2022 모의IMO총회
The 2022 Mock IMO Assembly

PROPOSAL

THE IMPLEMENTATION OF MANEUVER STANDARDS SINCE THE SHIP DESIGN PHASES

MSC.137(76) – Standards for Ship Maneuverability

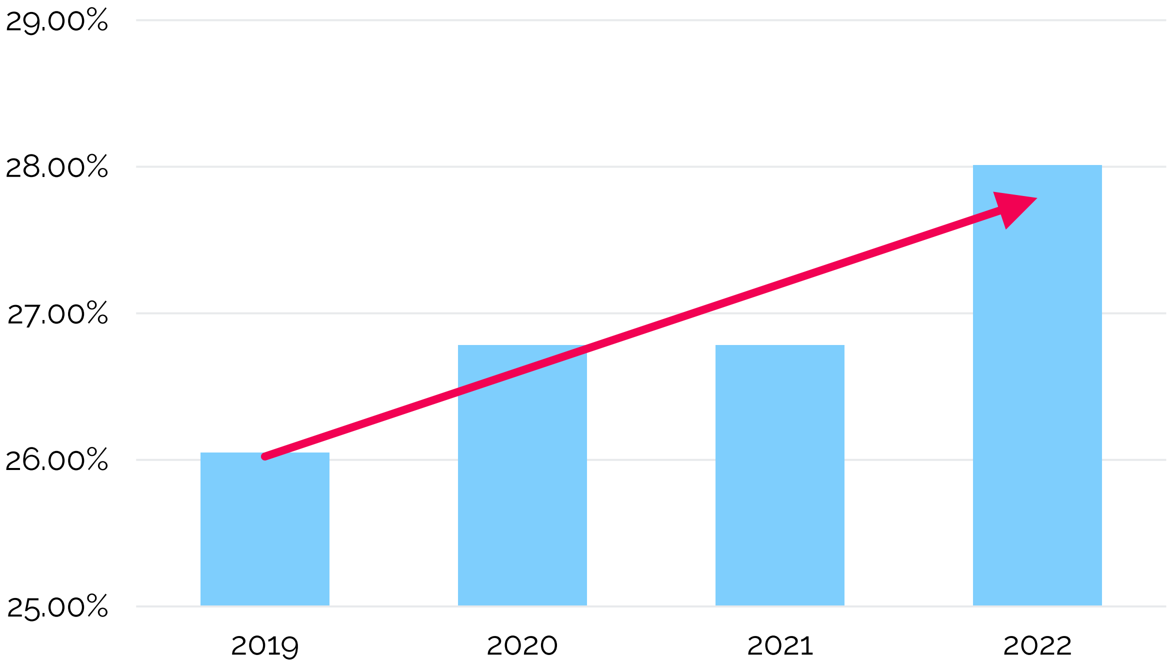
MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability

Team: Mother's Prayer

Contents

1.
BACKGROUND

COLLISIONS AS A FACTOR OF MARINE ACCIDENT



From 2019-2022, collision has become the main factor in marine accidents.
It contributes 691 cases from 2589 cases or about 26.69% of total accidents that happened in 2019-2022 (as of June 30, 2022).

References : [3]

CONDITION ANALYSIS

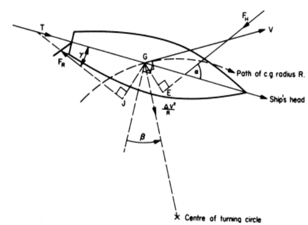
Ships' Collision


Human Error

Education and Training


Maritime Autonomous Surface Ships (MASS)


Absence of Ship Operators



Maneuverability Design

ACTUAL CONDITION

"

Maneuvering performance has traditionally received **little attention** during the **design stages** of a commercial ship.

A primary reason has been the **lack of** maneuvering performance **standards** for the ship **designer to design to**, and/or **regulatory authorities to enforce**.

Consequently, some ships have been built with **very poor maneuvering qualities** that have resulted in **marine casualties and pollution**.

Designers have **relied** on the **ship-handling abilities** of **human operators** to **compensate** for **any deficiencies** in the inherent maneuvering qualities of the hull.

The **implementation of maneuvering standards** will **ensure** that ships are **designed** to a **uniform standard** so that an undue burden is not imposed on ship handlers in trying to compensate for deficiencies in inherent ship maneuverability.

MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability – Chapter 1 General Principles – 1.1 Philosophy and Background – 1.1.2.

References : [2]

EXISTING STANDARDS

"**Scale model tests** and/or computer predictions using **mathematical models** can be performed to predict compliance at the **design stage**. In this case, **full-scale trials** should be conducted to **validate** these results."

MSC.137(76) – Standards for Ship Maneuverability – Annex – 2 General – 2.1

"To be able to **assess** the maneuvering performance of a new ship at the **design stage**, it is necessary to predict the ship maneuvering behavior on the basis of **main dimensions, lines drawings,** and **other relevant information** available at the **design stage**."

MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability – Chapter 3 Prediction Guidance – 3.1 General – 3.1.1

"The first and **simplest method** is to base the prediction on experience and existing data, **assuming** that the maneuvering characteristics of the **new** ship **will be close** to those of **similar existing ships**."

MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability – Chapter 3 Prediction Guidance – 3.1 General – 3.1.3

"The second method is to base the prediction on results from **model tests**. Model tests are **described** in section 3.2."

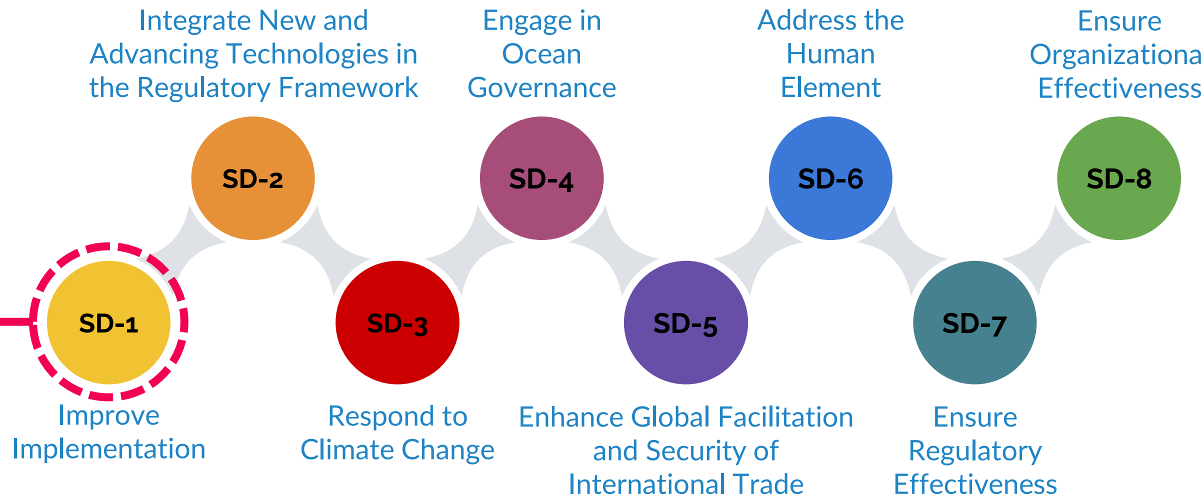
MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability – Chapter 3 Prediction Guidance – 3.1 General – 3.1.4

"The third method is to base the prediction on results from **calculation/simulation** using a **mathematical model**. Mathematical models are **described** in section 3.3."

MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability – Chapter 3 Prediction Guidance – 3.1 General – 3.1.5

References : [1] [2]

STRATEGIC DIRECTION OF IMO (2018 – 2023)



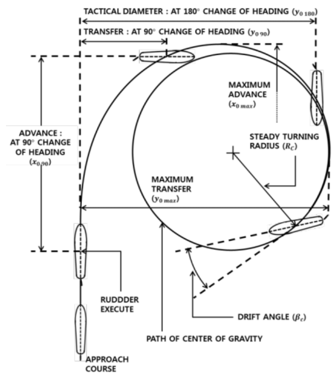
Introducing the proposal for implementation of maneuvering standards since design phases in order to have a uniform standard on understanding maneuverability to minimize maneuverability failure.

References : [4]

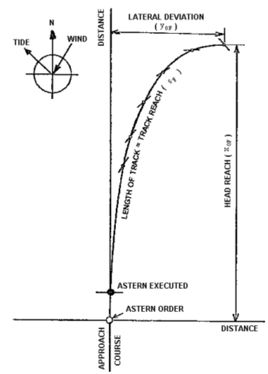
2.

PROBLEM ANALYSIS

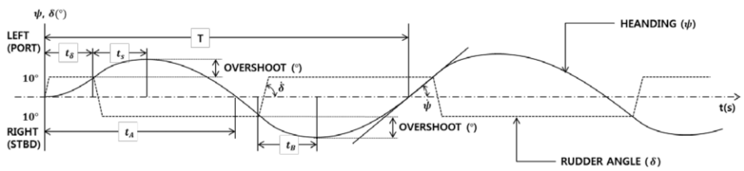
MANEUVER TESTS



Turning Test



Stopping Test



Zig-zag Test

References : [5]

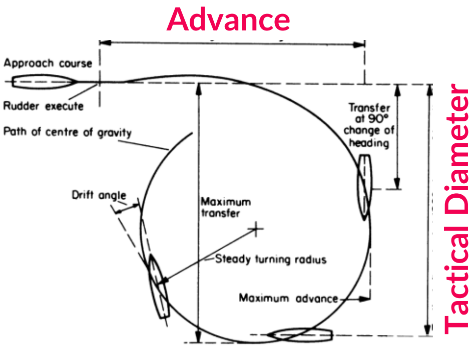
TURNING CIRCLE MANEUVER

"**Turning circle maneuver** is the maneuver to be performed to both starboard and port with **35° rudder angle** or the **maximum rudder angle** permissible at the test speed, following a **steady** approach with **zero yaw rate**"

MSC.137(76) – Standards for Ship Maneuverability – Annex – 4 Definitions – 4.2 Standard Maneuvers and Associated Terminology

"The **advance** should **not exceed 4.5 ship lengths (L)** and **the tactical diameter** should **not exceed 5 ship lengths** in the **turning circle maneuver**."

