

LIFE CYCLE OF SHIPS AND OFFSHORE STRUCTURES - INSPECTION AND SURVEY OF SHIP STRUCTURES: AN INTRODUCTION

Cesare Mario Rizzo

Department of Naval Architecture and Marine Technologies, University of Genova, Italy

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Summary

This chapter introduces the inspection and survey of ships looking at this intricate topic from several different viewpoints. Numerous stakeholders play various roles in the shipping industry, ranging from ship and cargo owners to insurance companies, from society at large represented by maritime administrations to regulatory and inspection bodies, etc. As shipping is intrinsically an international and strategic business, its regulations and standards, as well as the relevant inspection activities have long been the subject of international agreement.

Indeed, due to the large number of actors on the scene, the inspection and survey regime of ships is not easy to unravel. Though many books and documents present the matter from the viewpoint of one of the stakeholders, very few give an overall presentation of this subject in a rational way. Some bibliographical references are provided at the end of this chapter, together with some brief explanations for further elucidation.

In the following, the ship inspection or survey is treated as an event occurring at various times within a ship's life. As such, the discussion starts by identifying who requires, and who carries out inspections and surveys. This is done in some detail, thus introducing the main regulatory instruments (rules and conventions) applicable to ships and the various inspection and survey bodies which verify their application.

A brief summary is given of the frequency of inspections and surveys, operational and environmental conditions during inspections and the location on ships and of items to be inspected or surveyed.

A more comprehensive description of items to be inspected or surveyed and relevant degradation modes and/or expected defects follows, with particular reference to structural deterioration.

State of the art of inspection and survey methods and techniques are reviewed: the focus is not on non-destructive testing (NDT) or test techniques, rather on the onboard practices covering safety measures, accessibility and scope and extension of inspections and surveys. Although NDT techniques are applied, the survey practice and management is the dominant factor, crucial for the success of the survey or inspection.

The conclusion of this chapter deals with the "Inspection Matrix": such a matrix is a proposal to establish a rational tool for the judgment of the ship inspection and survey regime, identifying areas that may be subject to possible over-inspection and areas possibly requiring further strengthening of the inspection and survey regime.

The terms "inspection" and "survey" are often incorrectly used as synonyms. Within the marine environment they carry quite different definitions. An inspection is a verification that a specific item, whether a piece of structure or item of equipment, meets a specific regulatory or other standard at the time that it is inspected. For example, a flag State inspector will verify that a fire extinguisher certificate is current and has not expired at the time that it is visually inspected. At a scheduled inspection, all fire extinguishers on the ship will be checked to verify compliance in this manner.

A survey is carried out by a classification society surveyor. It is a risk-based approach to assessing the overall compliance of a vessel's structure and machinery with the applicable Rules of that society by sampling based on empirical experience. Such sampling allows the surveyor to use his professional judgment to determine if the vessel will continue to remain in compliance with the relevant Rule requirement for the period until the next scheduled survey. The sampling approach is necessary because of the size and complexity of modern ships. For example, a large tanker will have many kilometers of welds within its hull structure. It is not practical to visually inspect every centimeter of those welds on a periodic basis. However, experience will indicate that certain areas of the ship are subject to higher stress or greater corrosion and so the survey will focus on those areas.

A further term "audit" should also be introduced as certain regulatory requirements are subject to periodic audit. These are principally the ISM and ISPS Codes (see Section 6.1.2.1.1.1 below). These are management systems. Verification of compliance is carried out through an audit of the system by a trained auditor.

In many instances the classification society surveyor will attend a ship in multiple roles: he may conduct a periodic class survey; he may then act as a flag State inspector to conduct a regulatory inspection; and, if appropriately trained, he may then act as an auditor to verify continued compliance with the statutorily mandated ISM and ISPS Codes.

1. Introduction

The regulatory regime affecting marine structures is a very complex scenario and the related inspection and survey regime, generated by several applicable regulations, is not easy to screen. Indeed, several inspections and surveys are carried out, either mandatorily or industry driven. At this time it is appropriate to analyze and better understand the inspection and survey practices, thus giving an overview of the current ship inspection, survey and maintenance process.

