Current Status of New Generation Intact Stability Criteria Development

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ABSTRACT

At the International Maritime Organization (IMO) the new generation intact stability criteria is now under development. This paper describes a current status of this development for facilitating discussion among experts in stability research. It was already agreed to consist of 3 levelled criteria and onboard operational guidances for four different stability failure modes, which include pure loss of stability, parametric rolling, broaching and stability under dead ship condition. Member states submitted available methodologies with sample calculation results so far but the first level criteria for pure loss of stability and parametric rolling are still missing and the first level criterion for broaching is required to be further upgraded. More verification and validation are essential for finalising this criterion set.

KEYWORDS

Vulnerability criteria, direct stability assessment, stability failure, IMO, SLF, 2008 IS Code

1 INTRODUCTION

The first part of the long work undertaken in the revision of the IMO Intact Stability Code in 2001 with the establishment of an ad-hoc Working Group (ISWG) operating during the Sessions of the Sub-Committee on Stability, Load Lines and on Fishing Vessel Stability (SLF) and intersessionally between them, has been completed in 2008 (Bulian et al., 2009)

This part of the ISWG activity was mostly devoted to restructuring the previous Intact Stability Code (IMO Res. A.749(18)) in several parts and making Part A of the new "International Code on Intact Stability, 2008 (2008 IS Code) " (IMO, 2009) mandatory under the provisions of both SOLAS and ILLC Conventions. The new Part A contains mandatory instruments for passenger and cargo ships since 1 July 2010, while Part B contains recommendations for other ship typologies. An originally planned “Part C” containing nomenclature, an historical part describing the origins and the developments of intact stability criteria and explanatory notes to the new International Intact Stability Code 2008, has been finalized as an MSC Circular (IMO, 2008).

Notwithstanding the importance of this work, the most important part of the initial scope of the revision, i.e. the formulation and implementation of a new generation intact stability criteria performance-based (Bulian et al, 2006; Umeda and Francescutto, 2008) is still to a large extent lying on the carpet. The time flown was in any case important for proving the potential cost-effectiveness implied in the new criteria and for the maturation of some important concepts connected with the dangerous phenomena to be covered, the basic structure and dictionary, and the philosophy of application of the new criteria (Chairman of ISWG, 2008).

It was subsequently decided that the following four dangerous situations should be individually addressed:

- stability failures under dead ship conditions;
- stability failures in following/stern quartering seas associated with matters related to stability variation in waves, in particular reduced righting levers of a ship situated on a wave crest;
- stability failures caused by parametric resonance, including consideration of matters related to large accelerations and loads on cargo and stability variation in waves;
- stability failures caused by broaching including consideration of matters related to manoeuvrability and course keeping ability as they affect stability.

Moreover the new generation intact stability criteria should be structured in three levels:

- Vulnerability 1st level;
- Vulnerability 2nd level;
- Direct stability assessment.

Specific Operational Guidelines should be added as a sort of "fourth level", in the acknowledgement that not all dangerous situations can be avoided only by design prescriptions.

In the following of this paper, the situation synthetically described in this Introduction is presented and discussed in some detail together with the potential methodologies identified up to now for the implementation in the 3x4 matrix of dangerous situation/level of criteria. Finally, some comments concerning the voids on the matrix are presented.

2 THE SCOPE AND APPLICATION OF THE NEW GENERATION INTACT STABILITY CRITERIA

The scope of new generation intact stability criteria is to provide methods to assess ships which may be vulnerable to particular stability failure modes not adequately assessed by the existing criteria. These ships have typologies or sizes outside the ships for which existing regulations were developed.

The new generation intact stability criteria is based on a multi-tiered assessment approach, which is considered for the time being, as a supplement or as part of an alternative to the existing criteria contained in part A of the 2008 IS Code. Since new generation intact stability criteria are focused on the assessment of ships that are vulnerable to stability failures, neither explicitly nor properly covered by the existing stability regulations (defined as "unconventional ships"), a particular ship under consideration must first be determined to be conventional or unconventional, for each specified stability failure mode. The first tier of the new generation intact stability criteria is therefore intended to serve this purpose.

If the first tier of the criteria (vulnerability criteria level 1) is passed, a ship is conventional for a particular failure mode and the 2008 IS Code on its own should be applied, if appropriate. If it is not passed, this indicates that the ship is unconventional, and therefore may be vulnerable to that particular dynamic stability failure, then direct stability assessment of this mode may be needed. However, in view of the additional complexity of direct stability assessment, an intermediate assessment is provided to confirm vulnerability, before requiring direct stability assessment. The objective of the second tier of the new generation stability criteria (vulnerability criteria level 2) is to provide justification for application of the direct stability assessment. If the vulnerability level 2 criteria does not confirm vulnerability for a particular dynamic stability failure, the 2008 IS Code is applied, if appropriate.

If a ship is confirmed to be vulnerable by the second tier of new generation stability criteria, for a particular failure mode, direct stability assessment with performance-based

criteria will then be applied (as a supplement to 2008 IS Code on its own, if appropriate). The results of direct stability assessment are then used to reduce vulnerability, by either revision of the design, or development of ship-specific operational guidance to assist the crew in operating the ship in as safe as possible manner. The results of direct stability assessment are also expected to a provide indications on the safety level. The overall procedure scheme is shown in Fig. 1 (Bassler et al, 2009).