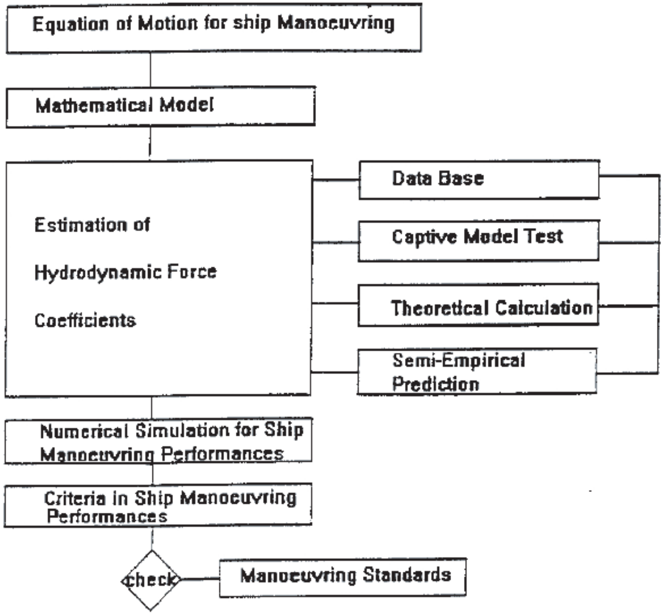
MSC.137(76) – Standards for Ship Maneuverability – Annex – 5 Standards – 5.3 Criteria



EXISTING GUIDANCE

"In such cases, it will be required to **predict** the manoeuvring performance in full load condition by means of some method that uses the results of the sea trial.
As an **alternative** to **scale model tests**, usually conducted during the ship **design phase**, a **numerical simulation** using a **mathematical model** is a **useful method** for **predicting** ship manoeuvring performance in **full load** condition."

MSC/Circular. 1053 – Explanatory Notes to the Standards for Ship Maneuverability – Chapter 3 – Prediction Guidance – 3.3 Mathematical Model – 3.3.1.2



MANEUVER ASSESSMENT AT DESIGN STAGE

APPENDIX 2

GENERAL VIEW OF PREDICTION OF MANOEUVRING PERFORMANCE

1 A mathematical model of the ship manoeuvring motion can be used as one of the effective methods to check whether a ship satisfies the manoeuvrability standards or not, by a performance prediction at the full load condition and from the results of the sea trial in a condition such as ballast.

2 Existing mathematical models of ship manoeuvring motion are classified into two types. One of the models is called a 'response model', which expresses a relationship between input as the control and output as its manoeuvring motion. The other model is called a "hydrodynamic force model", which is based on the hydrodynamic forces that include the mutual interferences. By changing the relevant force derivatives and interference coefficients composed of a hydrodynamic force model, the manoeuvring characteristics due to a change in the ship's form or loading condition can be estimated.

3 Furthermore, a hydrodynamic force model is helpful for understanding the relationship between manoeuvring performance and ship form than a response model from the viewpoint of design. Considering these situations, this Appendix shows the prediction method using a hydrodynamic force model. Certainly, the kind of mathematical model suitable for prediction of the performance depends on the kind of available data. There are many kinds of mathematical models.

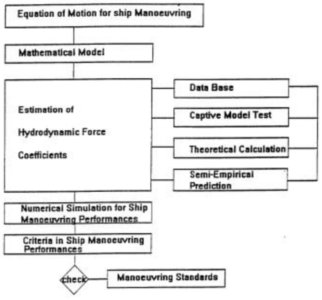
4 In figure A2-1, the flow chart of prediction method of ship manoeuvring performance using a hydrodynamic force model is shown. There are in general various expressions of a hydrodynamic force model in current practice, though their fundamental ideas based on hydrodynamic considerations have little difference. Concerning the hydrodynamic force acting on a ship in manoeuvring motion, they are usually expressed as a polynomial term of motion variables such as the surge, sway and angular yaw velocities.

5 The most important and difficult work in performance prediction is to estimate such derivatives and parameters of these expressions to compose an equation of a ship manoeuvring motion. These hydrodynamic force coefficients and derivatives may usually be estimated by the method shown in figure A2-1.

6 The coefficients and derivatives can be estimated by the model test directly, by data based on the data accumulated in the past, by theoretical calculation and semi-empirical formulae based on any of these methods. There is also an example that uses approximate formulae for estimation derived from a combination of theoretical calculation and empirical formulae based on the accumulated data. The derivatives which are coefficients of hydrodynamic forces acting on a ship's hull, propeller and rudder are estimated from such parameters as ship length, breadth, mean draught, trim and the block coefficient. Change of derivatives due to a change in the load condition may be easily estimated from the changes in draught and trim.

7 As mentioned above, accuracy of manoeuvring performance predicted by a hydrodynamic force model depends on accuracy of estimated results by hydrodynamic forces which constitutes the equation of a ship manoeuvring motion. Estimating the hydrodynamic derivatives and coefficients will be important to raise accuracy as a whole while keeping consistency of relative accuracy among various hydrodynamic forces.

