国 际 船 级 社 协 会

(IACS)

普 通 散 货 船

船体结构检验、评估

和修理指南

2002

IACS

INTERNATIONAL ASSOCIATION
OF CLASSIFICATION SOCIETIES

BULK CARRIERS

Guidelines for Surveys, Assessment and Repair of Hull Structure

1 Introduction

The International Association of Classification Societies (IACS) is introducing a series of manuals with the intention of giving guidelines to assist the surveyors of IACS Member Societies, and other interested parties involved in the survey, assessment and repair of hull structures for certain ship types.

This manual gives guidelines for a bulk carrier type ship which is constructed with a single deck, single skin, double bottom, hopper side tanks and topside tanks in cargo spaces, and is intended primarily to carry dry cargo, including ore, in bulk. **Figure 1** shows the general view of a typical single skin bulk carrier with 9 cargo holds.

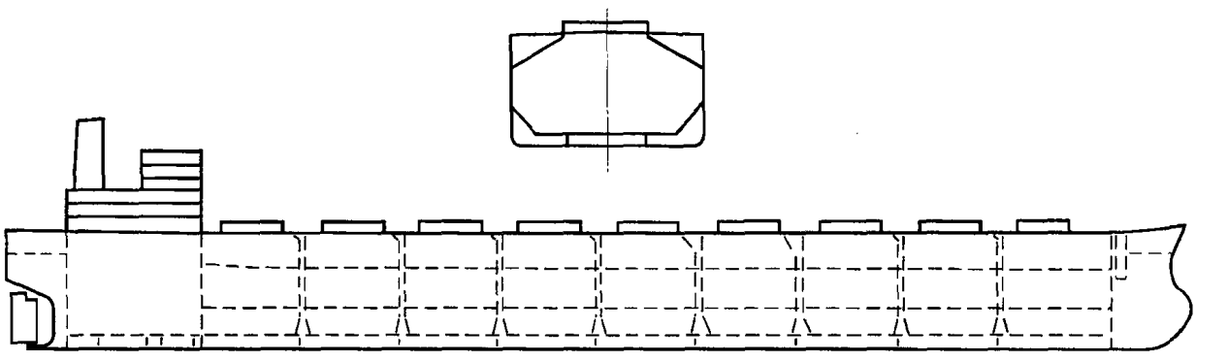

Figure 1 General view of a typical single skin bulk carrier

The guidelines focus on the IACS Member Societies' survey procedures but may also be useful in connection with inspection/examination schemes of other regulatory bodies, owners and operators.

The manual includes a review of survey preparation guidelines, which cover the safety aspects related to the performance of the survey, the necessary access facilities, and the preparation necessary before the surveys can be carried out.

The survey guidelines encompass the different main structural areas of the hull where damages have been recorded, focusing on the main features of the structural items of each area.

An important feature of the manual is the inclusion of the section which illustrates examples of structural deterioration and damages related to each structural area and gives what to look for, possible cause, and recommended repair methods, when considered appropriate.

The "IACS Early Warning Scheme (EWS)", with the emphasis on the proper reporting of significant hull damages by the respective Classification Societies, will enable the analysis of problems as they arise, including revisions of these Guidelines.

This manual has been developed using the best information currently available. It is intended only as guidance in support of the sound judgment of

surveyors, and is to be used at the surveyors' discretion. It is recognized that alternative and satisfactory methods are already applied by surveyors. Should there be any doubt with regard to interpretation or validity in connection with particular applications, clarification should be obtained from the Classification Society concerned.

Figure 2 shows a typical cargo hold structural arrangement in way of cargo hold region.

