

# Regulatory framework of a computer-based stowage planning: safety and efficiency considerations

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**Abstract.** Stowage planning is a tedious job. It involves technical and administrative tasks. Evolving data along the process and information completeness should be considered, when dealing with the updating of stowage plans. Recent IMO Regulations have brought forward a set of advanced stability criteria, far beyond the computation of metacentric height. The paper outlines the challenges on the implementation of proper stowage planning practices from the perspectives of safety and operational efficiency.

## 1. Introduction

A growing global trade is deeply connected to the ocean freight. Some ninety percent of the commodities traded globally are transported by ships. The ship size grows as a result of economy of scale, in particular for container shipping. Efficiency improvement has always been a key in order to make every sector competitive and profitable. For port operation, it means a higher cargo handling productivity [1].

Information on the incoming cargoes must be available in a sufficient period of time beforehand. In order to maximize the certainty of the so-called cargo loading list (CLL), many container terminals apply the closing time rule. Containers must be ready at the container yard about two days before the ship's arrival. The above is strictly applied for all international cargoes. Unfortunately, it does not necessarily apply for domestic cargoes in Indonesia.

On the other hand, the portrait of marine safety still raises awareness. Number of accidents remains high. Apparently a huge portion of the source of accidents attributed to the loading process [2]. Some of this accidents could be viewed as a systematic in nature, instead of a human error. It is therefore imperative to emphasize the importance to improve the quality of load planning, also known as stowage planning. This paper outlines the typology and requirements of a stowage planning tool, its regulatory framework, efficiency and human error issues and how to overcome them.

## 2. Loading Software: Typology and Requirements

The above portrait of a modern container shipping operations becomes a challenge for the planning process of allocating containers on board the ship. This process is called stowage planning. Time available for allocating thousand of containers on board virtually, through six big LED monitors, becomes an increasing challenge. It has direct cost consequences. A restow is a process where a container must be forced to be discharged first, in order to give a way for discharging another container, then this container will be reloaded again on board the ship. This restow is costly. For domestic shipping in Indonesia, it is approximately 10% of the freight rate. For bigger ships, and for voyages with multiple

ports of call, the chance of producing restows is significantly higher. An optimality strategy has always been the vision of a majority of algorithm development in order to automatize the planning process, fully or partially [3,4].

Approved stability software is not a substitute for the approved stability information, and is used as a supplement to the approved stability information to facilitate stability calculations. The input/output information shall be easily comparable with approved stability information so as to avoid confusion and possible misinterpretation by the operator relative to the approved stability information.

The types stowage planning software also known as loading software or stability software are determined from the scope of calculations performed [5]:

1. Type 1 Software calculating intact stability only (for vessels not required to meet a damage stability criterion).
2. Type 2 Software calculating intact stability and checking damage stability on basis of a limit curve (e.g. for vessels applicable to SOLAS Part B -1 damage stability calculations, etc.) or checking all the stability requirements (intact and damage stability) on the basis of a limit curve.
3. Type 3 Software calculating intact stability and damage stability by direct application of pre-programmed damage cases based on the relevant Conventions or Codes for each loading condition (for some tankers etc.).
4. Type 4 Software calculating damage stability associated with an actual loading condition and actual flooding case, using direct application of user defined damage, for the purpose of providing operational information for safe return to port (SRtP).

The following regulations and guidelines serve as a reference:

