CLASS GUIDELINE

DNVGL-CG-0004

Edition July 2019

Safe return to port

The electronic pdf version of this document, available free of charge from http://www.dnvgl.com, is the officially binding version.

DNV GL AS

FOREWORD

DNV GL class guidelines contain methods, technical requirements, principles and acceptance criteria related to classed objects as referred to from the rules.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

This document supersedes the April 2016 edition of DNVGL-CG-0004.

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or subsection, normally only the title will be in red colour.

Changes July 2019

Topic	*Reference*	*Description*
General revision **SRTP**	Whole document	The document is generally revised and expanded to support the new class notation **SRTP** for safe return to port, orderly evacuation and abandonment.
SRTP class notation	Sec.1 [4]	The approach for the new **SRTP** class notation is described.
Work process and responsibilities	Sec.2	The section is rearranged and expanded with more content on the life-cycle implications of the SRtP scheme, i.a. related to roles and responsibilities.
Intentions and key terms - SRtP and OEA	Sec.3	The section is rearranged and expanded with more content on the intentions, key terms and implications of the SRtP and OEA regulations.
Documentation and approval	Sec.4	New section on documentation and approval.
SRtP in service	Sec.5	New section on the operational implications of the SRtP scheme.
Hydrodynamical calculation report	App.E	New appendix giving guidance on the calculation of the hydrodynamical capabilities of the ship.

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.

CONTENTS

Contents

SECTION 1 GENERAL

1 Introduction

The SOLAS regulations for safe return to port (SRtP) and orderly evacuation and abandonment (OEA) were introduced in 2010 and apply to passenger ships above a certain size, see [5.3].

The overall intention of the regulations is to increase the safety level of passenger ships and reduce the likelihood of an evacuation. This is achieved through more redundant and segregated system arrangements, providing increased robustness and fault tolerance.

The regulations entail a close connection between the ship design and the intended operation, and this may have a significant impact on the design and arrangement of the various ship systems as well as operational implications.

The regulations necessitate changes in the traditional work process and the scope of work for the key parties involved in a newbuilding project. The most protruding topics in this connection are related to the need for various early phase activities involving the owner, yard/designer, flag administration and Society, and also the need for a more multi-disciplinary/system-engineering based approach throughout the newbuilding project.

The regulations are given as a goal based standard, giving functional as well as performance requirements to the capabilities of the systems deemed necessary to enable a safe voyage back to port after a casualty or to support an orderly evacuation if the situation demands so.

The regulations are given on a quite superior level, and supplementary guidance and interpretations from the International Maritime Organization (IMO) are given in different circulars developed in the Maritime Safety Committee (MSC).

DNV GL has implemented the SRtP/OEA regulations in a class notation. Further elaboration is given in [5].

The relevant SOLAS regulations, IMO circulars and other references are listed in [7].

2 Background

The background for the introduction of the SRtP/OEA regulations in 2010 was an increasing concern of the operational risk of passenger ships, i.e. based on the following aspects:

— previous incidents of fire in passenger ships
— increasing size of vessels and number of passengers
— more remote and exposed operational patterns
— the risk associated with life boat evacuation.

The intention was to increase the ship's capabilities and robustness in order to mitigate and reduce the risk associated with the above listed aspects, to strengthen the safety of passengers and crew and to reduce the probability for evacuation.

The regulations as written in SOLAS are design requirements, but the primary guidance document MSC.1/Circ.1369 links the design requirements closely to the ship operation, i.a. by allowing for local manual intervention and restoration of system capabilities in the event of a casualty.

This implies that the SRtP scheme:

— demands early phase activities involving owner, yard/designer, flag administration and Society
— assumes multi-disciplinary co-operation by the technical disciplines
— affects the design and arrangement of many ship systems
— closely links system design to ship operation and may impose operational limitations
— links class and statutory schemes.

It is essential that the stakeholders involved in the design or operation of an SRtP ship recognize the implications of the above aspects, and the need to address these at the earliest possible stage, even also before the class contract is assigned.

3 Scope

This guideline is intended to give background and context to the SRtP scheme and the **SRTP** class notation by:

— providing general guidance on SRtP to the different stakeholders
— addressing the SRtP work process and responsibilities in a life cycle perspective
— providing supplementary information to the **SRTP** class notation
— giving background, context and intentions of the key requirements
— addressing the key challenges related to operations.

4 Application

This guideline may be applied by all stakeholders that are involved in SRtP projects to get an introduction to the intentions, background, context and challenges related to the SRtP scheme as well as supplementary information to the **SRTP** class notation.

5 Class notations

5.1 **SRTP** class notation

Due to the goal-based nature and complexity of the SRtP scheme, DNV GL has implemented the SRtP/OEA statutory regulations as a separate class notation **SRTP**. The class notation is based on industry best practices and experience gained through all the SRtP projects classed with DNV GL since the regulations came into force in 2010. The **SRTP** notation is mandatory for the applicable passenger ships classed with DNV GL where DNV GL is authorized by the flag administration to issue the PSSC certificate (passenger ship safety certificate) or the SPS certificate (special purpose ship).

Certain flag administrations may have additional requirements related to SRtP, which are included in the class scope when authorized by the flag administration.

The relevant DNV GL interpretations for the SRtP regulations have until 2019 been included in the DNVGL-SI-0364 *SOLAS interpretations* (SI). The new SRtP class notation covers the full scope of the SRtP regulations and compliance with the notation constitute the full basis for the SRtP scope in the issuance the PSSC or SPS certificate. The requirements of the SRtP class notation are for the applicable newbuilding projects made mandatory by a reference to the class notation in the applicable sections of the SI, all other SRtP related interpretations are removed from the SI (July 2019).

The goal based nature of the regulations is reflected in the notation by giving the system requirements on three layers:

— Layer 1: goals. On the top level, the SRtP goals provide the fundamental rationale and intent behind a particular rule. The goals in the class notation are basically the regulations as given in SOLAS, e.g:
  — The internal watertight doors system shall, after any SRtP casualty, remain operational outside the casualty threshold.
— Layer 2: functional requirements. On the mid level, the goals are supported by one or more functional or performance requirements. These explain in greater detail the type of functions or performance a system shall achieve in order to fulfil the intent of the goal, either in part or in whole, e.g:
  — The internal watertight doors system is considered to remain operational when:
    — after a fire casualty, the indication at bridge as required by SOLAS II-1/Reg.13.8.2 remains operational for all doors outside the casualty threshold.
— Layer 3: detailed requirements. On the lower level, functional and performance requirements are supported by detailed rules and guidance notes. These provide a set of generally acceptable solutions to meet the goals, functional and performance requirements, either in part or in whole, e.g:

— The position indication sensors (open and closed) for a door shall be connected to both system units. The connections shall be arranged/routed so that an SRtP casualty can only impair the connection to one of the system units.

The three-layer approach is intended to support the goal based nature of the regulations. The detailed requirements on layer three are intended to provide criteria for generally acceptable solutions, but alternative ways to fulfil the functional requirements of the upper layers may be accepted. Note that in the notation, the three layer structure is applied for the SRtP and OEA system specific requirements only.

The SRtP regulations do not prescribe detailed requirements for fleet in service. Owners should be aware of operational procedures and maintenance requirements to be adequately documented and effectively implemented through the safety management system. Until IMO regulations are fully developed, flag guidelines/requirements should be adhered to.

5.2 Class notation for redundant propulsion - **RP(3, x)**

The additional class notation **RP(3, x)** ensures redundancy and fault tolerance in propulsion and steering systems, and will in different ways ensure a higher availability and robustness on some of the key technical and operational aspects as mentioned above. So even though there is a big overlap in the scope of the **SRTP** notation and the **RP(3, x)** notation, there are several advantages of the **RP(3, x)** notation and it is therefore strongly recommended to consider the **RP** the notation for new SRtP projects.

5.3 Application of the **SRTP** notation

The SRtP regulations apply to passenger ships (i.e. ships required to be issued with a PSSC certificate) having a length of 120 m or more, or having three or more main vertical fire zones (MVZ).

An MVZ may be extended to a length of 48 m, meaning that any vessel above 96 m has three or more MVZ's and the SRtP regulations initially apply.

However, if the spaces/appendages within the exceeding zone are of limited size with restricted access and contain only tanks, voids or open decks, the zone may upon special evaluation be considered not to constitute an MVZ, and the SRtP regulations may therefore not apply. In such cases, the approach shall be duly justified and accepted by the key stakeholders: flag administration, owner and Society.

The regulation also applies to special purpose ships (SPS certificate/notation according to 2008 SPS code) intended to carry more than 240 persons in total (e.g. an offshore construction vessel).

Further, naval vessels that shall be constructed in compliance with the naval ship code ANEP 77 are required to fulfil a set of requirements (given in ANEP 77) that basically are equivalent to the SOLAS regulations for fire casualties in the SRtP scheme.

6 Definitions and abbreviations

Table 1 Definition of terms

Term	*Definition*
SRtP assessment	structured analysis of the possible consequences any incident of fire or flooding may have for the systems required to remain operational, covering all possible scenarios within the casualty threshold
casualty threshold	maximum physical extent of a SRtP casualty where the ship shall be capable of returning to port in accordance with SOLAS II-2/Reg.21
manual actions	manual intervention by the crew that may be necessary to restore and maintain functionality of the SRtP systems after a SRtP casualty
multi-disciplinary approach	to ensure that the system design and verification incorporate the concerns of all different technical disciplines This may assume that individuals possess competence beyond own discipline (‘system’ competence) and that the work process includes methods to ensure that the concerns of the various technical disciplines are included.
remain operational	general term denoting the situation after an SRtP casualty where the SRtP systems shall be able to continue it's function for the voyage back to port, outside the casualty threshold
SRtP casualty	any incident of fire or flooding limited by the applicable casualty threshold

Table 2 Abbreviations

Abbreviation	*Description*
ANEP 77	naval ship code (NATO)
BF	Beaufort
BMA	Bahamas Maritime Authorities
FiS	fleet in service
FMEA	failure mode and effect analysis
IACS	International Association of Class Societies
IMO	International Maritime Organization
ISM	international safety management
MVZ	main vertical fire zone
MSC	Maritime Safety Committee (IMO)
nm	nautical miles
OEA	orderly evacuation and ebandonment
P&ID	piping and instrumentation diagram
PSSC	passenger ship safety certificate
rpm	revolutions per minute

Abbreviation	Description
SPS	special purpose ship
SRtP	safe seturn to port
UPS	un-interruptible power supply
WTD	water tight doors

7 Regulations and reference documents

Table 3 gives an overview of the DNV GL service documents related to SRtP, Table 4 provides a list of external references related to SRtP.