8 A stage in which theoretical calculations can provide all of the necessary hydrodynamic forces with sufficient accuracy has not yet been reached. Particularly, non-linear hydrodynamic forces and mutual interferences are difficult to estimate with sufficient accuracy by pure theoretical calculations. Thus, empirical formulae and databases are often used, or incorporated into theoretical calculations.

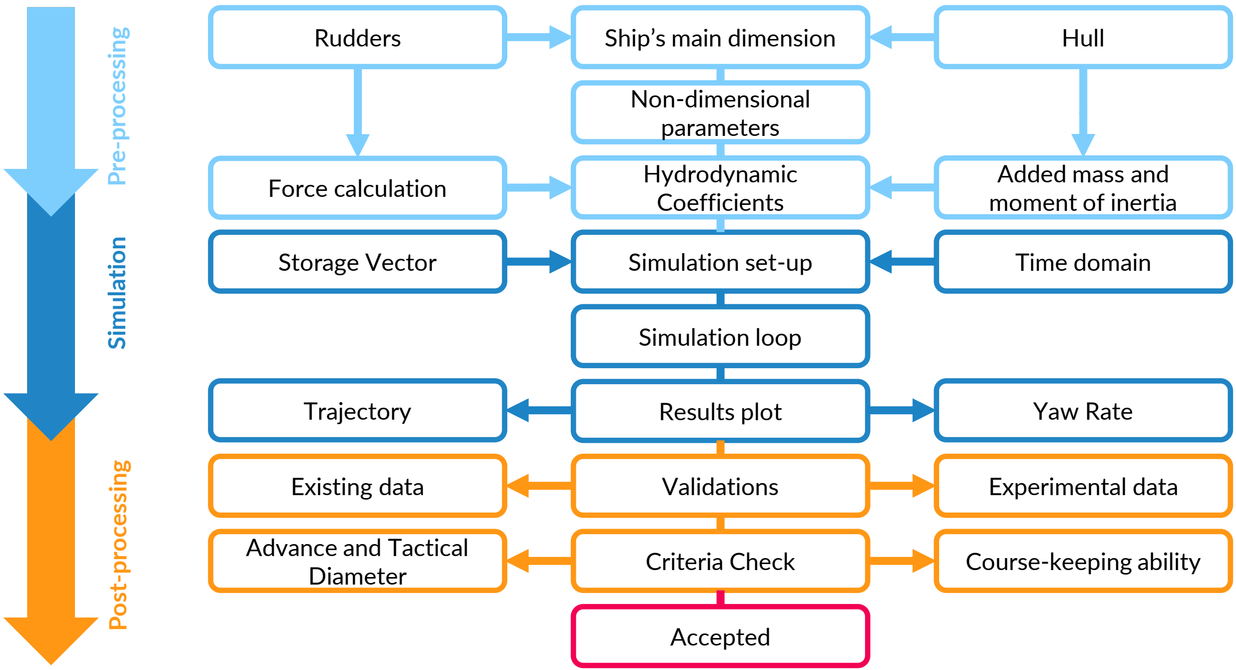


Flow chart for prediction of ship manoeuvring performance

Figure A2-1

References : [2]

SIMULATION PROCESS

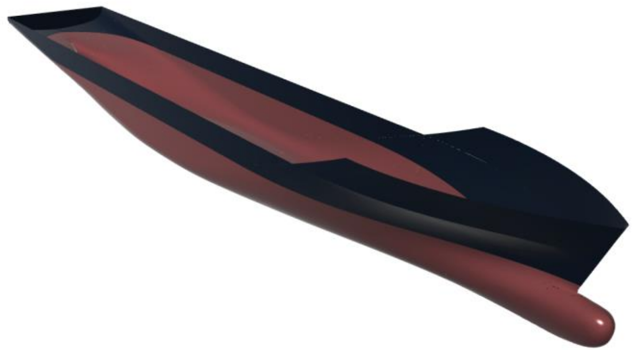


References : [6]

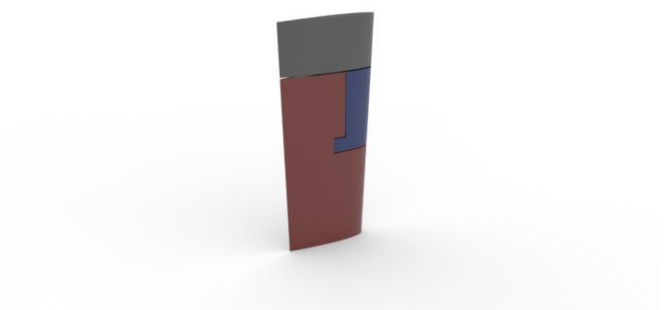
3.
CASE STUDY

MOERI CONTAINER SHIP (KCS)

HULL CHARACTERISTICS	
Length between Perpendiculars	230.0 m
Moulded Breadth	32.2 m
Immersed Draft	10.8 m
Coefficient Block	0.651