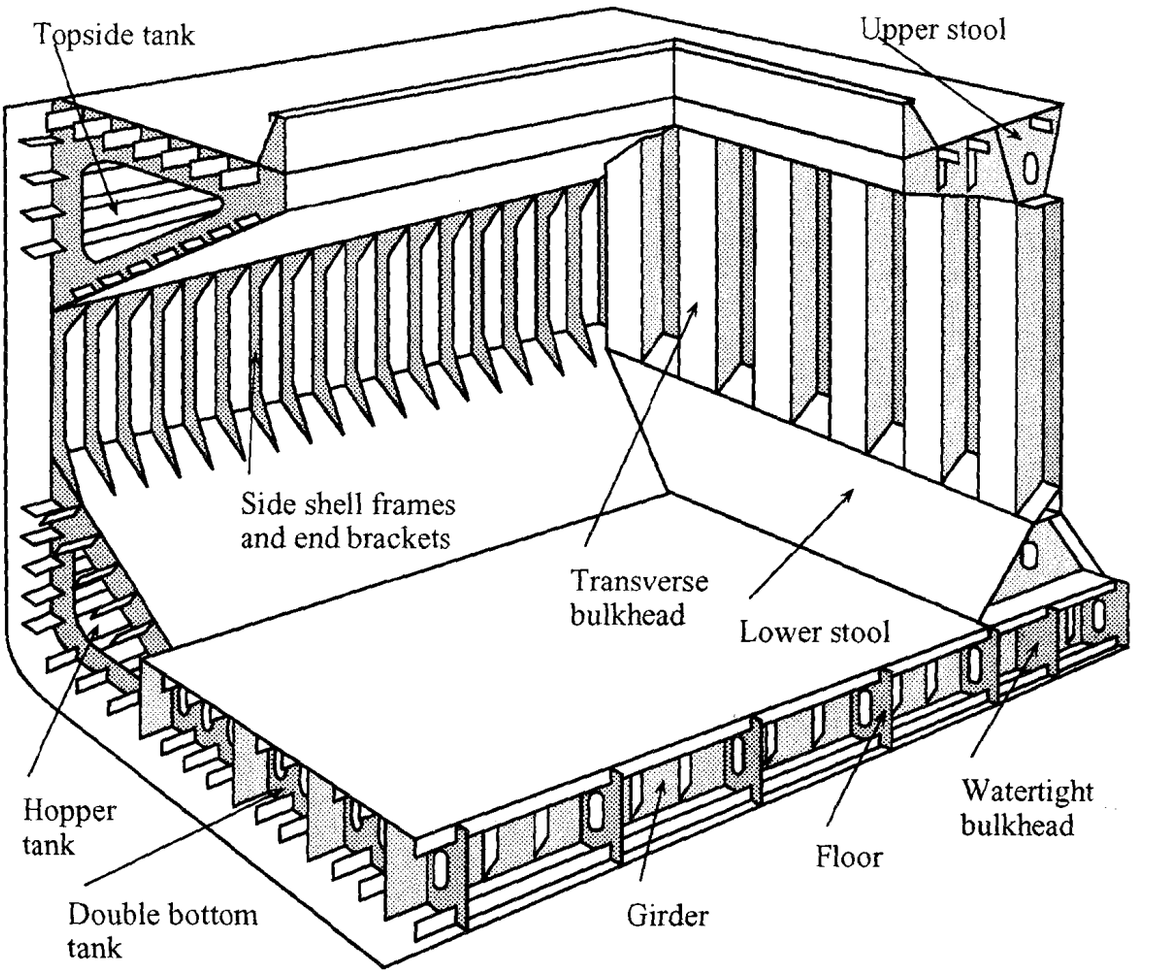

Figure 2 Typical cargo hold configuration for a single skin bulk carrier

2 Class survey requirements

2.1 General

2.1.1 The programme of periodical surveys is of prime importance as a means for assessment of the structural condition of the hull, in particular, the structure of cargo holds and adjacent tanks. The programme consists of Special (or Renewal) Surveys carried out at five-year interval with Annual and Intermediate Surveys carried out in between Special Surveys.

2.1.2 Since 1991, it has been a requirement for new bulk carriers to apply a protective coating to the structure in water ballast tanks which form part of the hull boundary, and, since 1993, to part of the side shell and transverse watertight bulkheads structures in way of the cargo holds.

2.1.3 The International Maritime Organization (IMO), in 1997 SOLAS Conference, adopted structural survivability standards for new and existing bulk carriers carrying the high density cargoes. All new single side skin bulk carriers, defined as ships built on or after 1st July 1999, are required to have sufficient strength to withstand the flooding of any one cargo hold taking dynamic effects into account. All existing single side skin bulk carriers, defined as ships built before 1 July 1999, must comply with the relevant IACS criteria for assessing the vertically corrugated transverse watertight bulkhead between the first two cargo holds and the double bottom in way of the first cargo hold with the first cargo hold assumed flooded. The relevant IMO adopted standards, IACS UR S19 and S22 for existing ships, and recommended standards, IACS UR S17, S18 and S20 for new ships, and the extent of possible repairs and/or reinforcements of vertically corrugated transverse watertight bulkheads on existing bulk carriers are freely available at IACS web site www.iacs.org.uk.