Table 3 Internal references

Document code	*Title*
DNVGL-RU-SHIP Pt.6 Ch.2 Sec.11	Safe return to port, orderly evacuation and abandonment
DNVGL-RU-SHIP Pt.5 Ch.4	Passenger ships
DNVGL-RU-SHIP Pt.6 Ch.2 Sec.7	Redundant propulsion - RP
DNVGL-RU-SHIP Pt.6 Ch.5 Sec.7	Special purpose ships - SPS
DNVGL-SI-0364	SOLAS interpretations

Table 4 External references

Document code	*Title*
SOLAS II-1/Reg.8-1.2	System capabilities and operational information after a flooding casualty on passenger ships
SOLAS II-2/Reg.21	Casualty threshold, safe return to port and safe areas
SOLAS II-2/Reg.22	Design criteria for systems to remain operational after a fire casualty
IMO MSC.1/Circ.1369	Interim explanatory notes for the assessment of passenger ship systems capabilities after a fire or flooding casualty
IMO MSC.1/Circ.1368	Interim clarifications of SOLAS chapter II-2 requirements regarding interrelation between the central control station, navigation bridge and safety centre
IMO MSC.1/Circ.1291	Guidelines for flooding detection systems on passenger ships
IMO MSC.1/Circ.1532	Revised guidelines on operational information for masters of passenger ships for safe return to port
IMO MSC.1/Circ.1437	Unified interpretations of SOLAS regulation II-2/21. (capabilities after a fire or flooding casualty)
IMO MSC.1/Circ.1400	Guidelines on operational information for Masters of passenger ships for safe return to port by own power under tow

Document code	*Title*
IMO MSC.1/Circ.1129	Guidance on the establishment of medical and sanitation related programmes for passenger ships
IACS UR E15	Electrical Services Required to be Operable Under Fire Conditions and Fire Resistant Cables
IACS UR M69	Qualitative Failure Analysis for Propulsion and Steering on Passenger Ships
BMA Information Bulletin no. 179	Bahamas Maritime Authority information bulletin on Safe return to port

SECTION 2 WORK PROCESS AND RESPONSIBILITIES

1 General

The SRtP scheme is goal based and the regulations are given on a functional level. The regulations allow for different design solutions, which may largely influence the operation of the ship. The work-process shall be adapted, and it is necessary to apply a life cycle approach to ensure that the relevant aspects are addressed at the most appropriate stage in the development of the project.

A simplified illustration of the work process, roles and responsibilities in a project life cycle perspective is shown in Figure 1. The illustration shows key aspects that should be addressed in the various stages of the project and the superior roles of the different parties involved. It is essential that the owner acknowledges their responsibilities in this life cycle, in particular that the necessary decisions and directions are made in the pre-contract phase in relation to the planned operation of the ship.

The following subsections describe key aspects of the early phase activities and implications for the work process.

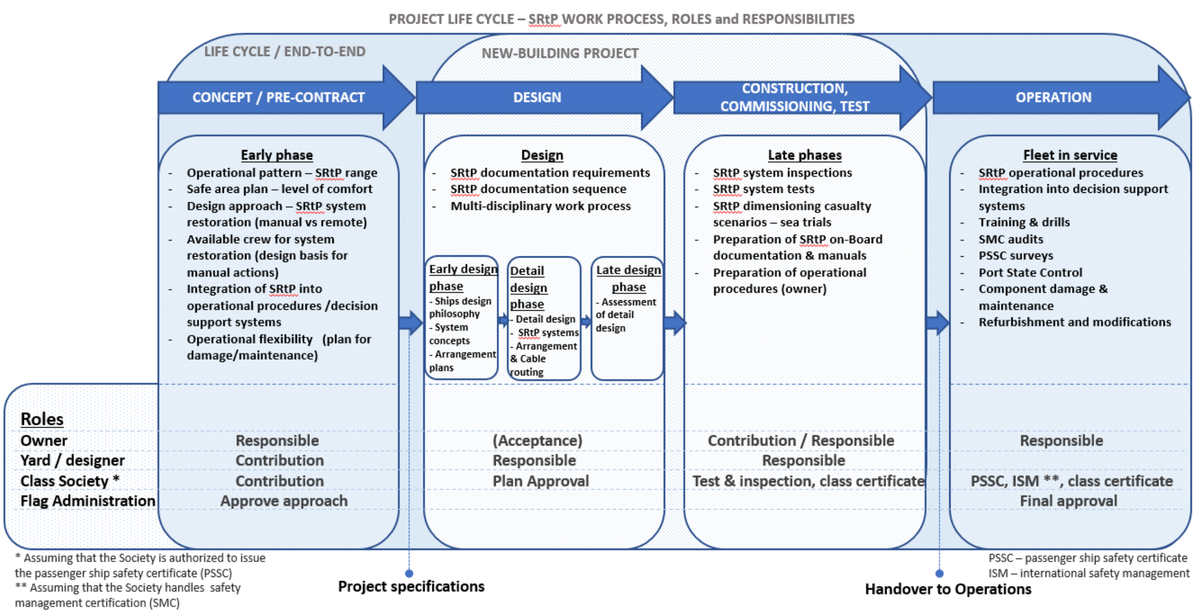

Figure 1 Project life cycle: SRtP end-to-end work process, roles and responsibilities

2 Early phase activities

2.1 SRtP operational pattern and limitations

The capability requirements for many of the SRtP systems depend largely on the intended operation or operational profile of the vessel. This includes i.a. the following:

- The designed SRtP range is normally based on the planned operational area.
- The approach for system restoration and level of performance after a SRtP casualty is decisive for the system design.

- The number of crew members available for system restoration and operation is a key parameter for system design and the dependability of manual actions.
- The number of passengers and crew and the intended catering- and comfort level will be the basis for the design of safe areas.

Many cruise liners built after 2010 have 1000 nautical miles [nm] as the defined SRtP range, ensuring sufficient capacity to reach port from any position in the Atlantic Ocean after a casualty. Vessels that are intended to cross the Pacific Ocean have been designed with a SRtP range of approx. 1450 nm, which is claimed to be sufficient to reach a safe port from any position during a Pacific crossing.

For vessels built to serve a specific route, e.g. a RoPax vessel operating on a 100 nm crossing, the minimum SRtP design range may be set to 50 nm. This implies that i.a. the fuel capacity may be qualified for the expected duration of that specific 50 nm voyage.

For all SRtP ship, this capability will be listed in the onboard list of operational limitations as required by SOLAS Reg.V/30. This implies that any SRtP vessel will have an operational limitation decided by the defined SRtP range - which may have an impact on eventual future change of trade/operational pattern or change of ownership.

2.2 System redundancy

The SRtP regulations demand redundancy and fault tolerance for many systems for the ship to be SRtP compliant. The two redundant parts shall be individually capable of the serving an eventual return to port voyage after a casualty. This implies that if a key component in a redundant system is unavailable due to damage or maintenance, the vessel may no longer be SRtP compliant, even if basic SOLAS and class requirements are still met.

In such cases, it may be necessary to determine the remaining SRtP capabilities of the ship, to evaluate the remaining capabilities in relation to the planned route and environmental conditions and approach the flag administration for permission to leave port in the degraded condition.

As an example, a diesel electrical propulsion arrangement is often configured with four diesel generators in two separate engine rooms. If one of these four generators is unavailable, the vessel may no longer be SRtP compliant. This depends on whether or not the remaining single engine has sufficient power to provide necessary SRtP power balance in a return to port voyage following a possible casualty in the other engine room. This may, depending on the flag administrations practice, impose operational limitations to the vessel.

At present (May 2019), there is no common established industry practice or procedures for handling such cases on SRtP vessels, but leading flag administrations have - or are in the process of - developing instructions to the recognized organizations and owners on the operational aspects of the SRtP scheme.

2.3 System restoration

The intended approach for system restoration after a casualty should be duly considered in the early phase, see Sec.3 [4].

2.4 Concepts and design basis

The above items illustrate that the owner shall be heavily involved in the early project phases, and that certain operational intentions are pre-requisites for developing the SRtP system conceptual documents.

The early phase activities shall result in certain conceptual documents and arrangement drawings reflecting i.a. the basic directions for the project. These documents are subject to approval, but the owner must endorse the documents to ensure that the project intentions are aligned with the planned operation. All subsequent detail design activities as well as approval, test and verification shall be done with basis in the intended capabilities as described in the conceptual documents.

It is considered essential that sufficient efforts are put into defining and describing the system concepts, particularly the design intention, that this is adequately described in the concepts and most importantly that these documents are known and available to any party involved with design and verification.

The principle connection between the chosen design approach for SRtP system restoration and the potential operational impact is illustrated in Sec.3 Figure 2.

It is highly recommended to arrange SRtP meetings and workshops in the early phase of each project where key personnel from both the owner, yard/designer and Society meet to align the approach for the SRtP processes and review the documentation strategy and -sequence to the necessary detail.

The flag administration should also be involved to the extent necessary in the early phase of the project, i.a to endorse the chosen approach.

3 Multi-disciplinary work process

3.1 Consistent design approach

The various technical disciplines and eventual suppliers involved in the design of the different systems required by SRtP shall observe and apply the same principal design intent and operational philosophy. This is necessary to ensure that all the systems supporting a function have a coherent arrangement related to the possible casualties that may otherwise impair the overall function.

This implies e.g. that the piping arrangement for a process system shall correspond to the arrangement of power, control and any other supporting systems necessary to maintain the function taking the same possible casualties (i.e. casualty thresholds) into consideration. This applies to all the SRtP systems that depend on one or more auxiliary and supporting systems.

Some of the auxiliary systems that a function, e.g. propulsion, depend on, may have a service for several different SRtP functions in different categories. Examples of such auxiliaries may be technical water (if needed for e.g. priming), or instrument/control air which shall be arranged to support the design intention of the different systems they serve.