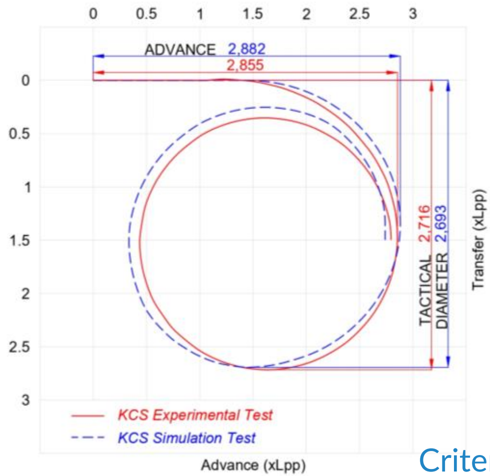
RUDDER CHARACTERISTICS	
Lateral Area	54.45 m^2
Height	9.90 m
Mean Chord Length	5.50 m



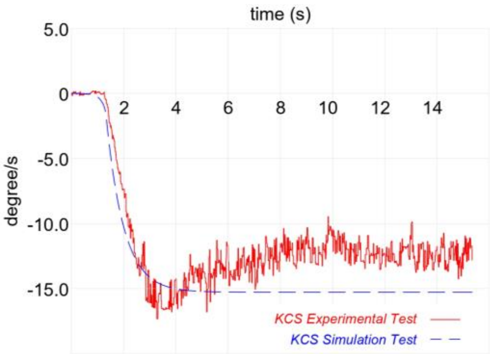
References : [7]

VERIFICATION RESULTS

Turning Circle Maneuver



Yaw Rate



Criteria Acceptance

Characteristics	Criteria	Experimental	Simulation	Differences		Status
Advance	< 4.5 L	2.855 L	2.882 L	0.032	1.10%	Passed
Tactical Diameter	< 5 L	2.716 L	2.693 L	-0.017	-0.63%	Passed
Course Keeping	C > 0	-	8.829×10^{-7}	-	-	Passed

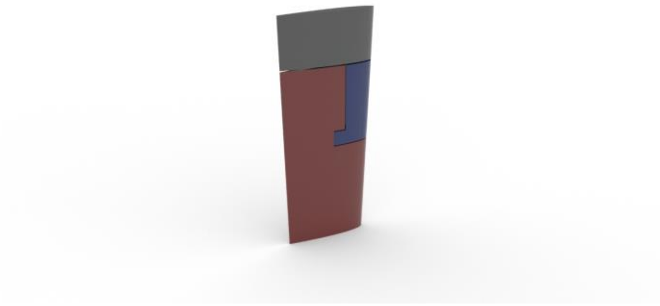
The simulation was conducted using MATLAB R2018b. The time domain is set to 50.0 s with a 0.1s interval for each step.

References : [8]

COLLIDED SHIP – JANE DOE

HULL CHARACTERISTICS	
Length between Perpendiculars	190.0 m
Moulded Breadth	32.26 m
Immersed Draft	10.8 m
Coefficient Block	0.842

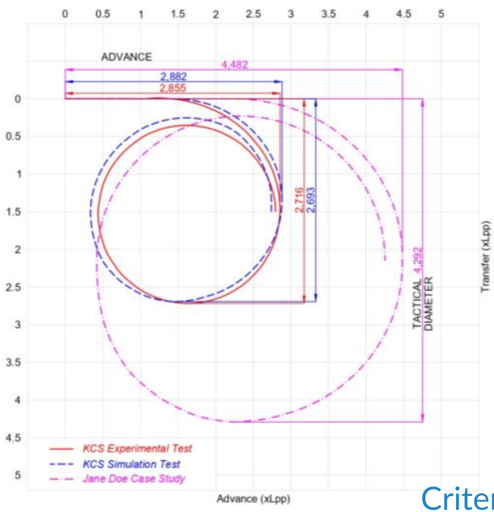
RUDDER CHARACTERISTICS	
Lateral Area	54.45 m^2
Height	9.90 m
Mean Chord Length	5.50 m



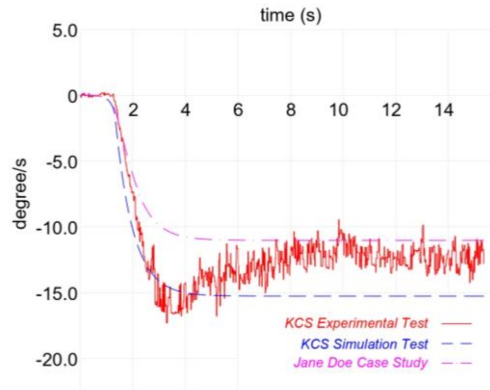
References : [9]

JOHN DOE MANEUVER RESULTS

Turning Circle Maneuver



Yaw Rate



Criteria Acceptance

Characteristics	Criteria	Simulation	Status
Advance	< 4.5 L	4.482 L	Passed
Tactical Diameter	< 5 L	4.292 L	Passed
Course Keeping	C > 0	-3.511×10^{-5}	Not Passed

The simulation was conducted using MATLAB R2018b. The time domain is set to 50.0 s with a 0.1s interval for each step.