2.1.4 From 1 July 2001, bulk carriers of 20,000 DWT and above, to which the Enhanced Survey Programme (ESP) requirements apply, starting with the 3rd Special Survey, all Special and Intermediate hull classification surveys are to be carried out by at least two exclusive surveyors. Further, one exclusive surveyor is to be on board while thickness measurements are taken to the extent necessary to control the measurement process.

2.1.5 The detailed survey requirements complying with ESP are specified in the Rules and Regulations of each IACS Member Society.

2.1.6 The ESP is based on two principal criteria: the condition of the coating and the extent of structural corrosion. Of primary importance is when a coating has been found to be in a "poor" condition (more than 20% breakdown of the coating or the formation of hard scale in 10 % more of the area) or when a structure has been found to be *substantially* corroded (i.e. a wastage between 75 % and 100 % of the allowable diminution for the structural member in question.).

2.2 Annual Surveys

2.2.1 The purpose of an Annual Survey is to confirm that the general condition of the hull is maintained at a satisfactory level.

2.2.2 As the ship ages, cargo holds are required to be subjected to more extensive overall and close-up examinations at Annual Surveys.

2.2.3 In addition, overall and close-up examinations may be required for ballast tanks as a consequence of either the coating deteriorating to a *poor* condition or the structure being found to be *substantially* corroded at previous Intermediate or Special Surveys.

2.3 Intermediate Surveys

2.3.1 The Intermediate Survey replaces the second or third Annual Survey in each five year Special Survey cycle and requires that, in addition to the Annual Survey requirements, extended overall and close-up examinations including thickness measurements of cargo holds and ballast tanks used primarily for salt water ballast, are carried out.

2.3.2 The survey also includes re-examination and thickness measurements of any suspect areas which have substantially corroded or are known to be prone to rapid wastage.

2.3.3 Areas in ballast tanks and cargo holds found suspect at the previous Special Survey are subject to overall and close-up surveys, the extent of which becomes progressively more extensive commensurate with the age of the vessel.

2.3.4 As of 1 July 2001, for bulk carriers exceeding 15 years of age, the requirements of the Intermediate Survey are to be of the same extent as the previous Special Survey, except for pressure testing of cargo/ballast holds and ballast tanks which is not required unless deemed necessary by the attending surveyor.

2.4 Special Surveys

2.4.1 The Special (or Renewal) Surveys of the hull structure are carried out at five-year intervals for the purpose of establishing the condition of the structure to confirm that the structural integrity is satisfactory in accordance with the Classification Requirements, and will remain fit for its intended purpose for another five-year period, subject to proper maintenance and operation of the ship and to periodical surveys carried out at the due dates.

2.4.2 The Special Survey concentrates on close-up examination in association with thickness determination and is aimed at detecting fractures, buckling, *substantial* corrosion and other types of structural deterioration.

2.4.3 Thickness measurements are to be carried out upon agreement with the

Classification Society concerned in conjunction with the Special Survey. The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date.

2.4.4 Deteriorated protective coating in salt water ballast spaces and structural areas showing substantial corrosion and/or considered by the surveyor to be prone to rapid wastage will be recorded for particular attention during the following survey cycle, if not repaired at the survey.

2.5 Drydocking (Bottom) Surveys

2.5.1 A **Drydocking Survey** is required in conjunction with the **Special Survey** to examine the external underwater part of the ship and related items. Two Bottom surveys are required to be carried out during the five year period of validity of SOLAS Cargo Ship Safety Construction (SC) Certificate, and the maximum interval between any two successive Bottom Survey is not to exceed three years.

2.5.2 From 1 July 2002, for bulk carriers of 15 years of age and over, inspection of the outside of the ship's bottom is to be carried out with the ship in dry dock. For bulk carriers less than 15 years of age, alternative inspections of the ship's bottom not conducted in conjunction with the Special Survey may be carried out with the ship afloat. Inspection of the ship afloat is only to be carried out when the conditions are satisfactorily and the proper equipment and suitably qualified staff are available.

