GUIDANCE NOTES
GD 21-2019

INTERNATIONAL SHIP CLASSIFICATION

SURVEY GUIDELINES FOR OIL TANKERS IN SERVICE

Effective from 1 February 2020

October 2019

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PREAMBLE

Oil Tanker is attributed to the high-risk vessel for the flammability and explosibility features of the cargoes carrying on it. Once the oil spill occurs on an Oil Tanker, the ocean circumstance will encounter a serious pollution, especially as the oil tankers have become larger and larger, the oil spill after damage of oil tanker might lead to a great hazard to the ocean and the adjacent coastlands. Therefore, International Maritime Organization (IMO), Flag States, Port States, Members of International Association of Classification Societies (IACS), Organizations of Oil Companies, etc. have to place the Safety of Oil Tankers on a very important position, and provide more and more requirements through Conventions, Regulations, Uniform Requirements of IACS, Various Rules of classification societies, Inspection Questionnaires of Oil Companies, etc. to request strictly inspections to Oil tanker with high safety standards.

The Guidelines apply to power-driven oil tankers classed with International Ship Classification (hereinafter referred to as ISC), engaged on international voyages, provided with integrated tanks, and assigned with ESP notations. The Guidelines may also be used as references for other oil tankers.

In the Guidelines, introduction is given firstly on survey preparation, including a review of requirements, safety aspects, equipment, and details of carrying out and reporting different types of surveys. The analysis of structure failure data follows with the interpretation of wastage and structural defects in terms of the effects on local strength or overall structural integrity. Basic maintenance and repair guidelines are provided along with sketches of experienced structural failures and proposed repairs. The book also incorporates the experiences of IACS and ISC about inspection and maintenance of oil tanker equipment.

The Guidelines are developed based on the relevant applicable parts of IMO Conventions, IACS uniform requirements and the latest Rules of ISC, taking into account of ISC plan approval of oil tankers under construction, experiences built during newbuilding surveys, technical analysis results of structural failure of ships in service as well as feedbacks on the 2014 version of the Survey Guidelines for Oil Tankers in Service since their implementation. Revisions have been made to the 2014 version and therefore the 2019 version is developed. The Guidelines are provided to interested parties as guidance documents only, as a support for their decision-making. When addressing specific technical issues, the decisions made in accordance with surveyors' professional judgment are to be followed. The Guidelines cannot replace relevant provisions of ISC rules and international conventions. In the event of any consistency or conflict between the provisions of the Guidelines and that in the latest version of ISC Rules for Classification of Sea-going Steel Ships (hereinafter referred to as Steel Ship Rules), the latter shall prevail.

In case of any comment and/or revision suggestion from users of the guidelines, please send it to the mailbox of Classed Ship in Service Department in ISC Headquarters: cdwork@ISC.org.cn。

CHAPTER 1 GENERAL

SECTION 1 TYPE OF SHIPS

1.1.1 Definitions

1.1.1.1 Oil tanker means a ship constructed or adapted primarily to carry oil in bulk in its cargo spaces, while oil means petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products (other than those petrochemicals specified in MARPOL Annex II) and includes, not limited to the above general principle, substances listed in Appendix I of MARPOL Annex I. Oil tanker also includes combination carrier, any "NLS tanker" as defined in Annex II of MARPOL Convention and any gas carrier as defined in SOLAS 74 (as amended) Reg. II-1/3.20, when carrying a cargo or part cargo of oil in bulk.

1.1.1.2 According to the requirements of MARPOL Annex I, the oil tanker can be subdivided into:

(1) Crude Oil Tanker
(2) Product Carrier
(3) Crude Oil/Product Carrier
(4) Chemical Tanker/Product Carrier
(5) Combination Carrier (when carrying oil)

1.1.2 Ship Type Feature of Crude Oil Tanker

1.1.2.1 Crude oil tanker means an oil tanker engaged in the trade of carrying crude oil, the deadweight of which is generally up to 322,000 tonnes. The oil tanker is divided into several categories based on DWT by the shipbuilding and ship industry:

(1) Panamax: The type of ship is terms for the size limits for ships traveling through the Panama Canal (such as the allowable size is limited by the width and length by the Canal), which are with deadweight between 50,000 and 80,000 DWT. With the widening of the Panama Canal, navigable ships became larger. The following definitions have been redefined in accordance with the shipping notices issued by the Panama Canal authority (ACP).

① Panamax: ship size and maximum draft meet the actual lock limits, i.e. 289.6m in length, 32.31m in width, and 12.04m in tropical fresh water draft.

②Panamax Plus: *Panamax* vessels authorized for tropical fresh water (TFW) draft greater than 12.04 meters up to 15.2 meters and approved for transit of the new locks.

③New Panamax*:* All vessels with dimensions greater than Panamax or Panamax Plus that comply with the size and draft limitations of the new locks; namely, 366 meters in length by 49 meters in beam by 15.2 meters, TFW draft. The limitations of navigable oil tankers increased from 70,000-76,000 deadweight tons to 200,000-300,000 deadweight tons (VLCC).

(2) Aframax: The type of ship is the Average Freight Index (AFRA) highest ship, which have the best economic and was the optimum tanker which suitable for the Baltic Sea ice class sailing. This type of ships is with deadweight between 80,000 and 120,000 DWT.

(3) Suezmax: The type of ship is terms for the size limits for ships traveling through the Suez Canal, which are with deadweight between 120,000 and 200,000 DWT.

(4) VLCC: The very large crude oil carrier which are with deadweight between 200,000 and 320,000 DWT. The VLCC are also divided into middle cross tie and side cross tie types in the aspect of different cross tie installation.

(5) ULCC: The ultra large crude oil carrier which are with deadweight over 320,000 DWT.

1.1.2.2 Crude oil tankers are generally equipped with Crude Oil Washing system (COW), Inert Gas System (IGS), Oil Discharge Monitoring system (ODME), oil-water interface detector, deck foam system and etc. Currently, the vapor control system (VCS)/ vapor control system-transfer (VCS-T) is required to be installed on oil tankers in some ports or oil terminals (such as U.S. port). The appropriate technical requirements have been given in ISC Rules for Classification of Sea-going Steel Ships. Due to loading of high sulfur content products in crude oil tankers, and according to the

PSPC requirements, an additional corrosion protective coating is painted on the deck side and lower part and floor in cargo tank for more protecting the internal structure of cargo tank.

1.1.3 Ship Type Feature of Product Carrier

1.1.3.1 Product carrier means an oil tanker engaged in the trade of carrying oil other than crude oil and which are with displacement less than tens of thousands DWT. Product carriers have one or more longitudinal bulkheads and are normally provided with internal corrosion protective coating inside the cargo oil tank.
1.1.3.2 According to the transport distance, product carriers are normally divided into MR-medium range and LR-long range. Handy size is normally with deadweight between 10,000 and 60,000 DWT; MR oil tanker is one of the Handy size, normally with deadweight between 30,000 and 50,000 DWT. LR oil tanker is further divided of two categories: LR1, normally with deadweight between 50,000 and 80,000 DWT; and LR2, normally with deadweight between 80,000 and 160,000 DWT.

1.1.4. Ship Type Feature of Crude Oil/Product Carrier

1.1.4.1 Crude oil/product carrier means the tanker which has the crude oil carrier characteristics, the system is equipped both to meet the requirements of crude oil carrier and the requirements of other oil products in accordance with MAROPL Annex I.

1.1.5 Ship Type Feature of Chemical Tanker/Product Carrier

1.1.5.1 Chemical tanker/product carrier is the ship used for the carriage in bulk of chemical and oil, the cargo maintenance system of which can meet the requirement of carrying oil in bulk.
1.1.5.2 The structure is similar with that of oil tanker, and normally deck longitudinals and deck web frames are designed above deck face. In general, a certain cargo oil tank is designated as a slop tank and dedicated cargo oil slop tank is unnecessary to be equipped.

SECTION 2 SPECIAL REQUIREMENT FOR OIL TANKER SURVEY

1.2.1 Compared with bulk carrier, survey of oil tanker has its particularities which include:
1.2.1.1 Structural safety requirements of oil tankers, including oil tanker structural design details, arrangement and division of cargo oil tank and machinery spaces, double-hull protection of cargo oil tanks, arrangement of pump rooms, safety access to tanker bows, arrangement of safety access to cargo oil tank area and its vicinity area and of permanent means of access (PMA), and the coating requirement of Cargo area sea water ballast tank, cargo oil tank and void spaces, etc.
1.2.1.2 Pollution prevention requirements of the cargo area of oil tankers, including crude oil washing system (COW), oil discharge monitoring system (ODME), oil water interface detector and bilge water/oil residue discharge control, vapor control system (VCS/VCS-T), etc.
1.2.1.3 Fire protection, fire detection and fire extinguishing requirements, including fire-resisting divisions and openings of accommodation bulkheads which facing cargo oil area, arrangement of fire-fighting equipments (fixed deck foam system in cargo area, water spray system, Inert gas system (IGS)), the protection of fire and explosion of pump room, and emergency towing arrangements, etc.
1.2.1.4 Technical requirement of cargo maintenance, including fixed tank gauging and alarm system, arrangement of venting system, etc.
1.2.1.5 Protection of explosion of oil tankers, including hazardous area classification and arrangement of flammable gas detector, etc.
1.2.1.6 Arrangement and requirement of steering gears.
1.2.1.7 Arrangement and requirement of life-saving equipment.
1.2.1.8 The requirements of OCIMF and oil companies.
1.2.2 The above mentioned will be described in details in the following sections.

SECTION 3 TYPICAL ARRANGEMENTS AND STRUCTURAL TYPE OF OIL TANKER

According to the structural type, oil tanker can be divided into single-hull oil tanker, double-hull oil tanker and the oil tanker with independent tanks (Unless otherwise especially specified, oil tankers mentioned in the Guidelines mean double-hull oil tankers). Since the oil tankers with independent tanks, such as certain asphalt ships, have not been involved with enhanced survey programme, it is unnecessary to meet the requirements of IACS URZ10.1 and URZ10.4, so they are not included in the guidelines.

1.3.1 Typical Arrangement of Oil Tanker

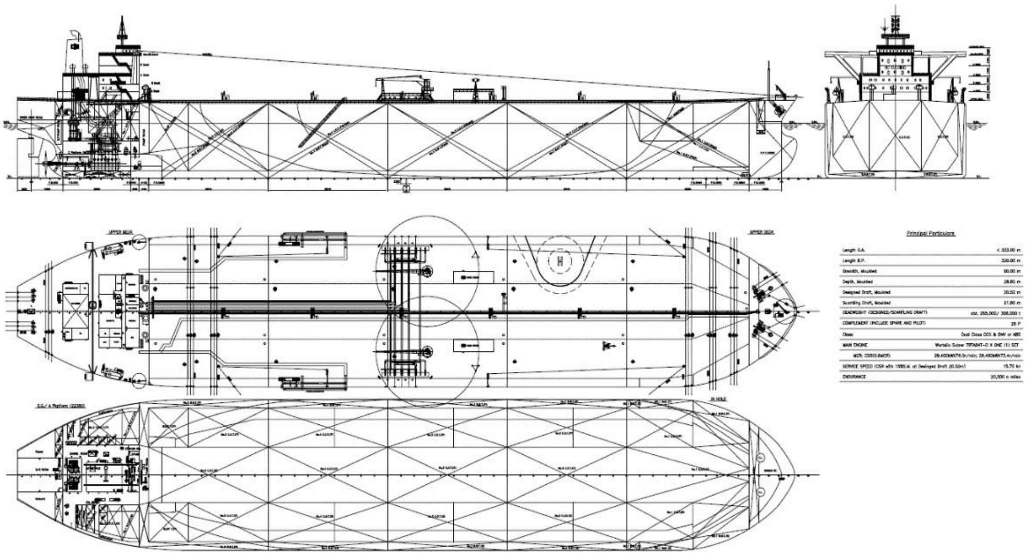


Figure 1.3.1 Typical Arrangement of Oil Tanker

1.3.1.1 Oil tankers are normally stern-engined ships, according to the requirements of SOLAS, bridge wings on both sides of the tankers of which keel laid on or after 1 July 1998 are to extend to both port and starboard sides, from each bridge wing the horizontal field of vision is to extend over an arc of at least 225°, both sides are to be visible from the bridge wing. The bow deck is to be raised slightly or forecastle is to be fitted. For the oil tankers with the flash point ≤60℃it is forbidden to fit the forecastle on the cargo tanks and the entrance for the forecastle is provided in front of the gas hazardous area.

1.3.1.2 The cargo area was isolated from machinery space by cargo pump rooms, oil fuel bunker tanks or cofferdams, etc. The ballast piping, bilge piping, ventilation piping, piping of cargo handling and maintenance system in cargo areas are to be fully independent / isolated from machinery space. The pumps in cargo areas may be locally controlled in the cargo pump rooms, which are driven by shaft of generator or ejector in machinery space through pump room bulkheads where the shaft seal is fitted. For some oil tankers fitted with cargo pumps driven by saturated steam, the bulkhead between machinery space and cargo pump room may not be fitted with the shaft seal where the this kind of driving system is arranged in cargo pump rooms.

1.3.1.3 Generally, the cargo area and ballast tanks in bow are isolated by cofferdams. Where the cofferdam is not fitted between fore peak and cargo area, such fore peak area is to be capable of entrancing from gas safety zone on the weather deck directly.

1.3.2 Double Hull Oil Tanker

1.3.2.1 The oil tankers[①] of 5,000 tonnes deadweight and above delivered on or after 6 July 1996 are to be provided with double hull structures, which are to comply with the requirements of ISC Rules for Classification of Sea-going Steel Ships and MARPOLAnnex I. The detail requirements are as follows:

(1) Oil tanker of 5,000 tonnes deadweight and above:

① The breadth of wing tanks or spaces: w = 0.5 + DW/20,000 (m), or w = 2.0 m, whichever is the lesser. The minimum value of w = 1.0 m.

② The height of double bottom tanks or spaces: h = B/15 (m) or h = 2.0 m, whichever is the lesser. The minimum value of h = 1.0 m.

(2) Oil tanker of less than 5,000 tonnes deadweight:

① The wing tanks and double bottom tanks may be fitted as the requirements of oil tanker of 5,000 tonnes deadweight and above, or

② At least to be fitted with double bottom tanks or spaces having such a depth that: h = B/15 (m), with a minimum value of h = 0.76 m, and

③ be provided with cargo tanks so arranged that the capacity of each cargo tank does not exceed 700 m^3 unless wing tanks or spaces are arranged: w = 0.4 + 2.4 DW / 20,000 (m) with a minimum value of w = 1.0 m.

1.3.2.2 It is to be noted that, for oil tankers of 20,000 tonnes deadweight and above delivered on or after 6 July 1996, the damage assumptions are to be supplemented by the following assumed bottom raking damage (MARPOLAnnex I, Reg. 28.6):

(1) Longitudinal extent:

① Ships of 75,000 tonnes deadweight and above: 0.6L measured from the forward perpendicular;

② Ships of less than 75,000 tonnes deadweight: 0.4L measured from the forward perpendicular;

(2) Transverse extent: B/3 anywhere in the bottom;

(3) Vertical extent: breach of the outer hull.

1.3.2.3 The typical structural arrangement of double-hull oil tankers are longitudinal frames for double bottom, double side, single deck structure; water tanks or cofferdams are to be provided between the internal and external hull in cargo areas. The oil tankers with the length of 150 m and above which comply with the CSR requirements are the typical double-hull structures. The difference is that the loading analysis and structure calculation are more reasonable.

(1) For a large double-hull oil tanker, one central cargo tank and two wing cargo tanks are fitted, cross ties are fitted in the central cargo tanks or wing cargo tanks, and the longitudinal bulkhead is the plane type. The figure of its typical cross section is shown as below:

[①] Such oil tanker means an a tanker

a. for which the building contract is placed on or after 6 July 1993; or

b. in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction after 6 January 1994; or

c. the delivery of which is on or after 6 July 1996; or

d. which has undergone a major conversion (conversion arranged to comply with the double hull requirements of the convention is not within this scope):

(i) for which the contract is placed on or after 6 July 1993; or

(ii) in the absence of a contract, the construction work of which is begun after 6 January 1994; or

(iii) which is completed on or after 6 July 1996.

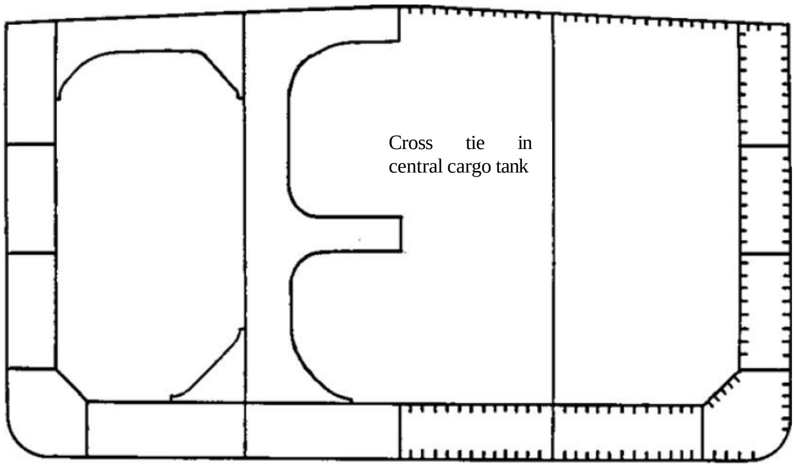


Figure 1.3.2.3(1)a Typical cross section of double-hull oil tanker – cross tie in central cargo tank

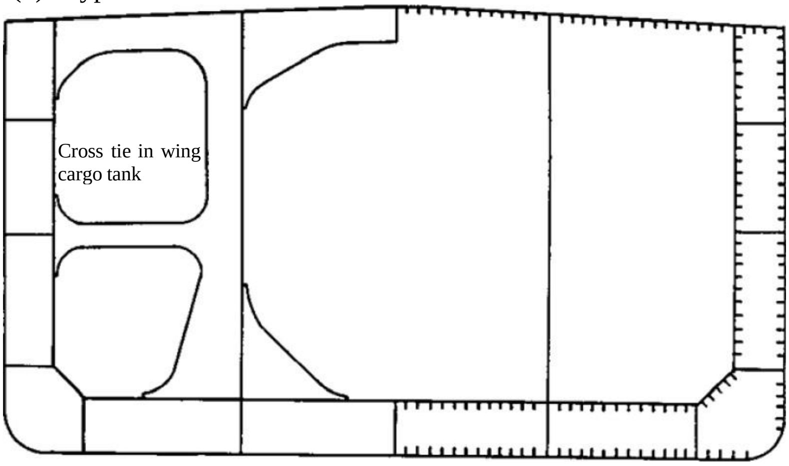


Figure 1.3.2.3 (1)b Typical cross section of double-hull oil tanker – cross tie in wing cargo tank

(2) Typical midship section of a double hull oil tanker with transverse bulkheads including nomenclature is shown in the figure below:

