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CIMAC Position Paper

On the development of the rules for stopping a ship with azimuthing thrusters

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Content

1 Preamble ... 3
2 Application ... 3
3 Purpose ... 3
4 Definitions ... 3
5 Framework of requirements ... 4
5.1 Current regulations and requirements ... 4
5.2 IMO goal-based standards ... 4
5.3 Main points MSC 105/18/1 proposed draft text revision ... 5
6 CIMAC analysis ... 5
6.1 Practical experience ... 5
6.2 Background of MSC 105/18/1 proposed draft text revision ... 6
6.3 CIMAC analysis of the current requirements ... 6
6.4 CIMAC analysis of the MSC 105/18/1 proposed draft text revision ... 6
6.5 CIMAC proposal ... 8
6.5.1 Goals (Tier I) ... 9
6.5.2 Functional requirements (Tier II) ... 9
6.5.3 Verification of conformity (Tier III) ... 9

1 Preamble

This document discusses the development of the rules for stopping a ship with azimuthing thrusters. The current SOLAS requirements for means of going astern do not consider modern ship designs with a big variability in propulsion systems and hybridisation of propulsion. Neither do the requirements consider the technological progress in propulsion equipment themselves but also in, digital design tools, simulation tools and manoeuvring prediction methods. Especially the requirements do not consider the capability of the azimuthing thrusters to stop the ship in most efficient and controlled manner.
Amendment of SOLAS related to the steering and propulsion systems is ongoing by the International Maritime Organization (IMO). IMO MSC 105 took place 19 – 29 April 2022 where they agreed a new work proposal:

> ***Revision of SOLAS chapters II-1 (Part C) and V and related instruments to address both traditional and non-traditional propulsion and steering systems***.

This work proposal was referred to the SSE sub-committee. The proposal of the draft text revision is annexed in the MSC 105/18/1 document.

It is expected that the outcome of the work IMO proposal will be implemented into the Classification Society Rules and national regulations. CIMAC members would like, through their world class industry experience, to provide support for the draft text revision further development.

2 Application

This position paper can be applied to all ships under SOLAS requirements but is also applicable to non-SOLAS ships. The paper is focusing on stopping a ship and the related procedure using azimuthing thrusters because steering function of these units can be part of the stopping procedure.

3 Purpose

The purpose of this document is to provide industry recommendation based on experience to support the development of rules and regulations considering ships with azimuthing thrusters. The aim is an approach with a holistic view on a ship as a system and to reflect the goals and functional requirements.

One aim of the paper is to provide an expert view on the most efficient manners to stop a ship with azimuthing thrusters.

The document is structured such that there is first the current requirement framework for the background information, then the analysis of the current situation and then a set of informed recommendation from the industry experts.

4 Definitions

.1 Stopping of a ship efficiently is one of the basic safety manoeuvres. Sometimes terms “crash stop” or “full astern” are used as the last chance to avoid a potential accident which may impact on safety of life and the environment. Traditionally, SOLAS, Chapter II-1 Part C Regulation 28, is using term “means of going astern”. Thus, in this context stopping a ship means a procedure where the ship is stopped in sufficient time and in a reasonable distance from maximum ahead service speed.

.2 Azimuthing thruster is an assembled unit with a propeller, including podded drives, that produce thrust and is capable to rotate the thrust direction around its vertical axis for ship main propulsion and steering.

.3 Steering system is the holistic system consisting of components and sub-systems that together enable the ship personnel to influence the ships course direction.

5 Framework of requirements

5.1 Current regulations and requirements

Current requirements for minimum going astern capability for ships are set in:

- SOLAS Consolidated Edition, 2020 – Chapter II-1 Part C Machinery installations
- IMO RESOLUTION MSC.137(76) - STANDARDS FOR SHIP MANOEUVRABILITY
- IMO CIRCULAR MSC/Circ.1053 - EXPLANATORY NOTES TO THE STANDARDS FOR SHIP MANOEUVRABILITY
- IMO CIRCULAR MSC.1/Circ.1416/Rev. 1 - UNIFIED INTERPRETATIONS OF SOLAS REGULATIONS II-1/28, II-1/29 AND II-1/30
- IMO RESOLUTION A.601(15) - PROVISION AND DISPLAY OF MANOEUVRING INFORMATION ON BOARD SHIPS

Individual classification societies base their rules on the above-mentioned requirements. The classification societies are free to set requirements on top of the minimum requirements, but generally the classification societies are following SOLAS and the IMO resolutions and circulars.