2.6 Damage and repair surveys

2.6.1 Damage surveys are occasional surveys which are, in general, outside the programme of periodical hull surveys and are requested as a result of hull damage or other defects. It is the responsibility of the owner or owner's representative to inform the Classification Society concerned when such damage or defect could impair the structural capability or watertight integrity of the hull. The damages should be inspected and assessed by the Society's surveyors and the relevant repairs, if needed, are to be performed. In certain cases, depending on the extent, type and location of the damage, permanent repairs may be deferred to coincide with the planned periodical survey.

Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the surveyor, will affect the vessel's structural watertight or weathertight integrity, is to be promptly and thoroughly repaired. Areas to be considered to are to include:

Side shell frames, their end attachments and adjacent shell plating, deck structure and deck plating, watertight bulkheads, and hatch covers and coamings.

2.6.2 In cases of repairs intended to be carried out by riding crew during voyage, the complete procedure of the repair, including all necessary surveys, is to be submitted to and agreed upon by the Classification Society reasonably in advance.

2.6.3 IACS Unified Requirement Z 13 "Voyage Repairs and Maintenance" provides useful guidance for repairs to be carried out by a riding crew during a voyage.

2.6.4 For locations of survey where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage. A suitable condition of class will be imposed when temporary measures are accepted.

3 Technical background for surveys

3.1 General

3.1.1 The purpose of carrying out the periodical hull surveys is to detect possible structural defects and damages and to establish the extent of any deterioration. To help achieve this and to identify key locations on the hull structure that might warrant special attention, knowledge of any historical problems of the particular ship or other ships of a similar class is to be considered if available. In addition to the periodical surveys, occasional surveys of damages and repairs are carried out. Records of typical occurrences and chosen solutions should be available in the ship's history file.

3.2 Definitions

3.2.1 For clarity of definition and reporting of survey data, it is recommended that standard nomenclature for structural elements be adopted. Typical sections in way of cargo holds are illustrated in **Figures 3 (a)** and **(b)**. These figures show the generally accepted nomenclature.

The terms used in these guidelines are defined as follows.

(a) Ballast Tank is a tank which is used primarily for salt water ballast.

(b) Spaces are separate compartments including holds and tanks.

(c) Overall examination is an examination intended to report on the overall condition of the hull structure and determine the extent of additional close-up examinations.

(d) Close-up examination is an examination where the details of structural components are within the close visual examination range of the surveyors, i.e. normally within reach of hand.

(e) Transverse Section includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom and inner bottom, hopper side tanks and top wing tanks.

(f) Representative Spaces are those which are expected to reflect the condition of other spaces of similar type and service and with similar corrosion protection systems. When selecting representative spaces, account should be taken of the service and repair history on board.

(g) Suspect Areas are locations showing Substantial Corrosion and/or are considered by the surveyor to be prone to rapid material wastage.

(h) Substantial Corrosion is an extent of corrosion such that assessment of corrosion pattern indicates a material wastage in excess of 75 per cent of allowable margins, but within acceptable limits.

(i) Coating Condition is defined as follows:

Good – condition with only minor spot rusting.

Fair – condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20 per cent or more of areas under consideration, but less than as defined for Poor condition.

Poor – condition with general breakdown of coating over 20 per cent or more of areas or hard scale at 10 per cent or more of

areas under consideration.

(j) Transition Region is a region where discontinuity in longitudinal structure occurs, e.g. at forward bulkhead of engine room and collision bulkhead.