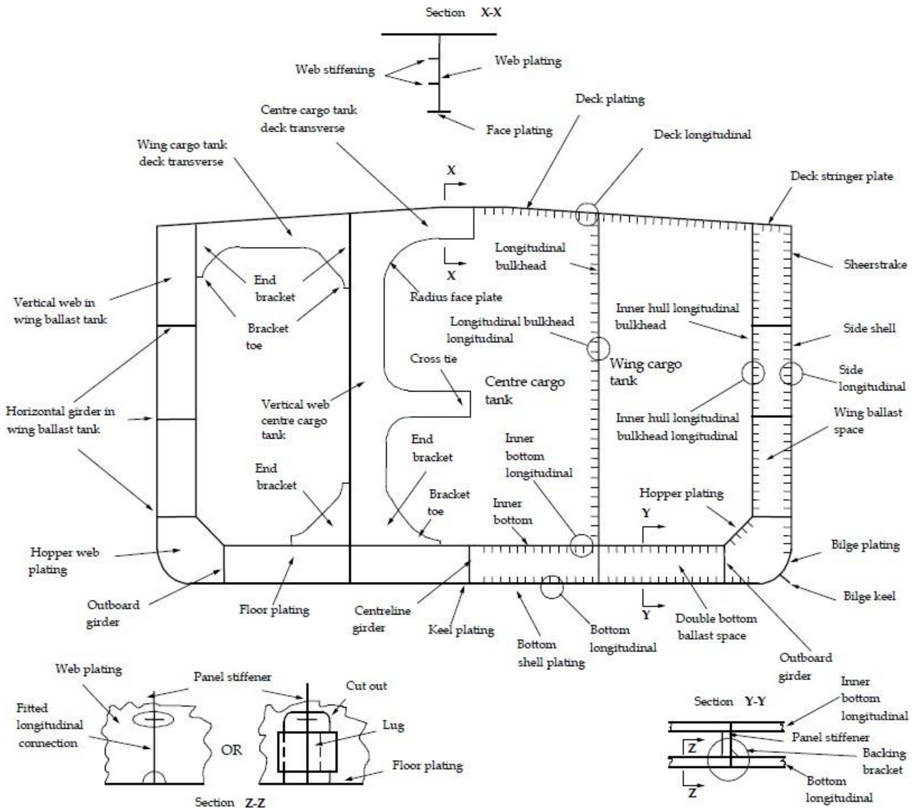


Figure 1.3.2.3 (2) Typical transverse section of a double hull oil tanker including nomenclature

(3) For a double-hull oil tanker, two wing cargo tanks are fitted, the longitudinal bulkhead is plane type (for product carrier it is normally designed as corrugated type), and there is no cross tie in the cargo tank. The typical midship sections are shown in the two figures below:

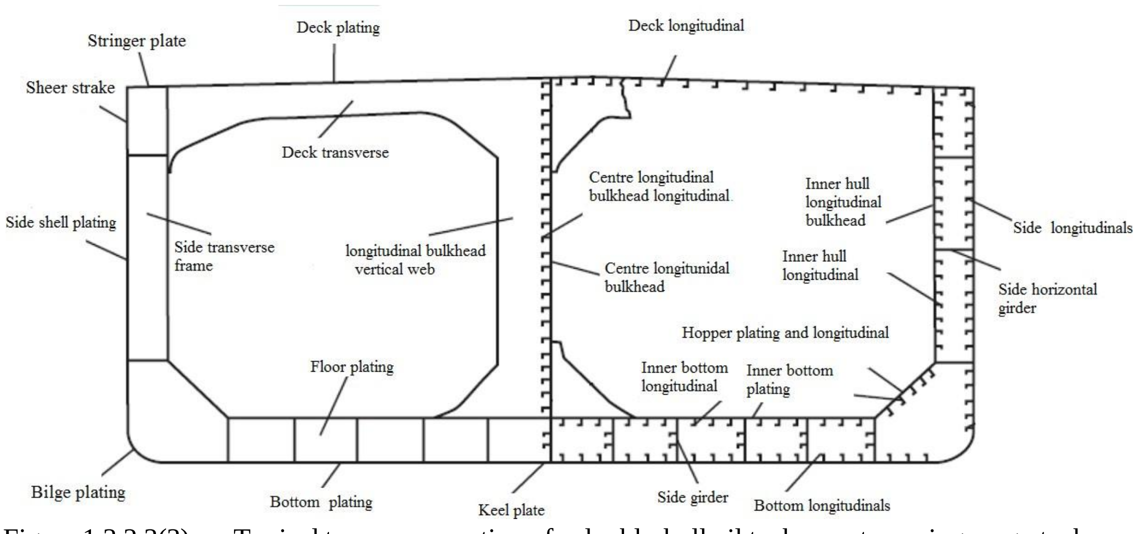


Figure 1.3.2.3(3)a Typical transverse section of a double-hull oil tanker --- two wing cargo tanks

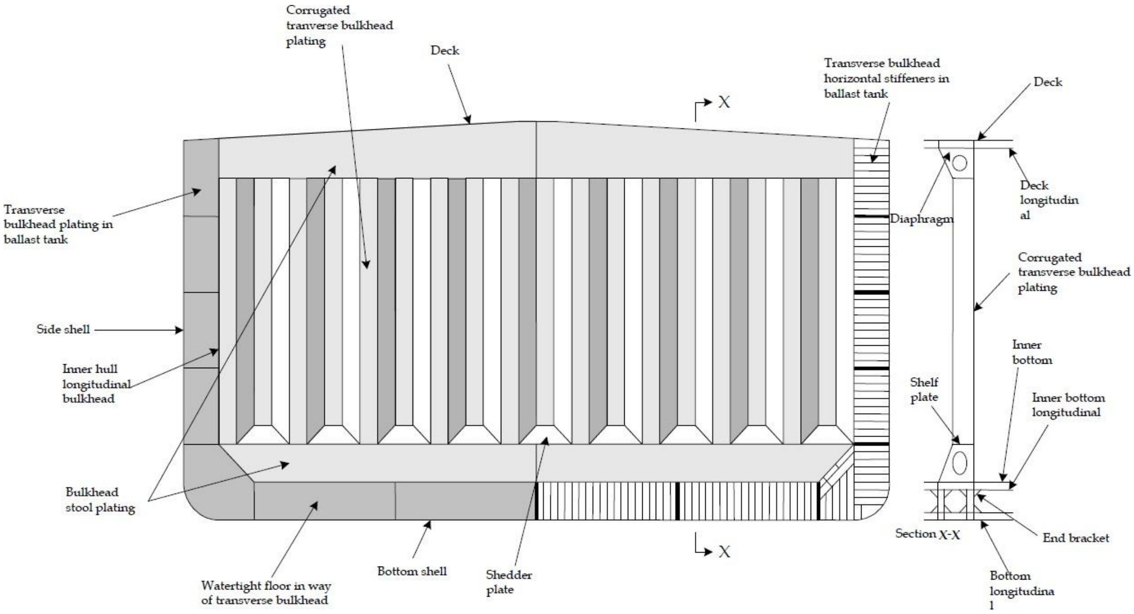


Figure 1.3.2.3 (3)b Double-hull oil tanker typical corrugated transverse bulkhead

1.3.3 Single Hull Oil Tanker (some non-conventional ships or bunker ships, etc.)

1.3.3.1 The oil tankers of 600 to 5,000 DWT delivered on 6th July 1996 or after are to be fitted with double bottom tanks or spaces, and meanwhile the capacity of each single cargo tank is to be less than 700m^3. Double bottom and double hull may not be fitted for the oil tankers less than 600 DWT. The single hull oil tankers are arranged as non-double hull structural types. In general, the single hull oil tankers have the single deck, longitudinal frame structure of independent double bottom or independent sides, as shown in the figure below:

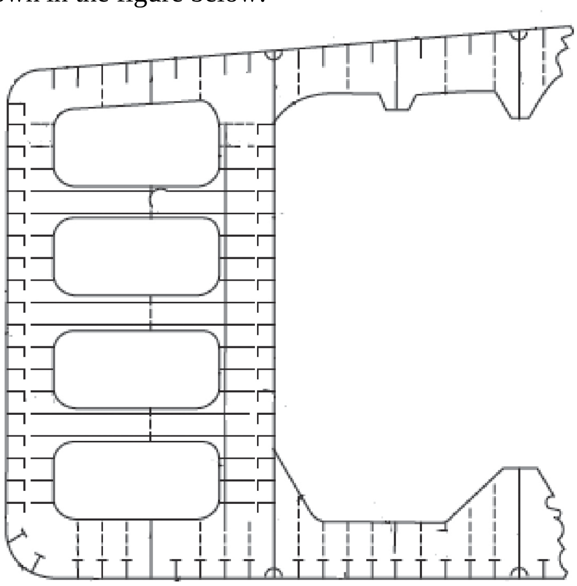


Figure 1.3.3.1 Typical transverse section of a single-hull oil tanker

1.3.4 Double Bottom Protection of Cargo Pump Room

1.3.4.1 It is stipulated in Reg.22 of MARPOL Convention Annex I that all of oil tankers of 5,000 DWT or above constructed on 1st January 2007 or after are to be provided with double bottoms in cargo pump rooms with the height of h=b/15m, or h=2.0m, whichever is the less, but the minimum h=1.0m. Where the structure of oil tanker ensures the bottom of cargo pump room is higher than value required in MARPOL, double bottom may be exempted to fit in the cargo pump room. The protective double bottom may be a cofferdam, a ballast tank or a fuel tank not restricted by other stipulations (for the oil tankers delivered on 1st August 2010 or after[①], the fuel oil tank is to be so arranged to comply with the double hull protection requirements of Reg.12 in MARPOL Convention Annex I). Where the operation of ballast pump is not affected by the damage of double bottom, the ballast piping may penetrate the double hull. Bilge well is allowed to fit in the double bottom area, however, the dimension of bilge well is to be as small as possible, and height between well bottom and shell plating is not to be less than 0.5h.

[①] Such oil tanker means an a tanker:
a. for which the building contract is placed on or after 1 August 2007; or
b. in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction after 1 February 2009; or
c. the delivery of which is on or after 1 August 2010; or
d. which has undergone a major conversion (conversion arranged to comply with the double hull requirements of the convention is not within this scope):
(i) for which the contract is placed on or after 1 August 2007; or
(ii) in the absence of a contract, the construction work of which is begun after 1 February 2008; or
(iii) which is completed on or after 1 August 2010.

CHAPTER 2 SAFETY OF SURVEY AND INSPECTION

SECTION 1 GENERAL REQUIREMENTS

For all surveys, following safety factors are to be considered, e.g. fire protection, explosion prevention, fall prevention, toxicity and asphyxiation prevention, harmful radiation prevention and prevention of other dangerous factors which will affect health and safety. During survey of oil tankers, in addition to above safety factors, special attention is to be paid to the requirements for specific safety factors of oil tankers.

2.1.1 Toxicity of oil gas

2.1.1.1 The toxicity of oil gas depends on the composition of hydrocarbon in crude oil, and the existing of gases such as aromatic hydrocarbon (e.g. benzene) and hydrogen sulfide(H_2S) will substantially increase its toxicity and cause great harm to human body health. Typical symptoms after being exposed to H_2S are shown in the Table below:

Typical effects of exposure to hydrogen sulphide (H_2S) **Table 2.1.1.1**

H_2S Concentration (ppm by volume in air)	**Physiological Effects**
0.1 – 0.5 ppm	First detectable by smell.
10 ppm	May cause some nausea, minimal eye irritation.
25 ppm	Eye and respiratory tract irritation. Strong odour.
50-100 ppm	Sense of smell starts to break down. Prolonged exposure to concentrations at 100 ppm induces a gradual increase in the severity of these symptoms and death may occur after 4-48 hours’ exposure.
150 ppm	Loss of sense of smell in 2-5 minutes.
350 ppm	Could be fatal after 30 minutes’ inhalation.
700 ppm	Rapidly induces unconsciousness (few minutes) and death. Causes seizure, loss of control of bowel and bladder. Breathing will stop and death will result if not rescued promptly.
700+ ppm	Immediately fatal.
Note: Persons over-exposed to H_2S vapour should be removed to clean air as soon as possible. The adverse effects of H_2S can be reversed and the probability of saving the person’s life improved if prompt action is taken.	

2.1.1.2 Hydrogen Sulphide (H_2S) is a very toxic, corrosive and flammable gas. It has a very low odour threshold and a distinctive odour of rotten eggs. Precautions against high H_2S concentrations are normally considered necessary if the H_2S content in the vapour is 5 ppm by volume or above.
2.1.1.3 The absence of smell should never be taken to indicate the absence of gas. Comparatively

small quantities of petroleum gas, when inhaled, can cause symptoms of diminished responsibility and dizziness similar to intoxication, with headache and irritation of the eyes. The inhalation of an excessive quantity can be fatal.

2.1.1.4 These symptoms can occur at concentrations well below the Lower Flammable Limit. However, petroleum gases vary in their physiological effects and human tolerance to these effects also varies widely. It should not be assumed that, because conditions can be tolerated, the gas concentration is within safe limits. The smell of petroleum gas mixtures is very variable and in some cases the gases may dull the sense of smell, the impairment of smell is especially likely, and particularly serious, if the mixture contains hydrogen sulphide. The critical value of toxicity of oil gas is substantially lower than LEL. Instruments for detecting flammable gases cannot detect the concentration of toxicity accurately. In addition, inert gases also include toxic gases, e.g. nitrogen oxide, SO_2, CO, etc. In general, instruments for detecting toxic gases can only detect certain toxic gas, and as time goes on, the sensitivity of instruments will decrease, so satisfactory detection does not mean absolutely safe. Relevant requirements of ISC Guidelines for Customers on Survey Safety are to be strictly followed during surveys. Once abnormality occurs, survey is to be stopped and person is to be evacuated quickly to open area.

2.1.1.5 Since toxin in oil gas can accumulate in human body, inhalation of oil gas is to be avoided during survey. It is better for a person not to be below ventilation openings of oil tank, and when he is near oil tank door, measuring holes in use and open degassing openings, it is necessary for him to be located at side of wind direction and near upper wind direction. For details, see following figures.

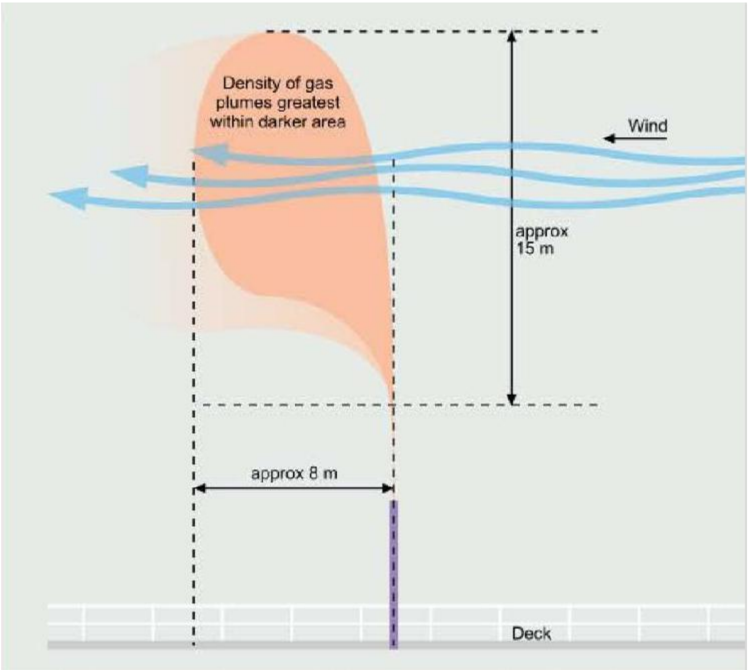


Figure 2.1.1.5(1) Flammable zone in way of adjacent vent above the deck

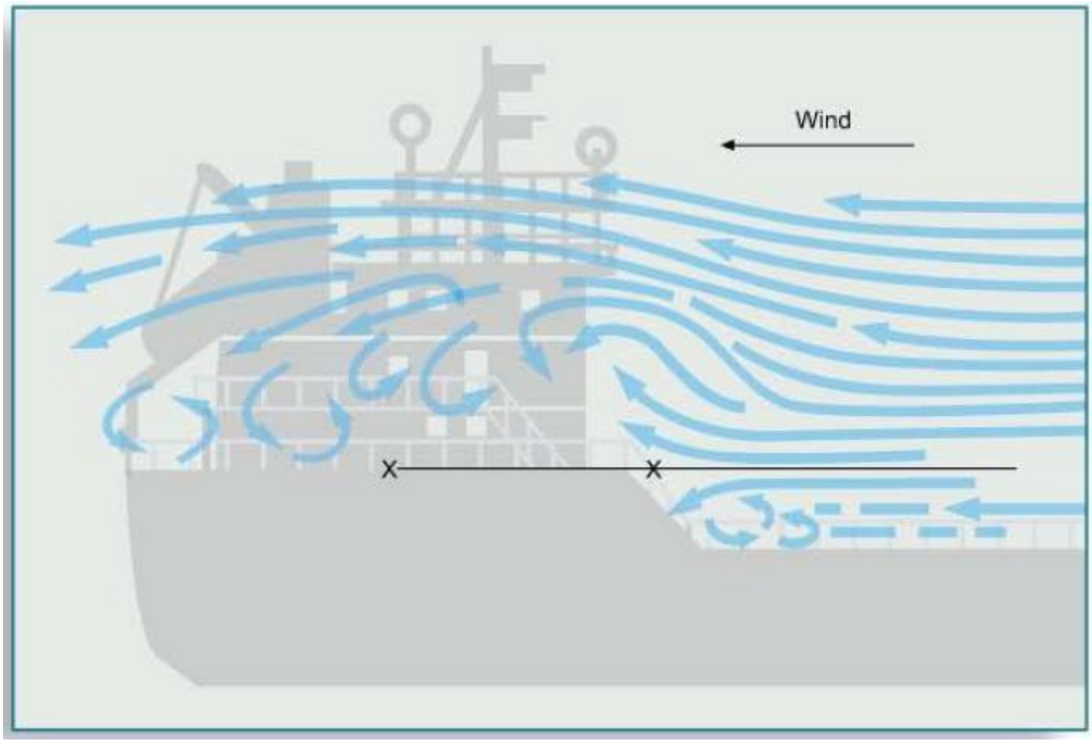


Figure 2.1.1.5(2) Typical pattern of airflow around an accommodation block

2.1.2 Safe content of O_2 in survey environment

2.1.2.1 Before entering enclosed spaces to carry out inspection, it is to be confirmed that relevant spaces have been fully ventilated. Continuous mechanical ventilation is to be arranged during survey. Prior to survey, it is to be confirmed that O_2 content of relevant tanks has been tested to meet intended requirements. The members of survey group are to carry personal oxygen analyzers and stop survey when alarm occurs or being uncomfortable. The impacts of oxygen content in the surroundings of survey on human body are shown in the figure below:

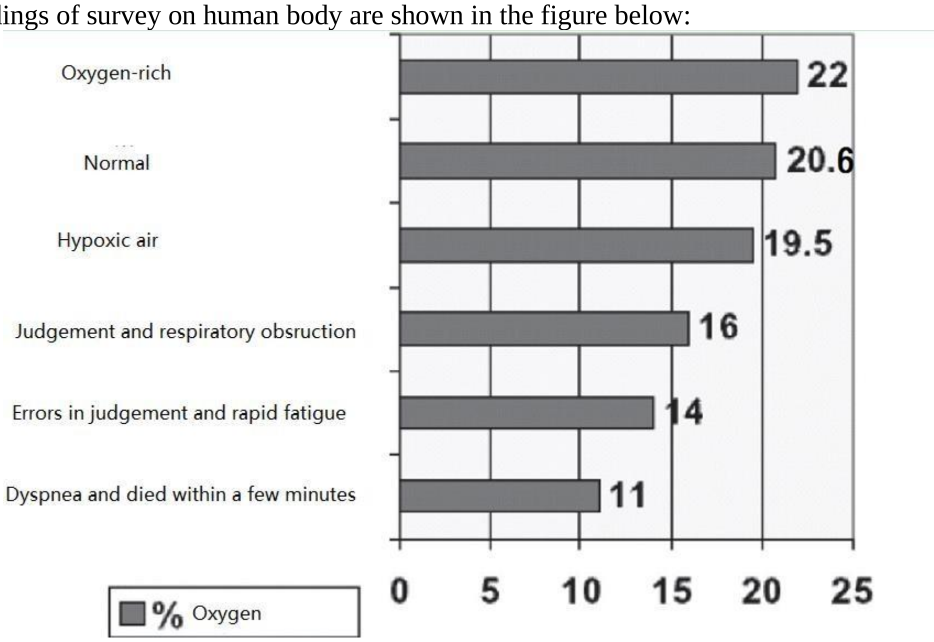


Figure 2.1.2.1 Impacts of different oxygen contents

2.1.3 Procedure for safe entry into enclosed spaces

2.1.3.1 Enclosed space means a space which has any of the following characteristics: 1) limited openings for entry and exit; 2) inadequate ventilation; and 3) is not designed for continuous worker occupancy. For oil tankers, as shown in the figure below, an enclosed space includes, but is not limited to, cargo oil tanks, double bottoms, fuel tanks, ballast tanks, cargo pump-rooms, cofferdams, chain lockers, void spaces, duct keels, boilers, engine crankcases, engine scavenge air receivers, sewage tanks, and adjacent connected spaces.