The International Association of Classification Societies (IACS) is entitled to provide interpretations (UI’s) of SOLAS requirements which will be implemented by individuals class societies into their rules. It should be noted that the MSC.1/Circ.1416/Rev. 1 is a direct outcome of the IACS work and based on the unified interpretation SC242 “Arrangements for steering capability and function on ships fitted with propulsion and steering systems other than traditional arrangements for a ship’s directional control”.

5.2 IMO goal-based standards

IMO has recognized that technologies develop faster than regulatory requirements. Therefore, the requirements are moving towards goal-based standards as defined by the IMO:

- IMO CIRCULAR MSC.1/Circ.1394/Rev.2 - Generic Guidelines for Developing Goal-Based Standards

The goal-based provisions will eventually be included in a Revision 2 of the “Guidelines on alternative design and arrangements for SOLAS chapters II-1 and III” (MSC.1/Circ.1212/Rev.1) and submitted to MSC for approval.

SOLAS Chapter II-1 Regulation 55 allows electrical and machinery installations to deviate from prescriptive requirements, provided an equivalent level of safety is achieved and the intent of the requirements are met.

5.3 Main points MSC 105/18/1 proposed draft text revision

SOLAS Ch.II-1 Regulation 28 - Means of going astern

- Heading changed to "Means of stopping and going astern"
- Added goal and function requirements.
- Added criteria for stopping distance as mandatory
- Added criteria for stopping distance in a failure condition, for multiple propulsion line ships

MSC/Circ.1053 – Explanatory Notes to the Standards for Ship Manoeuvrability

- Improved terminology to be technology neutral for steering type
- Modified procedure (heading towards wind changed to head from wind) as this is considered to be more conservative and less possible to exploit during tests
- Added procedure for tests in failure condition
- Added alternative procedure for stopping
- Added CFD simulation as prediction method

MSC.1/Circ.1416/Rev.1 – Unified interpretation of SOLAS Regulation II-1/28 and II-1/29 concerning the arrangements for steering capability and function on ships fitted with propulsion and steering systems other than conventional arrangements for a ship's directional control

- Content of document has been incorporated in proposed text for regulation 29
- Document may be considered obsolete.
- Please note that the proposal is accepting redundancy on ship level/system level to be equivalent to redundancy on component level. This may deviate from the interpretation in MCS.1/Circ.1416

Resolution A.601(15) – Provision and Display of Manoeuvring Information on board Ships

- Removed obsolete text
- Enforced wheelhouse poster
- Changed terminology to be technology neutral for steering type

6 CIMAC analysis

6.1 Practical experience

The current regulations and Classification Society rules have led to different interpretations and thus, to different non-uniform requirements. This has led to more complicated designs and unfavourable requirements for azimuthing thrusters compared to traditional rudder-steered ships. Clear requirements and definitions are necessary to avoid different interpretations and misunderstandings.

6.2 Background of MSC 105/18/1 proposed draft text revision

EMSA (European Maritime Safety Agency) has conducted the STEERSAFE project to provide a holistic analysis of the SOLAS regulations and associated circulars related to steering and maneuverability. The project final report 2020-1252, rev 2 by DNV concludes gaps in the SOLAS regulations:

"The investigation of the current SOLAS regulations reveals that the regulations are in many cases technology-specific and prescriptive. Also, they do not address hazards related to erroneous operation. Furthermore, the redundancy requirements and testing for multi-unit configurations are not properly addressed, nor is the dependency of/interaction with other systems and functions. Currently, no specific requirements for testing and verification of maneuverability are included for reduced service condition for any of the technical solutions."

The proposed amendments are taken directly into the proposed draft text revision of MSC 105/18/1.

6.3 CIMAC analysis of the current requirements

It is obvious that the SOLAS requirements need to be updated since the requirements don't consider the methods that azimuthing thrusters provides for stopping a ship. This has led to a situation where interpretations have to be made. The work carried out by IACS on the UI SC242 which resulted in several revisions and corrections shows that it is not simple to make logical and justified interpretations when the technology development is not considered. Clearly, one missing part is also the required safety level definition which has led to a situation where modern and applied technologies are subject to additional requirements on top of the requirements for traditional solutions without proper reasoning or justification how the additional requirements help to satisfy the existing regulations.