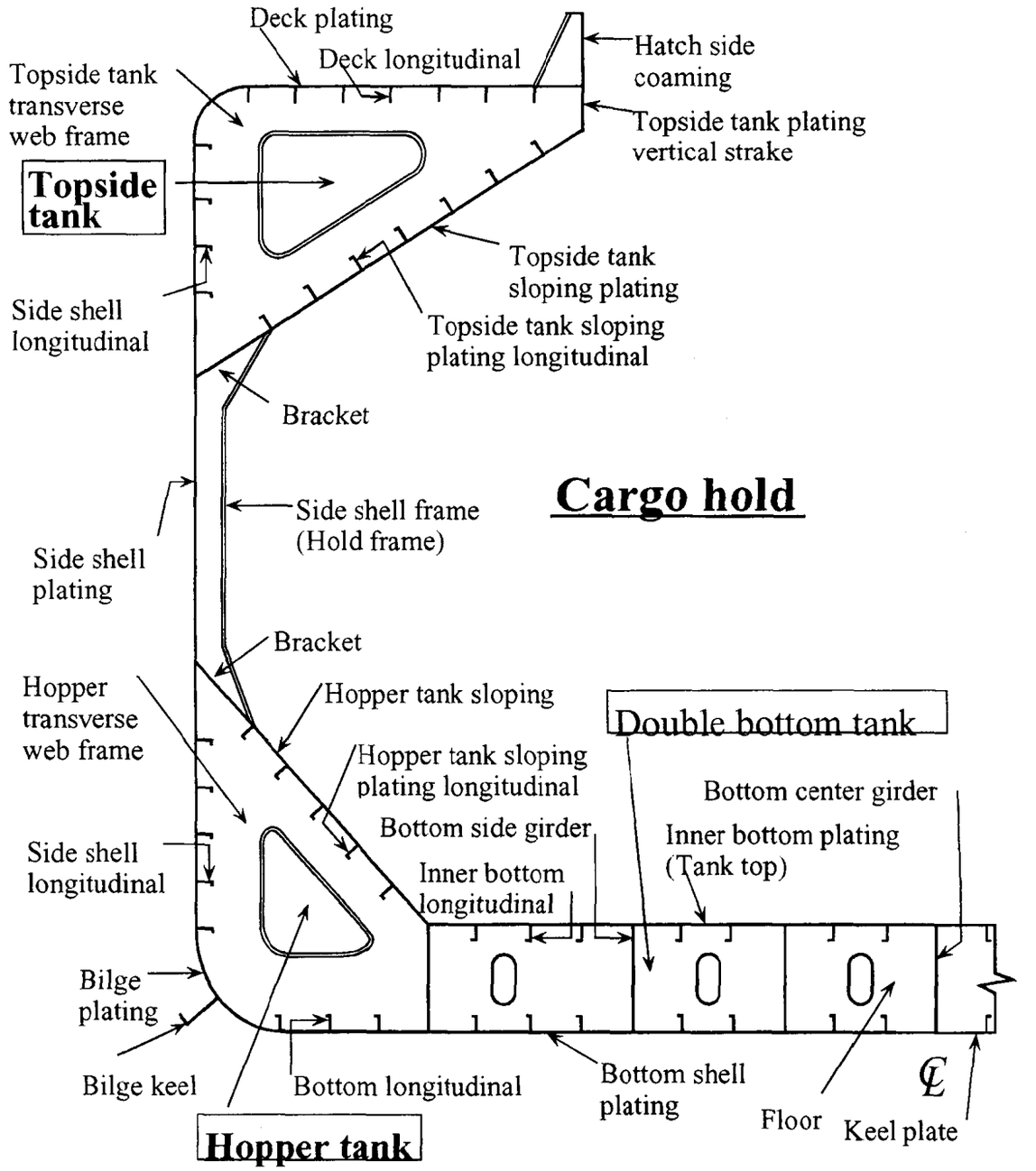

Figure 3 (a) Nomenclature for typical transverse section in way of cargo hold

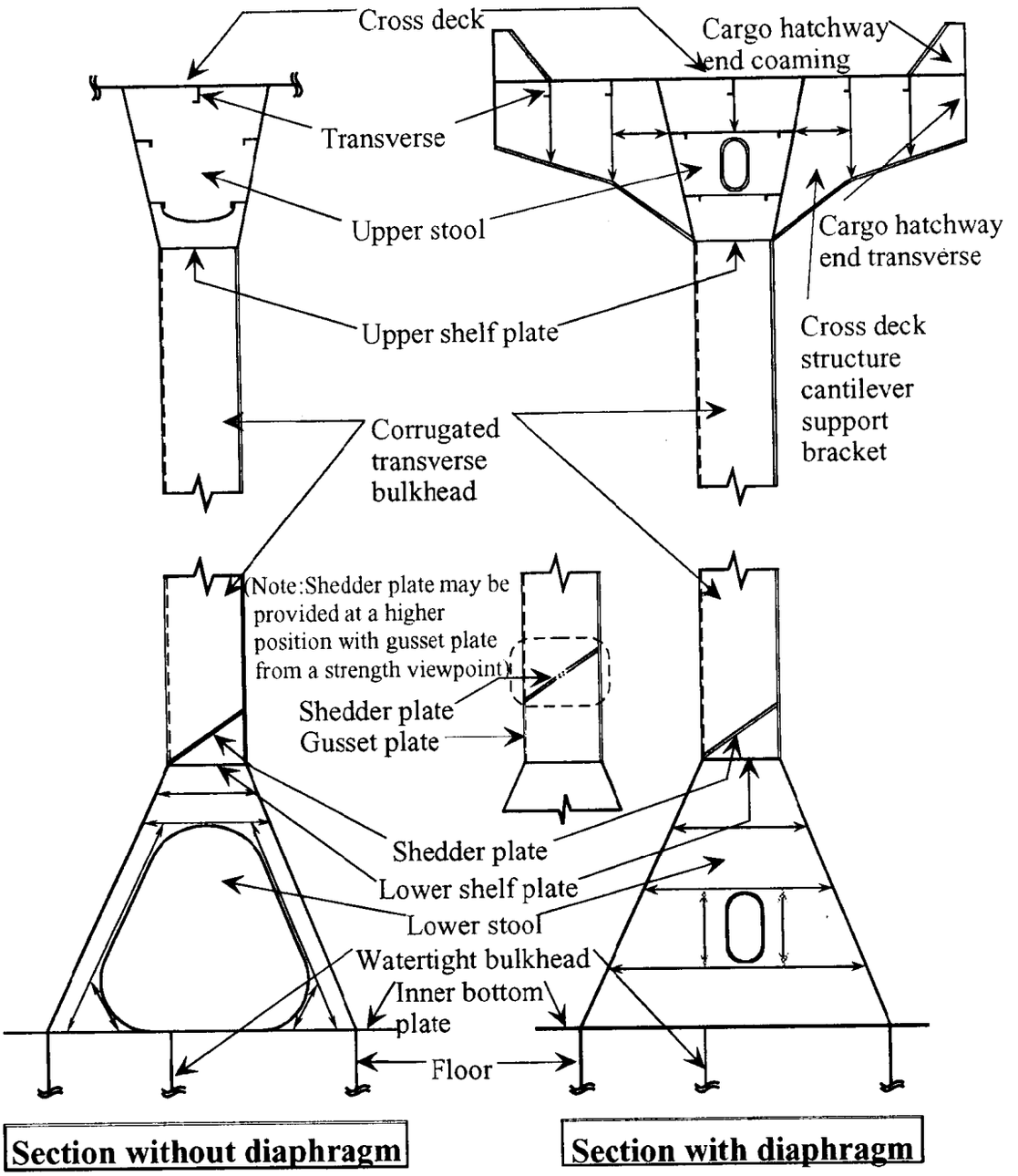

Figure 3 (b) Nomenclature for typical watertight bulkhead

3.3 Structural damages and deterioration

3.3.1 General

In the context of this manual, structural damages and deterioration imply deficiencies caused by:

- excessive corrosion
- design faults
- material defects or bad workmanship
- navigation in extreme weather conditions
- loading and unloading operations, water ballast exchange at sea
- wear and tear
- contact (with quay side, ice, touching underwater objects, etc.)

but not as a direct consequence of accidents such as collisions,

groundings and fire/explosions.
Deficiencies are normally recognized as:
- material wastage
- fractures
- deformations
The various types of deficiencies and where they may occur are discussed in more detail as follows:

3.3.2 Material wastage

In addition to being familiar with typical structural defects likely to be encountered during a survey, it is necessary to be aware of the various forms and possible location of corrosion that may occur to the structural members on decks, in holds, and in tanks.

General corrosion appears as a non-protective, friable rust which can occur uniformly on hold or tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. Thickness loss cannot usually be judged visually until excessive loss has occurred. Failure to remove mill scale during construction of the ship can accelerate corrosion experienced in service. Severe general corrosion in all types of ships, usually characterized by heavy scale accumulation, can lead to extensive steel renewals.

Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged.

Pitting corrosion is often found in the bottom plating or in horizontal surfaces, such as face plates, in ballast tanks and is normally initiated due to local breakdown of coating. Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal.

Erosion which is caused by the wearing effect of flowing liquid and abrasion which is caused by mechanical actions may also be responsible for material wastage.