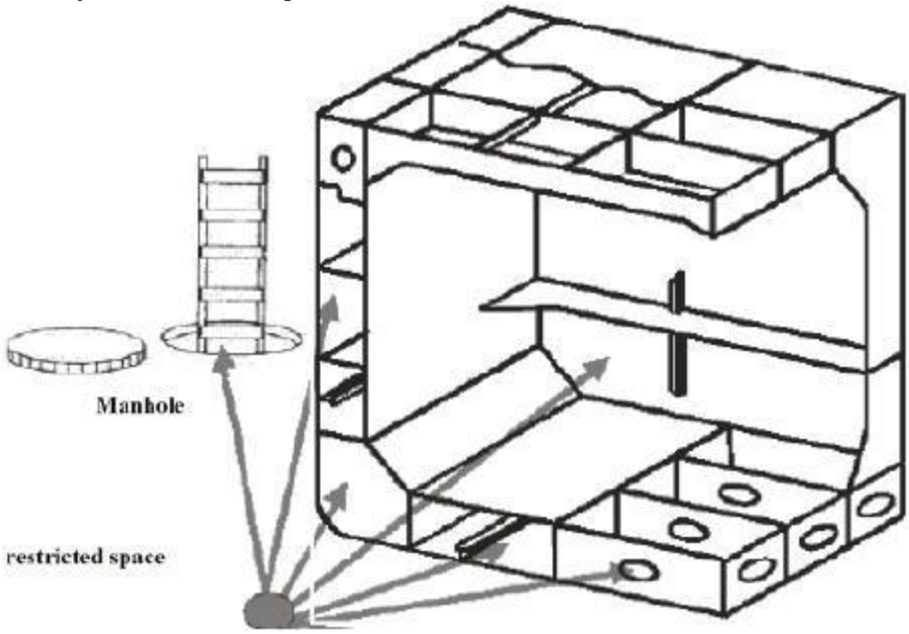


Figure 2.1.3.1 Typical enclosed spaces on board a ship

2.1.3.2 No person should open or enter an enclosed space unless authorized by the master or the nominated responsible person and unless the appropriate safety procedures laid down for the particular ship have been followed. The master or the responsible person should determine that it is safe to enter an enclosed space by ensuring that:

(1) potential hazards have been identified in the assessment and as far as possible isolated or made safe;

(2) the space has been thoroughly ventilated by natural or mechanical means to remove any toxic or flammable gases and to ensure an adequate level of oxygen throughout the space;

(3) the atmosphere of the space has been tested as appropriate with properly calibrated instruments to ascertain acceptable levels of oxygen and acceptable levels of flammable or toxic vapours;

(4) the space has been secured for entry and properly illuminated;

(5) a suitable system of communication between all parties for use during entry has been agreed and tested;

(6) an attendant has been instructed to remain at the entrance to the space whilst it is occupied;

(7) rescue and resuscitation equipment has been positioned ready for use at the entrance to the space and rescue arrangements have been agreed;

(8) personnel are properly clothed and equipped for the entry and subsequent tasks; and

(9) a permit has been issued, authorizing entry.

2.1.3.3 Checklist related to entry into enclosed spaces may be referred to in Resolution A.1050(27) Revised Recommendations for entering enclosed spaces aboard ships.

SECTION 2 SURVEY CONDITIONS AND MEANS OF ACCESS

2.2.1 Survey conditions

2.2.1.1 It is Owner/Management company's responsibility to provide the necessary facilities for a safe execution of the survey, which including but not limited to the following:
(1) In order to enable the attending surveyors to carry out the survey, provisions for proper and safe access in compliance with relevant requirements of IACS PR37 are to be agreed between the owner and ISC according to IMO Resolution A.1050(27) on Revised Recommendations for Entering Enclosed Spaces Aboard Ships;
(2) In preparation for survey and thickness measurements and to allow for a thorough examination, all spaces should be cleaned including removal from surfaces of all loose accumulated corrosion scale,. Spaces should be sufficiently clean and free from water, scale, dirt, oil residues, etc., to reveal corrosion, deformation, fractures, damages or other structural deterioration as well as the condition of the coating. However, those areas of structure whose renewal has already been decided by the owner need only be cleaned and descaled to the extent necessary to determine the limits of the areas to be renewed.
(3) Sufficient illumination should be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration as well as the condition of the coating.
(4) Where soft or semi-hard coatings have been applied, safe access should be provided for the surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft or semi-hard coating should be removed.
(5) The surveyor(s) should always be accompanied by at least one responsible person, assigned by the owner, experienced in tank and enclosed spaces inspection.

2.2.2 Access to Structures

2.2.2.1 Adequate and sufficient means of access to structures is a prerequisite for satisfactory completion of survey. One or more of the following means for access, acceptable to the surveyor, should be provided:
(1) permanent staging and passages through structures;
(2) temporary staging and passages through structures;
(3) hydraulic arm vehicles such as conventional cherry pickers, lifts and movable platforms;
(4) boats or rafts;
(5) portable ladders; and
(6) other equivalent means.
2.2.2.2 Before entering the tank, in addition to the safety precautions for entering enclosed spaces, attention should also be given to the following safety measures:
(1) Every one of inspector should take flashlights. When inspection for oil tank or its adjacent spaces is carried out, the torch should be explosion-proof type.
(2) The inspector should be careful not to fall.
(3) The inspector should pay attention to the impact of falling objects, such as rust, goods adheres at the top and other damage to the eyes. If necessary, the rust cleaning is to be required again.
(4) Before any examination, all means of access are to be subject to overall inspection. Only one person is allowed to pass a ladder one time.
(5) Attention is paid on slide of temporary. For details, please refer to IACS REC.78.
(6) Ensure that the means of access has enough support during survey for structural repair in process or complete repair.
2.2.2.3 In addition to the above requirements, the following issues are to pay attention when close-up survey carried out in way of craft:
(1) A communication system should be arranged between the survey party in the spaces and the

responsible officer on deck. This system should also include the personnel in charge of ballast pump handling if boats or rafts are used.

(2) Surveys of tanks or applicable holds by means of boats or rafts should only be undertaken with the agreement of the surveyor, who should take into account the safety arrangements provided, including weather forecasting and ship response under foreseeable conditions and provided the expected rise of water within the tank does not exceed 0.25 m.

(3) When rafts or boats will be used for close-up survey the following conditions should be observed:

① only rough duty, inflatable rafts or boats, having satisfactory residual buoyancy and stability even if one chamber is ruptured, should be used;

② the boat or raft should be tethered to the access ladder and an additional person should be stationed down the access ladder with a clear view of the boat or raft;

③ appropriate lifejackets should be available for all participants;

④ the surface of water in the tank or hold should be calm (under all foreseeable conditions the expected rise of water within the tank should not exceed 0.25 m) and the water level stationary. On no account should the level of the water be rising while the boat or raft is in use;

⑤ the tank, hold or space must contain clean ballast water only. Even a thin sheen of oil on the water is not acceptable; and

⑥ at no time should the water level be allowed to be within 1 m of the deepest under deck web face flat so that the survey team is not isolated from a direct escape route to the tank hatch. Filling to levels above the deck transverses should only be contemplated if a deck access manhole is fitted and open in the bay being examined, so that an escape route for the survey party is available at all times. Other effective means of escape to the deck may be considered; and

⑦ if the tanks (or spaces) are connected by a common venting system, or inert gas system, the tank in which the boat or raft should be used should be isolated to prevent a transfer of gas from other tanks (or spaces).

(4) Rafts or boats alone may be allowed for inspection of the under deck areas of tanks or spaces if the depth of the webs is 1.5 m or less.

(5) If the depth of the webs is more than 1.5 m, rafts or boats alone may be allowed only:

① when the coating of the under-deck structure is in GOOD condition and there is no evidence of wastage; or

② if a permanent means of access is provided in each bay to allow safe entry and exit. This means:

a. access direct from the deck via a vertical ladder with a small platform fitted approximately 2 m below the deck in each bay; or
b. access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform should, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of under deck structure. For this purpose, the ullage corresponding to the maximum water level should be assumed not more than 3 m from the deck plate measured at the midspan of deck transverses and in the middle length of the tank, as shown in the figure below:

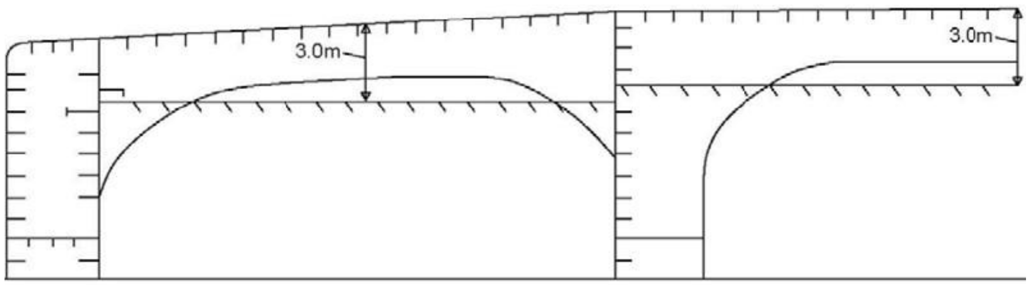


Figure 2.2.2.3(5)b. Diagram showing highest level in tank

c. If neither of the above conditions is met, then staging or other equivalent means should be provided for the survey of the under-deck areas.
(6) The use of rafts or boats alone in above 4 and 5 does not preclude the use of boats or rafts to move about within a tank during a survey.

2.2.2.4 During inspection process, inspectors are to be equipped with adequate personal safety equipment:
(1) White long sleeve jumpsuit made of non-flammable, wear-resistant, anti-static materials, equipped with multi-purpose pockets and decorative reflective tape, made of 100% cotton and required to absorb sweat;
(2) Safety work shoes (boots) with hard toe, non-slip heel, insulating or anti-static, oil-resistant;
(3) Various work gloves suitable for all kinds of inspection work with anti-slip and anti-static function, such as canvas gloves and cotton gloves;
(4) Flashlight of strong light, waterproof, with tightening straps, easy to carry and use;
(5) For inspection of enclosed spaces, a composite gas measuring instrument capable of measuring combustible gas (LEL), oxygen (O_2), hydrogen sulfide (H_2S) and carbon monoxide (CO) is to be provided.

2.2.3 Remote Inspection Techniques (RIT)
2.2.3.1 Remote Inspection Techniques (RIT) is a means used by ship surveyors to inspect any part of a structure without direct physical contact. (Refer to IACS Rec.42 Guidelines for Use of Remote Inspection Techniques for Surveys).
2.2.3.2 Site surveyors may consider accepting the use of RIT as an alternative of close-up surveys. RIT is not applicable in principle to the inspection of oil tankers and bulk carriers, but special provisions of the flag State should be noted. Surveys by means of RIT are to be conducted in a manner satisfactory to the site surveyor. When using RIT for close-up survey, measures for temporary access to structures for the corresponding thickness measurement are to be provided, unless the RIT is capable of performing the required thickness measurement. Surveys by means of RIT are to be conducted in accordance with the requirements of the existing ISC Rules for Classification of Sea-going Steel ships and the IACS Rec.42 Guidelines for Use of Remote Inspection Techniques for Surveys. Remote inspection techniques may normally include the use of:
(1) Unmanned robot arm;
(2) Remote Operated Vehicles (ROV);
(3) Unmanned aerial vehicle (refer to ISC Guidelines for Application of Surveys by means of Unmanned Aerial Vehicle);
(4) Other means acceptable to ISC.

CHAPTER 3 SURVEY SERVICES PROVIDED BY CLASS ON OIL TANKERS

Survey services provided by Class on oil tanker include both classification survey and statutory survey.

The purpose of classification survey is to confirm the effectiveness of hull structural strength and structural integrity, design requirement fulfillment of electromechanical equipment arrangement and energy efficiency. IACS URZ10.1 and URZ10.4 have stated the classification survey minimum requirement of oil tanker hull structure. Similar survey by ship owner or interested party is the measure to promote risk management level, which ought to be encouraged. Nevertheless this survey cannot take place of related classification survey.

It needs to be noted that ISC Rules for Classification of Sea-going Steel Ships and IACS UR just put forward the basic requirements of classification survey. Under condition of compliance with the requirements of ISC Rules for Classification of Sea-going Steel Ships, surveyors may, according to the practical situation of ship, enlarge the survey scope and extent where necessary, carry out the survey as careful and complete as possible, to ensure safety operation of ships.

Statutory survey is carried out on the basis of authorization, in accordance with international convention and government rules, laws and regulations which are accepted by the flag State, to ensure that the ship fulfills related statutory requirements. To carry out the statutory survey, special concentration should be paid on the commencement date of convention, tonnage of ship, date of construction and required date of implementation.

SECTION 1 DEFINITIONS IN RELATION TO SURVEYS OF OIL TANKERS

3.1.1 A *Combined Cargo/Ballast Tank* is a tank, which is used for the carriage of cargo, or ballast water as a routine part of the vessel's operation and will be treated as a Ballast Tank. Cargo tanks in which water ballast might be carried only in exceptional cases per MARPOL I/18.3 are to be treated as cargo tanks.

3.1.2 *Overall Survey* is a survey intended to report on the overall condition of the hull structure and determine the extent of additional Close-up Surveys.

3.1.3 *Close-up Survey* is a survey where the details of structural components are within the close visual inspection range of the Surveyor, i.e. normally within reach of hand.

3.1.4 *Transverse Section* includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom, inner bottom, and longitudinal bulkhead (where applicable, hopper side plating and bottom plating of top wing tanks). For transversely framed vessels, a transverse section includes adjacent frames and their end connections in way of transverse sections.

3.1.5 *Representative Tanks* are those, which are expected to reflect the condition of other tanks of similar type and service and with similar corrosion prevention systems. When selecting Representative Tanks account is to be taken of the service and repair history onboard and identifiable Critical Structural Areas and/or Suspect Areas.

3.1.6 *Critical Structural Areas* are locations which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship. For detailed critical structure areas in an oil tanker, please refer to the annexes of the Guidelines.

3.1.7 *Suspect Areas* are locations showing Substantial Corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

3.1.8 *Substantial Corrosion* is an extent of corrosion such that assessment of corrosion pattern indicates wastage in excess of 75% of allowable margins, but within acceptable limits. For vessels built under the IACS Common Structural Rules, substantial corrosion is an extent of corrosion such that the assessment of the corrosion pattern indicates a gauged (or measured) thickness between t_{ren} + 0.5mm and t_{ren}.

3.1.9 *Corrosion Prevention System* is normally considered a full hard coating. Hard Protective Coating is usually to be epoxy coating or equivalent. Other coating systems may be considered acceptable as alternatives provided that they are applied and maintained in compliance with the manufacturer's specification.

3.1.10 *Coating condition*:

- 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% or more of areas under consideration, but less than as defined for POOR condition,
- POOR condition with general breakdown of coating over 20% or more, or hard scale at 10% or more, of areas under consideration.

(Reference is made to IACS Recommendation No.87 "Guidelines for Coating Maintenance & Repairs for Ballast Tanks and Combined Cargo / Ballast Tanks on Oil Tankers" which contains clarification of the above.)

3.1.11 *Cargo Area* is that part of the ship which contains cargo tanks, slop tanks and cargo/ballast pump-rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

3.1.12 *Special consideration* or specially considered (in connection with close-up surveys and thickness measurements) means sufficient close-up survey and thickness measurements are to be taken to confirm the actual average condition of the structure under the coating.

3.1.13 *Prompt and Thorough Repair* is a permanent repair completed at the time of survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of classification.

3.1.14 *General corrosion* means general breakdown of coating or hard scale over 70% or more, including pitting corrosion, in the reference area, together with thickness reduction.

3.1.15 *Excessive corrosion* is the corrosion extent exceeding the allowable corrosion limitation.

3.1.16 *Uniform Corrosion* is presenting unprotected and inattentive scale, uniformly generating in the no-coating steel structure surface, scale fall off sequent with further corrosion in the exposed steel. Normally after serious thickness damage, the damage could be seen from the exterior.

3.1.17 *Pitting corrosion* is defined as scattered corrosion spots/areas with local material reductions which are greater than the general corrosion in the surrounding area. Pitting intensity is defined in the figure below:

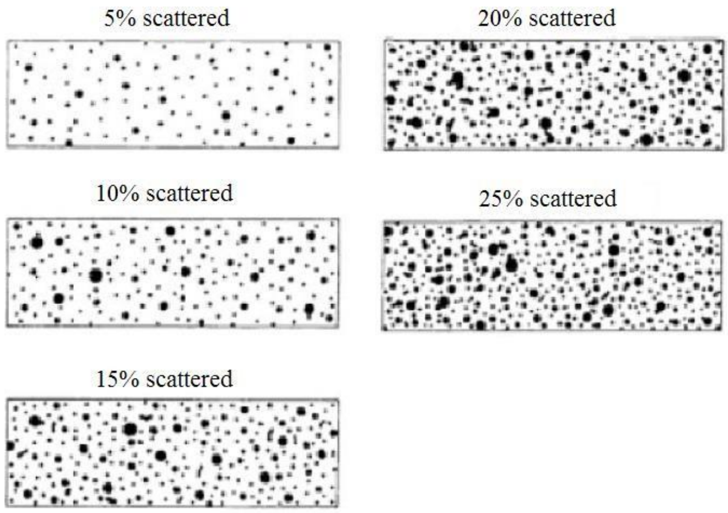


Figure 3.1.17 Pitting Intensity Diagrams

Pitting corrosion is normally initiated due to local breakdown of coating and flushing by water inside the tank. Severe pitting can weaken the strength of the structure and even leads to damage of tightness of tanks. Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal and will further develops into grooving corrosion.