The International Maritime Organization (IMO) was established as a UN agency to adopt legislation and manage the regulatory regime governing the international shipping industry. National Governments are responsible for enacting into domestic legislation and implementing the regulations adopted by the IMO. When a Government accepts an IMO Convention, it agrees to make it part of its own national law and to enforce it just like any other law.

Generally, each regulatory instrument implies inspections to verify the correct implementation of the rule requirements at specified intervals throughout the ship's lifetime. However, some countries lack expertise, experience and necessary resources to properly do this.

For these reasons some countries delegate the responsibility and outsource inspection and certification duties to third party authorities, termed Recognized Organizations (typically classification societies), trusting their knowledge and capabilities in fulfilling the government obligations.

On the other hand, it is the ship-owner who is ultimately responsible for compliance with international and national obligations. Yet, it is incumbent upon any State which allows the registration of ships under its flag to effectively exercise jurisdiction and control in administrative, technical and social matters.

In the following, the inspection and survey regime typically applied to ships is analyzed. The analysis is divided into five main issues making use of the “WWWWH” acronym (who, when, where, what and how):

1. WHO includes the study of who is setting the rule and who is supposed to verify its implementation; the regulatory bundle has been divided into mandatory inspections and voluntary ones.
2. WHEN takes into consideration both the frequency with which the inspections or surveys are carried out and the ship’s age at the time of the inspection or survey. Another consideration that should be included is the circumstances under which the inspections and surveys are performed, either from an operational or environmental point of view.
3. WHERE takes into account the geographical location of the ship during inspection or survey and the areas/parts of the vessel being inspected or surveyed.
4. WHAT describes the items subject to the inspection or survey, i.e. the ship’s components and their relevant function rather than their location. In this review the focus is on the structural items and their related deficiencies and degradation phenomena.
5. HOW means the approaches, techniques and methods applied for inspections and surveys. It takes into account mainly structural inspection or survey in the present document and focuses on the safety assessment during such inspections or surveys.

The W.W.W.W.H.: a rational approach to inspection procedures

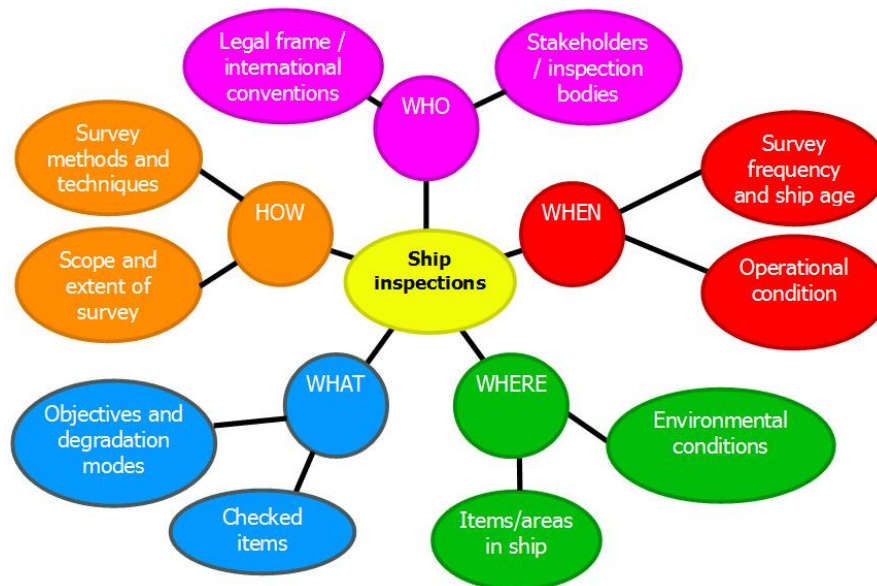


Figure 1. Rational overview of the ship inspection and maintenance regime

The diagram in Figure 1 shows a global viewpoint for the ship inspection, survey and maintenance regime. The attempt is to give a more rational and logical presentation of a

very complex and, some would argue, over-regulated situation with the aim both to improve the knowledge of the matter and to address possible modifications.