The potential casualty scenarios are decided by the arrangement of passive fire protection (A-rated bulkheads/decks), the extent of fixed fire extinguishing system and watertight bulkheads. It is very difficult to achieve necessary co-ordination in a newbuilding project through a fragmented design process performed in separate disciplines, a multi-disciplinary work process shall be adopted, applying principles of system engineering.

3.2 System dependencies

One of the main challenges is to ensure that all piping, power supplies and controls including necessary cabling for the SRtP functions including auxiliaries are designed correctly in accordance with the redundancy intent. All equipment and cables related to either of the redundant systems (e.g. system A) shall be routed through compartments that after an eventual casualty does not affect the other redundant system (system B) and this approach shall be taken for any other system allocated to the same redundancy group.

The multi-disciplinary nature of the SRtP regulations and the various tasks that shall be coordinated suggests that a dedicated SRtP co-ordinator should be assigned to deal with SRtP from the very beginning of the conceptual phase and throughout the newbuilding project. Each technical discipline shall be aware of i.a. the general design principles, intentions and casualty thresholds and generally engages beyond the traditional scope of the discipline. The physical location of components, piping systems, cables, etc. is essential for SRtP compliance, and the arrangement is therefore a key parameter in the design.

SECTION 3 INTENTIONS AND KEY TERMS - SRTP AND OEA

1 Introduction

The basic regulation for safe return to port is SOLAS II-2/Reg.21, but the notion SRtP is normally considered to cover also the regulations for OEA given in SOLAS II-2/Reg.22. In this document as well as the **SRTP** notation the implications of both Reg.21 and Reg.22 are covered as these two regulations are closely connected.

The connection between the two regulations is basically the following:

— SRtP: for a fire or flooding casualty scenario within the casualty threshold, the ship shall be capable of returning to port under its own power, the systems listed in Reg.21.4 shall remain operational and a safe area shall be provided for passengers and crew.

— OEA: if a fire casualty scenario exceeds SRtP the casualty threshold, Reg.22 assumes that any space within the whole MVZ containing the fire may be impaired, and the systems listed in Reg.22.3 shall remain operational in all other MVZ’s to support an orderly evacuation and abandonment.

The principles are illustrated Figure 1.

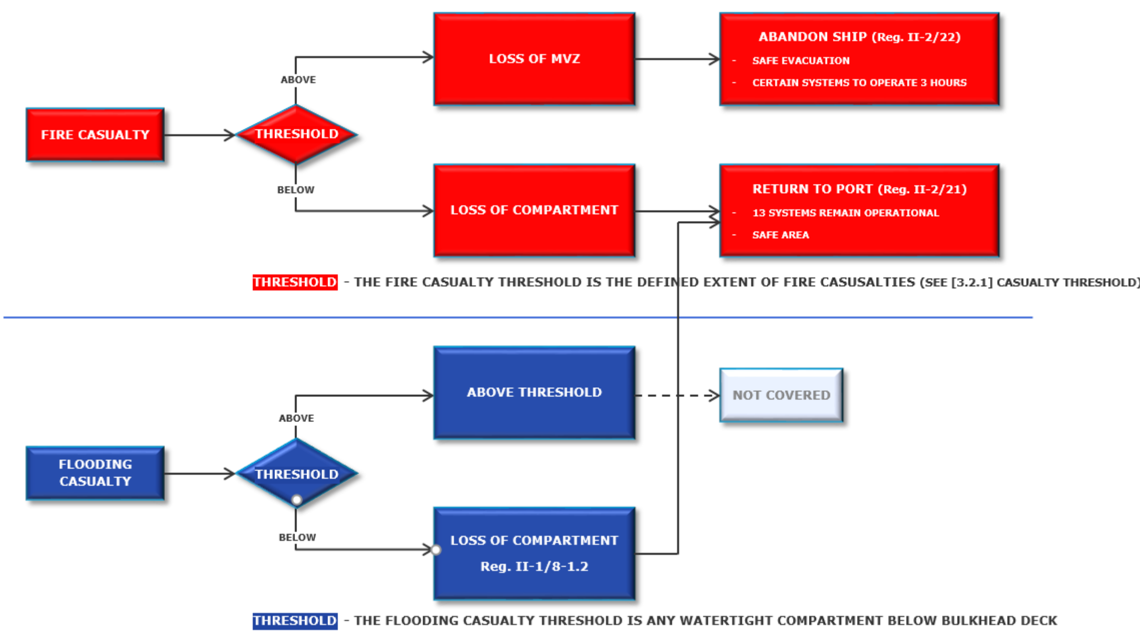

Figure 1 Main principles - safe return to port, orderly evacuation and abandonment

The intentions of the two regulations are described more in detail in [2] and [3].

2 Safe return to port (SRtP) - intentions

The overall intention with the SRtP regulations is - as described earlier - to increase the vessels robustness, fault tolerance and ability to safely return unsupported back to port.

The primary objective is to ensure that the required systems are designed and arranged with adequate redundancy and segregation so that any casualty will have very limited impact beyond the boundaries of the casualty threshold. The SRtP systems can then be restored in all relevant spaces outside the one exposed to the fire or flooding, and remain operational for the duration of the voyage back to port. This implies that

SRtP regulations do not target the ability to fight and mitigate the initial casualty but rather to ensure that the required systems are capable of being restored and remain operational - after the fire is fought or the flooding is dealt with. This means that the SRtP regulations primarily target system recovery - and not emergency response.

2.1 Casualty threshold

The regulations define the term 'casualty threshold' which is the anticipated extent of a fire or flooding casualty and, provided that the fire/flooding is limited within that threshold, the vessel shall be able to return to port in safe conditions by its own power, also providing a safe area for all passengers with a certain level of habitability/comfort/catering in the safe areas.

The casualty thresholds thereby determine the extent of the various failure modes that the systems shall be designed to handle, i.e. to remain operational. The term casualty threshold is in this guideline and the class notation generally used to describe a fire or flooding scenario in any space on board where such scenarios can occur, and it is then assumed that the fire or flooding impair the compartment(s) within the boundaries of the threshold.

The casualty thresholds are therefore fundamental constraints for the design and arrangement of all the SRtP systems, and it is therefore crucial for the project that a casualty threshold plan is made at an early stage, and that the importance of that plan is recognized by all technical disciplines involved with design and arrangement of the ship systems.

The number of possible casualty thresholds on a ship is decided by the number of areas/spaces/ compartments where there is a risk of fire/flooding, the physical boundaries of that space (A0/watertight) and whether or not the space has fixed fire-fighting systems installed. For more specific definition and description of the term casualty threshold, see DNVGL-RU-SHIP Pt.6 Ch.2 Sec.11 [3.2].

2.2 Two failure scenario

The SRtP regulations may be considered to cover 'two failure scenarios' and hence the regulations go beyond traditional SOLAS in many ways. The vessel shall first be able to withstand an incident of fire and flooding (within the threshold), and in that reduced state be capable of returning safely to port with necessary systems operational to handle a possible second incident of fire or flooding (i.a. fire detection and fighting, flooding detection, water-tight doors, bilge). Further, the machinery required to remain operational shall have necessary functions available to ensure the safety during the voyage back to port, e.g. protective shut-down functions. It should however be noted that the SRtP regulations do not include any requirements for the remaining capabilities after the occurrence of a possible second incident during the voyage back to port.

The regulations are made on a functional level, particularly as the different ship systems necessary to ensure this safe return to port capability shall remain operational after the casualty. The level of performance required for a system to remain operational is a key issue. SOLAS does not specify this level of performance, neither is it specified in the MSC.1/Circ. 1369. Therefore, for each of the 13 systems required to remain operational (SOLAS II-2/Reg.21), the intended level of performance shall be defined and specified in the project in accordance with the goals of SOLAS. (For a more clear interpretation of what the notion 'remain operational' implies, see DNVGL-RU-SHIP Pt.6 Ch.2 Sec.11.)

2.3 System restoration

The regulations shall ensure that the systems are designed to support the functional SRtP intentions and also that the SRtP onboard documentation and operational procedures enable a practicable and feasible restoration of systems after any casualty, i.e. that necessary guidance is given for the eventual manual actions.

The regulations relate to theoretical design criteria for situations of fire or flooding where the damage is contained within a casualty threshold - and everything inside the threshold is assumed to be lost - unless adequately protected. The SRtP system restoration following a casualty is therefore a theoretical situation where the damaged compartment(s) are isolated from the rest of the ship - and where all systems that may have been affected by the casualty is restored to the defined level of performance - to remain operational.

In a real damage scenario however, a fire casualty may be limited to specific components or parts of a casualty threshold only - or even extend beyond a casualty threshold to the next compartment. In either case, the system restoration after a casualty will normally depend on what impact the casualty actually had to the different systems, and where only the impaired systems have to be restored. The SRtP system design ensures that system isolation and recovery is possible, but the practical actions to restore the necessary systems after a casualty have to be decided in each case where the real impact on the systems are assessed. The SRtP onboard documentation and operational procedures shall support the crew in this process, but crew competence and knowledge of the system arrangement, functionality and design intent is still decisive for a successful system restoration.

3 Orderly evacuation and abandonment (OEA) - intentions

The overall intention with the OEA regulation in SOLAS II-2/Reg.22 is to ensure that the systems deemed necessary to support an orderly evacuation remain operational in all other MVZ's than the one exposed to the fire. Similar as for SRtP, the primary objective with the OEA regulation is that the listed systems shall be designed and arranged more robust, so that even in the event of a fire spreading to any area within a whole MVZ, the functions remain operational in the other MVZs.

Neither the regulations nor interpretations include any expected sequence of propagation or time lapse for the originating fire to develop into the OEA scenario.

4 Restoration of capabilities after a casualty

The MSC.1/Circ.1369 circular specifies that the systems shall be designed to allow for restoration within one hour following the casualty, which allow for a limited set of manual actions by the crew to restore system operation and remain operational for the return to port voyage. However, the extent of such manual actions shall be limited and there are strict pre-conditions for accepting the extent of manual actions that may be needed to restore system capabilities after a casualty. It should however be noted that this one hour criteria is a design requirement intended to limit the dependability of manual actions, and not related to the real practical restoration of systems after an incident during operation.