3.1.18 *Grooving corrosion* is typically local material loss adjacent to weld joints along abutting stiffeners and at stiffener or plate butts or seams. An example of groove corrosion is shown in the figure below:

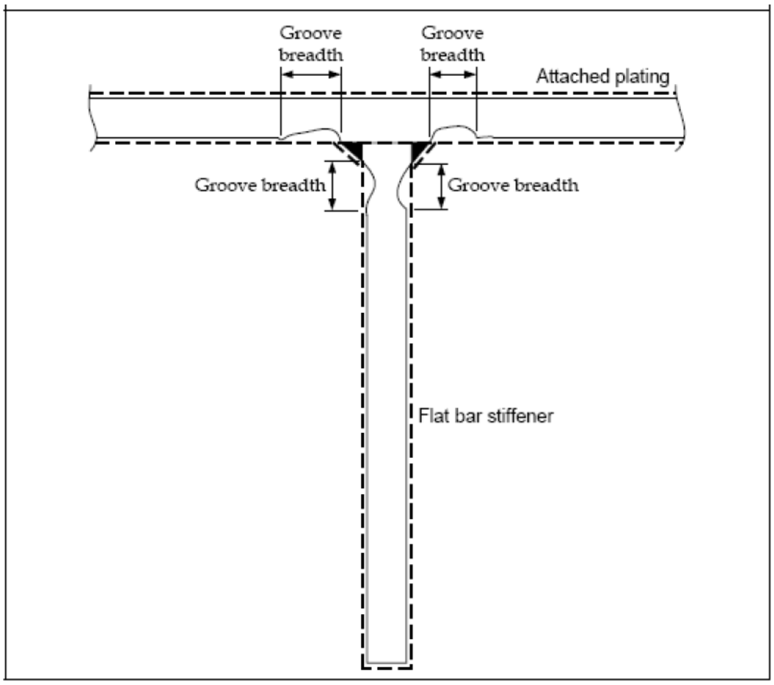


Figure 3.1.18 Grooving Corrosion

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. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process.

3.1.19 *Edge corrosion* is defined as local corrosion at the free edges of plates, stiffeners, primary support members and around openings. An example of edge corrosion is shown in the figure below:

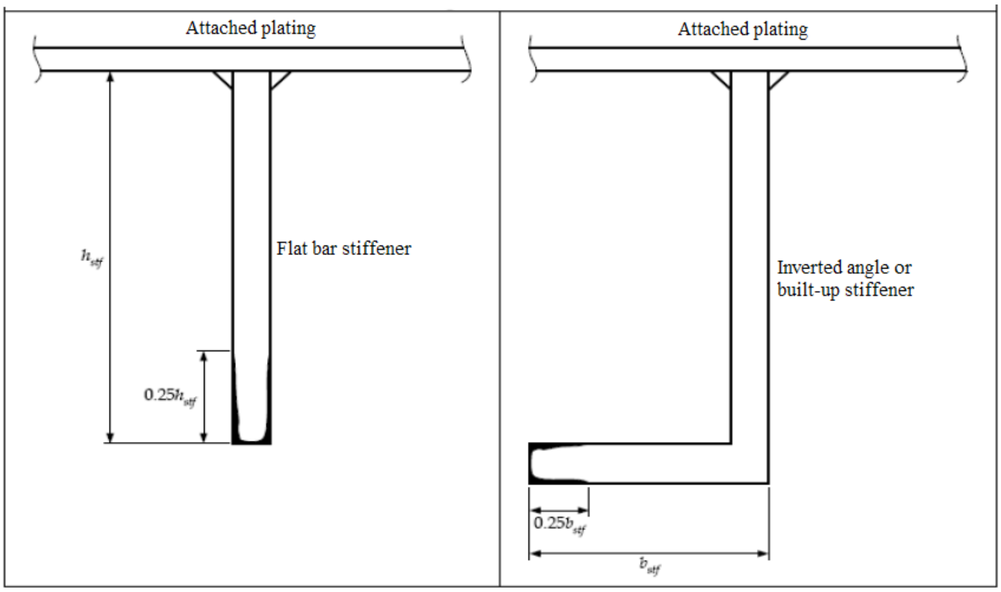


Figure 3.1.19 Edge Corrosion

Edge corrosion normally starts at the free edges of components, around openings, etc.

3.1.20 *Administration* means the flag State Administration or an organization recognized by the Administration.

SECTION 2 INTRODUCTION OF CLASS NOTATIONS OF OIL TANKERS

Due to the specialty of oil tankers, International Ship Classification provides corresponding different Class Notations

3.2.1 Type Notations

Class notation	Description	
Oil Tanker	Oil tankers	Ships carrying crude oil or oil products, note to be added according to flash point of oil carried: ① flash point above 60℃: F.P. > 60℃ ② flash point up to 60℃: F.P. ≤ 60℃
		For ships with distance between two hulls in compliance with the Rules for Classification of Sea-going Steel Ships, single deck and small-size hatches, carrying crude oil or oil products, the notation “Double Hull” may be added and separated by a comma “,”, i.e. Oil Tanker, Double Hull
Oil Barge	Oil barges	Barges carrying crude oil or oil products within holds
Oil FSV fixed at XXX	Oil floating storage vessels	Oil floating storage vessels (FSV) satisfying the following conditions:

Anchorage	fixed at anchorage	(1) a laid-up double hull oil tanker, of which the cargo tanks and relevant systems have oil storage function; (2) a fixed anchorage in restricted marine environment with an offshore distance not exceeding 20 nautical miles

3.2.2 Special Features Notations

Class notation	Description	
ERS	Emergency response service	Upon prior ERS agreement between the owner and ISC and an electronic database for stability and structural strength of a ship, ISC will in case of emergency of the ship, e.g. collision at sea, grounding, oil spillage, etc., and at request of the owner, initiate an emergency response procedure to provide calculation and analysis for damage stability, structural strength and spillage, giving technical support to the ship in getting out of danger and recommendations to the owner/master in making final decision
ERS*	Emergency response service	Where ERS agreement or statement is signed by shipping company or shipping operator and ERS onshore service unit designated by the Administration, the notation may be added with the application of the owner
CSR	Common Structural Rules	For ships designed and constructed in accordance with Common Structural Rules, this notation is to be added after type notation。
PSPC	Protective coating	Ships of which specific spaces comply with IMO Performance Standard for Protective Coatings may be assigned this notation, with one or more of suffixes B, C and V being added thereafter. Meanings of the suffixes are as follows: B: protective coatings applied in dedicated seawater ballast tanks of all types of ships; C: protective coatings applied in cargo oil tank spaces of crude oil tankers; V: protective coatings applied in void spaces of bulk carriers and oil tankers. Note: B, C and V can operate both separately and together
MCRS	Corrosion resistant steel	Corrosion resistant steel is used as an alternative to protective coating for cargo oil tanks of crude oil tankers in accordance with IMO resolution MSC.289(87)

3.2.3 Special Equipment and System Notations

Class notation	Description	
Emergency Towing Arrangements	Emergency towing arrangements	Tankers provided with emergency towing arrangements may be assigned this notation
Loading Computer	Loading computers	Ships provided with approved loading computers are to be assigned this notation, with one or more of suffixes S, I and D being added

		thereafter. Meanings of the suffixes are as follows: S: Capable of calculating and checking hull strength under various loading conditions; I: Capable of calculating and checking intact stability; D: Capable of calculating and checking damage stability
Equipped with Single Point Mooring Connecting installation	Equipped with Single Point Mooring Connecting Installation	Ships equipped with single point mooring connecting installation according to relevant requirements are to be assigned the notation
IGS	Inert gas systems	For ships provided with inert gas system. Note: "IGS" has the same meaning as "Inert Gas System"
COW	Crude oil washing system	This notation may be added for ships fitted with crude oil washing system
CBT	Clean ballast tank	This notation may be added for ships fitted with clean ballast tanks。
SBT	Segregated ballast tank	This notation may be added for ships fitted with segregated ballast tanks. Where segregated ballast tanks are in a protective location, the notation PL is to be added after SBT
VCS	Vapour control systems	For ships fitted with systems for control of vapour emission from tanks in compliance with the Rules (excluding requirements for VCS-T) , this notation may be added
VCS-T	Vapour control systems – transfer	For ships fitted with systems for control of vapour emission from tanks in compliance with the Rules, this notation may be added

3.2.4 Special Survey Notations

Class notation	Description	
ESP	Enhanced survey programme	This notation is required for oil tankers, oil/bulk carriers, oil/bulk/ore carriers, chemical tankers, bulk carriers, self-unloading bulk carriers engaged on international voyages. This notation is optional by the owner for oil tankers, oil/bulk carriers, oil/bulk/ore carriers, chemical tankers, bulk carriers, self-unloading bulk carriers subject to ESP and engaged on non-international voyages, with attention being given to the special requirements of the flag States

SECTION 3 PREPARATIONS OF SURVEY PLANNING QUESTIONNAIRE

3.3.1 Ensuring the safe operation is the responsibilities and obligations of ship owner. Qualified survey control is the important part of ship operating risk management. Sufficient preparation is the requirement to complete the survey. Before the start of survey, the owner should understand the survey requirement and make the survey scheme, then submit the Survey Planning Questionnaire

and ESP survey programme, meanwhile make necessary preparation for survey.
3.3.2 Before the survey, surveyor should read the related information of the ship, including ship type feature, survey guidelines, historical damage records and analysis of historical damage records of similar ships. The surveyor is to, follow the detailed “survey guidelines” (if any), review and approve the survey programme and confirm survey scope, survey key points and survey implementation.
3.3.3 When doing special survey or intermediate survey in scope of special survey (for over 10 years of age) for all oil tankers with ESP notation, ship owner needs to submit Survey Planning Questionnaire which should be provided to ISC before the development of survey programme. In order to make the survey programme precisely and guide the smooth implementation of survey, the content of the questionnaire should be as detailed as possible.
3.3.4 The form of Survey Planning Questionnaire is given in Appendix 11B of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships, includes at least following contents:
3.3.4.1 Particulars of ship
3.3.4.2 Information on access provision for thickness measurement and close-up survey
3.3.4.3 History of cargo with H_2S content or heated cargo for the last 3 years together with indication as to whether cargo was heated and, where available, Marine Safety Data Sheets (MSDS) (refer to MSC.150(77) on Recommendation for Material Safety Data Sheets for MARPOL Annex I Cargoes and Marine Fuel Oils)(if any);
3.3.4.4 Ship owner self-checklist for at least the past 3 years, which should cover the coating protection, coating condition, structural defect and structural damage history of all ballast tanks, void tanks and cargo oil tanks (cargo oil /ballast tank is regarded as ballast tank). Structural defect and structural damage history should be described in detail and constitute a valid part of the questionnaire. It is to be noted that the inspection result should be recorded in the questionnaire no matter the fore peak is ballast tank or not.
3.3.4.5 Detail report of hull structural related deficiencies found in PSC/FSC inspection.
3.3.4.6 Detail report of non-conformities on maintenance of ship structures in safety management system.
3.3.4.7 Contact details and addresses of the approved TM companies. Name lists of Hull thickness measurement companies that are approved by ISC are available in ISC website.
3.3.4.8 Other documents deemed as necessary by ship companies.

SECTION 4 PREPARATION OF SURVEY PROGRAMME

3.4.1 Before the start of the planned survey, the survey programme is to be developed jointly by the ship owner and ISC. Survey can only be started after the survey programme is approved. For details on survey programme, please refer to Appendix 11A of Chapter 5 of PART ONE ISC Rules for Classification of Sea-going Steel Ships, which at least include the following:
3.4.1.1 Survey status and particulars of ship;
3.4.1.2 Survey report files and supporting documents, including structural inspection report, hull structure conditional assessment report, thickness report, survey programme, drawing of main structures of cargo oil tank and ballast tank (for CSR ships, these plans should include the as-built and renewal thickness of each structure member), the previous repair history, history of loading and ballast, the crew check records, and the scope of application of inert gas and tank washing procedure, etc.;
3.4.1.3 History and specifications of coating and corrosion-prevention system;
3.4.1.4 Survey conditions (e.g. information on cleaning, gas-freeing, ventilation and lighting, ect.);
3.4.1.5 Means of access to the structures should be provided according to ISC Rules for Classification of Sea-going Steel Ships. Before the survey, these means of access should be checked

and assessed as appropriate to ensure the safety and completeness of survey;
3.4.1.6 Related testing and safety equipment such as thickness measuring instrument, NDT equipment, explosion meter, oxygen meter, breathing apparatus, life line, climbing belt and its ropes, hook and whistle, and associated instructions and guidance, etc. Safety checklist is to be provided;
3.4.1.7 Survey scope and requirement: ISC Rules for Classification of Sea-going Steel Ships have provided the basic survey scope requirement for overall inspection and close-up examination. On the basis of survey questionnaire, if coating condition is poor, structural defects are found and repair records show that structure defects were found several times and may occur in some other same type ships, the scope of overall inspection and close-up examination should be expanded and the expanded scope should be listed;
3.4.1.8 Compartment structural test requirement: ISC Rules for Classification of Sea-going Steel Ships have provided the basic survey scope and requirement for compartment structural test, if deformation, buckling, crack, excessive corrosion or large scale repair were witnessed on board, the scope should be expanded and this part should be listed;
3.4.1.9 Scope of thickness measurement: ISC Rules for Classification of Sea-going Steel Ships have provided the basic survey scope requirement of thickness measurement. On the basis of survey questionnaire, if a structure has been found to be general corroded, substantially corroded, buckling deformation and may occur in some other same type ships, the scope of thickness measurement should expanded and this part should be listed;
3.4.1.10 Corrosion and wastage allowance of hull structure: ISC has provided the limits of various structural corrosions;
3.4.1.11 To confirm if the conditions of the TM company indicated in the Questionnaire are changed;
3.4.1.12 The historical structural damage data of the ship and similar ships: this information is an important part to determine the key focuses of survey. Ship owner should collect this information as much as possible;
3.4.1.13 Areas identified with substantial corrosion from previous surveys;
3.4.1.14 Critical structural areas and suspect areas;
3.4.1.15 Other relevant comments and information.

SECTION 5 INTRODUCTION OF CLASS SURVEY AFTER CONSTRUCTION

3.5.1 Arrangement of Class Survey

3.5.1.1 Class survey for oil tanks is to ensure that the hull structures, machinery installations and electrical equipment are in compliance with the intended purposes, and enhanced survey programme (ESP) is mainly to evaluate the coating condition and corrosion of structural members, to confirm when the coating has been found to be in a “less than good” condition and when the structure has been found to be substantially corroded.
3.5.1.2 Collection and Review of Documents. Prior to survey, the Surveyor is to collect and examine the documentation as far as possible to guide the implementation of survey. In addition to the documents collected during the preparation of the survey programme in accordance with 5.1.6.5(2) of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships, at least the following documents are to be collected during the implementation of the survey:
(1) loading manual and loading instrument;
(2) Inspection records of the OCIMF and other relevant parties;
(3) Approved ESP;
(4) GBS oil tanker construction file:
It is provided in Reg.3-10 of Chapter II-1 of SOLAS that oil tankers of 150 m in length and above: ① for which the building contract is placed on or after 1 July 2016;② in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July

2017; or ③ the delivery of which is on or after 1 July 2020, shall comply with Goal-based ship construction standards for bulk carriers and oil tankers(GBS). A Ship Construction File (SCF) with specific information on how the functional requirements of the Goal-based Ship Construction Standards for Bulk Carriers and Oil Tankers have been applied in the ship design and construction shall be provided upon delivery of a new ship, and kept on board the ship and/or ashore and updated as appropriate throughout the ship's service. The items of the SCF that are required to be kept on board should be available onboard;

(5) CAP report (if any);

(6) Any other information as necessary and useful.

3.5.1.3 In addition to the above, due to high risk of oil tankers, ISC and other RO have made some detailed provisions. Compared with general cargo ships, relevant information regarding to inspection for oil tanks to be kept on board is as following:

(1) Manuals to be approved. As the request of ship's owner and under the authority of Administration, ISC can approve the following relevant manuals:

① Ship oil pollution emergency plan(SOPEP)/ Ship marine pollution emergency plan(SOMEP) (For SOPEP, If the products carried are listed in Annex II to MARPOL convention, it is SMPEP). The emergency plan for oil tankers of 5,000 DWT and above is to include the agreement of shore-based computer calculation procedure);

② Oil record book (format 1: machinery space/ format 2: cargo area);

③ Crude oil washing manual, as applicable (It should be noted that COW effectiveness test report should be provided after the third voyage of carriage of crude oil, or within one year after the first time carriage of crude oil, whichever is the later. In accordance with the requirements of 4.2.11 of Resolution A.446 (XI), sister ships may, with the approval of the Administration, be exempted from crude oil washing verification based on the verification report of the first vessel);

④ ERS documents, as applicable;

⑤ ODME manual;

⑥ STS manual, where applicable;

⑦ VOC management plan for crude oil tankers.

(2) Evidential documents

① Cargo hose pipe/ cargo piping test reports (insulation test to be conducted annually as per ISGOTT requirements);

② Periodical inspection report of Oil content meter and ODEM (normally every 5 years);

③ Pressure adjusting of PV valves (for oil tankers, Pressure/ Vacuum Valve and P/V Breaker);

④ Product certificates of emergency towing equipment;

(3) Refer to Chapter 8 of the Guidelines for requirements of OCIMF and oil companies.

3.51.4 Survey Planning Meeting

(1) Adequate preparation and close cooperation between the on-site surveyor and the ship owner's representative before and during the survey is an important aspect for the safe and effective conduct of survey. Regular safety meetings are to be held during survey onboard.

(2) Prior to commencement of any part of the renewal and intermediate survey, a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance, the thickness measurement company operator (as applicable) and the master of the ship or an appropriately qualified representative appointed by the Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

(3) The following is an indicative list of items that are to be addressed in the meeting:

① schedule of the ship (i.e. the voyage, docking and undocking manoeuvres, periods alongside, cargo and ballast operations, etc.);

② provisions and arrangements for thickness measurements (i.e. access, cleaning/de-scaling, illumination, ventilation, personal safety);

③ extent of the thickness measurements;
④ acceptance criteria (refer to the list of minimum thicknesses);
⑤ extent of close-up survey and thickness measurement considering the coating condition and suspect areas/areas of substantial corrosion;
⑥ execution of thickness measurements;
⑦ taking representative readings in general and where uneven corrosion/pitting is found;
⑧ mapping of areas of substantial corrosion; and
⑨ communication between attending Surveyor(s), the thickness measurement company operator(s) and owner's representative(s) concerning findings.