However, overlapping of the above mentioned categories occurs since it is almost impossible to give a complete picture strictly divided into separate chapters. The inspection, survey and maintenance of a ship is a complex, multifaceted process involving not only technical engineering issues but also economical and social interests.

2. Who

2.1. Who Requires Inspections (Legal Framework / International Conventions)

Merchant shipping is one of the most strictly regulated industries and was among the first to adopt widely implemented international safety standards. Regulations concerning shipping are developed at the global level. Because shipping is inherently international, it is vital that shipping is subject to uniform regulations on matters such as construction standards, navigational rules and standards of crew competencies. The alternative would be a plethora of conflicting national regulations resulting in commercial distortion and administrative confusion which would compromise the efficiency of world trade.

The shipping industry is principally regulated by the International Maritime Organization (IMO, www.imo.org), which is the London based United Nations agency responsible for the safety of life at sea and the protection of the marine environment. The International Labour Organization (ILO, www.ilo.org) is also responsible for the development of labor standards applicable to seafarers worldwide. IMO has adopted a comprehensive framework of detailed technical regulations in the form of international diplomatic conventions which govern the safety of ships and protection of the marine environment. The IMO web site and, to a lesser extent, the ILO one summarize the conventions' implementation over the last decades.

National governments, forming the membership of IMO (and ILO), are required to implement and enforce these international rules and verify that the ships which are registered under their national flags are in compliance. The level of ratification and enforcement of IMO Conventions is generally very high in comparison with international rules adopted for shore based industries.

The following sections provide further details of international conventions and regulations requiring inspections onboard, divided into mandatory and industry driven inspections. Note also the details about inspection bodies that actually carry out physical inspections.

2.1.1. Mandatory Inspections

International conventions issued by IMO (i.e. SOLAS, MARPOL, LL, Tonnage etc) and rules of the main classification societies are the documents essentially governing the inspection practice for commercial ships. Some brief summaries are given in the following regarding the required inspections of the main regulatory instruments issued by IMO and/or recalled by international conventions. Major Classification Societies (i.e. those members of the International Association of Classification Societies, IACS) also

establish self-regulatory and therefore voluntary standards that are subject to surveys as well. The IMO has tried to synchronize the various types of inspections under the HSSC 5 year scheme (IMO “Harmonized System of Survey’s and Certification”, entered into force on 3 February 2000 adopted since 1988). It gives a time frame for annual (A), intermediate (I) and renewal or special (R or S) surveys required by the main conventions and rules, repeating every 5 years as shown in Table 1:

Years	1			2			3			4			5	
Months	9	12	15	21	24	27	33	36	39	45	48	51	57	60
SOLAS passenger	R		-	R		-	R		-	R		-	R	-
SOLAS cargo	A			A or I			I or A			A			R	
MARPOL	A			A or I			I or A			A			R	
ILLC	A			A			A			A			R	
Class hull & machinery	A			A or I			I or A			A			R	
IGC/GC (Gas)	A			A or I			I or A			A			R	
IBC/BCH Chem.)	A			A			A			A			R	

Table 1. Survey requirements of main international conventions and of IACS class rules
Main conventions and regulations are briefly presented in the following.

2.1.1.1. SOLAS

Among all international conventions dealing with maritime safety, the most important is the International Convention for the Safety of Life at Sea, better known as SOLAS, which covers a wide range of measures designed to improve the safety of shipping.

The convention is also one of the oldest of its kind: the first version was adopted in 1914 following the sinking of the Titanic with the loss of more than 1500 lives. Since then, there have been four more versions of SOLAS. The present version was adopted in 1974, entered into force in 1980 and has been modified by several amendments during the last years, as reported on the IMO web site.

The certificates covered by SOLAS are the Cargo Ship Safety Equipment Certificate for the life-saving appliances and other safety equipment of cargo ships, the Cargo Ship Safety Radio Certificate for the radio and radar installations and the Cargo Ship Safety Construction Certificate which includes initial, periodical and occasional surveys of structures, machinery and ship equipment. A Passenger Ship Safety Certificate is issued to passenger ships covering all cited aspects and subject to renewal inspections every year.