COMPARISON SUMMARY

Characteristics	KCS	JANE DOE
Length between Perpendiculars	230.0 m	190.0 m
Moulded Breadth	32.2 m	32.26 m
Immersed Draft	10.8 m	10.8 m
Coefficient Block	0.651	0.842
Rudder Lateral Area	54.45 m^2	54.45 m^2
Rudder Height	9.90 m	9.90 m
Rudder Mean Chord Length	5.50 m	5.50 m

Ships	KCS			JANE DOE		
Characteristics	Results	Safety Margin	Status	Results	Safety Margin	Status
Advance	2.882 L	1.618L	Passed	4.482 L	0.018L	Passed
Tactical Diameter	2.693 L	2.307L	Passed	4.292 L	0.708L	Passed
Course Keeping Ability	$8.829\text{x}10^{-7}$	-	Passed	$-3.511\text{x}10^{-5}$	-	Not Passed

SUMMARY OF JANE DOE CASE

- Based on **MSC.137(76) – Standards for Ship Maneuverability – Annex – 5 Standards – 5.3 Criteria** of Turning Circle Maneuver test, Jane Doe **passed** the standards with a relative minimum margin of safety. But still, this ship is considered to have **"good"** turning circle maneuverability with **4.482L for Advance**, and **4.292L for Tactical Diameter**.

- With an **amendment of additional guidance** proposed to access maneuverability since the **design stage**, the Jane Doe ship is considered to have **"poor"** turning circle maneuverability, indicated by the **high value** of **Advance**, and **Tactical Diameter** compared to ships with similar characteristics. Even though it still **passed** the existing criteria which are required by the IMO, it **failed** the **Course Keeping Ability** criteria check, where the ship's characteristics can be improved for better maneuverability performances to prevent a collision.

- A better **ship's design** could be chosen to have better **Course Keeping Ability**, and a **better rudder** could be chosen to **lower** the value of the **Advance** and **Tactical Diameter**.

- With a better understanding of ships' maneuverability since the **design stage** as proposed, it is believed that other **"poor" maneuverability** ships could be **prevented** which resulting a better future for ships' operation.

4.
PROPOSED SOLUTIONS

PROPOSED IDEAS

Section	Existing Standards	Analysis	Proposed Solutions
MSC.137 – 4 Definitions	Geometry of the ship and Standard manoeuvres and associated terminology	There is still a **lack** of definitions required in **maneuverability checks since the design stage.**	**Additional information** regarding **ships' geometry** and an additional section for **Geometry of Rudders**.
MSC/Circular. 1053 – Chapter 3.3	Prediction of Manoeuvring Performance	There is no **guidance** about how to perform the mathematical models based on the section	An additional section explain how mathematical models should be performed to **evaluate maneuverability since the design stages** should be **added**.
MSC/Circular. 1053 –Appendix 4	Additional trials to evaluate ships' course-keeping ability based on the overshoot angles from zig-zag maneuver	Course keeping stability can be **preliminary analyzed** using the empirical formula of hydrodynamic coefficients.	An additional section to explain how mathematical models should be performed to **preliminary assess the course-keeping ability since the design stages** should be **added**.

References : [2]

1. DEFINITIONS

MSC.137 – 4 Definitions

RESOLUTION MSC.137(76)
(adopted on 4 December 2002)
STANDARDS FOR SHIP MANOEUVRABILITY

MSC 76/23/Add.1
ANNEX 6
Page 3

3.4 The Standards should not be applied to high-speed craft as defined in the relevant Code.

4 **DEFINITIONS**

4.1 **Geometry of the ship**

4.1.1 *Length (L)* is the length measured between the aft and forward perpendiculars.

4.1.2 *Midship point* is the point on the centreline of a ship midway between the aft and forward perpendiculars.

4.1.3 *Draught* (T_a) is the draught at the aft perpendicular.

4.1.4 *Draught* (T_f) is the draught at the forward perpendicular.

4.1.5 *Mean draught* (T_m) is defined as $T_m = (T_a + T_f)/2$.

4.1.6 *Trim* (τ) is defined as $\tau = (T_a - T_f)$.

4.1.7 Δ is the full load displacement of the ship (tonnes).

Existing Course Keeping Ability assessment

Amendment Proposal
Additional sub-section 4.1.8 and 4.1.9 for Geometry of the Ship

4.1.8 C_B is the moulded block coefficient at Mean Draught (T_M)

Amendment Proposal
Additional Section 4.2 for Geometry of Rudders

4.2 Geometry of the Rudders

4.2.1 Mean height (h_R) is the mean of the rudder blade, see figure 4.1 Coordinate system of rudders

4.2.2 Mean chord length (C) is the mean breadth of the rudder blade, see figure 4.1 Coordinate system of rudders

4.2.3 Lateral Area (A_R) is the total lateral area of the rudder blade, see figure 4.2 Rudder areas

4.2.4 Aspect Ratio (Λ) is the ratio of the height of the rudder (h_R) divided by the breadth (C) of the rudder

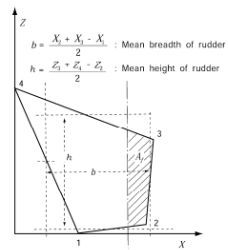


Figure 4.1 Coordinate system of rudders

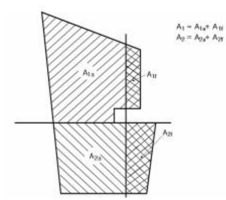


Figure 4.2 Rudder areas

2. TURNING CIRCLE MANEUVER CHECK

MSC/Circular. 1053 – Chapter 3.3 – Mathematical Model

3.3 Mathematical model

A "mathematical model" is a set of equations which can be used to describe the dynamics of a manoeuvring ship. But it may be possible to predict the manoeuvrability for the conventional ship's form with certain accuracy from the practical point of view using some mathematical models which have already been published. In this section, the method used to predict the manoeuvring performance of a ship at full load for comparison with the Standards is explained. The following details of the mathematical model are to be indicated:

.1 when and where to use;

.2 how to use;

.3 accuracy level of predicted results; and

.4 description of mathematical model

3.3.1 Application of the mathematical model

3.3.1.1 In general, the manoeuvring performance of the ship must be checked by a sea trial to determine whether it satisfies the manoeuvring standards or not. The Standards are regulated in full load condition from the viewpoints of marine safety. Consequently, it is desired that the sea trial for any ship be carried out in full load condition. This may be a difficult proposition for ships like a dry cargo ship, for which the sea trial is usually carried out in ballast or heavy ballast conditions from the practical point of view.

3.3.1.2 In such cases, it will be required to predict the manoeuvring performance in full load condition by means of some method that uses the results of the sea trial. As an alternative to scale model tests, usually conducted during the ship design phase, a numerical simulation using a mathematical model is a useful method for predicting ship manoeuvring performance in full load condition.

Existing Prediction of Maneuvering Performance

Amendment Proposal Additional explanation

.1 When and where to use;

(i) Since the design stage, mathematical models should be applied to assess ships' maneuverability.

(ii) Mathematical models are to be applied to ships of all rudder and propulsion types, of 100 m in length and over, and chemical tankers and gas carriers regardless of the length.

.2 How to use:

(i) Mathematical model are to be applied by using empirical formulas, and databases, incorporated with the theoretical calculations.

(ii) By using the available ship's geometry and rudder characteristics, numerical simulations of maneuverability predictions shall be applied to meet the maneuver criteria.

.3 Accuracy level or predicted results;

(i) Numerical simulation of maneuver results shall comply with MSC. 137(76) – 5.3.1 Turning ability, which shall be validated by model test or full-scale maneuver test.

.4 Description of the mathematical model

(i) The mathematical models are to be applied in accordance with the available data provided such as ships' geometry and rudder characteristics to evaluate the maneuverability by using the empirical formula, database, or any possible methods.

Note: MSC. 137(76) – 5.3.1 Turning ability

The advance should not exceed 4.5 ship lengths (L) and the tactical diameter should not exceed 5 ship lengths in the turning circle manoeuvre.

References : [2]

3. COURSE KEEPING ABILITY CHECK

MSC/Circular. 1053 – Appendix 4 – 1 Additional Methods to Assess Course Keeping Ability

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APPENDIX 4

ADDITIONAL MANOEUVRES

1 Additional methods to assess course keeping ability

1.1 The Standards note that additional testing may be used to further investigate a dynamic stability problem identified by the standard trial manoeuvres. This appendix briefly discusses additional trials that may be used to evaluate a ship's manoeuvring characteristics.

1.2 The Standards are used to evaluate course-keeping ability based on the overshoot angles resulting from the 10°/10° zig-zag manoeuvre. The zig-zag manoeuvre was chosen for reasons of simplicity and expediency in conducting trials. However, where more detailed analysis of dynamic stability is required some form of spiral manoeuvre should be conducted as an additional measure. A direct or reverse spiral manoeuvre may be conducted. The spiral and pullout manoeuvres have historically been recommended by various trial codes as measures that provide the comprehensive information necessary for reliably evaluating course-keeping ability. The direct spiral manoeuvre is generally time consuming and weather sensitive. The simplified spiral can be used to quickly evaluate key points of the spiral loop curve.

Existing Course Keeping Ability Assessment

Amendment Proposal
Additional sub-section of 1.3, 1.4, and 1.5 for Course Keeping Ability check

1.3 In a stable ship, any initial oscillation will decay to zero, or any disturbances will affect the ship's course only for a moment.

1.4 Course-keeping ability can be preliminary analyzed using the empirical formula of hydrodynamic coefficients. Which represents the effect of small disturbances such as wind or waves on the ship's course.

1.5 Standard Criteria:

(i) The course-keeping ability can be calculated by using the empirical formula of hydrodynamic coefficients;

(ii) The course-keeping coefficients shall not be less than 0;

(iii) The course-keeping coefficient can be calculated as follow:

$$\frac{N_r'}{(Y_r' - m')} > \frac{N_v'}{Y_v'}$$

$$N_r' Y_v' - N_v' (Y_r' - m') > 0$$

References : [2]

5.

CONCLUSION

SUMMARY

PROBLEMS

Collisions have become the main factor in marine accidents.

Ship operators who can compensate for ships' poor maneuverability will be absent as MASS develops.

But still, maneuverability received little attention at the design stages due to a lack of standards and references.

ANALYSIS

The turning Circle Maneuver is one of the maneuvers which perform the ships' maximum turning ability.

There is still no specific guidance regarding ships' turning ability for designers to design.

The ships' turning ability will be known after the full-scale trials, which lead to future remedial actions.