3.5.1.5 Requirements for Examinations of Tanks

(1) Requirements for examinations of tanks are different according to different kinds of survey. For more details, please refer to Sections 4 and 6 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships. If ship's condition is found poor, such as coating condition is poor, structural defects found, repairing records shown structural defects found frequently or it is indicated from other same ship types that defects in some spaces may occur, scopes of overall survey and close-up survey are to be extended as appropriate and the extended part is to be listed in detail;

3.5.1.6 Scope and Requirements for Thickness Measurements

(1) Requirements for thickness measurements are different according to different kinds of survey, and more attention is to be paid to thickness measurements of general corrosion, substantial corrosion and close-up area. For more details, please refer to Sections 4 and 6 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships and ISC Guidelines for thickness measurements. If general corrosion, substantial corrosion, buckling deformation are found in the tanks or it is indicated from other same ship types that accelerated or excessive corrosion in some spaces may occur, scopes of thickness measurements are to be extended and the extended part is to be listed in detail.

3.5.2 Attentions to be paid to class survey

3.5.2.1 Class survey including annual survey, intermediate survey, special survey, inspection of the outside of the ship's bottom (docking survey), damage and repair survey.

3.5.2.2 Annual survey

Compare with general cargo ship, more attention to be paid to inspection of cargo maintenance and handling systems for oil tanker, mainly including the following:

(1) Inspection of exposed deck area

① Cargo tank openings including gaskets, covers, coamings and flame screens. Examination of the intactness of gaskets, corrosion condition of hatch coamings, completeness of closing devices, provision of measures to prevent sparkle caused by collision and the intactness of flame screen of inspection hole. Generally speaking, flash screens are made up of stainless steel or copper; it is acceptable if the flowing area is not less than 1.5 times the pipe section area after an air pipe head with flame screen is installed, and the flash screens can effectively prevent fire from going through. The standard of the flash screens used at present is Chinese shipping industry standard- holes of flash screens for oil tank to be at least $12x12/cm^2$, if double flash screens used, the quantity of holes to be at least $8x8/cm^2$, which is a little higher than the requirement of USCG. For metal flame screen, metal screen with 30 meshes per square inch is to be used. If the screen with 20 meshes per square inch is used, it should be double screen and the gap between the two layers of screens is to be between 12.7mm~38.1mm.

② Examination of cargo tank pressure/vacuum valves and P/V breakers. Evidential documents of the adjusting record of PV valves P/V breakers are to be kept on board. Examination of integrity of metal flame screen.

③ Examination of flame screens on vents to all fuel oil tanks, oily ballast tanks, oily slop tanks and void tanks.

④ Examination of integrity of all piping systems on deck, including purging, gas-freeing systems and ventilation and vent piping systems including vent masts and headers. Attention is to be paid to cracks in way of penetrations of pipes through deck. Oil tankers of 500 gross tonnage or above, carrying cargoes having a flashpoint not exceeding 60℃ are to be provided with an auxiliary venting system, which can be realized by installing a second set of ventilation piping system or an additional pressure sensing system outside the first set of ventilation piping system.
⑤ Inspection of the integrity of cargo piping, crude oil washing piping and fuel piping as far as practicable, including valves on the pipeline, drainage devices and grounding pad to prevent adverse effect of electrostatic discharge.
⑥ Inspection of fast cut of cargo oil pipes and its valves;
⑦ For oil tanker of 500 gross tonnage or above carrying cargoes having a flashpoint not exceeding 60℃, inspection of integrity of safe means of access to the bow, including handrails, supporting pillars and wire ropes etc. It is to be noted that the material of access should all be flame retardant;
⑧ For oil tanker of 20,000 gross tonnage or above, emergency towing equipment are to be inspected, including inspection of recovery installation, short towing ropes, anti-friction device, fairlead device, towing points and brackets of rollers, ensuring the buoys of the recovery device are provided with indicator lights which are in good working condition and ready for use.
(2) Examination of cargo pump rooms and pipe tunnels. Focus is to be given on structural integrity - such as the presence of oil leakage traces/deformation/ integrity of shaft seal through the pump tank, the installation location and utility test of combustible gas detector, the sealing performance of cargo pump housing, and the integrity of pump tank sea valves and attached short pipes;
① Confirming that no potential sources of ignition are present in or near the cargo pump room, with attention paid to the cleanliness of the pump room and surrounding areas, securing of lifting appliances and the presence of leakage on the pump surface and bulkhead boundary, and that access ladders are in good condition;
② Carrying out visual inspection of all piping systems inside the pump room as far as possible; confirming that installed pressure gauges on cargo oil piping and level indicator systems are operational, and the pressure gauges are regularly calibrated;
③ Confirming that the pump room ventilation system is operational, ducting intact, dampers operational and flame screens are in good condition; conducting functional tests of ventilation system;
④ Examination, so far as practicable, of various piping systems for excessive gland seal leakage; check of the foundation of bilge pump, including confirming that the remote system and local operating systems and shutoff devices are in good condition;
⑤ Examination of all pump room bulkheads for signs of leakage or fractures, and in particular, the sealing arrangements of all penetrations in these bulkheads;
⑥ For oil tanker of 500 gross tonnage or above, carrying cargo having a flashpoint not exceeding 60℃, confirming that temperature sensing devices of shaft seal and audible and visible alarms are in good condition;
⑦ For oil tanker of 500 gross tonnage or above, carrying cargo having a flashpoint not exceeding 60℃, conducting functional test of bilge level monitoring devices and alarms; for oil tanker of 500 gross tonnage or above, carrying cargo having a flashpoint not exceeding 60℃, conducting examination of systems for continuously monitoring combustible gas. When the combustible gas concentration reaches a pre-set level which is not to be higher than 10% of the lower flammable limit, a continuous audible and visual alarm signal is to be automatically effected in the pump-room, machinery control room, cargo control room and bridge to alert personnel to the potential hazard. However, existing monitoring systems already fitted having a pre-set level not greater than 30% of the lower flammable limit may be accepted for oil tankers constructed before 1 July 2002, and it is acceptable that the audible and visual alarms are only provided in cargo pump room and cargo control room;

⑧ For oil tanker of 500 gross tonnage or above, loaded with cargo having a flashpoint not exceeding 60℃, the lightings in all cargo pump rooms are to be interlocked with ventilation so that the turn on of lighting will activate ventilation. For oil tankers constructed on or after 1 July 2017, The ventilation system should have been running for at least 5 minutes before the lighting is turned on and after the lighting is turned on, the failure of ventilation system is not to put out lighting;

⑨ Examination of emergency lighting in cargo pump room;

⑩ Examination of the fixed fire-fighting system for cargo pump rooms, and confirming, as far as practicable and when appropriate, the operation of the remote means for closing the various openings.

(3) Others

① Checking last ESP document and relevant files such as EHS report, confirming the extent of internal inspection of tanks;

② Checking the deck foam system, conforming that when the foam system is in operation, it should not affect the normal use of water sprinkler system;

③ Confirming that a corrosion prevention system is fitted in sea ballast water tanks of oil tankers;

④ For oil tankers of 500 gross tonnage or above, the keels of which are laid on or after January 1, 2005, confirming that permanent means of access in tanks is to be in good condition;

⑤ Confirming, when appropriate, the measures provided for a ship to regain steering capability in the event of a single failure;

⑥ Examining the integrity of pressure indicator of main cargo piping and level indicator systems including manual sounding devices in the cargo tanks;

⑦ Examination that all electrical equipment in dangerous zones are well protected and in good condition.

⑧Inspection of inert gas systems (IGS) (see Section 6 of Chapter 5 of the Guidelines); inspection of the inert gas scrubbers and overboard discharge outlets of deck seals;

⑨Two sets of portable oil and gas detectors and two sets of combustible gas detectors should be equipped. For IGS oil tankers, two sets of oxygen analyzers should be equipped. It is to be examined that they are in good condition and the documents of periodic testing is kept on board;

⑩ Examining portable or fixed instruments for measuring flammable gas in double hull spaces and fore peak tank(If the fore peak tank may be used in conjunction with other tanks for ballast/discharge operations);

⑪Other appropriate system, such as vapour recovery system etc.

3.5.2.3 Intermediate Survey. Since the intermediate survey replaces one annual survey, the requirement of annual survey should be fulfilled. Besides, the compartment internal examination requirements are also to be fulfilled. For details, see Sections 4 and 6 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships.

(1) Oil tankers, which are less than 10 years of age.

① Inspecting all the pipe systems, including the cargo handling pipe system, crude oil pipe system, fuel pipe system, ballast pipe system, steam heating pipe system, cargo ventilation/vent piping(including mast risers and vent pipe head and ventilation pipe system’s emptier where applicable). If obvious defects are observed, such as partially serious thickness diminution and pitting corrosion, related pipe system pressure test or thickness measurement should be carried out and make the record.

② The ventilation system spares in cargo area should be inspected, including duplicated system, spare motor and impeller, etc.

③ Inspection of insulation measurement of electrical circuits in gas-hazardous zones. If the ship operator has kept the continuous insulation measurement record and the inspection result is satisfactory, the measurement is not compulsory.

④ Internal examinations in representative ballast tanks are required for double hull oil tankers aged 5-10 years. If no obvious structural defects are found during the survey, it can only be confirmed that the hard coating is in “good” condition. If coating condition is poor, the structural defects are found, the repair record shows that structural defects had been seen for several times or the data of other ships of same types showed that defects are likely to occur in a certain space , close-up inspection should be arranged and recorded. If one of the following situations happens in the ballast tank, a memo is to be given, requiring internal examination in the sequent annual surveys. It will be decided whether to conduct thickness measurement depending on the internal examination result:

a. Hard coating is not applied during construction; or

b. Soft coating or semi-hard coating has been applied; or

c. Substantial corrosion is found within the tank; or

d. The hard protective coating is found as not reaching the GOOD condition and the hard protective coating is not repaired to the satisfaction of the surveyor.

e. In addition to the above requirement, all of the suspected areas determined in previous survey should be inspected.

⑤ Arranging inspection and thickness measurement in the suspected structural areas found in previous survey. Meanwhile based on the survey, confirming new suspected areas and areas where potential corrosion acceleration is very likely to happen.

(2) For oil tankers of 10 years or over, the intermediate survey are to be carried out according to the last special survey scope. It is not necessary to arrange a longitudinal strength assessment and tank structure test unless the surveyor considers it necessary, e.g. if there are more structural defects in the tank or if the previous longitudinal strength assessment showed that the strength margin is small, etc.

(3) For oil tankers of 20000 DWT and above, from the third special survey, during hull intermediate and special survey, the survey of the cargo tanks, cofferdams, cargo pump rooms, pipe tunnels and void spaces within cargo length area and surveys of hull structures and piping systems of all ballast tanks are to be carried out by at least two qualified full-time surveyors on board at the same time.

3.5.2.4 Inspection of the outside of the ship’s bottom (Docking Survey)

(1) Surveys on the external bottom and related items are to be carried out at least twice during the special survey period which is performed every 5 years. One should be combined with special survey. In all cases, the interval between any of the two surveys should not exceed 36 months.

(2) The intermediate survey is normally carried out in conjunction with docking survey. For oil tankers no more than 15 years, the external bottom inspection in conjunction with intermediate survey can be replaced by In-Water Survey. For oil tankers over 15 years, the external bottom inspection in conjunction with intermediate survey must be docking survey.

(3) Special survey or intermediate survey under the special survey scope are allowed to be carried out in stages, close-up inspections and thickness measurements of the space under light waterline should be finished together within the docking survey period. If a compartment is divided by the light loading line, the close-up inspections and thickness measurements should be finished before the end of docking survey.

(4) In addition to fulfilling normal docking survey requirements, the docking survey of oil tankers should also focus on the detailed inspection of IGS scrubber and the vicinity of underwater discharge outlet of deck seals.

3.5.2.5 Special Survey (including Survey in Scope of Special Survey)

(1) Except for the annual survey items, special survey should be carried out in conjunction with docking survey. Docking survey is part of special survey. For thickness measurement and tank inspection requirements during special survey, please refer should follow Sections 4 and 6 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships. The thickness measurement report within 15 months before the due date of special survey may be accepted as the TM results of this special survey if confirmed by surveyor.

(2) For an oil tanker with a length of L⩾65m, the hull girder section modulus at the deck and bottom of the ship in the midship 0.4L should not be less than 0.9 times the required hull girder section modulus required by ISC Rules for Classification of Sea-going Steel Ships. Section modulus is to be calculated using ISC-approved software (COMPASS). For oil tankers with a length of L⩾130m and more than 10 years of age, during special survey, the hull girder longitudinal strength assessment is to be carried out as required based on measured thickness or renewal thickness of the structural members according to practical situations. For detailed technical requirements for assessment, please refer to Appendixes 1 and 2 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships.

(3) For oil tanker with a length L⩾130m, first the deck section static moment is to be measured based on the thickness measurement report. If compared with design value, the diminution values are all less than 10%, there is no need to check the section modulus. If diminution of deck static moment of any section is greater than 10%, check of deck and bottom section modulus must be carried out. If check result cannot meet the requirement (i.e. less than the 90% of the required value of ISC Rules for Classification of Sea-going Steel Ships). Several sections are to be selected within the 0.5L of the mid-ship, which should cover all ballast tanks and cargo tanks in the cargo area. When cut for change, the renewal length of longitudinal structural members should not be less than 2 strengthened frames. If choosing cover plate method under the special consideration, the plate in the original substantial corrosion area should be replaced as a priority.

(4) The section structural thickness measurement arranged for longitudinal strength assessment should be carried out in full compliance with ISC rules for Classification of Sea-going Steel Ships. The section should be selected from the suspected area with the maximum thickness reduction, while areas that have been partially renewed or strengthened should be avoided. It should be noticed that the webs and face plates on each longitudinal and girder within an area of 0.1D downward from the upper deck and 0.1D (D being molded depth of the ship) upward from the bottom plating of each section is to be measured, and each plate between the longitudinals should be measured for at least 1 point.

(5) It is to be noted that for oil tankers of 10 years and upwards, during special surveys or surveys within the scope of the special survey, all vent pipe heads in the open area within the whole ship should be subject to overall survey(including external and internal inspection). If a head is so designed that the inside cannot be inspected as appropriate from the external, it should be dismantled from the air pipe to confirm that it is in good condition. Inspection can be exempted for air heads which have been renewed within 5 years.

3.5.2.6 Damage Survey and Repair Survey

(1) In the event of sea damage affecting or likely to affect a ship's classification, the owner should promptly apply for a damage survey by ISC in order to determine the extent of the damage and the necessary repairs. Improper delay or omission of report will lead to the suspension and cancellation of the ship classification, and will also lead to the non-conformity of ISM system. The description of defects should be detailed and as far as possible supported by sketches, drawings, photographs, etc. Any damage (including buckling, grooves, disconnection or fracture) related to structural erosion exceeding the allowable limit or erosion in a large area exceeding the allowable limit which affects or, in the opinion of the surveyor, affects the structural, watertight or weathertight integrity of the ship should be repaired immediately and thoroughly. Focus should be given to the following areas:

①Side structure and side plating;

②Deck structure and deck plating

③Bottom structure and bottom plating

④Watertight bulkhead

⑤Inner bottom structure and inner bottom plating

⑥Inner side structure and inner side plating

⑦Longitudinal bulkhead structure

(2) After observing the defects in survey, further examination should be carried as far as possible in the similar components or location in the area where defects are found. If possible, MT and PT should be used for the checking. If there is difficulty in completing the above repairs at the port where the defects are found, with the consent of ISC, the ship may be allowed to proceed directly to the competent port to complete the above repairs. The ship may be required to discharge the cargo and/or carry out temporary repairs for this voyage of repair. If the structural damage mentioned above is localized and does not affect the structural integrity of the ship and has been properly addressed, the surveyor may consider allowing appropriate temporary repairs to ensure watertight or weathertight integrity and may impose class conditions required for a specified period of time as required.

(3) If any structural defect is found to be caused by improper ship management or maintenance during the inspection, the surveyor will report the defect to the headquarters. If the ship's ISM certificate is issued by ISC, the defect report will be further analyzed. According to the analysis results of the defect report, it will be finally judged whether to arrange an additional ISM audit. If the ship's ISM certificate is not issued by ISC, the defect report will be forwarded to the ISM certificate issuing authority.

SECTION 6 STATUTORY SURVEYS

3.6.1 At present, ISC has accepted various states and areas' authorization of statutory survey, the scope of which covers various parts of SOLAS convention, LL convention, COLREG convention, ILO convention and MARPOL convention.

3.6.2 According to the classification rules of ISC: Classification survey is to be coordinated with the statutory survey. As a result, classification survey is normally taken when doing statutory survey. If the classification special survey cycle is restricted to less than 5 years for the reason of technical condition or structural condition of the ship, the interval of statutory certificate renewal survey should be in accordance with that of the classification special survey, and the relevant statutory periodic survey is to be adjusted accordingly.

3.6.3 The anniversary date of statutory survey determines the date of annual survey, intermediate survey and renewal survey. If the annual survey, intermediate survey and renewal survey are completed before specified time window (namely before 3 months of the anniversary date), the anniversary date need be revised to ensure that all kinds of regular survey will not exceed the specified period.

SECTION 7 CAP SURVEYS

3.7.1 The condition assessment procedure (CAP) is a technical service provided to applicants with no relation to classification. It is an independent and thorough assessment to grade the actual condition of the ship based on detailed inspection, thickness measurement, strength calculation and performance test.

3.7.2 CAP is applicable to oil tankers at the age of 15 years and above. It can also be used as reference for tankers at other ages.

3.7.3 The purpose of CAP is to provide the applicant with a technical document and statement of the actual condition of the ship in relation to the structural strength, mechanical equipment and maintenance of the life of the ship, which can be used by the shippers and/or interested parties in the event of a new lease or renewal after expiry.

3.7.4 CAP can also provide reasonable technical basis for the following aspects:
3.7.4.1 Repair and maintenance to extend the service life of a ship;
3.7.4.2 Ship sale and purchase.
3.7.5 CAP is generally composed of two modules: one is the hull structure condition assessment program (HCAP), and the other is the machinery condition assessment program (MCAP). The applicant may choose both of them, one of them or a part of one module upon request, but this should be indicated on the application form.
3.7.6 For specific requirements for CAP survey, please refer to the ISC Guidelines for Condition Assessment Programme for Existing Ships.

CHAPTER 4 SURVEY OF HULL STRUCTURES

In recent years, with the deepening of structural research, structural survey techniques have been greatly developed. It is the prerequisite to conduct structural survey to fully understand the structural stress characteristics and structural corrosion mechanism and accurately grasp the requirements of structural survey.

SECTION 1 INSPECTION OF HULL STRUCTURES

4.1.1 Structural Loads

4.1.1.1 The deck structures of oil tankers mainly withstand longitudinal bending stress and lateral load caused by cargo and waves. As deck area is relatively far from the neutral axis, bending stress suffered is higher. For machinery equipment fitted on deck, green sea, wave slamming loads and other local loads should also be considered.