4.1 Design requirements and operational implications

As described in Sec.1 [2], SOLAS gives design requirements, while the primary guidance document MSC.1/Circ.1369 gives allowance for operational procedures to meet the intentions of SRtP by accepting manual intervention and restoration of system capabilities in the event of a casualty. This implies that the design approach taken in a SRtP project may vary widely between:

1) systems based on highly redundant and segregated arrangements with remote system restoration and maintained level of automation
2) simpler design solutions where system restoration depends largely on operational procedures and local, manual intervention from of crew members

or any combination of 1 and 2.

The implications of the chosen design approach may therefore be quite significant, and it is strongly recommended that this aspect is considered carefully in the early project phases and that the chosen approach is agreed between the owner and yard.

The principle relation is illustrated in Figure 2 showing the different design approaches and the general implications for the design and operation.

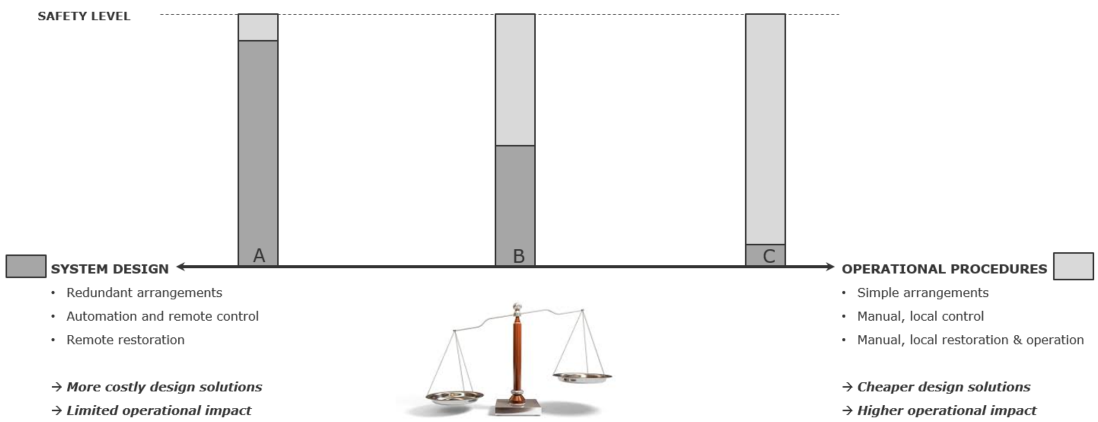

Figure 2 Illustration of the connection between alternative design solutions and operational impact

5 System arrangements

5.1 General

The safe return to port and OEA regulations give functional requirements to many different ship systems. These systems may be split in four principally different categories:

1) systems that shall provide propulsion, steering and navigation
2) systems related to fire safety and watertight integrity that shall remain operational across the vessel (fire detection and -fighting, watertight doors, flooding detection, bilge, etc.)
3) systems to support safe areas
4) systems that shall remain operational for a period of three hours to support orderly evacuation and abandonment (SOLAS II-2/Reg.22).

The reason for suggesting this split in these four categories is that the SOLAS requirement of remaining operational in the remaining part of the ship not affected by the fire has very different implications for the four categories, and this shall be duly addressed in the project.

The following subsections describe the four different categories.

5.2 Category 1 - Duplicated systems (propulsion, steering, power, navigation, external communication)

The various systems in the first category, e.g. power generation, propulsion and steering with necessary auxiliaries, shall be arranged to ensure simultaneous availability after a casualty that may occur in any compartment. These systems are naturally arranged with duplication/redundancy, a system 'A' and 'B', each system located within separate zones (i.e. casualty thresholds) dedicated for either system A or B. This means that not only the main mechanical components belonging to the various systems shall be arranged and located in the dedicated zones, but also that all necessary power supplies shall be provided from the correct distribution within the same zone, the control system shall be from the correct controller node, all cabling shall be routed through correct zones, and the same principle applies to any other system that the overall function depend upon, e.g. ventilation, instrument air to valves, cooling and ventilation.

In order to achieve this, the different design departments for the various systems shall work in accordance with the same redundancy intent and a common casualty threshold plan, taking height for the same possible casualties and the intended capabilities after the casualty. This means that these design intentions shall be clearly stated through system concepts in the very early phase of a project, that the casualty threshold plan and the design intentions are acknowledged and understood by all disciplines involved with the design. This may also involve sub-suppliers.

Most modern passenger ships that shall comply with the SRtP regulations have quite complex and integrated machinery installations, where the various systems and components depend on the integrated control and safety systems. It may be very hard or even unrealistic to operate the engine room safely and provide necessary capabilities for the return to port voyage without the support of functional control and safety systems. Even though it may in theory be possible to base the return to port capabilities on manual, local operation without functional automation systems, it is not considered feasible and practicable. It is therefore considered necessary to arrange the control and monitoring systems with a redundancy that supports the general redundancy of the machinery installations.

The general arrangement of the ship with a clear definition of which zones and compartments that are dedicated for the redundant systems (category 1) shall be made at an early phase, and the design and arrangement of all relevant systems shall be made in accordance with the zone definition. If such general arrangement drawings with clear identification of which compartments/sections/zones that are allocated to redundancy zone A or B respectively, these drawings may be used by all the various technical disciplines during the design phase, and thus reduce the likelihood of design clashes that otherwise may be revealed during later assessments and inspections.

5.3 Category 2 - systems with a general service across the vessel

When it comes to the systems in category 2, the challenge is different since the systems may serve any space on board - and then a duplication in separate zones A and B would not be sufficient, different design principles must be applied.

For a system in this category, e.g. fire detection or bilge system, this implies that the system shall be designed so that any casualty in one space does not impair the continued service in any other space - even within the same MVZ. This is a quite strict requirement and demands in general highly redundant and segregated systems where the service to a given space is provided e.g. by two segregated systems routed through segregated compartments, i.e. not within any common casualty threshold.

These systems and the different components within the systems may also depend on various auxiliaries (e.g. control, power supplies, technical water, instrument air, ventilation), and these different auxiliaries normally also serve other SRtP systems. The design and arrangement of the various auxiliaries shall therefore be aligned with the arrangement of each of the SRtP systems they serve.

However, for many of the systems in this category, MSC.1/Circ.1369 - and the SRtP class notation grant more lenient acceptance criteria for what may be considered as remain operational, i.a. for the bilge system, watertight doors, fire main - for which significantly reduced capabilities are accepted, see DNVGL-RU-SHIP Pt.6 Ch.2 Sec.11 [4].

The ballast system is in this category, but may however normally be exempted from the SRtP regulations if duly justified and accepted by the administration and the company. The justification for exempting the ballast systems from the SRtP regulations may be based on i.a. the following:

- There are no rules or requirements stating that flooding shall be compensated by ballasting, and if correction of heel is necessary after asymmetrical flooding, this shall not depend on the ballast system.
- There are no acceptance criteria introduced by IMO for stability analysis related to SOLAS II-1/Reg.8-1.2.
- The SRtP casualty threshold for incidents of flooding is limited to single watertight compartments below bulkhead deck, which is less severe than the general stability criteria for passenger ships of SOLAS II-1/Reg.8.

There may, however, be other operational reasons for ensuring that the ballast system remains operational in the context of SRtP - e.g. to optimize the vessel performance in the water or related to passenger comfort. If the ballast system is not exempted from the SRtP regulations, the requirements of the class notation apply.

5.4 Category 3 - Safe area systems

The systems required to be available in the safe areas to ensure habitability for passenger and crew, (i.a. water, sanitation, food, ventilation, light) shall be arranged to be simultaneously available in the safe areas assigned to the SRtP casualty, depending on in which MVZ the fire occurs.

It is assumed that after a fire casualty, the whole MVZ containing the fire is unsuited as a safe area - even though the fire itself is limited by the casualty threshold. This means that for any given incident of fire within the casualty threshold, a safe area shall be available in other main vertical zone(s) than the one exposed to the casualty. Note that the actual fire is still assumed to be only within the casualty threshold, and the systems or provisions outside the boundaries of the casualty threshold are still available to support the safe areas.

Depending on the number of persons on board, the simpler solution may be to provide two safe areas located in different MVZ's forward and aft, and where all the safe area systems are arranged so that it is supported within the zone, and possible to isolate from the neighbouring zone. In this way, the general design approach may be equivalent to the category 1 systems where the general requirement is that either one of the safe areas remain operational after any casualty on board.

Similar as for category 1 systems, a common redundancy intent and a general arrangement drawing identifying which compartments that are dedicated for components, piping and cables for each safe area must be developed and made available for all technical disciplines involved with the design and arrangement of the systems involved.

5.5 Category 4 - OEA systems

This category includes the systems listed in SOLAS II-2/Reg.22, i.e. those that are required to remain operational for a period of three hours to support an orderly evacuation and abandonment of the ship - the OEA systems. Most of the OEA systems also serve as SRtP systems in category 2 - and the requirements of both SRtP and OEA apply.

In the OEA scenario, it is assumed that any space within a full main vertical zone (MVZ) may be lost, and the listed systems shall remain operational in all other main vertical zones. This means that each system shall be designed in such a way that any casualty in one main vertical zone does not impair the continued service for three hours in the other main vertical zones. Eventual pipes and cables that shall remain operational through the exposed MVZ to support the services on the far side of the lost MVZ shall be adequately protected.

SECTION 4 DOCUMENTATION AND APPROVAL

1 Documentation requirements

The SRtP/OEA related documentation that is required for approval is listed in the class notation **SRTP**, see DNVGL-RU-SHIP Pt.6 Ch.2 Sec.11, and the list is based on the contents of SOLAS and the MSC.1/Circ.1369 circular.

The documentation required for SRtP is in the class notation split into the following categories.

- Ship level: overall/general documentation:
  - general arrangement drawings with specific information related to SRtP: casualty threshold plan, redundancy zone plan, safe area plan
  - ship description/design philosophy
  - safe area design philosophy
  - hydrodynamical calculation report
  - electrical load balance for SRtP and OEA
  - SRtP tests and trials procedure.
- System level: for each SRtP system listed in SOLAS Reg.II-2/21.4 and in addition the integrated control system as well as the power generation and distribution system:
  - system design philosophy
  - system arrangement plans
  - cable routing drawings
  - system assessment for each of the SRtP systems (the system assessment may be developed and presented in common or separate documents provided that necessary dependencies and interrelations are covered).
- Onboard documentation:
  - This is generally the full set of design documentation and in addition SRtP operational manual and maintenance manual, see [4]. The onboard documentation package in itself is not subject to approval by the Society, though the package largely consists of documents that are part of the approval scope.