According to HSSC Protocol to SOLAS a unique Cargo Ship Safety Certificate may be substituted for the Cargo Ship Safety Construction, the Cargo Ship Safety Equipment and the Cargo Ship Safety Radio Certificates.

So far, the issuance of each certificate requires inspections to be conducted at the beginning of and throughout ship’s life, according to Table 1.

Moreover, among others applicable to specific ship's categories, SOLAS explicitly adheres to the following codes and regulations that require additional surveys, inspections or audits:

- ISM

The International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention is mandatory under SOLAS for passenger ships (including high-speed craft), oil tankers, chemical tankers, gas carriers, bulk carriers and cargo high-speed craft of 500 gross tonnage and upwards. The Code provides a universal standard of safety and environmental protection subject to a formal audit procedure, which must be conducted by qualified auditors in accordance with internationally agreed criteria.

The certificate issued according to this code is the Safety Management Certificate (SMC), a document issued to a ship which signifies that the Company and its shipboard management operate in accordance with an approved safety management system. A document is also issued to the ship management company. Under the ISM Code and the Safety Management System a safety and environmental protection policy must be formulated with specific written procedures being available onboard each ship. This certificate is similar to the well known quality assurance schemes adopted by other industrial process under ISO 9000 standards.

- ISPS

The International Ship and Port Facility Security Code (ISPS Code) was adopted in 2002 by a Conference of Governments, signatories to the SOLAS convention, and enforced as SOLAS amendments.

The ISPS Code was developed by the IMO as a response to the perceived threats to ships and port facilities in the wake of terrorism attacks such as the 9/11 attack in the United States. The ISPS Code was developed to function as a 'set of measures to enhance the security of ships and port facilities'. Under the ISPS Code, each SOLAS contracting Government which ratified the amendments is responsible for enforcing the ISPS Code and may add mandatory and recommended procedures.

The goals of the ISPS Code are aimed towards establishing an international framework for co-operation between Contracting Governments, Government agencies, local administrations and the shipping and port industries. It is organized to establish relevant roles and responsibilities at the national and international level. These objectives are to be achieved by the designation of appropriate personnel on each ship, in each port facility and in each ship owning company to make assessments and to put into effect the security plans that will be approved for each ship and port facility.

A ship is issued with an International Ship Security Certificate (ISSC) to indicate compliance with the applicable requirements. The Company Security Officer (CSO) is responsible for verifying that a Ship Security Assessment (SSA) is carried out for each of the ships in the Company's fleet requiring compliance with the provisions of this Code. The ISPS code also requires that security assessments are carried out and that security plans are developed for ports and terminals.

- ESP survey regime

Regulation 2 of SOLAS Chapter XI requires that bulk carriers and tankers shall be subjected to Enhanced Survey Program (ESP) of structures in accordance with guidelines adopted in 1993 and included in the new revision of the Unified Requirement Z.10 of IACS namely relevant to hull surveys of tankers and bulk carriers, also usually referred to as ‘ESP ships’.

After the implementation and adherence to these strict measures over the last few years a decrease in tanker and bulk carrier casualties was observed when compared with those in the late seventies and even later.

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TO ACCESS ALL THE 51 PAGES OF THIS CHAPTER
Visit: <https://www.eolss.net/Eolss-sampleAllChapter.aspx>

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In addition to rules, conventions guidelines and similar official and background documentation that may be found in the cited web sites, the following references are provided with comments indicating their specific topic:

Rizzo C.M. (2007). *Inspection methods: how to define the probability of detection and the probability of sizing of the degradation effects of ship structures*, MASTRUCT report MAR-W6.3.1-DINAV-02(1), Network of Excellence on Marine Structures (MARSTRUCT), financed by the E.U. through the 6th FP under Contract No. TNE3-CT-2003-506141. [This report analyze the uncertainties sources involved in the process of detection and sizing of degradation of ship structures, focusing mainly on practical aspects rather than theoretical issues]