4.1.1.2 The bottom structural members mainly withstand longitudinal bending stress of hull girder, as well as cyclical local loads including cargo oil, ballast and water pressure. As the bottom area is relatively far from the neutral axis, bending stress suffered is higher too. Lateral loads on bottom structures are obviously during alternate using of side tanks and centre tanks.

4.1.1.3 Side shell, longitudinal and transverse bulkheads are mainly subject to slamming load in internal tanks as well as external wave loads and other dynamic loads. And side shells, longitudinal bulkheads as the web of hull girder also withstand and transmit shear forces along ship length, and the transverse bulkheads and transverse web frame withstand and transmit the lateral shear forces.

4.1.1.4 Bow structures are mainly subject to slamming and green sea. The area above light waterline up to forecastle or bow deck plating should be the focus in survey. For stern structures, the effects of vibration and cavitation erosion are to be considered more, and structural corrosion and overboard outlet of various types of pipeline should be paid more attention in survey.

4.1.1.5 The force on the hull structure is usually combined effects of various factors. Being fully aware of this is of great benefit to inspection.

4.1.1.6 Accurately understanding and grasping the force on structure is very important for accurately determining the key points of structural inspection, critical structural areas, structural hard points and hot spots. During inspection, the possible areas of structural defects, structural defect types, causes of defects and defect handling requirements are be found and determined in full accordance with ISC Rules for Classification of Sea-going Steel Ships, combined with the ship's survey instructions (if any), hull structure construction monitoring plan (CMP), and analysis of historical maintenance and repair.

4.1.2 Cause and Analysis of Structural Defects

4.1.2.1 A major task for structural survey of oil tankers is to confirm the structural strength of the hull, structural integrity and tightness. The key is to accurately understand the force in structure, the damage patterns and causes. Focus is to be put on grasping the fatigue damage, especially fatigue damage characteristics of high strength steel.

4.1.2.2 Causes of structural defects are various. There are design defects, material defects, workmanship defects, welding defects, fatigue, adverse weather, unreasonable and improper transferring of ballast water at sea, and collision, etc.

4.1.2.3 Defects are mainly in the form of material wastage, buckling, dents, deformation and crack damage. These defects are usually caused by a variety of factors working together which affect each other, such as cracks commonly appear at the beginning or end of a run, or rounding corners at the end of a stiffener or at an intersection. In case of excessive structural corrosion, the anti-deflection and anti-cracking capabilities of the structure with reduced thickness is decreased when being subjected to external force, resulting in a large number of cracks and buckling. Plating which has buckled severely is easy to lead to layering and peeling off of anti-corrosion coating, thus resulting in serious corrosion.

4.1.2.4 The typical structural defects are categorized in the following table:

Table 4.1.2.4 Types and Location of Typical Structural Defects

Items	Corrosion	Buckling	Cracks
Longitudinal structural members	- upper deck plating and deck longitudinals - welding connections between structural elements, deck longitudinal to deck plating in particular - scallops and openings for drainage - webs of longitudinals on long. Bulkheads - flanges of bottom longitudinal - bottom plating, erosion near suction - longitudinal bulkhead plating	-upper deck plating -upper deck longitudinal -bottom plating -bottom longitudinals -upper and lower part of longitudinal bulkhead plating -girder in deck and bottom	- at discontinuities -at openings, notches -at connections with transverse elements
Transverse web frames	-Upper part, connection to deck -Just below top coating -Flange of bottom transverse	-web plating -Brackets -Flanges -Cross ties	-Connections with longitudinal elements -Bracket toes -holes and openings -crossing face flats
Transverse Bulkheads	-upper part, connection to deck -stringer webs -close to opening in stringers -high stress location	-Horizontal stringers, web plate -Girder / stringer brackets -Vertical girders, web plate -corrugated bulkhead plate	-connections with longitudinal elements -bracket toes -connection between girder systems
Swash bulkhead	-upper part, connection to deck -stringer webs -close to openings in stringer -high stress location	-Horizontal stringers, web plate -vertical girders, web plate -Girder/stringer brackets -bulkhead plating around openings	-connections with longitudinal elements -bracket toes -connections between girder systems

4.1.2.5 Brief Introduction to Structural Corrosion

(1) In general, Corrosion is divided into general corrosion and local corrosion. Uniform corrosion is a lower dangerous corrosion, which is easier to control in the design. Uniform corrosion rate can be assessed with thickness measurement evaluation software approved by ISC. Local corrosion in structural elements is more popular in fact. Local corrosion is divided into pitting, grooving and edge corrosion.

(2) Comprehensive comparison of the various factors affecting the structural safety of oil tankers, corrosion is the greatest impact for tanker hull structure. Due to its characteristics of tanker and the loading cargo, the corrosion is relatively common. To understand the corrosion mechanism of the structure can efficiently complete inspection of the ship's structure, and also provide the necessary

information for the owner's maintenance and repair of structures.

(3) Corrosion of the conventional hull structure without PSPC coating is divided into the following three stages:

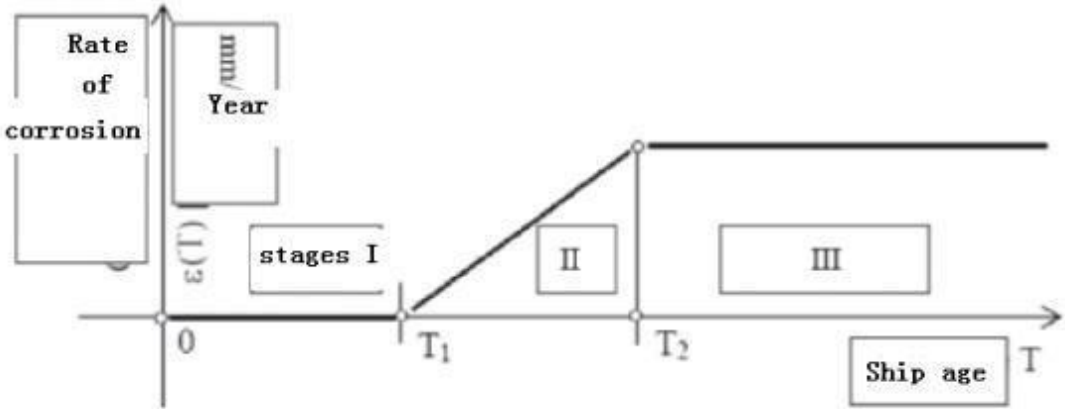


Figure 4.1.2.5(3) Corrosion Rate

In the first stages of ship's service life, as the coating is in good condition, the structure generally has no corrosion. As time goes by, the second stage of structure corrosion comes and effect of protective coatings is lessening. Corrosion rate of structure is rapidly increasing in exponential function. In the third stage, the protective coating is completely damaged, and the structure reaches a maximum corrosion rate. According to analysis of thickness measurement of lots of older ships, the first stage is at age between 0 to 10.54/11.49 years, and the second stage is at the age between 10.54/11.49 to 19.73/28.10 years.

(4) It is to be particularly noted that individual classification societies have different requirements on the maximum allowable limit for structural corrosion, which is related to rules calculation methods and margin used during ship's design and construction. The maximum allowable structural corrosion limit is matched to the rules applicable to the ship.

(5) The problem of corrosion is the focus of the maintenance of oil tanker structure, and summary and analysis of its regularity is conducive to the formulation of a reasonable routine maintenance plan, and it is also conducive to the targeted inspection, so as to ensure the safety of the structure. Factors which may have effects on corrosion of oil tanker structures are categorized as follows:

① Frequency of Tank Washings

a. Increased frequency of tank washings can increase the corrosion rate of tanks. For uncoated tanks, it is often possible to see lines of corrosion in way of the direct impingement paths of the crude oil washing machines.

② Composition and Properties of Cargo

a. Carriage of crude oil can result in the tank surfaces in contact with the cargo being coated with a "waxy" or "oily" film, which is retained after cargo discharge. This film can reduce corrosion. Less viscous cargoes such as gasoline do not leave behind a similar film.

b. Carriage of crude oil that has high sulphur content can lead to high rates for general corrosion and tank bottom pitting corrosion. By reacting with water many sulphur compounds can form acids, which are very corrosive. This will often mean that water bottom dropping out of the cargo will be acidic and corrosive.

c. Carriage of cargoes with high water content can increase corrosion rates.

d. Carriage of cargoes with high oxygen content (e.g. gasoline) can lead to high corrosion rates.

e. Carriage of cargoes with low pH values (acidic) can lead to high corrosion rates.

③ Time in Ballast

a. For ballast tanks where the coating has started to fail, corrosion increases with the time in ballast

④Microbial Induced Corrosion

a. Microbial influenced corrosion is the combination of the normal galvanic corrosion processes and the microbial metabolism. The presence of microbial metabolites generates corrosive environments, which promote the normal galvanic corrosion.
b. For tanks that remain filled with contaminated ballast water for a long time, the potential for microbial induced corrosion, in the form of grooving or pitting, is increased. The microbes could penetrate pinholes and accelerate the coating breakdown and corrosion in the infected areas. Proper procedures, such as flushing with clean (open sea) salt water, will help reduce the potential for this type of corrosion.
c. Cargo oil often contains residual water, which may contain microbes leading to microbial induced corrosion attacks in the tank bottom or other locations where the water may collect.
d. Biocide shock treatment to exterminate the microbes is a method that could be used in cargo and ballast tanks. In addition clean water flushing at regular intervals will help reduce the potential of microbial induced corrosion. Proper maintenance of coating integrity, or blasting and coating the uncoated surfaces, would be an effective method to deal with microbial induced corrosion.

⑤ Humidity of Empty Tank

a. Empty tanks, e.g. segregated ballast tanks during laden voyages, can have high humidity and are thus susceptible to general atmospheric corrosion, especially if corrosion control is by anodes which are ineffective during these periods.
b. During prolonged periods, when the tanks are left empty, such as lay-ups, maintenance of low humidity atmosphere in the tanks should be considered to minimise corrosion.

⑥ Temperature of Cargo in Adjacent Bunker or Cargo Tanks

a. Carriage of heated cargoes may lead to increased general corrosion rates at the ballast tank side of a heated cargo tank/unladen ballast tank bulkhead. This may also apply for tanks adjacent to heated bunker tanks.

⑦ Coating Breakdown

Intact coatings prevent corrosion of the steel surface.
However:
a. A local absence of coating (due to coating depletion, deterioration, damage, etc.) can result in corrosion rates similar or greater than those of unprotected steel.
b. Holidays or localized breakdown in coating can lead to pitting corrosion rates higher than for unprotected steel.
c. Periodic surveys at appropriate intervals and repair of coating as required are effective in minimising corrosion damage.

⑧ Locations and Density of Anodes

a. Anodes immersed in bottom water can afford protection against bottom corrosion.
b. Anodes are not effective in reducing underdeck corrosion rates.
c. Properly designed systems with high current densities may afford greater protection against corrosion.
d. Electrical isolation or coatings, oily films, etc., on anodes can make anodes inoperative; abnormally low wastage rates of anodes may indicate this condition.

⑨ Structural Design of Tank

a. High velocity drainage effects can lead to increased erosion in the vicinity of cut-outs and some other structural details for uncoated surfaces.
b. Horizontal internals and some details can trap water and lead to higher corrosion rates for uncoated surfaces.
c. Less rigid designs, such as decreased scantlings and increased stiffener spacing, may lead to increased corrosion due to flexure effects, causing shedding of scale or loss of coating.
d. Sloping tank bottoms (e.g. as with double bottom tanks) to facilitate drainage may reduce bottom corrosion by permitting full stripping of bottom waters.

⑩Gas Inerting

a. Decreased oxygen content of ullage due to gas inerting may reduce corrosion of overhead surfaces.

b. Sulphur oxides from flue gas inerting can lead to accelerated corrosion due to formation of corrosive sulphuric acid.

⑪Navigational Route

a. Solar heating of one side of a ship due to the navigational route can lead to increased corrosion of affected wing tanks.

b. Anodes used to protect ballast tanks on voyages of short duration may not be effective due to insufficient anode polarisation period when high corrosion may occur.

⑫ Accelerated structural corrosion in water ballast and cargo tanks

a. A limited but significant number of double hull tankers have been found to be suffering from accelerated corrosion in areas of their cargo and ballast tanks. It is now generally agreed that the "thermos bottle effect", in which heated cargoes retain their loading temperatures for much longer periods, promotes an environment within the cargo and ballast tanks that is more aggressive from the viewpoint of corrosion (as temperatures rise, corrosion activity increases - warm humid salt laden atmospheres in ballast tanks, acidic humid conditions in upper cargo tank vapour spaces and warm water and steel eating microbes on cargo tank bottom areas - all factors which promote corrosion).

b. If corrosion remains undetected during surveys, loss of tank integrity and oil leakage into the double hull spaces may occur (increased pollution and explosion risk). In the worst cases, corrosion can lead to a major structural failure of the hull.

(6) In summary, the tanks of oil tankers have the following corrosive properties, and the corrosion allowance is shown as follows:

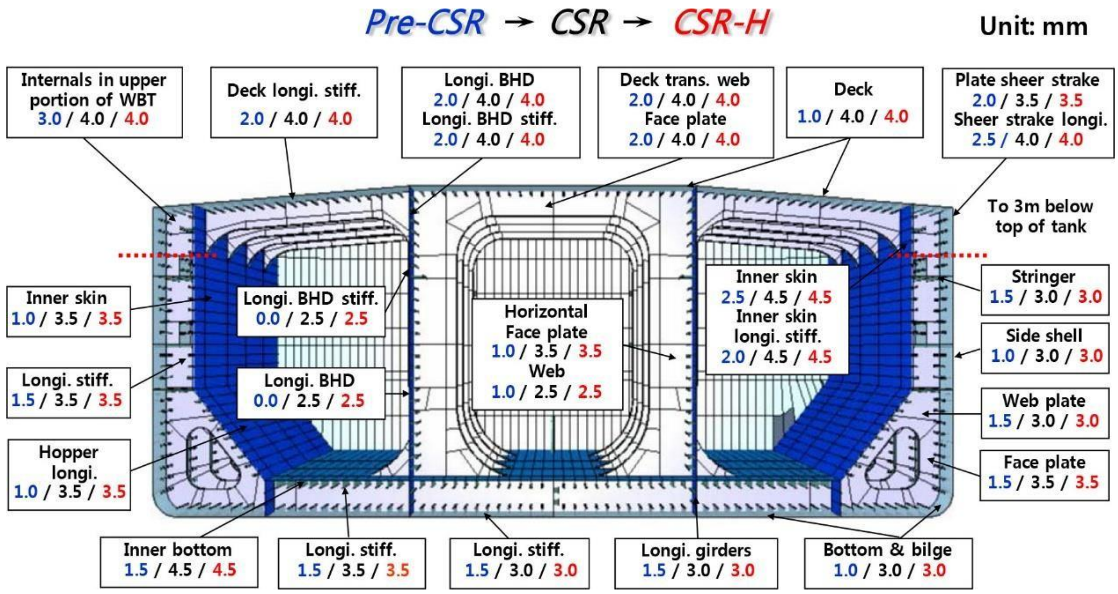


Figure 4.1.2.5(6) Development trend of corrosion allowance of each component of double hull oil tanker[①]

① Cargo tanks: In general, the corrosion of cargo tanks is concentrated in the following locations:

a. Due to the sulphur content of loaded crude oil is large, under the effect of temperature change of day and night, a cargo vapor layer with corrosive property has been formed between cargo oil and

① a. For the plate boundary between ballast tank and heated cargo oil tank, plate surface exposed to ballast water is to be increased by 0.5mm. The web and face plate surface of aggregate connected with boundary between ballast tank and heated cargo oil tank or heated fuel oil/lubricating oil tank in ballast tank is to be increased by 0.3mm. The heated cargo oil tank is defined as tank arranged with any form of heating capacity (the most common form is heating coil).

b. The plate surface of plate boundary between ballast tank and heated fuel oil tank/lubricating oil tank and exposed to ballast tank is to be increased by 0.7mm.

deck to cause the layered homogeneous corrosion under the deck structure. According to the statistics, the corrosion rate is about 0.1mm for each year. Typical corrosion is shown as follows:

b. Water in cargo oil often accumulates at the tank bottom, but the oil residue causes the local enclosure of water so that obvious pitting corrosion will appear on the bottom plating, in a severe condition, the corrosion rate is about 1.5~2.5mm for each year. Typical corrosion is shown as follows.

c. At the suction of cargo oil piping, obvious pitting corrosion will occur on the bottom plating in the said area due to flushing effect.

d. Heating pipes are generally provided in cargo tanks, heat conduction in way of bracket of heating pipe on bottom plate is greater than that in other areas, so it is easy to cause coating damage thus fasten corrosion.

e. Obvious pitting corrosion/grooving corrosion are easy to occur due to combined action of liquid surface impact, corrosive gas and vapor in way of alternative location of liquid surface in cargo tanks.

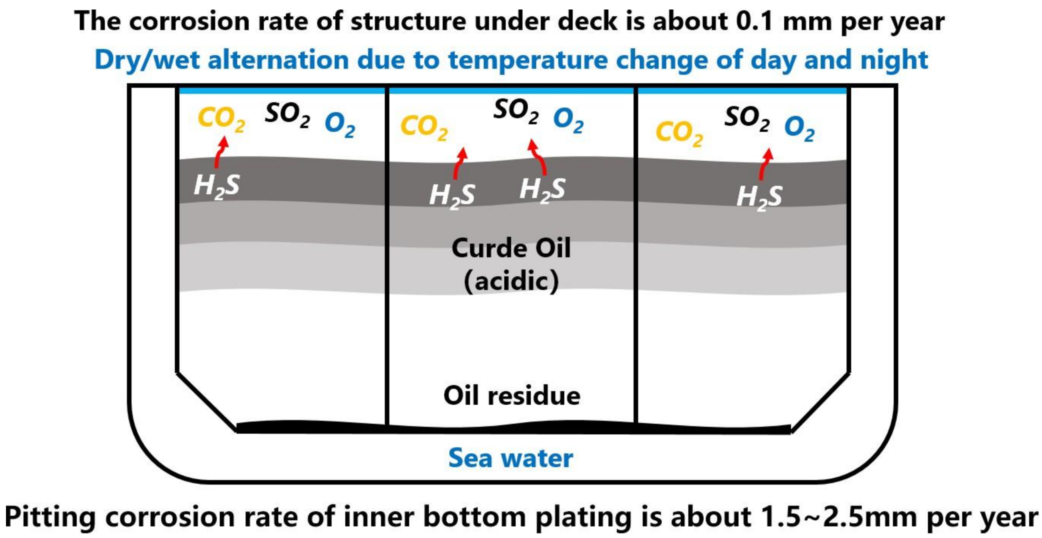


Figure 4.1.2.5(6)①a Corrosion rate of structure under deck and inner bottom plating

Figure 4.1.2.5(6)①b Typical pitting corrosion of inner bottom plating in cargo oil tank

② Seawater ballast tank:

a. Obvious grooving corrosion is easy to occur in vicinity of weld connections between longitudinals and bulkheads, especially buckling is easy to appear in way of bulkhead plating and longitudinal by the periodical interacting force of cargo oil and ballast water in adjacent tanks, and by the accumulation of water, sludge and rust block, such corrosion is aggravated, such two alternative factors make the corrosion worse. With the increasing age of the tanker, not only the strength of structural members, but also the rigidity are influenced by the corrosion, and the buckling and deformation make the coating layer and peal to reduce the corrosion protection so as to form the worse circulation; For tanks which are often partially ballasted, impacting effect will occur due to shocking in way of ballast water level so as to aggregate the corrosion; If dirty ballast water is used, due to inadequate passage of water, the lower part of tank will easily cause sludge accumulation and acidic materials by bred microorganism to damage the coating; Vertical girder on longitudinal bulkhead and transverse props on ring frame bear stronger shearing stress so as to aggravate the corrosion; The bow ballast tank is also to consider stress corrosion caused by local stress concentration due to sea wave impact.

b. Slop tanks in cargo areas are easy to have corrosion in way of liquid level and tank bottom.

