



BSI Standards Publication

Ships and marine technology — Good practices of preventing capsizing during turning of ships with large profile height

National foreword

This Published Document is the UK implementation of ISO/TR 9814:2025.

The UK participation in its preparation was entrusted to Technical Committee SME/32, Ships and marine technology - Steering committee.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

This publication is not to be regarded as a British Standard.

© The British Standards Institution 2025
Published by BSI Standards Limited 2025

ISBN 978 0 539 29632 7

ICS 47.020.01

Compliance with a Published Document cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 June 2025.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------



Technical Report

ISO/TR 9814

Ships and marine technology — Good practices of preventing capsizing during turning of ships with large profile height

*Navires et technologie maritime — Bonnes pratiques de
prévention du chavirement lors du virage des navires à grande
hauteur de profil*

**First edition
2025-06**

Reference number
ISO/TR 9814:2025(en)

© ISO 2025  **Documents**
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2025

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	2
5 Analysis of capsized accidents of five ships	3
5.1 General	3
5.2 Ship categories based on cargo space requirements	4
5.2.1 Weight carrier	4
5.2.2 Volume carrier	4
5.2.3 Area carrier	4
5.3 Analysis of capsized accidents	4
5.3.1 General	4
5.3.2 Similarities	4
5.3.3 Differences	5
6 Effect of KG on the GZ curve	5
6.1 KG and its role in capsizing accidents	5
6.2 Characteristics of hull form and GZ curves	9
6.2.1 General	9
6.2.2 Hull forms with two inflection points along the GZ curve	9
7 Three good practices to prevent capsizing during turning of ships	10
7.1 General	10
7.2 Semi-automatic inclining tests before loaded departure	10
7.2.1 General	10
7.2.2 Features of inclining test before departure	11
7.2.3 Stability screening without inclining test	12
7.3 Maximum heeling angle while turning	14
7.3.1 General	14
7.3.2 Maritime autonomous surface ships	15
7.3.3 Considerations on cargo slippage	16
7.4 Precise calculation of free surface moment (FSM)	17
7.4.1 Slack limit of NAPA software	17
7.4.2 FSM at 98 % filling level	17
7.4.3 Improvement of stability calculation software	18
Annex A (informative) Cases of capsizing accidents	19
Annex B (informative) Additional information on ship features	28
Bibliography	30

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document is prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

There are many similarities between the following ship accidents: the Golden Ray in 2019, the Hoegh Osaka in 2015, the Sewol ferry in 2014, the Crown Princess in 2006 and the Queen Hind in 2019. By comparing and analysing the causes of these five accidents, identifying similarities between them, and generalizing the findings, this document aims to help prevent similar accidents from occurring in the future.

Based on the analysis of the five ship accidents and a similar land truck accident, this document describes three good practices to prevent similar accidents from recurring. Since similar accidents can occur not only in old ships but also in the new ships, additional measures are described, as similar accidents can occur again unless these points are corrected.

Ships and marine technology — Good practices of preventing capsizing during turning of ships with large profile height

1 Scope

This document gives good practices on how to prevent the capsizing of ships with large profile height during turning.

The following are covered this document:

- a) ship turning, centrifugal force, and consequent heeling;
- b) accident use cases of capsizing during turning;
- c) effect of the KG on the ship stability;
- d) three good practices of preventing capsizing during turning of ships.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

capsize

to (cause a boat or ship to) turn upside down by accident while on water

3.2

fishtailing

to cause the tail of an aircraft or the back of a motor car to swing from side to side

3.3

free surface effect

mechanism which can cause a watercraft to become unstable and *capsize* ([3.1](#))

Note 1 to entry: It refers to the tendency of liquids to move in response to changes in the attitude of a craft's cargo holds or liquid tanks.

3.4

inclining test

test performed on a ship to determine its stability, lightship weight and the coordinates of its centre of gravity

3.5

integrated monitoring, alarm, and control system

IMACS

computer-based system used for monitoring and controlling various processes in industries such as oil and gas, power generation, water treatment, and manufacturing

3.6

maritime autonomous surface ship

MASS

increased automation on board ships, which could ultimately reach full autonomy or become a remotely controlled unmanned vessel

3.7

overturn

single-vehicle accident event in which the vehicle rolls at least 90°

[SOURCE: ISO 6813:1998, 3.2.1, modified — note 1 to entry has been removed.]

3.8

profile height

distance from the waterline to the high point on the ship's structure or cargo, such as a stack of containers or superstructure which continues more than about 70 % of the ship length

Note 1 to entry: This term is distinct from "air draft", which refers to the height used to assess whether a vessel can pass beneath a bridge. In contrast, profile height is introduced in this document to specify the height influencing the vessel's stability. While related to the *wind pressure area* ([3.10](#)), profile height represents a different concept.