The system design philosophies are key documents describing i.a how the systems shall be arranged to fulfil the intentions of the SRtP regulations. Note that these document serve different purposes, one of the important aspects is to ensure that all parties from different technical disciplines involved in the design of different sub- and auxiliary systems are made aware of the design intentions, to ensure a coherent design in compliance with the regulations.

The detail design of the individual systems affected by the SRtP regulations should not be done before the design philosophies are developed. When approving the detailed system documentation, e.g. P&ID's for a given system, compliance with the intentions of the design philosophy is an essential aspect - and the concepts shall be therefore be available before approval of the detail design drawings can commence.

The general intention of the documentation sequence is shown in Figure 1.

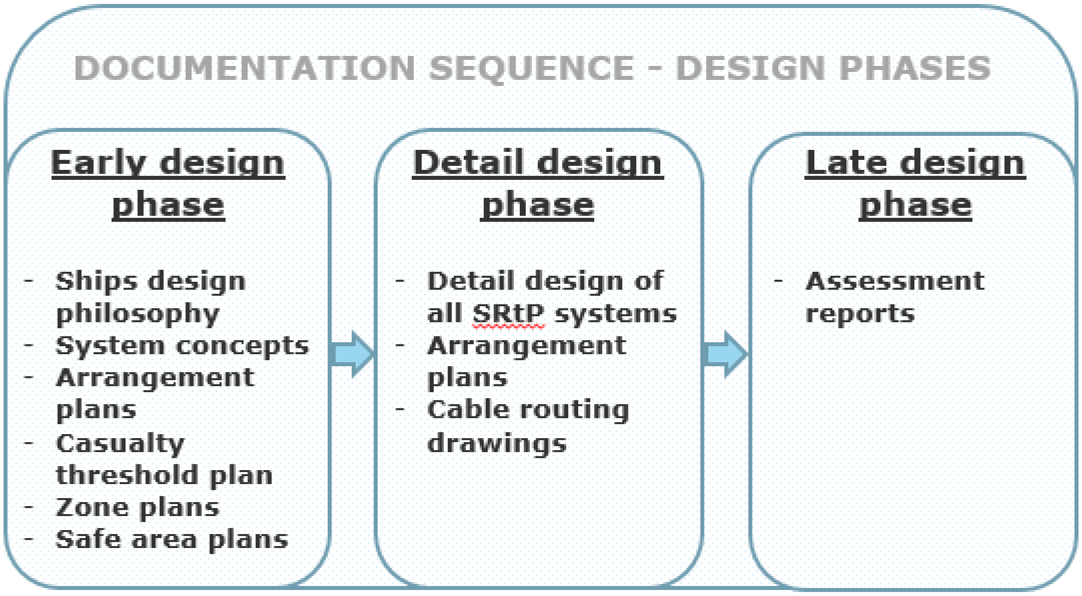

Figure 1 General intention of the documentation sequence.

The ship design philosophy, the system concepts and the general arrangement plans describe the intended way of designing and arranging the systems affected by the SRtP regulations. These documents are then used as part of the design basis for the various disciplines and units that design the different part of the overall systems.

When the detail design is proceeding, the actual design shall then be assessed for compliance with the SRtP regulations and the design intentions, resulting in a conclusive assessment report. The final verification of compliance is then done through inspections, tests and trials.

It is strongly recommended for the yard to plan and describe the intended approach for various SRtP documentation e.g. in the ships description document, to inform all stakeholders of which documents that will be made at what stage in the project, in particular how the concepts and assessment reports will be organized for the various systems.

A principal sketch of the overall time-line the SRtP document production is shown in App.D. Note that most of the SRtP documents are developed in the early phase of the project. If the conceptual documents are structured and clear, and if the general arrangement drawings support the different system philosophies, this may greatly simplify the subsequent SRtP process.

App.A gives an example of an overall structure of 'ship's description' document, and App.B shows a proposed structure of a 'system design philosophy'.

2 Assessment of the ship system capabilities

2.1 General

The capabilities of the SRtP and OEA systems shall be assessed through a structured analysis where the effects of fire and flooding casualties shall be analysed and documented in a report. The assessment report shall be conclusive on compliance with the regulations. The assessment and the report serves different purposes, both as part of the verification of the ship system design and also as a key document for the preparation of operational procedures.

The assessments are considered crucial for analysing and verifying compliance with the SRtP regulations, and the work involved with these assessments may be quite significant. The assessments require a structured analysis quite similar to the failure mode effect analysis (FMEA) approach, and this activity should be planned for and incorporated in the project plans. The assessments should ideally be conducted by an unbiased independent party, and not by the design teams.

2.2 Actual design

The system assessments shall document how the actual design of all SRtP systems meet the intentions of SRtP regulations, in particular to verify that the outcome of the detail design process is in accordance with the approved concepts, and in compliance with the SRtP regulations. The assessment shall identify and analyse the systems response to applicable fire and flooding casualties and demonstrate that the systems remain operational. The assessment shall be conclusive for each system where it is confirmed that each system is designed and constructed in accordance with the SRtP requirements. Eventual assumptions or pre-conditions, findings or uncertainties may have to be verified through deeper scrutiny and relevant tests.

2.3 Manual actions

The assessment report shall identify the eventual manual actions that may be necessary for the crew to perform for restoration of the SRtP systems, following the various casualties that affect the system. These manual actions include any manual intervention that is needed to restore and maintain the system functionality - both actions that have to be done locally at the machinery/component and remotely if the remote control is intended to be available.

The assessment shall be based on the detail drawings and documentation of the actual design, and it is necessary to identify clearly on what basis the assessment is done, i.e. the input documentation, data models or other sources - with identification of revisions. The SRtP regulations is very much concerned with physical arrangement and location of components, routing of pipes and cables and the assessment must be based on sufficiently detailed piping and cable routing information to conclude on compliance.

2.4 Level of detail

The level of detail in the assessment of a system depends on the arrangement and dependencies of other systems. If e.g. a system is clearly separated by design and arranged in different compartments belonging to different redundancy groups, and that no cross-connection or common system dependencies exist, the assessment may be concluded at a higher level. However, most systems depend on e.g. power supplies, control systems and other supporting systems located in other compartments, and will therefore require a detailed analysis of component location and cable/pipe routing of all sub functions needed for the system to remain in operation.

2.5 Tests and trials

An important part of performing the assessments is to identify relevant tests that may be required to verify assumptions and findings. If e.g. the loss of a central compartment may affect both redundant systems, and it is necessary to manually intervene to re-establish the function, this should to some extent be verified on board - either when the ship is alongside or in some cases at sea trials. The extent of tests needed to verify compliance with the SRtP regulations should be determined as part of the system assessments, and planned for when the various test protocols for system testing as well as quay - and sea trials are developed.

2.6 Assessment method

The assessment is normally a very complex exercise, and may be based on different methods and tools - from manual desktop analysis of drawings to computerized models and simulators. The assessment method/

approach and also the format of the report should generally be agreed upon by the owner, yard and Society at an early stage in the project, in particular as the assessment in a crucial part of both the verification and the SRtP onboard documentation. Where computer based models are used, the approach for building the model and the structure of the assessment should be documented to justify the quality and reliability of the outcome.

If a computer model is used for the assessment, the model may - depending on the technology - also be developed further to a decision support system (DSS) to support the crew in practical system restoration after a casualty. In such cases, the model and its accuracy should be verified and 'calibrated' through the inspection and commissioning phase where the physical location and functionality of components are inspected and tested - to ensure that the model represents the actual installation.

2.7 Other voluntary notations

SRtP vessels that are specified with the additional notations for redundant dynamic positioning **DYNPOS(AUTRO)** or redundant propulsion **RP(3, x)** shall be subject to an FMEA where i.a. the redundancy in machinery and power arrangements are analysed. Even though the intentions, requirements and acceptance criteria for these notations differ from those of SRtP, there is a big overlap and it is highly recommended to align and combine the FMEA exercise with the SRtP assessment. The necessary tests and trials at sea for the different schemes may also be largely combined and made more efficient if planned and performed simultaneously.

An example of the expected structure and content of a system assessment is given in App.C.

3 SRtP test strategy

3.1 General

SRtP compliance shall be tested and documented, and an SRtP test strategy should be made early in the project to ensure that necessary tests are performed efficiently at the most appropriate stage in the process. In order to avoid extensive testing of SRtP compliance at the later stages, the tests should as far as possible be done in connection with normal system commissioning and tests. The test strategy should include a plan for when and how and to what extent it may be verified that the consequence of representative SRtP casualties (fire/flooding) does not render any of the required systems inoperable in other compartments.

If a good SRtP test strategy is made and this strategy is reflected through the various phases of installation, mechanical completion and commissioning, this may limit the extent of SRtP related tests in the late phases including quay - and sea trials. The test strategy may be a part of the ship description document, see App.A, or made as a separate document. In either case, it shall be submitted to class as part of the approval documentation.

3.2 Physical location

The SRtP regulations are very much related to the physical location of equipment, cables and pipes relative to the various casualty thresholds. In a 'traditional' project, the physical location is normally not a crucial aspect as fire and flooding scenarios is generally not a design criteria in the same sense as for SRtP, a single fire in a crucial space may leave the ship drifting. This implies that for a SRtP ship, additional testing and verification shall be performed for each of the SRtP systems to ensure that the actual installation is according to the design intention. It is therefore required that each of the SRtP systems are tested on board for compliance through simulation of fire in selected compartments (casualty thresholds). The assessment report shall in general for each system identify representative tests including eventual manual actions needed for system restoration.