1. MARPOL 73/78, Annex 1, Regulation 28 for Oil Tanker  
Maritime Pollution (MARPOL) 73/78 is an international convention signed in 1973 and amended by protocol in 1978. Its Annex 1, Regulation 28 stipulates the obligations of oil tanker using loading instrument.
2. IBC Code Chapter 2 for Chemical Tanker  
International Bulk Chemical Code (IBC Code) is an international code for the construction and equipment of ships carrying dangerous chemical in bulk. Its chapter 2 specifies that a bulkcarrier of the length of over 150 meter must be fitted with a loading instrument.
3. IGC Code Chapter 2 for Gas Carrier  
International Gas Carrier Code (IGC Code) is an international code for the construction and equipment of ships carrying liquefied gas in bulk. Its purpose is to provide an international standard for the safe carriage, by sea in bulk, of liquefied gases and certain other substances.
4. SOLAS 1974 Chapter XI I/11 for Bulkcarrier  
Safety of Life at Sea (SOLAS)1974 is the international convention that regulates shipping safety especially on three aspects namely ship construction, equipment and operation. Its Chapter XI I/11 specifies additional measures for bulkcarrier.
5. SOLAS 1974 Chapter II-1/8-1.3 for Passenger Ship  
Safety of Life at Sea (SOLAS)1974 is an international convention that regulates shipping safety in the areas of ship construction, equipment and operation. Chapter II-1/8-1.3 stipulates that Passenger vessel constructed after 1 January 2014 must be installed with loading instrument.
6. IS Codes  
Intact Stability Code (IS Code) is an international code that presents both mandatory and recommendatory stability criteria and other measures for ensuring the safe operation of ships, in order to minimize the risk to the ship, to the personnel on board and to the environment.
7. MSC.1/Circ.1229 Guidelines for the Approval of Stability Instruments  
Maritime Safety Committee (MSC).1/Circ. 1229 presents guidelines for the approval of stability instruments, and specifies the acceptable tolerance for the approval.
8. IACS UR L5  
International Association of Classification Societies (IACS) UR L5 is present Onboard computers for stability calculation.

9. IS Code Part B Chapter 4

Intact Stability Code (IS Code) Part B chapter 4 is present Stability calculation performed by stability instruments.

**Table 1.** Acceptable tolerance for loading software examination

<b>Stability Instrument</b>	<b>Acceptable Tolerance</b>
<b>Hull Form Dependent</b>	
Displacement	2%
Longitudinal center of buoyancy, from AP	1% / 50 cm max
Vertical center of buoyancy	1% / 5 cm max
Transverse center of buoyancy	0.5% of B / 5 cm max
Longitudinal center of floatation, from AP	1% / 50 cm max
Moment to trim 1 cm	2%
Transverse metacentric height	1% / 5 cm max
Longitudinal metacentric height	1% / 50 cm max
Cross curve of stability	50 mm
<b>Compartment dependent</b>	
Volume or deadweight	2%
Longitudinal center of gravity, from AP	1% / 50 cm max
Vertical center of gravity	1% / 5 cm max
Transverse center of gravity	0.5% of B / 5 cm max
Free surface moment	2%
Shifting moment	5%
Level of contents	2%
<b>Trim and Stability</b>	
Draught (forward, aft, mean)	1% / 5 cm max
GMt	1% / 5 cm max
GZ values	5% / 5 cm max
FS Correction	2%
Downfoading angle	2%
Equilibrium angles	1
Distance to unprotected opening or margin line from WL, if applicable	± 5% / 50 mm
Areas under righting arm curve	5% or 0.0012 mrad

A stability booklet contains in particular the geometry, hydrostatic properties, tank tables of a ship. A validity of a stability booklet is shown by the class approval. A loading software refers to the stability booklet, which it represents. The classification society or a recognized organization examines the accuracy of the calculation in line with the IACS Guidelines, see Table 1 [5].

### 3. Regulatory Framework

The mandatory installation of loading software is scheduled in phases, see Table 2. Bulkcarrier of the length of over 150 meter must be fitted with a loading instrument, starting from 1 July 2016 Gas carrier, liquefied gas, oil tanker and chemical carrier constructed before 1/1/2016 must be installed before 1/1/2016 [6]. Thus applies also for tankers with a renewal survey between 1 January 2016 and 1 January 2021 [7]. Passenger vessel constructed 1 January 2014 must be installed with it [8].

Standards of Training, Certification and Watchkeeping for Seafarers (STCW) – Manila Amendments 2010 emphasizes the importance of adopting ICT in the seafarers' education and training [9]. A computer-based education for stowage planning must be deployed in their education.

After decades of waiting, Indonesia finally ratified the International Maritime Organization (IMO) regulations on Safety of Life At Sea (SOLAS) in December 2017, under them Presidential Act 57/2017

[10]. It demonstrates a firm effort to improve the marine safety of the Indonesian maritime industry. This is a major step the government undertakes to improve the marine safety portrait of Indonesia.

