External personnel with equipment	100%	100%	100%	Personnel not belonging to the crew
Ship logistic material	100%	100%	100%	On board documents, equipment for repairs
Foods	100%	66,6%	33,3%	Otherwise specified uniformly distributed in storage spaces
Ammunition	100%	66,6%	33,3%	In storage spaces above the ship centre of gravity
Helicopters with their logistic	100%	100%	100%	At location as specified
Fuels (propulsion, auxiliaries, helicopters,...)	100%	66,6%	33,3%	Otherwise specified uniformly distributed in storage spaces The filling of the overflow fuel oil tanks is to be limited to 75% of the net volume of these tanks
		100%	100%	For capability provided with an automatic continuous compensation system
Lubricant storage	100%	66,6%	33,3%	Otherwise specified uniformly distributed in storage spaces
Other consumable materials	100%	66,6%	33,3%	Otherwise specified uniformly distributed in storage spaces
Drinking water	100%	66,6%	66,6%	When produced on board
Drinking water	100%	66,6%	33,3%	When not produced on board
Industrial waters	100%	66,6%	66,6%	
Grey and black waters	0%	33,3%	33,3%	
Ballast waters	0%	0%	0%	For the minimum operation condition, ballast necessary to comply with the stability criteria may be accepted, subject that the total displacement including the ballast tanks does not exceed the displacement corresponding to the operational condition
Stabilizing tanks	op. level	op. level	op. level	At the operational level
Non consumables and pumping residues	100%	100%	100%	Corresponding to 2% of the net volume of the capacities; if a value lower than 2% is used, this value is to be justified
Miscellaneous	100%	100%	100%	Mobile liquid or solid ballast

On-board modification:
Prayer room converted into 18-person cabin

MANDATORY DOCUMENTATION AND ON-BOARD DECISION

REQUIRED STABILITY DOCUMENTATION

Extract from BV NR 483 Pt B, Ch 3, Sec 1

3.1.1 List of documents

For the purpose of the examination of the stability, the documentation listed in Ch 1, Sec 3, [1.1.2] is to be submitted for information.

The stability documentation to be submitted for approval, as indicated in Ch 1, Sec 3, is as follows:

- Inclining lightship test report for the ship, as required in [3.2] or:
  - where the stability data is based on a sister ship, the inclining test report of that sister ship along with the lightship measurement report for the ship in question, or
  - where lightship particulars are determined by methods other than inclining of the ship or its sister, the lightship measurement report of the ship along with a summary of the method used to determine those particulars
- trim and stability booklet, as required in Ch 3, App 2
- damage stability calculations, as required in Ch 3, Sec 3, [1.1.1]
- damage control documentation, as required in Ch 3, Sec 3, [1.2].

A copy of the trim and stability booklet, the damage control documentation and the loading computer documentation is to be available on board for the attention of the Captain.

From rules:

- Trim & stability booklet
- Damage control plan and booklet
- Loading manual

➢ 2 books for Commanding Officer (and Chief Engineer) information: theoretical analysis and a dedicated book for damage stability

From crew:

- Stability analysis
- On-board stability manual

➢ 1 book for theoretical analysis and 1 book used by the crew with Commanding Officer (and Chief Engineer) information

REQUIRED STABILITY DOCUMENTATION

Possible optimisation:

- **Stability manual: dedicated to crew:**
  - ✓ Ship general description
  - ✓ Information to Commanding Officier
  - ✓ Stability limits (Draft, trim, heel, KG, GM)
  - ✓ Draft mark positions
  - ✓ Ullage of capacities
  - ✓ KN curves and hydrostatics
  - ✓ Detailed loading cases and lightship for inclining test
  - ✓ KGMAX curves
  - ✓ Damages cases and righting process (when and what)
  - ✓ Shear forces and bending moment
  - ✓ Calculation model for manual stability calculations

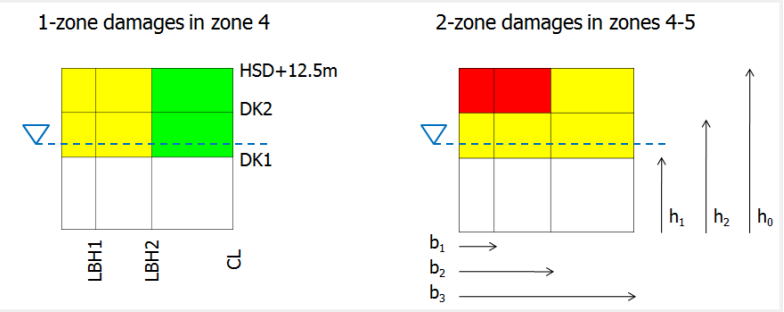
- **Stability document:**
  - ✓ Watertight hypothesis
  - ✓ Intact and damage Stability criteria
  - ✓ Input Hypothesis for criteria: wind moment, icing…
  - ✓ Wind profile
  - ✓ Position of Openings and progressive flooding if needed
  - ✓ Detailed loading case and associated GZ curves
  - ✓ Detailed intact stability results for each loading case
  - ✓ Definition of theoretical damage cases
  - ✓ Detailed damage stability results for each loading case
  - ✓ Cross-flooding and equalization time calculation