3.3 Sea trials

However, certain tests are anyway deemed necessary during the sea trial to verify the vessel capabilities after the dimensioning failure scenarios. This normally includes simulated loss of each engine room, and possibly loss of other critical spaces that require high machinery load or for other reasons are difficult to test alongside. The test programme for SRtP quay and sea trials shall be submitted for approval. This includes testing of the worst-case damage scenarios, which is normally considered to be loss of each complete engine rooms and possibly also loss of control room, loss of bridge or another critical compartment. The worst case damage scenarios in the engine spaces may, depending on the arrangement of A-class and watertight bulkheads, be defined by either a flooding or a fire scenario. The main purposes of running these tests at sea are to:

— demonstrate that the complex machinery arrangement is designed to support simultaneous availability of all auxiliaries and supporting systems to enable operation of the remaining propulsion line after a casualty, that all power supplies are provided from the correct distributions
— demonstrate that the power needed to achieve the intended speed necessary to reach port may be generated without exceeding thermal stability in the operable engine room
— to verify that the intended speed is achieved with the SRtP power demand (i.e. to verify that the ship is capable of providing 6 knot at BF8 - based on calculations from the prevailing weather conditions)
— demonstrate that the operation is feasible – that necessary means of control and monitoring for all necessary systems are actually available, that eventual manual actions necessary to restore and remain in operation are identified, available and manageable
— as for all tests to demonstrate that the actual installation is done in accordance with the approved design drawings.

3.4 Test configuration

The intention is to run these tests as realistically as possible, both the simulated loss of the casualty threshold with all it's systems, the isolation of the systems affected by the casualty as well as the system restoration. This normally includes to disconnect all power supplies to any equipment within the spaces, to disconnect eventual UPS's, to operate all isolation valves in order to isolate any cross-over lines etc. Then the applicable SRtP systems shall be restored including eventual manual actions, before the remaining capabilities of the affected SRtP systems can be verified. The design criteria for the system restoration is that it shall be possible to complete within one hour and this is normally verified through these tests. The test programme for quay and sea trials should describe the different steps of these tests to the necessary detail to ensure an efficient and co-ordinated accomplishment.

In addition to the above described tests that shall be performed at the sea trial, it is assumed that the assessment, see [2], identify certain tests that may be needed to demonstrate conclusions or assumptions from the analysis.

4 Onboard documentation

4.1 General

The SRtP regulations shall ensure that all relevant systems are designed in a way that make it possible and feasible for the crew to restore capabilities and remain operational after an incident of fire or flooding. However, the SRtP systems often depend on manual actions by the crew to restore functionality after a casualty. In order to support the crew in the system recovery, the MSC.1/Circ.1369 circular has quite extensive requirements for the set of onboard documentation that shall be developed as part of the delivery.

4.2 Contents

The onboard documentation shall in practice cover the full SRtP design documentation package and in addition operation manuals covering the SRtP casualty cases as well as test, inspection and maintenance plans. The operation manuals shall include details of manual actions that are necessary to restore capabilities of the various systems after fire or flooding casualties. This onboard documentation shall form the basis for operational procedures and provide support to the crew in the event of a casualty.

4.3 Geographical approach

The theoretical approach for the operational manual may be to develop lists that identify all manual actions that shall be operated to fully isolate all systems that may be affected if there is a casualty in any given casualty threshold (i.e. compartment(s)). This may be seen as the 'geographical' approach, where each casualty threshold is associated with a list of manual actions for any system affected. However, in a real scenario, it is not given that all systems in the casualty threshold are affected, and operation of all manual actions on the list may be unnecessary and also lower the actual performance/capabilities of any system that was fully functional.

4.4 System approach

The more practical approach for the operational manual may be to provide guidance on the redundancy intent of the individual systems, i.e. to provide readily available documentation on how the systems have been arranged and segregated to enable system recovery. Then the manual actions related to the various casualty scenarios for the specific system may be identified/listed. This may be seen as the 'system approach', which is more likely to match the actual needs of the crew in a practical scenario. For a practical system recovery after an incident of fire or flooding, the crew competence and knowledge of the system arrangement is essential, as it was before the introduction of the SRtP regulations.

4.5 SRtP casualty

A 'SRtP casualty' is not different from any other incident of fire or flooding, but the term SRtP casualty is used to define the extent of the fire or flooding and thereby giving the general acceptance criteria for system design. The SRtP regulations generally result in systems with a higher degree of redundancy in design and hence availability, and it is therefore more likely that system restoration is successful, but the SRtP scheme does not require a shift in the practical system recovery operation onboard.

4.6 Practical system restoration

In order to meet the intentions of the SRtP regulations and enable the crew to handle system recovery operations, the owner and yard shall clarify and agree on the content and form of the onboard documentation and the SRtP operational manual in particular. The identification and description of the manual actions that may be required for system recovery after casualties in the various compartments is the key issue. Whether the operational manual is based on a 'geographical', or a 'system' approach, the owner should consider what is actually needed to support the crew in the practical system restoration after a casualty, the manning level, other operational procedures and eventual decision support systems - and develop necessary SRtP procedures accordingly.

The onboard documentation is also intended to be the design basis for future modifications and refurbishment, so that eventual changes to the system arrangements, or casualty thresholds, do not impair the robustness or system capabilities.

SECTION 5 SRTP IN SERVICE

1 Operational implications of the SRtP scheme

1.1 General

The SRtP scheme ensures that the ships are designed with system capabilities beyond the traditional level of SOLAS. The systems are designed with higher degree of redundancy and segregation to allow for system restoration, and the capability to return unsupported to port even after serious incidents. This implies that the ships are more robust and fault tolerant and it is more likely for the crew to handle damage scenarios with less impact for the passengers and crew. Further, the SRtP regulations require that necessary operational manuals and procedures are available to support the crew in practical system recovery after a casualty.

However, the SRtP scheme does not include any regulations giving operational instructions to the master or the crew. In the event of a casualty it is fully up to the master to decide if and when SRtP systems shall be restored, the eventual sequence of restoration, the eventual use of safe areas, whether or not to return back to a safe port etc. The SRtP scheme is not about emergency response but system recovery and the one hour limitation that is given in the MSC.1/Circ.1369 circular is therefore considered to be a design criteria only and not related to the practical system recovery after a real casualty on board.

1.2 SRtP casualty

In practical operation, there is no such thing as an 'SRtP casualty', an 'SRtP casualty' is a design criteria. If there is a real fire or flooding situation on board, the crew should handle the situation basically the same way regardless of whether or not the casualty is beyond, at or above the SRtP casualty threshold: first emergency response and then system recovery as applicable, with aim to fight the fire and minimize the consequence of the casualty and the impact on the passengers and crew.

SRtP should initially be handled in line with existing operational procedures and schemes on board, SRtP does not require a separate operational scheme. The SRtP operational procedures should therefore be aligned with the other procedures and eventual decision support tools, where the capabilities of the redundant SRtP systems with the ability to isolate a casualty and restore operation is included (i.a. the additional valves and components installed to provide the required SRtP capabilities). However, as discussed in Sec.3 [4.1], the regulations allow different design approaches to reach the goals of SOLAS, with different implications for the operation.

The SRtP regulations have been in force since 2010, but at present (spring 2019), the industry has not reached a common practice for the operational aspects of the SRtP scheme. However, different initiatives among the key players and maritime organizations are proceeding with the aim to clarify this area and to establish an industry standard for the SRtP operational scheme.

2 Operational challenges

The key operational challenges related to the SRtP regulations are considered to be within the following areas:

1) How to ensure that the crew is aware, trained and capable of handling casualty scenarios where the additional components and capabilities of the SRtP systems are utilized? How to align these with other operational procedures and the general instructions for emergency response and system recovery? There are normally numerous casualty threshold scenarios, each scenario may demand a different set of manual actions and operation of components installed to provide the SRtP capabilities. If system restoration largely depends on manual actions by the crew, the operational procedures, crew allocation, responsibilities and implementation on board shall enable practicable system restoration.
2) The SRtP regulations demand that the systems are redundant and fault tolerant. Any damage or maintenance of components or systems impairing the redundancy may potentially affect the SRtP

capabilities. This may, depending on the criticality of the system and the operational conditions, impose operational limitations, e.g. that the vessel may not be allowed to leave port in degraded condition ('safe return to sea' capabilities).

3) There is at present no harmonized scheme for the SRtP scope of PSSC surveys or ISM audits, neither is there an industry practice for the scope of port state control (PSC). This may imply that inspectors/auditors/surveyors from different organizations focus on different aspects of SRtP and have different expectations and acceptance criteria to the implementation of SRtP on board.
4) Refurbishment and modifications of SRtP vessels may affect the SRtP capabilities. The SRtP capabilities are the result of a complex, multi-disciplinary effort through the newbuilding project. Any modification of the SRtP systems or the boundaries/bulkheads/decks defining the casualty thresholds may affect the SRtP capabilities. Modifications shall therefore be evaluated with due regards to the initial design intent to ensure that the SRtP capabilities are not impaired. This may also demand a revision of the assessments and include revision of SRtP onboard documentation and operational procedures.

When it comes to the SRtP operational manuals, the theoretical damage scenarios of SRtP cover incidents of fire or flooding where everything within the casualty threshold is considered to be damaged - unless adequately protected. The list of manual actions that may be necessary for the crew to operate in the restoration of the different systems possibly affected is therefore a theoretical worst case scenario where all affected systems actually require restoration. In practice however, it is expected that before initiating any system restoration after a casualty, the crew shall evaluate if the system functionality is really impaired and if any actions are really needed. Then, depending on the situation at hand, the crew shall for each system evaluate which actions to take, the order of actions, prioritizing the needs and co-ordinate the efforts. This implies that any list of manual actions identifying all components that may have to be operated in case system restoration is needed after a given SRtP scenario shall be evaluated by crew with necessary knowledge of the system before the system restoration can commence.

The **SRTP** notation is for fleet in service followed up through the scheme for renewal of the statutory certificates (PSSC or SPS).

APPENDIX A EXPECTED CONTENTS OF A SHIP DESCRIPTION/ DESIGN PHILOSOPHY

The ship description/design philosophy is the top SRtP document, defining the basic design intent and operational criteria for the project, covering both SOLAS Reg. II-1/8.1.2, Reg.II-2/21 (SRtP) and 22 (OEA).