Rizzo C.M. (2008). *Inspection methods for degradation of structures: the current inspection regime and its effectiveness*, MASTRUCT report MAR-W6.3.1-DINAV-05(1), Network of Excellence on Marine Structures (MARSTRUCT), financed by the E.U. through the 6th FP under Contract No. TNE3-CT-2003-506141. [This report gives a comprehensive review of the ship inspection regime, focusing on structural degradation; the current chapter is mainly based on this report]

Rizzo C.M., Lo Nigro A. (2008). *A review of ships surveys practices and of marine casualties and incidents partly due to aging effects*, paper OMAE2008-57847, Proceedings of OMAE2008, 26th International Conference on Offshore Mechanics and Arctic Engineering, 15-20 June, 2008, Estoril, Portugal [This paper proposes to analyze the ship inspection regime in the light of ships casualties’ statistics, thus originating the idea of a rational analysis of ship inspections]

ISSC (2003). Committee V.2, *Inspection and monitoring*, International Ship and Offshore Structures Congress, 11-15 August 2006, San Diego, CA. [This ISSC report covers several topics associated with assessment of structural integrity of aging structures, providing a state of the art until 2002]

ISSC (2006). Committee V.6, *Condition assessment of aged ships*, International Ship and Offshore Structures Congress, 20-28 August 2006, Southampton, UK. [This ISSC Committee was established in 2003, the report provides detailed information about structural inspections and structural maintenance and repair, thus integrating the brief overview given in the present document]

ISSC (2009). *Condition Assessment of Aging Ships and Offshore Structures*, International Ship and Offshore Structures Congress, 16-21 August 2009, Seoul, Korea [This ISSC report continues the work of the ISSC 2003 and 2006 Committees and expands the subject covering some additional specific topics like offshore structures, also updating the state of the art up to 2008]

Paik J.K., Melchers R.E. (2008). *Condition assessment of aged structures*, Woodhead Publishing Ltd. ISBN 1-84569 334-5 [This book covers a wide range of topics associated with assessment of structural integrity of aging structures. Chapters 1, 13 and 15 specifically deal with inspection and maintenance of ship and offshore structures]

Report SSC-332 *Guide For Ship Structural Inspections*; Report SSC-372 *Maintenance of Marine Structures; A State Of The Art Summary*; Report SSC-389, *Inspection of Marine Structures*; Report SSC-408, *Detection Probability Assessment for Visual Inspection of Ships*; Report SSC-421 *Risk Informed Inspections of Marine Vessels*, all available at www.shipstructures.org [These reports provide a comprehensive guide of ship structures inspections, covering all aspects, especially in their first chapters before dealing with a few specific issues. They also may give an overview of the evolution in the last years and of the future trends]

Useful Links

Classification societies

- [1] American Bureau of Shipping (ABS), www.eagle.org
- [2] Bureau Veritas (BV), www.bureauveritas.com
- [3] China Classification Society (CCS), www.ccs.org.cn
- [4] Det Norske Veritas (DNV), www.dnv.com
- [5] Germanischer Lloyd (GL), www.gl-group.com
- [6] International Association of Classification Societies Ltd. (IACS), www.iacs.org.uk
- [7] Korean Register of Shipping (KR), www.krs.co.kr
- [8] Lloyd's Register (LR), www.lr.org
- [9] Nippon Kaiji Kyokai (ClassNK or NK), www.classnk.or.jp
- [10] Registro Italiano Navale (RINA), www.rina.org
- [11] Russian Maritime Register of Shipping (RS), www.rs-head.spb.ru
- [12] Indian Register of Shipping, www.irsclass.org

International and national regulatory bodies

- [13] American Petroleum Institute (API), www.api.org
- [14] European Maritime Safety Agency (EMSA), www.emsa.europa.eu
- [15] Health and Safety Executive, www.hse.gov.uk
- [16] International Maritime Organization (IMO), www.imo.org
- [17] International Organization for Standardization (ISO), www.iso.org
- [18] International Labour Organization (ILO), www.ilo.org
- [19] Standard of Training, Certification & Watchkeeping (STCW), www.stcw.org
- [20] Norwegian Petroleum Directorate (NPD) www.npd.no
- [21] United States Coast Guard (USCG), www.uscg.mil