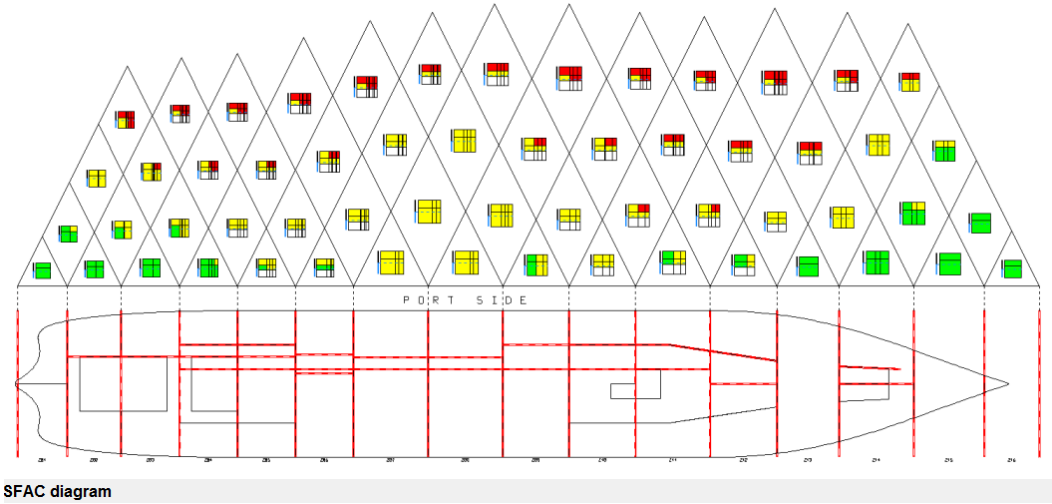
DAMAGE CONTROL

How to support efficiently the crew after damage?

SFAC diagram inspired from civil rules (SOLAS) and applied to navy rules

S: survivability factor (depends on GZmax curve, range and equilibrium angle)
GREEN (3) when 0.99 <= s
YELLOW (7) when 0.05 <= s < 0.99
RED (2) when s < 0.05
White when p*r*v < 0.00001





SFAC diagram

DOCUMENTATION AND INCLINING TEST

Extract from BV NR 483 Pt B, Ch 3, Sec 1:

3.1.3 Final documentation

Final stability documentation based on the results of the inclining test or the lightweight check is to be submitted for examination.

And all documentation shall be submitted after inclining test which shall be done close to delivery to be as close as ship real operating displacement…

INCLINING TEST PROCESS

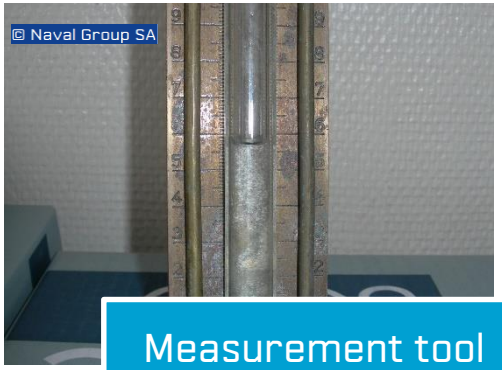
WEIGHING PROCEDURE

Draft measurement

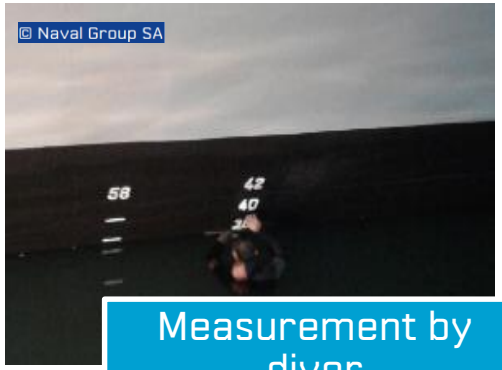
Uncertainty:

- Number of measurements (ship rolling, chop sea),
- Position of draft marks
- Hogging/ sagging correction (measure at each draft to evaluate shape of the hull)

Draft measurements



Measurement tool



Measurement by diver

Measurement from boat

CONDITIONS FOR DENSITY MEASUREMENT

Density measurement

Uncertainty:

- Number of measurements (aft, bow),
- Water sampling position (not on free surface but half draft deep)
- Measuring tools (2 differents)