The document is supposed to serve different purposes, i.a the following:

— To ensure that the information that is required in the early phase of the project is properly addressed and defined, in particular the operational criteria. This includes the planned operational routes, dimensioning return to port range, duration of the voyage back to port, environmental conditions.
— The operational implications of SRtP are very much about how system restoration is supposed to be done - and how the functionality shall be maintained during the voyage back to port.
  A project approach for system restoration should be described, i.e. if system restoration shall be based on manual actions or if restoration is based on remote operation with highly automated, redundant and segregated systems - or something in between. For maintaining the functionality in SRtP mode, it shall e.g. be decided if remote operation shall be available after a casualty or not.
  The approach should be stated to ensure that this is well anchored among the different parties, in particular the owner, designer, yard - and available for other stakeholders like different technical design disciplines, system suppliers, class.
— Anybody involved in any phase of the project may use it as an entry to the SRtP scheme, to get an overview of the intentions, the design approach, the scope, which systems are affected, which documents are made, etc.
— Eventual approach for operational flexibility. SRtP may impose operational limitations, e.g connected to damage of components that impair the redundancy.

Since SRTP is about the ship's remaining capabilities after an incident of fire or flooding, the system arrangement, location and segregation of components, pipes, cables in different compartments (i.e. within different 'casualty thresholds') is essential. Therefore, the following arrangement drawings should be developed in parallel with the ship's description/design philosophy:

— SRtP casualty threshold plan
— machinery redundancy plan/zone plan
— safe area plan.

The below subsections illustrate a structure of proposed chapters with key words for what kind of information that is recommended to include - or consider in the ship description/design philosophy.

1 Ship's description

1) Introduction
   — purpose of the document, the intention and the use
   — state the SRtP approach, i.e. that MSC.1/Circ.1369 will be applied (note that 1369 is 'Interim explanatory notes…') unless otherwise agreed with the administration.
2) SRtP documentation strategy:
   — description/overview of the SRtP documentation process/flow
   — the sequence and at what stages in the project the different documents will be made
   — which systems will be covered in separate system design philosophies, separate assessment reports (will e.g. the auxiliary machinery systems be covered in separate documents – or as part of the function they serve, e.g. lub oil serving propulsion)
   — approach for SRtP operation manual, test protocols
   — supplementary information for easy understanding of the drawings, if applicable.
3) Reference documents:
   — applicable rules and regulations

— which SRtP documents will be made, numbering structure
— project specific documents, e.g. watertight integrity plan, fire zone plan, structural fire protection plan.

4) Ship's description/main characteristics:

— Main characteristics of the vessel:

  — basic layout of the vessel
  — number of PAX
  — machinery configuration.

— Operation:

  — planned operation and intended area of operation
  — safe return to port range/distance
  — vessel capabilities – speed and SRtP speed (worst case return to port casualty scenario)
  — duration of the dimensioning SRtP voyage – preliminary calculation
  — approach for operational flexibility, possible extra redundancy/capacity to enable continued operation when certain components are unavailable (e.g. due to damage).

— ambient temperatures

— SRtP bridge location

Note: hydrodynamical calculations and eventual model test results shall be documented in a separate report.

5) SRtP system overview:

— Identification and possibly a high-level description of all systems affected by the SRtP regulations (SOLAS Reg. II-1/8-1.2, 1, Reg.II-2/21) including the OEA regulations (SOLAS II-2/Reg.22). Note: it is not the intention that this system overview shall give detailed information of all the SRtP systems since that shall be covered in separate system concepts.

6) Casualty threshold:

— intended approach for the extent of casualty thresholds, installation of fixed fire-fighting/sprinkler, A-class bulkheads
— intended approach for areas of negligible fire risk.

7) System restoration:

— general approach for 'remain operational' - is the intention to largely depend on manual intervention/action for system recovery, or to ensure highly redundant systems designed and arranged to remain operational with limited need for manual intervention
— definition and intended level of manual actions to restore capabilities and remain operational
— number of crew needed/allocated to handle system restoration
— intended approach for accessibility, marking, lighting of location where manual operation may be necessary
— eventual intended use of fire resistant cables/fire protection of pipes, eventual routing on open deck, trunks and pipe tunnels.

8) Load balance and capacity:

— overall power balance for the SRtP and OEA scenario (on an overall level - detailed power balance is covered in other main class documents, a hydrodynamical calculation is required as a separate SRtP document, see DNVGL-RU-SHIP Pt.6 Ch.2 Sec.11 Table 2)
— initial fuel capacity calculation for the dimensioning SRtP voyage, fuel supply intention.

9) Safe areas:

— intended arrangement of the safe areas to accommodate all persons on board

— available space and toilets
— intended level of catering/service level for the systems supporting safe areas
— access to life saving appliances

Note: this part of the document should be on a high level only, the specific intentions of the various systems supporting the safe areas shall be covered in the safe area design philosophy.

10) Test and verification strategy:

— intended approach for test and verification of SRtP compliance, how will SRtP compliance be demonstrated, what will be done at different stages, intentions for quay and sea trials, covering both SRtP and OEA
— intentions for the scenario testing systems and dimensioning scenarios.

APPENDIX B EXPECTED CONTENTS OF A SYSTEM DESIGN PHILOSOPHY/CONCEPT

This appendix shows the possible structure and expected contents of a system design philosophy/concept. Such a document shall be developed for each of the systems listed in SOLAS II-1/Reg.21 and in addition, the power generation/distribution system and the integrated control and monitoring system.

The propulsion system depends on a number of auxiliary systems. If each of the auxiliaries are described in individual concepts, the overall propulsion function should be covered by a specific concept tying all the auxiliaries together.

The extent of the philosophy document and the need for illustrations naturally vary for the different systems, for a system like e.g. the flooding detection system, the system arrangement may be quite simple and the dependencies of other systems are limited - whereas the propulsion system demands a more extensive description to cover necessary design intentions of both the system itself but also the various auxiliaries supporting the propulsion function.

1 SRTP system concept

1) Introduction:
   - to describe the intended arrangement and redundancy of the system to ensure that the requirements of SRtP are met, both with regards to SOLAS II-1/reg.8-1.2 (flooding casualty), SOLAS II-2/Reg.21 (SRtP) and Reg.22 (OEA) - as applicable.
   - to give the detail design teams sufficient information to ensure that all parties involved with the design of system xx are informed, understand and follow the system design intentions.
2) Design intention:
   - the overall system arrangement and design intention, in particular the principles of redundancy/ separation/protection intent, physical arrangement, principle location of equipment
   - the intended system capabilities after a casualty, i.e. what does 'remain operational' imply for this system - after a casualty of fire or flooding. This may e.g. be that the remaining system will continue at it's initial level of functionality with remote control and automation available
   - the approach for eventual manual actions/local interventions that may be needed to restore system capabilities, and to support operation for the voyage back to port, in relevant locations
   - the eventual use of protection of cables, pipes, equipment to achieve the robustness, e.g. planned use of fire resistant cabling where appropriate routing is impractical.
3) Sub-systems:
   - identify and describe the design intention of eventual sub-system that are part of the main system (e.g. for the fuel oil system this may consist of storage system, transfer system, treatment system etc).
4) Auxiliary systems:
   - identify and describe all auxiliary/supporting systems that the main system depends upon, and how these are arranged to support the design intention and robustness of the main system
   - describe in particular the intended arrangement of power supplies and control and safety systems.

   Examples: 1. for propulsion, this may be e.g. the fuel oil, lub oil, cooling, ventilation etc in addition to electrical power, control and monitoring, control air, ventilation etc. 2. For watertight doors, this may include e.g. the control system and electrical power.

Supporting principle illustrations/drawings should be given in the text or as attachments showing the main system arrangement, the intended location in compartments and MVZ's, principal cabling and routing, identification of relevant boundaries/bulkheads/MVZ's.

APPENDIX C EXPECTED CONTENTS OF A SYSTEM ASSESSMENT

This appendix shows the possible structure and expected contents of a system assessment. Each of the systems required to remain operational after a casualty shall be assessed. As the nature of the systems vary widely, the contents and extent of the assessment may vary accordingly, but the principle structure as indicated below may be used as a general basis for all the systems. The assessment report may be developed as one common report covering all systems, or in separate reports for each individual system covered by the regulations.

As for the system design philosophy, the propulsion system may be covered in separate assessments of each auxiliary, but the propulsion function must be based on an assessment of the simultaneous availability of all auxiliaries. This implies that the propulsion assessment must tie all the underlying assessments together.

Note that the assessment shall cover both the restoration of the function and also what is needed to keep the function in operation during the voyage back to port.

1 SRTP system assessment

1) Introduction:
   - purpose
   - reference documents, identify clearly on what documentation basis the assessment is done (i.e. which documents, databases, models
   - abbreviations and definitions (if necessary).
2) SRtP requirements (applicable for the system):
   - relevant rules and regulations
   - additional requirements.
3) Design intent/redundancy intent:
   - What the design intention is, how the redundancy is arranged, what level of performance is intended to be available after a casualty, are there particular casualties that may render the system in a state that demands extensive manual intervention.
   - What the intended use and dependency of fire rated cables and pipes are for the systems to remain operational.
   - What is considered as 'remain operational' for the system and what the intended level of performance/capabilities is (i.e. will automatic functions and remote control be available or will any particular manual intervention be required to restore and maintain operation).
4) System description:
   - general system layout, drawings and sketches of the system arrangement
   - detailed system layout – to the extent necessary to enable the assessment including cable runs and piping
   - dentification of all supporting/auxiliary systems needed for the system to remain operational (e.g. power, control, ventilation, instrument air etc.)
   - identification of eventual x-connections between the redundant systems.
5) System assessment (covering both the safe return to port scenarios (reg.21) and abandon ship scenarios (reg.22):
   - Casualty scenarios.
   - Identification of the different categories of casualties that may affect the system, preferably containing graphical illustration of casualties in the different compartment containing system components (e.g. – if there is a fire in the emergency centre in a MVZ, the control unit for the watertight doors may be lost whereas a fire/flooding in another watertight compartment may only cause loss of a single watertight door).
   - Assessment of the consequence of all relevant casualty scenarios and the system capabilities, including all the supporting/auxiliary systems identified above. The assessment must conclude on

compliance with the SRtP regulations, and if there are conflicts, possible compensating or mitigating measures must be described. Particular focus on casualties that may affect the x-connections or other common mode failures. If there are numerous scenarios, the casualty scenarios may be grouped for the different categories of casualties.

- Specification of the acceptance criteria, i.e. what is the intended level of performance for the system to be deemed 'operational'.
- Identification of necessary manual actions if needed to restore and maintain system capabilities in accordance with the design/redundancy intent described above.