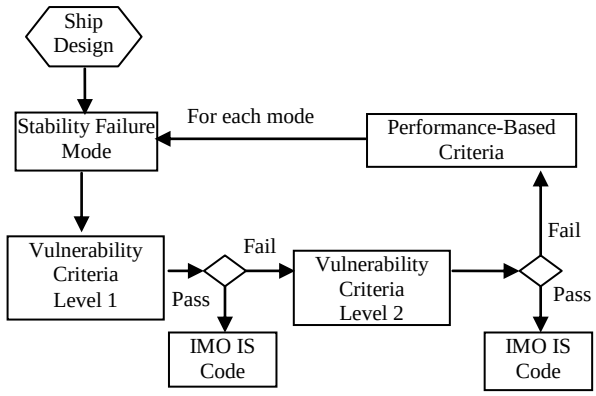

Figure 1 The proposed assessment process for next generation intact stability criteria

3 THE STRUCTURE AND PRELIMINARY SPECIFICATIONS OF THE NEW GENERATION INTACT STABILITY CRITERIA AFTER SLF52

During the 52nd Session of the SLF Sub-Committee held at IMO headquarters in London in January 2010 (Chairman of ISWG, 2010), the Ad Hoc Working Group for the Development of New Generation Intact Stability Criteria examined the proposal submitted from the member state delegations participating to the call issued at the end of previous session. It was agreed on the following specifications for the new criteria:

- Vulnerability Level 1 should consist in formulae or simple procedure based on geometry / hydrostatics, load condition and basic operational parameters, with low complexity and high safety margins;
- Vulnerability Level 2 should consist in simplified physics-based calculations with reduced computational efforts and straight forward application following suitable guidelines, with moderate complexity and safety margins;
- Direct assessment (third level) should be based on the best "state-of-the-art" concepts available. Time-domain numerical simulation with "hybrid" method and probability theory, as appropriate, should be used for the failure mode considered. The "hybrid" method includes potential flow + empirical viscous models. Specifically, rigid body-nonlinear dynamics model with undisturbed wave pressure (Froude-Krylov assumption). Specified formulation for added mass / wave damping / diffraction, externally specified coefficients for viscous / hydrodynamic lift components of roll damping and manoeuvring, and propulsion force, external environmental actions should be included, as appropriate. Suitable guidelines and procedures (e.g., wave scatter diagram, ship operation conditions, etc.) should be clearly stated. Assessment is expected to be made using a probabilistic measure to evaluate safety level. High complexity and low safety margins are expected.

Along the same lines, taking into account that the dangerous phenomena cannot in general be avoided only by design requirements, ship specific operational guidelines should be developed. This is an expected outcome of the direct assessment methodologies.

4 THE AVAILABLE ASSESSMENT METHODOLOGIES FOR THE DIFFERENT LEVELS

Hard work was done intersessionally between SLF51 and SLF52 with the active participation of many delegations. As a result, several methodologies have been submitted. The developed methodologies cover most of the cells of the matrix, as appears from the following Table 1.

Table 1 Submitted methodologies for four stability failure modes

Stability failure mode	Level 1	Level 2	Direct assessment	Operational guidance
Pure loss of stability		**X**	**X**	**X**
Parametric roll		**X**	**X**	**X**
Surf-riding/Broaching	**X**	**X**	**X**	
Dead ship condition	**X**	**X**	**X**	

This does not mean that these methodologies will be taken as they are for the foundations of the new generation intact stability criteria. There has been a lively discussion on the quality and validity of the presented methodologies and it was decided to move forward very cautiously, after through verification and validation. To this end, the terms for submission have been reopened until June 2010. Following the preliminary specifications stated, as reported in previous paragraph, it would have probably been better a reversal of the timeline, starting from the direct assessment to develop level 2 and from this level 1. This to some extent would ensure a low ratio of false positive and false negative by passing from a level to the higher one.

The different dangerous situations, on the other hand, are not equal in respect of the structure in levels. The scope of the first level vulnerability is to check the possible vulnerability of the subject ship to the considered phenomenon, so classifying her as an *unconventional* ship with respect to that phenomenon (but not necessarily vulnerable). Now, it is known since long time that *every ship* is vulnerable to the beam sea condition, which is a condition very close to the so-called dead-ship condition. This is, on the other hand, the only point where there was full agreement on a 1st level vulnerability based on present Weather Criterion but with extended wave steepness table.

Not very easy is the situation of the other cells of the first column. The proposal for 1st level vulnerability for the surf-riding and broaching is indeed based on the pure checking of the maximum service speed exceeding a critical speed defined through a critical Froude number. From a practical point of view, this means that a significant part of present ships having high Froude numbers could be categorised as "unconventional", irrespective of their actual dimensions, and would need to pass the 2nd level with the consequence of the need for applying more complex calculation methodologies. In this case, as well as the cases connected with stability variation in waves, it appears that design criteria should be supplemented by the development of ship-specific (and/or non ship-specific) operational guidelines.

The lack of first tier criteria for the phenomena connected with stability variation in waves, in particular, creates some difficulty inasmuch as it could entail that all ships are in principle vulnerable and have to pass at least through the second tier. Therefore, the development of the first tier criteria for pure

loss of stability and parametric rolling is a top priority at this stage.

5 CONCLUSIONS

The deadline for proposing new methodologies with sample ship calculation is the end of June 2010 so that their development is urgent. Then verification, validation and refinement of the proposed methodologies will be required under collaboration of member states via their own or international research projects among experts in this research area for finalising the new generation intact stability criteria by 2012, which is the target date agreed at the IMO.

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