National regulations have paid the stability issues as a measure to ensure marine safety. Ministry of Transportation Regulation no. 39/2016 on Loadline and Ship Loading asserts accurate stability calculations as a pre-requisite for the Port Clearance (Surat Pemberitahuan Berlayar) [11]. Considering the increasing role of the information technology, the Ministry of Transportation Regulation no. 154/2015 introduces an Online Harbour Master Declaration (Surat Pemberitahuan Syahbandar), also known as SPS Online [12]. SPS Online contains three main services, namely: a. Clearance-in; b. Maneuvering and Clearance-out approval documents.

**Table 2.** Schedule stability instrument IMO

<b>Type of Ship</b>	<b>IMO Regulation</b>	<b>Constructed</b>	<b>Application</b>
Tanker	MARPOL 73/78 Annex 1.Reg 28(6)	01/01/2016	Survey of the ship on or after 1 January 2016 but not later than 1 January 2021
Bulk Carrier	IBC Code Chapter 2	01/01/2016	Bulk Carriers of 150 m in length and upwards shall be fitted with a loading instrument
Gas Carrier	IBC Code Chapter 2.2.7	01/01/2016	Survey of the ship on or after 1 January 2016 but not later than 1 January 2021
Passenger ships	SOLAS 1974 Chapter II-1/8-1.3	01/01/2020	Passenger ships constructed on or after 1 January 2014 shall have: 1. Onboard stability computer 2. Shore-based support

In spite of the above progress, a firm regulation mandating the inspection on ships on their compliance towards the deployment of a loading computer still does not exist yet.

#### **4. Efficiency Issues**

Efficiency is a key success factor for well-functioning of all industries. Shorter port time serves as an important instrument to boot efficiency in marine transport. This instrument affects the execution of stowage planning considerably. Preparing a stowage plan for a container ship of about 200 teus capacity takes some two hours by using a spreadsheet program. A closing time rule is a time windows provided to the shipper to deliver their containers. The purpose is to ensure that all containers are already available lates one day before the arrival of the ship. By doing so, the stowage plan could be done in time and accurately.

Time pressure is obvious, especially at ports where no closing time rule is applied. Cancellation of booked containers or arrival of new containers may still take place even two hours before the departure of the ship. This practice puts the chief officer in time pressure to update the list of cargoes, the bayplan and the stability calculation. This portrait repeats almost every time when a ship calls a port.

Other types of vessel have a different operation profile at port. A ferry must complete both discharging and loading operations in 45 minutes. A tanker and bulkcarrier with usually one or only a few types of cargoes has been in a better position. The loading list is usually fixed. The stowage planner

has sufficient time to prepare a stowage plan. Their stowage plan is usually prepared in phases, the so-called loading sequence. This loading sequence is usually in a sequence of 0%, 25%, 50% and 100% loading conditions.

Another important issue in loading operations of a ship is the information accuracy of cargoes. Ministry of Transportation Regulation no. 53/2018 on the Feasibility of Containers and Verified Container Gross Mass obliges shipper to inform the verified gross mass to the ship and port prior to delivering them to the terminal. This measure is established in order to ensure the input correctness for stability calculation.

In spite of the above measures, the compliance on fulfilling the above regulations raises some concern. The result, the quality of stability calculation could be less trustworthy.