3.9

weigh station

facility near a road where vehicles, especially large trucks, can be weighed

3.10

wind pressure area

total area of the ship's exposed surfaces that are subject to wind pressure

3.11

KG

vertical distance (along the ship's centreline) between the keel (K) and the centre of gravity (G)

4 Abbreviated terms

BWT	ballast water tank
CCTV	closed-circuit television
DWT	deadweight
FSM	free surface moment
GM	metacentric height
GT	gross tonnage
GZ	stability arm
IMACS	integrated monitoring, alarm, and control system
ISC	international code on intact stability
KG	vertical centre of gravity

kn	knot
KST	Korean Standard Time
MARIN	Maritime Research Institute Netherlands
MASS	maritime autonomous surface ship
MSC	Maritime Safety Committee
PCTC	pure car and truck carrier
SOG	speed over the ground
SOLAS	International Convention for the Safety of Life At Sea
USCG	US Coast Guard
UMSC	US Coast Guard Marine Safety Center

5 Analysis of capsized accidents of five ships

5.1 General

Ships can be distinguished by the type and amount of cargo they carry, which has a significant impact on the shape and stability of the hull of each ship. These ship categories are:

- a) weight carrier;
- b) volume carrier;
- c) area carrier.

In general, ships carrying cargoes heavier than water have a margin of stability. On the other hand, ships carrying cargoes lighter than water need to secure more volume or deck area to increase revenue. This requires increasing the structure above the water, which is likely to reduce stability.

The stability of the ship varies across these categories, and ship types have evolved to produce these differences in stability owing to differences in cargo-carrying efficiency and thus income. The ship types of volume carriers and area carriers generally tend to have a large profile height.

Ship operation is based on revenue, which is determined by the amount of cargo that the ship can transport. To increase revenue, ship types such as PCTC have evolved to have a large profile height. The safety of the ship is closely related to the revenue of ship operations.

NOTE It is similar to the reason why weigh stations are operated for land trucks. The maximum weight that can be loaded onto the truck is displayed, and drivers are well aware of the changes in vehicle safety according to the weight and loading of the cargo. Many drivers drive illegally to earn more money. Ships are in a similar situation, and safety is generally closely linked to economic efficiency, ship designers are expected to consider this reality to ensure the safety of ships.

This document is about ships that have stability problems even in calm waters. These are area carriers and some volume carriers. Area carriers are a relatively new type of ship, so greater attention to detail can help to address their stability weakness.

Ship capsizing is a problem related to dynamic stability while the ship turns and the centrifugal force generates a heeling moment. For a detailed analysis of five ship capsizing incidents involving large profile heights, see [Annex A](#). For information on ship features, see [Annex B](#).

5.2 Ship categories based on cargo space requirements

5.2.1 Weight carrier

For heavy-duty cargo ships, such as bulk carriers (e.g. iron ore, coal) and crude oil carriers, the deadweight (DWT) is an important indicator of profitability. These types of ships generally have a margin of stability.

5.2.2 Volume carrier

In cargo ships that carry lighter (porous) items, such as container ships and general cargo ships, the volume or gross tonnage (GT) of the hull is an important indicator of profitability. These types of ships are generally likely to lack stability because the number of floors above the waterline increases to secure space. Among these types of ships, many ships are observed to have a large profile height.

5.2.3 Area carrier

For ships that require a large parking lot or living area, such as car carriers or cruise ships, the deck area is an important indicator of income. Since this type of vessel increases the number of floors, it is generally likely to have a large profile height and therefore lack stability.

5.3 Analysis of capsized accidents

5.3.1 General

[Table 1](#) compares the major parameters of the five ship accidents. The similarities and differences in these accidents are summarized in [5.3.2](#) and [5.3.3](#).

Table 1 — Comparison of five ship accidents

	Golden Ray	Hoegh Osaka	MV Sewol	Crown Princess	Queen Hind
Year of accident	2019	2015	2014	2006	2019
Year and location of construction	2017, Mipo, Korea	2000, Japan	1994, Japan, imported and modified 2013 in Korea	2006, Italy	1980, Japan, imported and modified 2017 in Romania
Profile height (above waterline)	About 39,4 m (3,7 times of design draft)	About 32,4 m (3,2 times of design draft)	About 21,6 m (3,5 times of design draft)	About 50,7 m (5,8 times of accident draft)	About 13,1 m (2,08 times of design draft)
Draft (design)	10,6 m	10,15 m	6,2 m	8,74 m (accident)	6,30 m
Displacement	34 609 tons (at accident)	16 886 tons (DWT)	9 750 tons	unknown	unknown
GT	71 000 tons	51 770 tons	6 800 tons	113 561 tons	3 785 tons
Cause of accident	Lack of stability while turning (13,3 kn at 20 rudder angle)	Lack of stability while turning (12 kn at 10 rudder angle)	Lack of stability while turning (18 kn at 5 rudder angle)	Officer's incorrect wheel commands (20 kn at 30 rudder angle)	Lack of stability while towing and wheel (4 kn)
Metacentric height (GM)	0,45 m	0,7 m	0,3 m to 0,5 m		
NOTE 1 kn = 1,852 km/h.					

5.3.2 Similarities

Common observations among the capsized accidents listed in [Table 1](#) can be drawn, including:

- a vessel type with a hull structure that rises high above the waterline (large profile height) generally has marginal stability;