3.3.3 Fractures

In most cases fractures are found at locations where stress concentration occurs. Weld defects, flaws, and where lifting fittings used during ship construction are not properly removed are often areas where fractures are found. If fractures occur under repeated stresses which are below the yielding stress, the fractures are called fatigue fractures. In addition to the cyclic stresses induced by wave forces, fatigue fractures can also result from vibration forces introduced by main engine(s) or propeller(s), especially in the afterward part of the

hull.

Fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of inspection. It is therefore important to identify, clean, and closely inspect potential problem areas. If the initiation points of a fracture is not apparent, the structure on the other side of the plating should be examined.

Fracture initiating at latent defects in welds more commonly appears at the beginning or end of a run of welds, or rounding corners at the end of a stiffener, or at an intersection. Special attention should be paid to welds at toes of brackets, at cut-outs, and at intersections of welds. Fractures may also be initiated by undercutting the weld in way of stress concentrations. Although now less common, intermittent welding may cause problems because of the introduction of stress concentrations at the ends of each length of weld.

It should be noted that fractures, particularly fatigue fractures due to repeated stresses, may lead to serious damages, e.g. a fatigue fracture in a frame may propagate into shell plating and affect the watertight integrity of the hull. In extreme weather conditions the shell fracture could extend further resulting in the loss of part of the shell plating and consequent flooding of cargo hold.

3.3.4 Deformations

Deformation of structure is caused by in-plane load, out-of-plane load or combined loads. Such deformation is often identified as local deformation, i.e. deformation of panel or stiffener, or global deformation, i.e. deformation of beam, frame, girder or floor, including associated plating.

If in the process of the deformation large deformation is caused due to small increase of the load, the process is called buckling.

Deformations are often caused by impact loads/contact and inadvertent overloading. Damages due to bottom slamming and wave impact forces are, in general, found in the forward part of the hull, although stern seas (pooping) have resulted in damages in way of the after part of the hull.

In the case of damages due to contact with other objects, special attention should be drawn to the fact that although damages to the shell plating may look small from the outboard side, in many cases the internal members are heavily damaged.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or contact damage. Elastic buckling will not normally be directly obvious but may be detected by evidence of coating damage, stress lines or shedding of scale. Buckling damages are often found in webs of web frames or floors. In many cases, this may be attributed to corrosion of webs/floors, wide stiffener spacing or wrongly positioned lightening holes, man-holes or slots in

webs/floors.

Finally, it should be noted that inadvertent overloading may cause significant damages. In general, however, major causes of damages are associated with excessive corrosion and contact damage.

3.4 Structural detail failures and repairs

3.4.1 For examples of structural defects which have occurred in service, attention is drawn to **Section 5** of these guidelines. It is suggested that surveyors and inspectors should be familiar with the contents of **Section 5** before undertaking a survey.

3.4.2 Any damage to or excessive wastage of the following structures that are considered affecting the ship's Classification is to be promptly and thoroughly repaired:

(a) Side shell frames, their end attachments and adjacent shell plating
(b) Deck structure and deck plating between hatches
(c) Watertight bulkheads
(d) Hatch covers and coamings

3.4.3 In general, where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Doubler plates must not be used for the compensation of wasted plate. Repair work in tanks requires careful planning in terms of accessibility.

3.4.4 If replacement of defective parts must be postponed, the following temporary measures may be acceptable at the surveyor's discretion:

(a) The affected area may be sandblasted and painted in order to reduce corrosion rate.
(b) Doubler may be applied over the affected area. Special consideration should be given to areas buckled under compression.
(c) Stronger members may support weakened stiffeners by applying temporarily connecting elements.
(d) Cement box may be applied over the affected area.

A suitable condition of class should be imposed when temporary measures are accepted.

3.5 IACS Early Warning Scheme (EWS) for reporting of significant hull damage

3.5.1 IACS has organised and set up a system to permit the collection, and dissemination amongst Member Societies of information (while excluding a ship's identity) on significant hull damages.

3.5.2 The principal purpose of the IACS Early Warning Scheme is to enable a Classification Society with experience of a specific damage to make this information available to the other societies so that action can be implemented to avoid repetition of damage to hulls where similar structural arrangements are employed.

3.5.3 These guidelines incorporated the experience gained from IACS EWS Scheme.