6.4 CIMAC analysis of the MSC 105/18/1 proposed draft text revision

.1 The proposed MSC 105 amendment fails in being non-technology specific which is an inherent property of a goal-based design. The reference is made to Chapter 2 "GUIDELINES FOR THE APPLICATION OF THE STANDARDS" of the proposed amendment. The proposed amendment assumes that in a failure of a steering gear the azimuthing thruster is locked in the neutral position and operated at full available propulsion power. Whereas conventional rudder-steered ship is entitled to reduce operational speed even full propulsion power is available.

This, together with the proposed amendment to MSC.137(76) "Stopping ability criteria" impose stricter requirements for ships with non-rudder-steering than for rudder-steered ships.

Citation to the proposed amendment 2.2.1.5 in the annex 2:

The following general procedure is recommended:

> *.1 The ship is brought to a steady course and speed according to the specific approach condition.*
>
> *.2 The recording of data starts.*

.3 The manoeuvre is started by giving a stop order. The full astern engine order is applied.

.4 Data recording stops and the manoeuvre is terminated when the ship is stopped dead in the water.

For rudder-steered ships, the rudder shall be maintained at neutral position throughout the test.

When testing a ship with multiple propulsion lines, the procedure shall be repeated with the following modifications:

.1 The test is performed with one propulsion system and its corresponding steering system out of operation.

.1 The inoperative propeller may be allowed to windmill (depending on manufacturers specification and recommendation).

.2 The steering system corresponding to the inoperative propulsion line shall be placed at neutral position.

.3 The approach speed shall consequently be adjusted based on remaining available propulsion.

.2 For non-rudder-steered ships where the stopping in normal operational condition is done by turning the steering force units to change thrust direction, the test in .1 shall be performed with all the propulsion systems active until the stop order is given. Consequently, the approach speed shall be the same as in normal operational condition.

The sentence .2 makes the requirements unclear and unfavourable for azimuthing thruster ships, because rudder-steered are entitled to reduce speed.

Although, the proposed amendment is under “GUIDELINES FOR THE APPLICATION OF THE STANDARDS” CIMAC is concerned that it becomes a mandatory requirement. Even if it would not be a mandatory requirement, the industry would have to argue case by case which would lead to a variety of solutions being in contradiction to unified requirements.

The SOLAS rules require steering gears to be redundant for a ship. SOLAS Ch. V, regulation 26 defines steering gear test within 12 hours before departure. In case a steering gear fails during the voyage the ship master must announce the reduced steering capability to the authority. In this respect both non-rudder-steered and rudder-steered ships are handled in the same manner. Therefore, there is no need for higher redundancy requirements for the non-rudder-steered ships with respect to steering.

Since non-rudder-steered ships may also use the steering gear to perform a stopping procedure to stop a ship in a more efficient manner, a steering gear failure requires a fault tolerance in stopping function. The consequence is that a non-rudder-steered ship shall also be able to perform the stopping function in steering gear failure situation. The performance requirement for the stopping function is defined in resolution MSC.137(76) – standards for ship manoeuvrability. Consequently, a non-rudder-steered ship can demonstrate the full compliance with stopping function requirements without using steering gear. In such cases there is no reason to impose higher redundancy for the steering gear.

.2 In the proposed MSC 105 amendments it should be considered how goal-based requirements can be imposed to be technology independent, with the aim of improving the capability and avoid human errors.

.3 The proposed MSC 105 amendments should enable the most efficient way to stop a ship.

For a ship with azimuthing thrusters, an efficient practice would be to reduce the power from the propellers and rotate the azimuthing thrusters into toe-out (or toe-in) position and leave them to watermill. As the ship resistance curve is an exponential one, the ship would start to efficiently reduce its speed immediately.

Below a certain ship speed the azimuthing thrusters can be fully rotated and can produce full thrust in the opposite direction. The ship power plant ramping up and down characteristics shall be considered to avoid power management issues and other potential risks from occurring. Alternative procedures are available even one steering gear is out of operation.

As propellers are designed mostly for forward operation, they can be used more efficiently to lower the ship speed by keeping a positive forward operating rotation rather than reversing rotation of the propeller. The rules should not result in a reduction of efficiency, impact on the performance of the azimuthing thruster or have a potential detrimental impact on safety.

.3 Predictive assistance methods might be available onboard a ship and available to predict the performance before and during the stopping procedure, or other manoeuvres as well. For example, the ship track reach could be estimated by the prediction system for the ship personnel in charge thereby allowing more effective decision making. The proposed amendments should consider also the role of predictive assistance methods.