6) Verification and test:

- The assessment should identify relevant tests to substantiate the analysis and eventual assumptions. If manual actions are needed after a casualty for the system to 'remain operational' – relevant manual actions should be covered. The eventual tests identified in the assessment may be done in connection with system tests or included as part of the quay- and sea trial programme.

7) Conclusions:

- The assessment shall conclude on compliance. If additional detailed assessment is required to reach a conclusion, or if additional documentation from e.g. sub-suppliers are needed, or if detailed assessment of cable are necessary to reach a conclusion, the assessment shall be continued in a second revision when such information is available.

APPENDIX D DOCUMENTATION TIMELINE

An illustration of the expected timeline of the development of the SRtP related documentation relative to the newbuilding project schedule is shown in Figure 1.

1 SRtP documentation

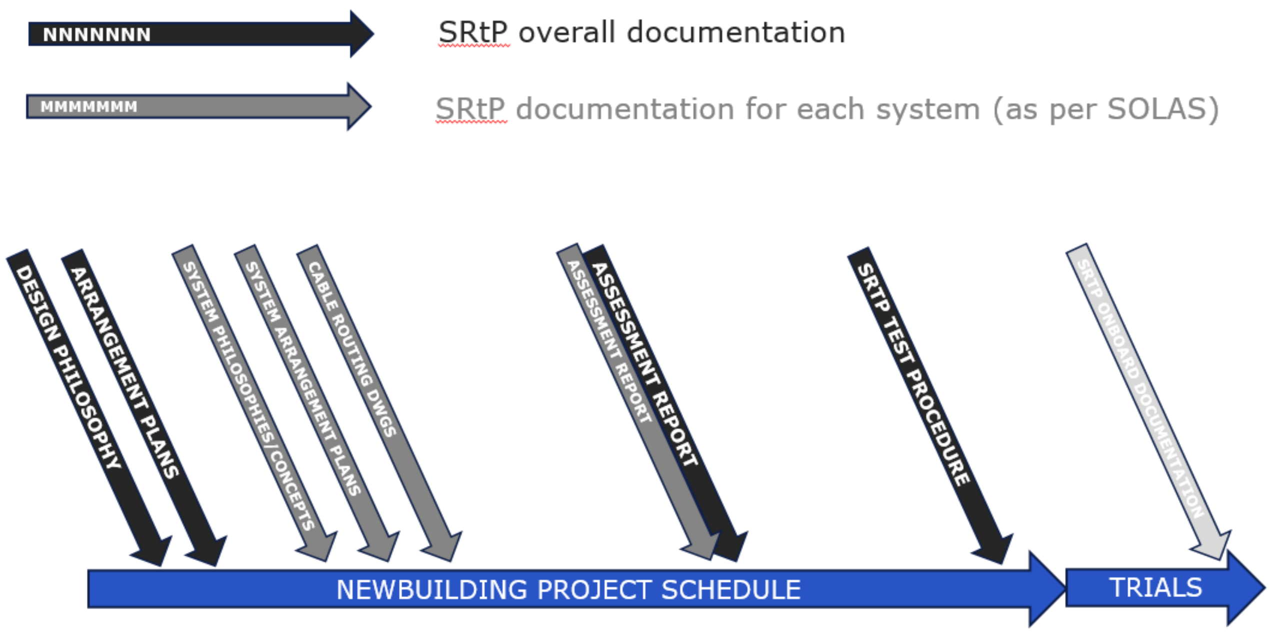

Figure 1 SRtP documentation flow and sequence

Note:

— The SRtP design philosophies and arrangement plans shall be developed in the early phase of a project, and forms part of the specification for the detail design phase. This means that both the relevant sections at the yard as well as sub-suppliers shall be aware of these documents when doing the detail design.

— The SRtP design philosophies and arrangement plans shall be available for the approval engineer before any detail design drawings may be approved for the specific systems covered by the SRtP regulations (e.g. – the P&ID's for the bilge system may not be approved before the bilge design philosophy document is available).

---e-n-d---o-f---n-o-t-e---

APPENDIX E EXPECTED CONTENTS OF THE HYDRODYNAMICAL CALCULATION REPORT

The capabilities for each propulsion line of a SRtP vessel shall - after any SRtP casualty - be sufficient to provide a speed of 6 knots while heading into Beaufort 8 (BF8) weather conditions. This capability shall be documented in a calculation report.

This appendix describes the recommended approach for the hydrodynamical calculations.

1 Assumptions

The environmental conditions representing Beaufort as specified in the **SRTP** notation represent a calculated 'average' BF8 sea state. This implies that a vessel satisfying the assumptions stated in this appendix may not be able provide 6 knots in any BF8 sea state, nor reach port in the determined time under all conditions.

1.1 Environmental conditions

The hydrodynamical calculations should be based on the following environmental conditions:

— constant uniform head wind of 19 m/s
— long crested head sea Pierson Moskowitz wave spectrum
— significant wave height of 5.0 m
— wave peak period of 13.0 s
— no current
— water density: 1026 kg/m^3.

This corresponds to an 'average' BF8 sea state.

1.2 Vessel state

The computation should be performed at even keel, zero heel and summer load line draught. When assessing the ability to achieve 6 knots in BF8, the 6 knots speed of the vessel should be taken into consideration. The radii of gyration should be taken from the loading condition in the stability booklet closest to this condition. The drag resistance of the faulty propulsion line including propeller may be neglected in the computations.

2 Propulsion capabilities - six (6) knot in BF8

The documentation of the calculations should include all relevant input data, justify all assumptions made and explain how the different values are obtained.

Results obtained from eventual model tests should capture the same effects as set forth in this section. The model test report should document how the different calculation requirements are included in the model test results.

The calculation of required engine torque in BF8 conditions should include the physical effects given in the following subsections.

2.1 Calm water resistance

The trial condition of the vessel should be considered. This means that effects like appendages, rudder and roughness should be included. Air resistance should not be included. The calm water resistance may be calculated by published and recognized empirical methods, e.g. Holtrop or Hollenbach. For vessels larger than 120 m the wave making resistance may be neglected. As a minimum the wetted surface, and the frictional, viscous, appendage and roughness resistance coefficients should be reported.

2.2 Wind resistance

The wind resistance may be computed based on published and recognized empirical methods, e.g. Blendermann. The wind speed in the calculations should be 22.1 m/s, which includes the 6 knots forward speed of the vessel. As a minimum frontal projected area and applied drag coefficient should be reported.

2.3 Added resistance in waves

The added resistance in waves should be computed in an irregular sea state. The added resistance in waves may be calculated based on published and recognized methods, e.g. ISO 15016 Annex D.2. As a minimum the added resistance operator (ARO, added resistance per meter wave amplitude squared as function of wave period) and the added resistance in waves should be reported.

2.4 Thrust deduction and wake fraction

The applied thrust deduction and wake fraction at six (6) knots should be reported and justified.

2.5 Propeller open water curve

The thrust from the propeller should balance the forces from calm water resistance, wind resistance, added resistance in waves and thrust deduction:

$$T = R/(1-t)$$

where:

— T = propeller thrust
— R = total resistance (calm water, wind and waves)
— t = thrust deduction.

The necessary propeller revolutions per minute [rpm] to achieve the required thrust should be determined based on the propeller open water curve. In lack of data for the design propeller, an equivalent propeller from a published and recognized propeller series, e.g. the B-series, with same main particulars may be used. As a minimum the propeller diameter, pitch ratio, number of blades, blade area ratio, open water curves and required rpm should be reported.

2.6 Torque limit curve of engine

The engine shall have sufficient power to turn the propeller at the required rpm. The required brake torque of the engine should be determined from the propeller open water curves, required propeller rpm, mechanical losses (between the propeller and engine) and possibly gears. The available brake torque from the engine shall exceed the required brake torque. As a minimum the propeller torque, mechanical losses, gear ratio and engine torque limit curve should be reported.

2.7 Dimensioning time for the SRtP voyage

The duration of the dimensioning SRtP voyage, i.e the time needed for the vessel to return to port from the most remote location of the planned operation, may be calculated based on same procedure as the 6 knots in BF8 calculation.

For the voyage back to port, the following conditions should be applied:

— 3 hours of the voyage at 6 knots in the BF 8 conditions specified above.
— The remaining part of the voyage at the designed speed while heading into a Beaufort 4 sea state with the following conditions:
    — constant uniform head wind of 7 m/s

— long crested head sea Pierson Moskowitz wave spectrum
— significant wave height of 1.0 m
— wave peak period of 10.0 s
— no current.

Table 1 and Table 2 give an overview of the parameters for the hydrodynamical calculation.

Table 1 Main results

Parameter	*Value*	*Unit*
Capable of doing 6 knots in Beaufort 8	Yes/No	n/a
SRtP distance (maximum distance to port)		nm
Attainable speed in Beaufort 4		knots
Time to port		hours

Table 2 Detailed results

Parameter	*Value at 6 knots in Beaufort 8*	*Value at X knots in Beaufort 4*	*Unit*
Vessel draught			m
Vessel trim			m (positive bow up)
Wetted surface			m^2
Frictional resistance coefficient			n/a
Viscous resistance coefficient			n/a
Appendage resistance coefficient			n/a
Roughness resistance coefficient			n/a
Wave resistance coefficient (for vessels having a length less than 120 m)			n/a
Calm water resistance			N
Frontal projected wind area			m^2
Wind resistance drag coefficient (based on apparent wind speed and frontal projected wind area)			n/a
Wind resistance			N
Added resistance operator (added resistance per meter wave height squared)			Nm^2
Added resistance in waves			N
Total resistance			N
Thrust deduction			n/a
Wake fraction			n/a
Required thrust			N

Parameter	*Value at 6 knots in Beaufort 8*	*Value at X knots in Beaufort 4*	*Unit*
Propeller diameter			m
Propeller pitch ratio			n/a
Propeller number of blades			n/a
Propeller blade area ratio			n/a
Propeller open water curves	Plot		n/a
Propeller speed			rpm
Propeller torque			Nm
Mechanical efficiency			n/a
Gear ratio			n/a (> 1 means engine is faster)
Engine torque limit curve	Plot		Nm

CHANGES – HISTORIC

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There are currently no historical changes for this document.

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DNV GL is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.

SAFER, SMARTER, GREENER