Incidents investigation

- [22] Global Integrated Shipping Information System, <http://gisis.imo.org>
- [23] Australian Transport Safety Bureau www.atsb.gov.au,
- [24] Bureau d'enquêtes sur les événements de mer www.beamer-france.org
- [25] Marine Accident Investigation Branch, www.maib.gov.uk
- [26] Transportation Safety Board of Canada <http://bst-tsb.gc.ca>
- [27] Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE), www.cedre.fr
- [28] United States Coast Guard, www.uscg.mil/hq/g-m/moa/casua.htm
- [29] U.S. National Transportation Safety Board, www.nts.gov
- [30] Marine Accident Investigation and Shipping Security Policy Branch, www.mardep.gov.hk
- [31] Danish Maritime Authority, www.sofartsstyrelsen.dk
- [32] Accident Investigation Board Norway, www.aibn.no
- [33] MARS - The Nautical Institute Marine Accident Reporting Scheme, <http://www.nautinst.org>

- [34] USCG Casualty Reports, <http://www.uscg.mil/hq/g-m/moa/casua.htm>
- [35] Hong Kong Marine Dept. Reports, <http://www.mardep.gov.hk/en/publication/ereport.html>
- [36] Lloyd's MIU, www.lloydsniu.com
- [37] Marine incidents annual reports, www.msq.qld.gov.au

Ship owners and charterers associations

- [38] International Association of Dry Cargo Ship owners (INTERCARGO), www.intercargo.org
- [39] International Association of Independent Tanker Owners (INTERTANKO), www.intertanko.com
- [40] International Chamber of Shipping (ICS), www.marisec.org
- [41] International Tankers Owners Pollution Federation (ITOPF), www.itopf.com
- [42] Oil Companies International Marine Forum (OCIMF), www.ocimf.com
- [43] Chemical Distribution Institute (CDI), www.cdi.org.uk
- [44] Rightship, www.rightship.com
- [45] Baltic and International Maritime Council, BIMCO, www.bimco.com

Port State Control, Memoranda of Understanding

- [46] Paris MoU, Europe and Canada, www.parismou.org
- [47] Tokyo MoU Asia Pacific Region, www.tokyo-mou.org
- [48] Carribean MoU, www.caribbeanmou.org
- [49] Viña del Mar Agreement, Latin American Region, http://200.45.69.62/index_i.htm
- [50] Indian Ocean Memorandum of Understanding, www.iomou.org
- [51] Mediterranean Memorandum of Understanding, www.medmou.org
- [52] Black Sea MoU, www.bsmou.net
- [53] Arab States of the Gulf (Riyadh MoU)
- [54] West and Central Africa (Abuja MoU, www.abuja-mou.org)
- [55] United States Coast Guard (USCG, <http://homeport.uscg.mil>)

Protection & Indemnity Clubs

- [56] UK P&I, www.ukpandi.com
- [57] The London Steam-Ship Owners' Mutual Insurance Association Ltd., www.lssso.com
- [58] American Steamship Owners Mutual Protection and Indemnity Association, Inc., www.american-club.com
- [59] International Group of P&I, www.igpandi.org
- [60] The American club, www.american-club.com
- [61] The Shipowners' P&I Club, www.shipownersclub.com

Biographical Sketch

Cesare Mario Rizzo, MSc in Naval Architecture and Marine Engineering, PhD in Design of Marine Structures at the University of Genova (Italy), Dept. of Naval Architecture and Marine Technologies (DINAV). He was field surveyor to a classification society and consultant. Currently, he holds the position of assistant professor and researcher at DINAV, dealing with ship structures and shipbuilding. He is involved in national and international research programs in the field, recently with particular reference to the condition assessment of ageing ships and offshore structures, including degradation, inspection and maintenance. He is also involved in activities of the DINAV Ship Structures Laboratory, performing large and full scale tests of ship structures and unconventional sea trials.

He is author of more than 60 papers and some booklets for students of Naval Architecture and Marine Engineering courses; he is appointed professor of courses about ship structural design at the University of Genova and at the Italian Navy Academy in Livorno.