## 5. Human Error Issues

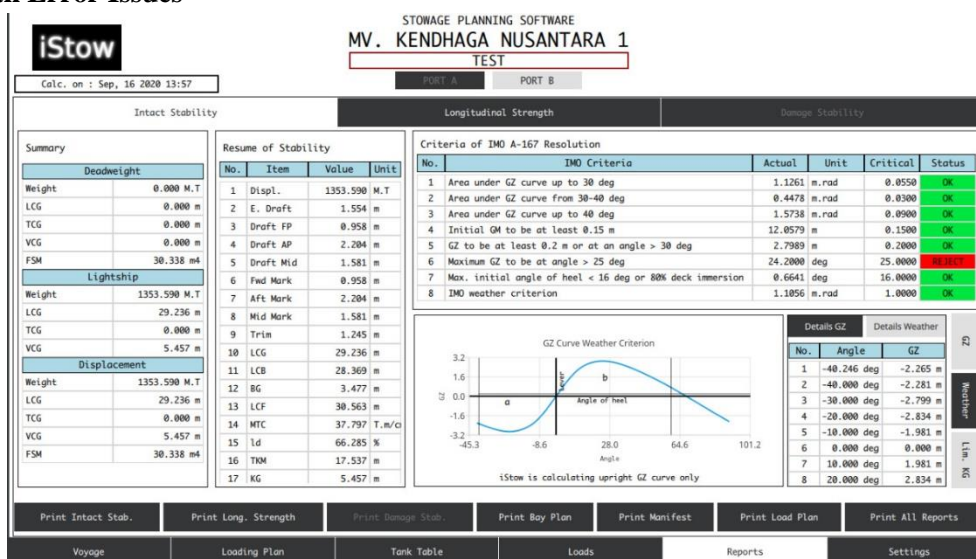


Figure 1. Stability criteria compliance in iStow: visual



Figure 2. Stability criteria compliance of iStow: audio setting

The portion of accidents involving human cannot simply be neglected. Human error is a dominating source of ship accidents. For clearance-out purposes, the metacenter height (GM) suffices. This operational requirement in practice is much softer than what IMO obliges to all operating ships.

iStow stowage planning software has been equipped with an visual warning system by showing the compliance of the stability criteria for the ship type in concern with green colour, other wise red, see Figure 1. Additionally, an audio warning system is also embedded, in order to improve the stability criteria compliance, see Figure 2.

Having those facilities in place, unnecessary human error could be minimized.

## 6. Concluding Remarks

1. At present, a stability calculation summary is often prepared by using a computer spreadsheet or manually. An accurate stability calculation summary is a pre-requisite for the issuance of a clearance-out document.
2. This stability calculation summary regards the metacentric height (GM) as the only stability criterion, which is far less than the full list of IMO stability criteria. Depending up on its type, a ship must fulfill at least seven stability criteria.
3. The usage of a loading software enables us to automate the process of stability calculations and the checking of stability criteria compliance. By doing so, unnecessary human error could be minimized, operational efficiency could be accomplished.
4. It is recommended to implement usage of loading computer strictly, in order to make ship operations satisfy both the operational efficiency and IMO safety requirements.

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## References

- [1] Nugroho S. (2007). "Reoccurrence in planning: Foundational principles and lessons learned from it", Proc. of Operations and Supply Chain Management (OSCM), Thailand, May 18-20.
- [2] Komite Nasional Keselamatan Transportasi. (2014). Investigasi Kecelakaan Pelayaran: Tergulingnya KM BJL 1 di Dermaga 107 Pelabuhan Tanjung Priok, Jakarta. Laporan Final KNKT - 1 4 - 0 1 - 0 2 - 0 3, Komite Nasional Keselamatan Transportasi, 14 January.
- [3] Nugroho S. (2009). Penerapan Piranti Lunak Perencanaan Stowage Kapal Peti Kemas. Program insentif percepatan difusi dan pemanfaatan iptek, Institut Teknologi Sepuluh Nopember (ITS).
- [4] Nugroho S, Abidin A Z, and Zulkarnaen F. (2017) "Stowage planning for container vessels: Methodology development and implementation issues in the light of intelligent transportation systems implementation". Int. J. of Business Economics, 2(6):119–134.
- [5] IACS. (2017). UR L5 Onboard Computers for Stability Calculations. Technical report.
- [6] International Maritime Organization. (2020). IBC CODE, 2020 ed. International Maritime Organization.
- [7] International Maritime Organization. (2017). MARPOL 73/78 Annex 1 Rev. 3 Reg. 28(6) Subdivision and Damage Stability, 2017 ed. International Maritime Organization.
- [8] International Maritime Organization. (1974). SOLAS, 2018 Consolidated ed. International Maritime Organization.

- [9] International Transport Workers' Federation. (2018). STCW a Guide for Seafares, 2018 ed. International Transport Workers' Federation.
- [10] Presiden Republik Indonesia. (2017). Peraturan Presiden No.57 tahun 2017 tentang Pengesahan Protocol of 1988 Relating to the International Convention for the Safety of life at Sea. Technical report.
- [11] Menteri Perhubungan Republik Indonesia. (2016). Peraturan Menteri Perhubungan No.39 tahun 2016 tentang Garis Muat Kapal dan Pemuatan. Technical report.
- [12] Menteri Perhubungan Republik Indonesia. (2018). Peraturan Menteri Perhubungan No.154 tahun 2015 tentang Surat Pemberitahuan Berlayar Online. Technical report.