.4 The proposed amendment Annex 2 paragraph 5.2

"*Ships provided with multiple propulsion lines shall have stopping ability meeting the criteria in paragraph 5.3.4.2 of resolution MSC.137(76) while any one of the propulsion systems and its corresponding steering system is out of operation.*"
asks to consider two-failure case (propulsion and steering) which is in contradiction to current single failure philosophy.

.5 There are several definitions in the amendments and that can lead to misunderstandings. There are terms like "propulsion line", "propulsion system", "steering system", "steering control system", "steering gear", "remote steering gear control systems". As the definitions are used in several documents one must be very careful that definitions are coherent, and the required performance and redundancy are defined at the correct level. For example, requirements for steering system must match ship performance requirements level. The validation and testing should follow the same approach. The argumentation path should be clear.

.6 The amendment proposal does not consider how ships with hybrid propulsion and energy saving devices should demonstrate their compliance. The energy saving devices, like rotor sail, rigid sail or wind kite, effect the behaviour of a ship. For example, how do you perform a crash stop with rigid sails and how the performance criteria should be defined and at what wind conditions?

6.5 CIMAC proposal

The goal-based requirements for azimuthing thrusters should be set on an equal ship system level as the requirements for traditional shaft line and rudder systems are.

The CIMAC proposal summarizes things that azimuthing thruster manufacturers consider important requirements from their point of view.

IMO goal-based strategy is taken as a master for the below mentioned CIMAC proposals. Therefore, the requirement for stopping a ship should be based on a set of goal-based targets and functions independent of the propulsion and steering system design. Also, the testing requirements should be aligned with industry best practice and the testing requirements should allow demonstration of the compliance with the predefined goals.

6.5.1 Goals (Tier I)

The goal is to:

.1 Ensure sufficient stopping capability of the ship to avoid damage, collision, grounding, loss of life and environmental pollution,

.2 Prevent accidents arising from equipment malfunction,

.3 Ensure correct means of going astern procedure is followed to stop the ship,

.4 Be aware of the ship's behavior during the stopping,

.5 Enable the ship operator to use the most suitable procedure for the equipment in use.

6.5.2 Functional requirements (Tier II)

.1 Ensure efficient and safe stopping procedure to fulfill the stopping function.

Traditionally rapid ship deceleration has been done by performing a crash stop by turning the telegraph from ahead to full astern. This command is given intuitively by the ship master based on a traditional operation.

In case of azimuthing thrusters one does not have a telegraph anymore but operates the azimuthing thrusters directly and can achieve same result with different procedures. In some cases the stopping procedure can be supported by automatic means of operation.

The stopping procedure can be different depending on the azimuthing thruster manufacturer and ship design. It typically involves sequencies that can include for example:

- reducing delivered torque (power),
- waiting for the correct ship speed,
- turning the azimuthing thrusters and/or changing the rotation direction of the propeller.
- increasing delivered torque (power) again.

Therefore, any type of propulsor will require clearly defined procedures, advice and training to make the crash stop in an efficient and safe way whilst maintaining the control and maneuverability of the ship during a potentially stressful situation.

.2 Azimuthing thruster(s) shall be controllable during the stopping process.

.3 Be possible to stop the ship in case of malfunctioning of any component or even complete propulsor.

- Single failure in a system should not prevent performing a safe stopping procedure.
- In case of an automated crash stop procedure it has to account of that situation and still be operatable.

6.5.3 Verification of conformity (Tier III)

.1 Define the stopping procedure that is the most efficient for the ship. Include in the procedure how to perform crash stop in case of any single failure.

.2 Demonstrate ship stopping functionality with azimuthing thruster(s) against single failure using a defined risk assessment process.

.3 Perform test as defined in RESOLUTION MSC.137(76)MSC. Record the track and the stopping distance.

.4 In a ship with multiple azimuthing thrusters, perform test as defined in RESOLUTION MSC.137(76)MSC with the most effective propulsor inactive at corresponding reduced ship speed. Record the track and the stopping distance.

In case of steering gear failure of one azimuthing thruster the reduced ship speed (as per conventional shaft line ships) shall be applied. In such case it shall still be efficient enough to fulfil the criteria using the defined stopping procedure for a failure (e.g. reversing of the propeller rotation direction of all propulsors).

> .2.1. Special unsymmetric propulsion after single failure shall be considered case by case and accepted by the authority and verified accordingly.
>
> .2.2. Proven simulation methods can be used instead of physical inactivation tests.

.5 The crew operating the azimuthing thrusters shall have training to ensure correct use of equipment and the procedures which will consider the holistic ship behaviour.

Imprint

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