PROPOSED SOLUTIONS

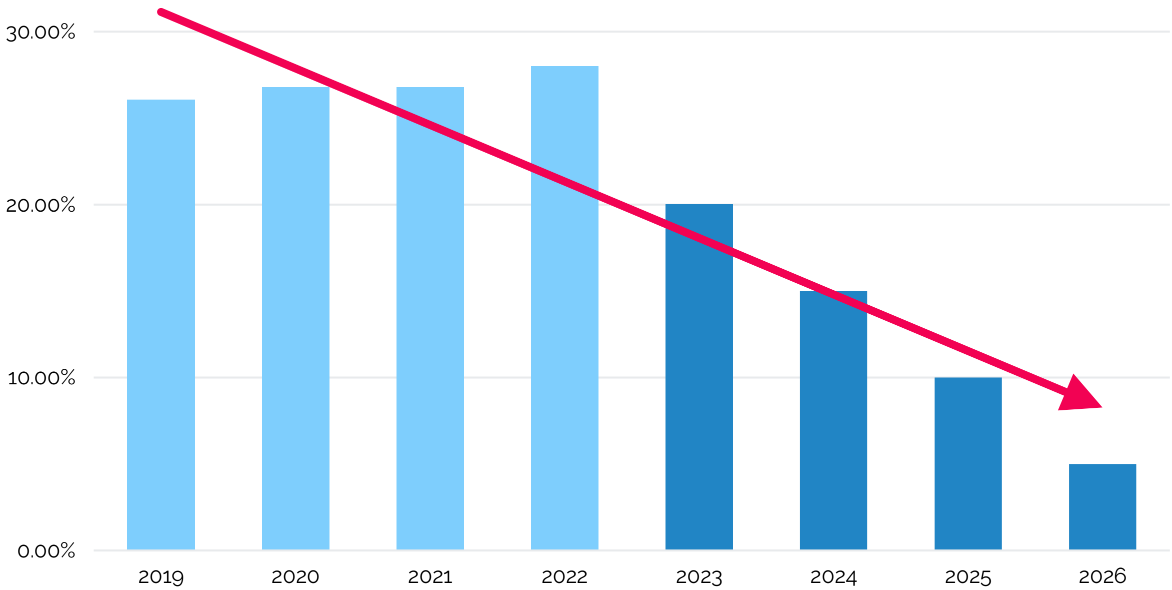
Amendments to MSC.137 - Chapter 4, regarding definitions of ships' geometry and rudder's geometry.

Amendments to MSC/Circular 1053 – Chapter 3.3, regarding additional explanations about maneuver prediction in the design stages.

Amendments to MSC/Circular 1053 - Appendix-4, regarding additional requirements of course-keeping ability check in the design stages.

CONCLUSIONS (1/2)

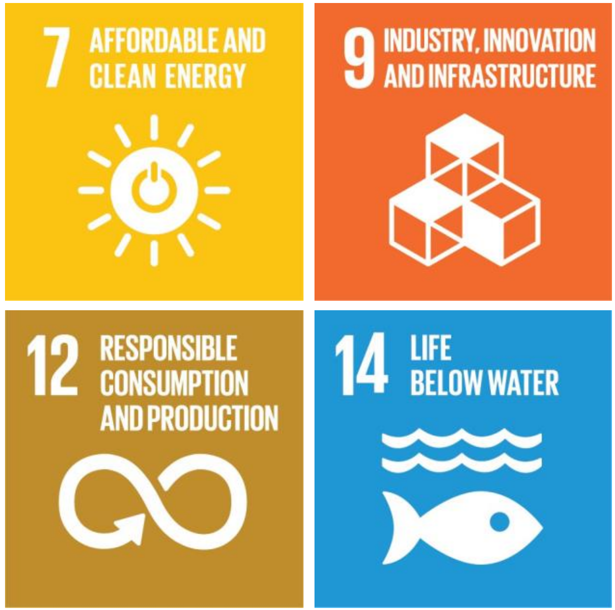
COLLISIONS AS A FACTOR OF MARINE ACCIDENT



CONCLUSIONS (2/2)

LESS FUEL CONSUMPTION

LESS PRODUCTION WASTE



SUSTAINABLE DEVELOPMENT GOALS

BENEFICIAL CHANGES IN SHIPS DESIGN

SAFE AND ENVIROMENTALLY SOUND

References:

[1] M. S. Committee, "MSC. 137(76) - Standards for Ship Maneuverability," Maritime Safety Committee, IMO, 2002.

[2] M. S. Committee, "MSC/Circular. 1053 - Explanatory Notes to the Standards for Ship Maneuverability," Maritime Safety Committee, IMO, 2002.

[3] J. T. S. Board, "Statistics of Marine Accident," [Online]. Available: https://www.mlit.go.jp/jtsb/statistics_mar.html.

[4] I. M. Organization, "Strategic Plan for the Organization," [Online]. Available: https://www.imo.org/en/About/Strategy/Pages/Default.aspx.

[5] ITTC, "Recommended Procedures and Guidelines - Full Scale Manoeuvring Trials," 2017.

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Prepare and prevent,
Don't repair and repent.
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