(7) The following Table shows the hazardous level of each type of corrosion in various tanks for reference during inspection.

Hazardous level of corrosion of various tanks in oil tankers Table 4.1.2.5(7)

Tank type	Fully-coated protection	Coating protection at upper and lower parts	Without any protection
Dedicated ballast tank	L	--	H++
Cargo oil tank	L-	L	H
Explanation: H++ = very high hazard H = high hazard L = low hazard L- = lower hazard			
Remarks: (1) Structural members to be given special attention Horizontal girder, longitudinal and longitudinal bulkhead, longitudinal bulkhead plate, parts on upper part of web frame close to longitudinal bulkhead, transverse brace, upper part of transverse bulkhead plate. (2) Area liable to pitting corrosion Horizontal plane of girder, bottom plate, bottom longitudinal plate and flange. (3) Other relevant factors affecting corrosion hazard			

Heating of adjacent cabins, partial coating peeling due to rough technology, unreasonable structure design considering from coating protection, locally high stress area, fast flowing area, washing machine nozzle injection area.
(4) For double hull oil tanker, typical working conditions of cargo/arrival ballast tank and cargo/departure ballast tank are completed under dedicated ballast, and the corrosion level evaluation is the same as that for dedicated ballast tank.
(5) If sacrificial anode is provided, corrosion hazard may be decreased.

4.1.2.6 Key points of structure inspection considering stress influence

(1) The hull structures bear longitudinal bending, static and dynamic loads for both inner liquid and seawater, and such loads reflect the low-cycle alternating stress. The hull components may lose stability under the action of longitudinal bending stress. For oil tanker, because of the structure characteristics, i.e. small plate thickness, large longitudinal span and with large amount of HTS, local instability will occur.

(2) Special attention is to be paid to the structure stress concentration, structure hard point and hot point areas during structure inspection of oil tankers. Risks will occur because hull structure defects cannot be handled in time due to uncleanness, insufficient lighting, unreachable or invisible pressed cracks, and it is to be careful. If there is any doubt, close-up inspection is to be carried out in way of shell plating in the vicinity of light or heavy load lines, bilge, platform, longitudinal penetrated notch and connecting bracket in high stress area, frame toe, etc. and a certain number of members are to be sampled for NDT testing, such as PT or MT.

(3) The areas that need special attention are as followings, for details, refer to Attachment – Inspection for Key Structure Zones:

① Longitudinal and transverse strength structures (located on shell plating, deck and bulkhead), web frame and ends of transverse brace, including connecting bracket, especially bracket toe end;

② Inspection in way of connection between shell plating, deck, bulkhead longitudinal and web frame, especially shell plating connection between light and heavy load lines (including bow area);

③ Inspection for structure alignment, such as connection of upper and lower longitudinal and transverse bulkheads in way of inner bottom plating, transverse brace in way of bulkhead connection, effective extension of longitudinal members in fore and aft locations in cargo tank areas, etc.;

④ Opening edges;

⑤ Critical structure area, structure hard point and hot point areas indicted by historical information/reference.

(4) During inspection, by comparison of similar areas, such as symmetrical locations in port and starboard, similar locations of similar tanks and structures in vicinity of same tanks, the reason of defects is to be determined in combination with force analysis and further repairing measures is to be taken.

4.1.2.7 Fatigue damage

(1) The fatigue damage mainly occurs in the form of crack and in way of heavily loaded members, the crack source occurs in high stress concentration area, and the damage concentrates in the midship.

(2) Structure fatigue damage can be prevented effectively by changing structure form, e.g. increasing structure size, using T section instead of angle steel/flange, optimizing toe end design, etc.

(3) Areas easily to cause fatigue damage--structure fatigue damage is easily caused in the following areas:

① Shell plating structure between light and heavy load lines;

② Connection between deck and deck web frame;

③ Connection between transverse bulkhead and upper/lower stool seats;

④ Connection between bottom slope plating and inner bottom plating.

(4) Effect of high-tensile steel (HTS) on structure fatigue strength

① Currently, HTS is widely used for construction of hull structure to reduce the weight of hull, the mainly used locations are decks within the range of cargo tanks and deck longitudinal, shear strake and its attached longitudinals, bilge strake, longitudinal bulkhead top and its attached longitudinals, bottom plating and bottom longitudinal, double bottom girder and its longitudinal structural members such as longitudinal stiffeners, etc. The oil companies prohibit wide usage of HTS, where HTS is used not less than 30% of the total steel amount, structure analysis including fatigue analysis is to be carried out by ISC with approved confirmation.

② In general, the structure inside tank is more easily damaged due to insufficient fatigue strength, and reducing stress concentration level is the effective means to control fatigue damage. During inspection, special attention is to be paid to the condition of structure nodes. For details, please refer to paragraph 4.4.6, Section 4 of this Chapter– Typical node damage cases and recommended treatment requirements.

4.1.3 Introduction of typical locations for structure inspection

4.1.3.1 The strength reliability for hull structure is to be verified by inspection and thickness measurement, currently, the ship structure strength criteria mainly includes two aspects, i.e. longitudinal strength and local strength, of which the longitudinal strength is checked during special survey through comparison of calculation of cross sectional area/cross sectional modulus of hull girder in way of main deck (deck and deck longitudinals) and bottom plating (bottom plating and bottom longitudinals) in amidship area with the value specified in ISC Rules for Classification of Seagoing Steel Ships. The longitudinal strength criteria of hull girder for oil tankers are to meet all requirements of Appendix 2, Chapter 5, PART ONE of ISC Rules for Classification of Seagoing Steel Ships.

4.1.3.2 Ship structure also has some problems relating to rigidity criteria, various deformations of structural members, such as fold, buckling, dent, etc. will reduce the load-bearing capability of structures.

4.1.3.3 The following introduces defect inspection and analysis for structures in typical areas in order to provide reference for surveyors and related persons. Different defects and treatment recommendations are provided in paragraph 4.4.6, Section 4 of this Chapter – Typical node damage cases and recommended treatment requirements. After defects are found, the surveyor can treat according to comparison.

(1) Exposed deck area is shown as follows:

Figure 4.1.3.3(1) Open deck area

① In general, the main deck of oil tanker adopts longitudinal frame type so that the structure within cargo areas can keep continuous and be capable of bearing the bending moment and shearing force of longitudinal strength due to cargo loading or sea action. According to the structure arrangement characteristics of oil tanker and comparison with other locations, the pulling or compressive stress of deck is the maximum under longitudinal bending moment. Meanwhile, it will also bear large loads due to green water. In addition, certain parts of main deck will bear the compressive stress caused by additional impacting and attacking in bow under severe weather conditions, and it is possible to cause the deck stability loss or dilacerations. At present, more oil tanker decks adopt HTS to reduce the scantling of structural members and weight as well as increase ship economy, however, it weakens deck rigidity and leads to stability loss.

② Corrosion defects are very easily to occur due to the fact that the main deck is influenced by humid environment caused by sea and the cargo vapour, and the sulphur content in cargo oil and heating effects to deck by sunlight also fasten the corrosion of steel plate and stiffener. Therefore, crew members are to clean the slops in such locations frequently, and carry out inspection and maintenance work.

③ Corrosion and crack of the longitudinal members on deck are to be fully noted during survey, especially at butt welds, where leads to fracture with high risk due to improper loading or potential defects during construction. Please refer to following figure.

Figure 4.1.3.3(1)③ Open deck area

④ The key points for inspection in deck areas are as followings:

a. Obvious pitting corrosion always occurs on the surface of main deck, and concentrated pitting corrosion will finally lead to whole thickness reduction of steel plate, so effective corrosion prevention will be achieved by periodical rust removal on the surface of corroded steel plates and paint application.

b. Another common issue for the main deck is the grooving corrosion, it is to be noted that the condition of side ballast tank under main deck is worse than that of deck, therefore, the grooving corrosion in way of welds on lower surface of main deck is generally worse than the upper surface.

c. The deck longitudinal and web frame for oil product tanker are arranged on the upper surface of deck, lots of sewage will accumulate in the trunk formed by beam and longitudinal, and this will cause severe corrosion to deck at the structure roots. For oil product tankers, in order to facilitate tank cleaning, sometimes the deck members are installed on the upper surface of deck plating, because the deck members stop deck sewage flow, it will make water accumulation at member root and lead to severe deck corrosion.

d. There are three common section types for sheer strakes onboard the oil tankers as follows, the first is the arc-typed, with oil baffle on the arc; the second is that the sheer strake is higher than the main deck, because such type of sheer bears large loads, it is to ensure smooth and continuous so as to effectively pass the stress. If there is opening or deformation, it is possible to have severe consequence such as hull fracture or buckling. During actual service, sometimes there will be openingor cutting by mistake during repair, crew members are to strengthen inspection in these locations and take measures as early as possible. The third is that the deck side plating is connected with sheer strake in right angle, and the upper surfaces of sheer strake and plywood are parallel and level. Such type has the same requirements for stress and maintenance as the second type.

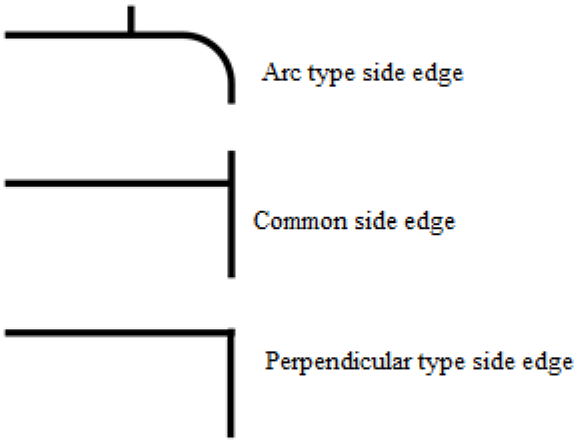


Figure 4.1.3.3(1)④d Bilge strake section type

e. At the location where the deck web frame and deck longitudinals connect, in general, stress concentration will occur in way of abrupt interfaces due to load transmitting, at this moment, the stress will increase suddenly in a minor area and cause crack at weak point.

f. Deck outfittings and fittings such as bollard, air pipe, ventilator, base of deck machinery, crane post and penetrating opening of deck piping, etc., except for inspecting external corrosion of such equipment, special attention is to be paid to the corrosion and crack at the roots.

g. Bulwark and handrail are the means to protect crew members. In case of certain degree of deformation, they are not to be regarded as a defect provided that they can still provide such protection. Where excessive corrosion or crack occurs on the bulwark bracket or handrail bracket, repair is to be carried out in time, especially when such defects occur at toe end, it will greatly reduce the strength. Under large wind and wave loads, stress concentration will occur at bulwark or handrail toe ends, therefore, cracks on the bulwark root deck are to be inspected. In addition, mooring equipment and supporting bracket on the bulwark always rust, and rust removal is to be carried out for daily maintenance.

(2) Cargo tank area

Locations where longitudinal and transverse structures connect in cargo tanks are the stress concentration areas due to load transmitting. Such areas will have defects such as crack, buckling, etc. under the action of alternating loads, therefore, careful inspection is to be carried out to such locations to find and eliminate the defects in time.

① Lower surface of deck will occur coating peeling, especially at the edge of structural members and welds. For the oil tankers carrying products with high sulphur content, due to stronger corrosive property of H_2S, severe pitting corrosion is also easy to occur on the top plate of cargo tank, and grooving corrosion may occur in heat effect area of welds connecting structural member and deck, severe grooving corrosion will lead to deck crack along the structure or make partial deck stability loss, so attention is to be paid during survey, and during practical operation, it can be realized by measuring the effective height of fillet welds of deck longitudinal, the effective height of throat is to be more than 0.8K (K is weld leg height). The node of toe end type for deck web frame has been optimized during the construction, and a good structure transition is formed, it is to ensure to maintain original toe end type during repair. Where crack damage is found, suitable repair plan is to be determined by the toe end type recommended by IACS or through FEM analysis and direct calculation for non-typical structures.

② Crack is easy to occur on the stiffeners under deck where lifting equipment is fitted, especially the bracket connected with deck longitudinal, such case has been verified in many oil tankers and high attention is to be paid during survey.

③ Where the cutting angle of web and face plate at bracket end is small, an abrupt change of toe transition section will be formed and stress concentration will occur to cause fatigue crack. Meanwhile, there is no necessary supporting at the end web to form sufficient end rigidity, leading to repeated deformation and quick generation of fatigue crack. The solution includes increasing the bevel angle of face plate, carrying out second softening treatment for web toe ends, increasing plate thickness and fitting tripping bracket, etc.

④ Where common brackets are used to connect transverse brace and longitudinal, cracks often occur at the transverse brace root cutting and toe end of connecting bracket due to connecting hard points. The solution is adopting soft toe bracket with arc free-edge soft toe instead of common bracket, and both sides of bracket are arranged symmetrically.

⑤ Buckling will occur on web at the corner connecting transverse brace and vertical girder due to insufficient plate thickness, and the solution is generally changing the plate and adding local stiffeners.

⑥ Between the longitudinal bulkhead and inner bottom plating, the bracket toe end of longitudinal bulkhead is a high stress area. When the longitudinal bulkhead longitudinals penetrate the vertical girder, notch is to be made. The notch near the bracket toe end is the weakest part of the structure, and crack is easy to occur at the notch edge, so attention is to be paid during routine inspection. The solution includes local renewal, increasing new plate thickness, filling the notch with watertight patching and increasing structural strength of secondary location.

⑦ Triangle bracket is used to connect the vertical girder of longitudinal bulkhead with bulkhead longitudinal at certain level, if the triangle bracket is a common bracket, crack is easy to occur at the toe end due to similar reasons as the bracket connecting transverse brace and bulkhead longitudinal. During repair, soft toe type is to be adopted at the bracket toe end, for detailed specifications, refer to the requirements of paragraph 4.4.3, Section 4 of this Chapter.

⑧ In general, the big bracket at the end of horizontal girder of transverse bulkhead is a place with serious stress concentration. For larger oil tankers, more attention is paid to the structure design in such locations. However, due to improper radius of free-edge arc for the bracket, crack will also often occur at the bracket toe end, and attention is to be paid during inspection. The solution includes increasing the bracket arm length, fitting smaller bracket on the basis of the original one or using bracket with larger radius of free-edge arc, and further softening the bracket toe end.

⑨ When the horizontal girder of transverse bulkhead transmits to a longitudinal bulkhead, a vertical girder penetrating longitudinal bulkhead is usually adopted to install bracket connecting the horizontal girder face plate and vertical girder. Sometimes, short girders may be fitted at the longitudinal bulkhead end as a transmit to the horizontal girder of transverse bulkhead, however, connecting brackets will also be fitted between vertical girder and short girder. Whichever type is selected, the bracket stress is large and crack is easy to occur.

⑩ If the damage occurs, the solution includes increasing bracket strength, using soft toe end bracket connection, etc. Where there is significant difference between longitudinal girder web and horizontal girder web, the web height of short girder is to be increased, and it is also a good solution to maintain the web height of other horizontal girder as the same as that of short girder.

⑪ Comparing the oil product tankers with crude oil tankers, the biggest difference is that the longitudinal and transverse bulkheads separating the oil tanks are corrugated bulkheads. At present, less new-built oil product tankers use such type, and such bulkheads are also required to arrange vertical girders to strengthen bulkhead. Thus, the convenient tank washing advantage for corrugated bulkhead cannot be put to maximum use.

⑫ Cracks sometimes will occur in vicinity of bracket toe ends at both ends of vertical girder of bulkhead due to stress concentration, therefore, careful inspection is to be carried out during inspection. The solution is to cut the plating with crack firstly, meanwhile, to add small transmitting brackets at the end of original vertical girder.

⑬ For the oil tankers with smaller tonnage, upper and lower stools are not fitted for the corrugated bulkhead, the bulkhead is directly connected with inner plating and deck. Cracks have occurred in way of bulkhead root of some oil tankers, mainly because there is no strengthened structure under groove side plating, and the inner plating in the vicinity of bulkhead root is damaged by repeated pulling of bulkhead. Therefore, the solution is to fit the corresponding strengthened bracket under the corrugated side plating.

⑭ For the corrugated bulkhead structure used for oil product tankers, cracks occur on the face plate due to the same reason as that mentioned above, the solution is the same, i.e. adding the corresponding bracket to the corrugated side plating. Due to the larger dimension of the oil tankers, the stress at such location is relatively larger. Therefore, the fillet welds on the face plating of upper/lower stools, side plating and corrugated bulkhead plate adopt full penetration type, and Z-directional steel is used for face plating of upper/lower stools as far as possible.

⑮ Due to the fact that both the inner bottom plating and lower stool face plating are stressed, crack will occur at the inner plating in the vicinity of lower stool root. The recommended repairing procedures are to renew the steel plate with defects, to change the connecting welds of inner bottom plating, lower stool side plating and frame corresponding to stool to full penetration type, and to add watertight patching on the penetration hole of frame.

⑯ At the bottom of cargo tanks, cargo oil heating pipes are usually arranged, this will cause the temperature difference between tank bottom and adjacent areas and lead to accelerated corrosion at such location, therefore, constant attention is to be paid to corrosion of tank bottom structure, where necessary, thickness measurement is to be carried out. Suction/groove is easy to have pitting corrosion due to effects of water flow, the solution includes bead welding or plate renewal, if necessary, proper thickening is to be carried out.

(3) Bilge structure is as follows:

Figure 4.1.3.3(3) Bilge structure type

The inclined bottom plating at bilge is an important part of hull girder, taking part in longitudinal strength and is a supporting structure for inner bottom plating and side inner shell plating. The intersection location of inclined bottom plating and inner bottom plating of double hull oil tanker is subject to significant fatigue stress in addition to corrosion, and the center lines of bilge inclined bottom plating, inner bottom plating and bottom side girder are intersected at one point. If there is a large error, stress concentration will occur, and the same issue will apply to the nodes of inclined plating top and inner shell plating and platform plating.

① Due to the fact that the lower end of inner bottom plating is subject to large stress, crack will usually occur on the penetration hole of web frame in the neighborhood. The repairing method is to renew the damaged plate, then to cover the penetration hole by semi-watertight patching.

② The inner bottom plating will be dilacerated due to stress concentration and fatigue at lower end of inclined bottom plating. The solution is changing the damaged steel plate to Z-direction steel, changing the fillet weld to full penetration type and ensuring that the central lines of three plates intersect at one point.