Bottle to get density at half draft

Density measurement

Electronic device

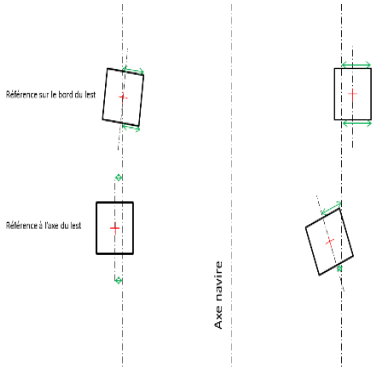
Density measurement

INCLINING TEST PHASES

Solid weight is the preferred solution for inclination

Uncertainty:

- Weighing of the solid weight
- Measurement of weight displacement distance (meter tool/laser)



Solid weight

Solid weight

Measurement of the distance

Maximum inclining

Maximum inclining

Maximum inclining

CONDITIONS FOR INCLINATION MEASUREMENT

Pendulum suspension

Water or oil tank

Precision

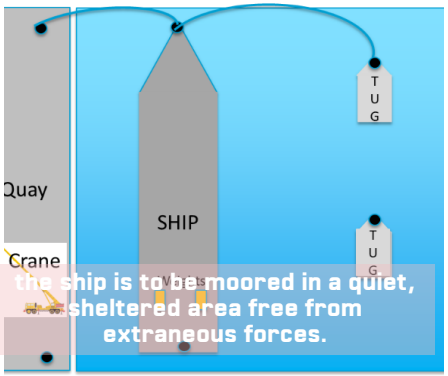
Reading conditions

Angle of heel

Uncertainty:

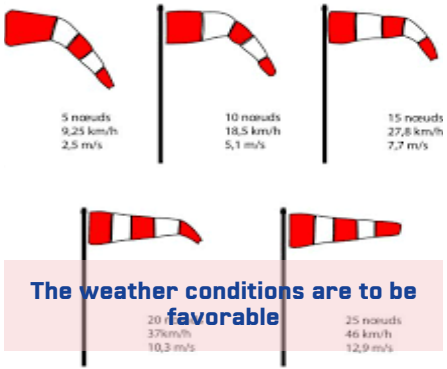
- Number of measurements (variation of the pendulum),
- Length of pendulum
- Avoid the pendulum to touch the rule or the tank wall
- Close the hangar door to avoid disturbance on pendulum motion

ENVIRONMENTAL CONDITIONS

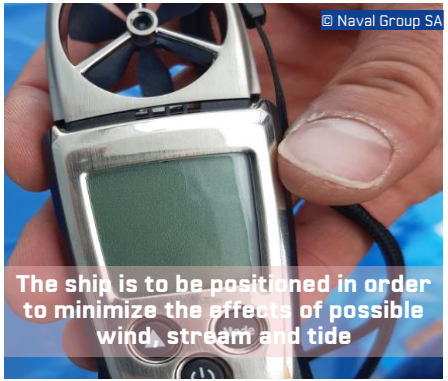


the ship is to be moored in a quiet, sheltered area free from extraneous forces.

Ship free from external forces: mooring lines slakes



The weather conditions are to be favorable



The ship is to be positioned in order to minimize the effects of possible wind, stream and tide

Environmental condition

Uncertainty:

- What are the limits: “weather conditions favourable: measure the wind at the beginning of each movement
- Slack of mooring lines: use of tug, head stern rope?
- Moored in a quiet sheltered area: dry dock? Quay without tide?

LIGHTSHIP COMPARED TO SHIP DURING TRIAL

Foreign weights:
Weight from deadweight or materials from shipbuilding (scafolding; spare part, tools etc.)

Liquid capacities: Manual gauging

Weight not at it operational position

Missing weight:
Equipment in maintenance or not yet installed

All king of weight: Technical Galery

Foreign weight in Passageway

Weight not at is operational position: Handling of cable before routing

Foreign weight: Manual jauging

Foreign weight: Laundry

Foreign weight: Scaffolding

Missing weight: Security equipment

Foreign weight: store

CONCLUSION

HOW TO IMPROVE?

Discussion with the regulations and with the crew to assess operational conditions and fit the theoretical loading condition

Example: Evaluate the real minimum loading condition instead of 33%

Secure the inclining test process, evaluate uncertainty to guarantee the ship stability as much as possible

Example during the inclining test: ship at maximum displacement? Or at lightship to reduce uncertainty due to foreign weight as liquid capacity?

Evaluates displacement limits and operating restriction when stability criteria are not met

Example: overloading cases or 10% loading cases

Indicate limits of operation and facilitate updating of ship displacement according to operating conditions

Example: clarify lightship/ deadweight, on-board stability calculator, draft measuring devices etc.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