③ Also due to stress concentration and fatigue, crack occurs at the cutting of transverse structure in the vicinity of inclined bottom ends. The solution is covering the cutting by watertight patching, and connecting web frame stiffener and inner bottom plating with soft toe bracket.

(4) Side structure

① Side structure is an important part of hull. The structural corrosion is an important defect type for side structures, especially at the top of side, due to the fact that for most of time, the structure is not only immersed in ballast water, the corrosion of top structure will be worse. The corrosion of side structures and longitudinal and transverse bulkheads is mainly reflected on the level of various structural members, such as longitudinal web and face plate, and butt welds, lightening hole and drain hole and thickness transmit zone are to be focused on.

② On the side of stiffeners fitting for side plating and transverse bulkhead, cracks are easy to occur in way of intersection locations for various members, and such cracks are easy to spread under periodical loads inside or outside tanks, which has certain hazard. Cracks usually occur on the unsymmetrical members, such as L-shaped section, bracket toe end and bulkhead member penetration. For large oil tankers, fatigue cracks in way of connection location of longitudinal and transverse structures in side structure above light load waterline are also defects which always occur, in general, crack occurs in way of intersection between horizontal girder of transverse bulkhead and longitudinal bulkhead, and cutting of horizontal girder of transverse bulkhead due to penetrating vertical stiffener.

③ In side structure, bracket between side longitudinal and web frame is very important, and the stress is large, especially in the vicinity of heavy load waterline where crack damage may occur. The measures are to increase the bracket between stiffener ends, to optimize toe end type, meanwhile, to fit connecting bracket with soft toe at the other side of web frame.

④ The web frame near the bilge at sides is to the location larger force, which is a key location to transmit loads between sides and double bottom. In order to meet the needs of inspection of ballast tank structure, it is necessary to make a lightening hole in this location on web frame, therefore, buckling will sometimes occur in the vicinity of lightening hole. The better solution is fitting stiffeners around the lightening hole.

⑤ The horizontal girder in the vicinity of transverse bulkhead at sides is the location bearing larger force, which is a key location to transmit loads between sides and transverse bulkhead. In order to meet the needs of inspection of ballast tank structure, it is necessary to make a lightening hole in this location on horizontal girder at sides, therefore, buckling will sometimes occur in the vicinity of lightening hole. The better solution is fitting stiffeners around the lightening hole.

(5) Bottom structure

① The bottom structure is also an important part of ship, taking part in longitudinal strength, supporting and protecting the cargo tanks. The corrosion of bottom structure is an important defect type, the bottom structures of oil tankers are to be regarded as key inspection area. For the tanks with coating protection, the main corrosion type is pit and scar corrosion at coating failure location; for coating mainly composing of inorganic zinc, the corrosion type is generally in block shape, and the thickness loss is not great; for the epoxy coating, the corrosive pit always in deep circular distribution. For tanks without any coating protection, corrosion is usually very common, mainly concentrates at the cutting of web frame, longitudinal lightening hole or water outlet, etc. The trimming design will cause water accumulation at the after part of tanks, and the corresponding drainage device is difficult to discharge all the water, therefore, full attention is to be paid to the bottom plating at the after half part of each tank during inspection. For the oil tankers with heating system in cargo tanks, inner bottom and its structural member will accelerate the corrosion rate due to influence of oil tank heating, and grooving corrosion often occurs at the longitudinal root.

② During load transmitting between transverse bulkhead and bottom structure, if the structure transfer is insufficient, it is easy to have stress concentration in way of inner bottom longitudinal in the vicinity of such location, and this will lead to crack at the bracket toe end structure between inner bottom longitudinal and solid floor. The solution is changing the nearby bracket to transmitting bracket with soft toe, and the same bracket with soft toe is fitted at the other side of solid floor.

③ The bottom girder in the vicinity of transverse bulkhead at bottom is a location bearing large force, and is a key location to transmit loads between transverse bulkhead and double bottom. In order to meet the needs of inspection of ballast tank structure, it is necessary to make a lightening hole at this location on bottom girder, therefore, buckling will sometimes occur in the vicinity of lightening hole. The better solution is fitting stiffeners around the lightening hole.

④ During load transmitting between longitudinal bulkhead and bottom structure, the bracket at vertical girder ends is the key location to transmit load, where large force is born, and cracks will occur when the longitudinal penetration hole of solid floor at such location is subject to large stress. In order to solve this problem, in general, watertight patching is provided for the penetration hole in the vicinity of bracket toe end. And watertight patching is also to be provided for the penetration hole near the lightening hole.

⑤ Cutting through is easy to occur due to the fact that the shell plating at lower part of sounding pipe is always impacted, and attention is to be paid during inspection.

⑥ Due to water flow below suction, it is easy to corrode, and during inspection, the suction is to be removed, if it is not possible, such means as manual touch or thickness measurement may be adopted for verification.

(6) Bow area

① The bow area is directly affected by liquid shacking and wave impacting loads, for the oil tankers with larger curvature of stem post, such effect is especially obvious.

② Corrosion is easy to occur at the foundation of anchor gear, base of out-fittings such as vent, ventilating pipe, etc. on the bow deck.

③ Buckling at the lower bracket of side frame within forecastle.

④ Depressed deformation is easy to occur at the connection of bow platform plating and shell plating, especially in the area with larger linear change. It is to be noted that corrosion is easy to occur due to abrupt change of section at the connection of platform plating and chain locker.

⑤ Penetration holes of longitudinals of inner or outer plating in forepeak tanks and large stiffened brackets are easy to have corrosion and even cracks, so high attention is to be paid during inspection.

(7) Engine room area

① Shell plating at bilge. Especially in the area below pumps, local corrosion is easy to occur on the shell plating due to the effect of oil water drip.

② Where ballast tank is provided at both sides of engine room, due to the fact that one side of the longitudinal or transverse bulkhead in ballast tank is near the engine room and the temperature difference effects cause the bulkhead and its stiffeners to corrode quickly, in general, the corrosion occurs in the ballast tanks, and attention is to be paid during inspection.

③ There are more overboard discharges in the engine room area, corrosion and crack will occur at the shell plating of overboard discharge and its side short pipes, so attention is to be paid.

(8) Stern area
Due to the effects of vibration, cavitation, wave impacting, etc. in the stern area, the shell plating is easy to have cavitation corrosion, homogeneous corrosion, etc.
(9) Pump room area
① Locations in the vicinity of shell plating at both ends of fore bulkhead of pump room may have cracks and local deformation due to wave load, rubbing at sea, etc.;
② Structures within 1/3 moulded height of fore and aft bulkheads in pump room have severe corrosion due to temperature difference;
③ Foundations of various pumps in pump room;
④ Corrosion at the bottom of fuel oil tank and pump room boundary;
⑤ Attention is to be paid during inspection if there is no doubling plate/thickened plate at the structure below swash opening of SLOP scavenge pipe;
⑥ Whether the suction inlet of sea chest valve and the valve body on the attached short pipes are leaking (in general, the compressed air pipe is provided on the attached short pipe, it can be verified by inspecting the compressed air pressure or whether the hull is bubbling) .

SECTION 2 COATING PROTECTION

4.2.1 General description

4.2.1.1 Corrosion is one of the important factors that cause structural damage. In recent years, IMO, IACS and the industry have paid more and more attention about the corrosion of structure. IACS issued the REC.87 as early as June 2004- “Guidelines for Coating Maintenance & Repairs for Ballast tanks and Combined Cargo/Ballast tanks on Oil Tankers”. IMO adopted “Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in All Types of Ships and Double-Side Skin Spaces of Bulk Carriers” (MSC.215(82), hereinafter as PSPC) on December 8, 2006.In June 2008, IACS adopted UI SC223 For Application of SOLAS Regulation II-1/3-2 Performance Standard for Protective Coatings (PSPC) for Dedicated Seawater Ballast Tanks in All Types of Ships and Double-side Skin Spaces of Bulk Carriers, adopted by Resolution MSC.215(82). Resolution MSC.291(87), entering into force on 1 Januarys 2012, specifies the mandatory use of coating or corrosion resistant steel in designated areas of cargo oil tanks in crude oil tankers. The coating performance standard is provided in MSC.288(87), and the corrosion resistant steel performance standard is provided in MSC.289 (87).

4.2.2 Requirements for Provision of Protective Coatings

4.2.2.1 SOLAS Ⅱ-1/3-2 (1996 Amendments): For oil tankers constructed on or after 1 July 21998 and not less than 500 gross tonnage, all dedicated seawater ballast tanks shall have an efficient corrosion prevention system, such as hard protective coatings or equivalent. The coatings should preferably be of a light color. The scheme for the selection, application and maintenance of the system shall be approved by the Administration, based on “Guidelines for The Selection, Application and Maintenance of Corrosion Prevention Systems of Dedicated Seawater Ballast Tanks” adopted by A.798(19). Sacrificial anodes may also be used if appropriate.
4.2.2.2 SOLAS Ⅱ-1/3-2 (2006 Amendments): applying to ships of not less than 500 gross tonnage and: 1. for which the building contract is placed on or after 1 July 2008; or 2.in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009; or 3. the delivery of which is on or after 1 July 2012. The dedicated seawater

ballast tanks shall comply with PSPC.
4.2.2.3 CSR oil tankers the building contracts of which are signed on or after 8 December 2006 must comply with PSPC requirements.
4.2.2.4 SOLAS Ⅱ-1/3-11 (Amendments on May 2010): applying to crude oil tankers of not less than 5000 gross tonnage, as defined in Regulation 1 of Annex I of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the 1978 Protocol, and: 1. for which the building contract is placed on or after 1 January 2013; or 2.in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July 2013; or
3. the delivery of which is on or after 1 January 2016. The performance standards of protective coatings for crude oil tankers provide the requirements on corrosion protection areas, coating selection, surface treatment of steel plate, coating, inspection, coating technical documents, and coating test procedures, etc., for cargo oil tanks using coating for corrosion prevention. Corrosion resistance steel performance standards provide the relevant performance standards (mainly the corrosion resistance steel performance standards), the required technical documents, the corrosion resistance area, and the corrosion resistance steel test procedure for the alternative measures for the coating of cargo oil tanks of crude oil tankers.

4.2.3 Type of Coating

4.2.3.1 In accordance with its protective performance, coating is divided to following type:
(1) Hard coating is a coating which chemically converts during its curing process, normally used for new constructions or non-convertible air drying coating which may be used for maintenance purposes. Hard coating can be either inorganic or organic.
①The most common hard coating is base line of the epoxy resin. If proved by the relevant tests and obtained an equivalent protective effect, other paints can also be defined as a hard coating. The standard of environment and process required by hard coating is very high, and the adhesion strength is usually not less than 3MPa.
②Hard coating required by PSPC Code should be epoxy coating system. The performance of other coating systems should comply with the test procedure stated in Annex 1 of MSC.215(82). The multi-coat systems are proposed, with each layer of coating in different contrast color. Surface coating should be light-colored, in order to be easy for check during service life.
(2) Semi-hard coatings are coatings that, after drying, remain flexible and hard enough to be touched and walked upon without damaging them and that are not affected by water erosion during de-ballasting operations.
(3) Soft coatings are coatings that do not dry, but remain permanently soft. The service life of soft coating is 2-4 years; please refer to the instructions of paint manufacturers for details. Soft coatings are generally not recommended. Where Soft Coatings have been applied, safe access is to be provided for the surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating

4.2.4 Assessment of Conditions of Protective Coatings

4.2.4.1 The condition of the protective coating is generally rated into three levels: good, fair and poor. See section 1 of Chapter 3 for definitions.
4.2.4.2 Further clarification is given in IMO Guidelines for Maintenance and repair of Protective Coatings (MSC.1/Circ.1330):
(1) GOOD: Condition with spot rusting on less than 3% of the area under consideration without visible failure of the coating. Rusting at edges or welds, must be on less than 20 % of edges or weld lines in the area under consideration.
(2) FAIR: Condition with breakdown of coating or rust penetration on less than 20 % of the area under consideration. Hard rust scale rust penetration must be less than 10 % of the area under consideration. Rusting at edges or welds must be on less than 50 % of edges or weld lines in the area under consideration.

(3) POOR: Condition with breakdown of coating or rust penetration on more than 20% or hard rust scale on more than 10% of the area under consideration or local breakdown concentrated at edges or welds on more than 50 % of edges or weld lines in the area under consideration.

Evaluation of Protective Coating Table 4.2.4.2

	GOOD(3)	FAIR	POOR
Breakdown of coating or area rusted (1)	<3%	3－20%	>20%
Area of hard rust scale (1)	-	<10%	≥10%
Local breakdown of coating or rust on edges or weld lines (2)	<20%	20-50%	>50%

Notes
(1) % is the percentage of the area under consideration or of the “critical structural area”
(2) % is the percentage of edges or weld lines in the area under consideration or of the “critical structural area”
(3) spot rusting i.e. rusting in spot without visible failure of coating

4.2.4.3 Evaluation Methods

(1) Recognizing that different areas in the tank experience different coating breakdown and corrosion patterns, the intent is to subdivide the planar boundaries of the tank for evaluation of coating, into areas small enough to be readily examined and evaluated by the Surveyor. Each area is then rated (GOOD, FAIR or POOR) and the tank rating is then to be not higher than the rating of its “area under consideration” having the lowest rating. Special attention should be given to coating in Critical Structural Areas, Each Critical Structural Area is rated (GOOD, FAIR or POOR) and the rating of each “area under consideration” is then to be not higher than the rating of its Critical Structural Area (if present) having the lowest rating.

(2) The “area under consideration” with the poorest coating condition will determine whether examination of ballast tanks is required at subsequent Annual Surveys. Hence, it is not intended to “average” the coating condition for all “areas under consideration” within a tank, to determine an “average” coating condition for the entire tank.

(3) Definitions of “areas under consideration” are as follows:

①Double bottom ballast tank: Areas of tank boundaries and attached structure, in lower and upper half of tank (two (2) areas to consider). Double hull side tank:

② Deck and bottom: Areas of deck and bottom plating with attached structure (one (1) area to consider for deck and one (1) area to consider for bottom); Side shell and longitudinal bulkheads: Areas of side shell and longitudinal bulkheads with attached structure, in lower, middle and upper third (three (3) areas to consider for side shell and three (3) areas to consider for longitudinal bulkhead).

③Transverse bulkheads (forward and aft): areas of transverse bulkhead and attached stiffeners, in lower, middle and upper third (three areas to consider for forward transverse bulkhead and three areas to consider for aft transverse bulkhead). Note: For the L-side tanks, should be considered separately as sides and double bottom tanks, as shown below:

Figure 4.2.4.3(3) Typical Area under Consideration for Oil Tanker Structures

4.2.5 Inspection of the Coating

4.2.5.1 The ship is to carry out inspection on the effectiveness of the corrosion prevention system within a specified period of time in accordance with the relevant requirements of the ISC Rules for Classification of Sea-going Steel Ships.

4.2.5.2 Where the coating of the tank is in less than "good" condition and the owner has not repaired or restored it to "good" condition, an internal inspection of the tank is required during annual survey and thickness measurement is required if necessary

4.2.5.3 If the tank is provided with hard protective coating the coating is in "good" condition, special consideration may be given to the extent of close-up inspection and thickness measurement.

4.2.5.4 The CSR oil tankers are to be inspected for identified substantial corrosion areas and additional thickness measurements are to be carried out during annual and intermediate surveys.

4.2.5.5 According to the requirements of the ISC Guidelines for Anticorrosion Inspection of Hull Structures, for an oil tanker with PSPC notation, annual, intermediate and special surveys are to be carried out on the coating of specific areas related to PSPC notation during the service life of the ship. The coating should be kept in "good" condition. The repair of the coating of areas in relation to PSPC is to be carried out in accordance with the requirements of "maintenance and repair procedures for ships in operation" in the coating technical file (CTF).

4.2.5.6 During inspection, attention is to be paid to the coating condition of the following positions:

(1) Structural positions where water is easily accumulated;

(2) Zones adjacent to auxiliary anode for external current protective device;

(3) End of bottom plating in cargo oil tank;

(4) The area where washings water direct scour in tank-washing;

(5) Common boundaries to tanks with heating;

(6) Bow parts which are usually attacked by seawater slap (above light waterline to the top of the

tank plate);
(7) Plate under suction;
(8) Around slots cut, drain hole and air hole in structural elements;
(9) At Welding.
4.2.5.7 Local maintenance, repairing, renewing or full re-coating may be carried out in accordance with the damage extent of coating where:
(1) larger areas of coating surface are attached with marine organisms under waterline;
(2) larger areas of corrosion appear on the structural surface; or area of individual rust is larger;
(3) obvious flaking, breakdown, crack or aging appears on the coating;
(4) wear, damage or pull appears on the coating during the service.

4.2.6 Maintenance and Repair of Protective Coatings
4.2.6.1 During the service life of the ship, the effectiveness of the protective coating system is be verified in accordance with the IMO Guidelines for maintenance and repair of protective coatings (MSC.1/Circ.1330). If the coating is found to be in "good" condition, it may be maintained in "good" condition through maintenance; if the coating is found to be in "fair" condition, it may be maintained "fair" or reaches "good" condition by repair; if coating condition is found to be "poor", it must be repaired to achieve "good" condition.
4.2.6.2 For repairs to non-PSPC coatings, coating operations are to be carried out in accordance with the requirements of chapter 8 of the existing ISC Guidelines for Anticorrosion Inspection of Hull Structures. Repair plans for damaged old coatings are to be developed after being subject to defects assessment in accordance with appendix E of the above Guidelines.
4.2.6.3 For ships that need to meet the PSPC requirements, the coating repair is to be in accordance with the IMO Guidelines for maintenance and repair of protective coatings, and the in-service maintenance, repair and local recoating are to be recorded in the coating technical file. If coating damage is found during in-service surveys, the owner should be advised to arrange repair as soon as possible. Grinding or sandblasting tools can be used for surface treatment according to different damage degree and type before repair. The coating used should be matched with the original coating system, and the coating incompatible with the original coating system should not be used. Coating repair and maintenance should comply with IMO Guidelines for maintenance and repair of protective coating and the painting specifications provided by the builder. In-service maintenance, repair and local recoating is to be recorded in the coating technical file (CTF). If overall re-painting is carried out, it should be recorded in the CTF according to the items specified for construction survey. For specific requirements, please see Resolution MSC.216(82). For coating repair principles, please see paragraph 6 of IMO Guidelines for maintenance and repair of protective coatings (MSC.1/ Circ.1330).

SECTION 3 SAFE ACCESS OF OIL TANKERS

For the purpose of crew safety and enhancement of structure survey, IMO has adopted several resolutions to give detailed requirements for structural access of oil takers.

4.3.1 Safe access to bow
4.3.1.1 Oil tankers constructed on or after 1 July 1998 are to be provided with means to enable the crew to gain safe access to the bow even in severe weather conditions. The arrangement of safe access is to be approved in accordance with Resolution MSC.62(67) Guidelines for Safe Access to Tanker Bows. Detailed technical specifications include following points:
4.3.1.2 For oil tankers constructed on or after 1 July 1998, the access is to be by means of either a

walkway on the deck or a permanently constructed gangway of substantial strength at or above the level of the superstructure deck or the first tier of a deckhouse which is to:

(1) be not less than 1 m in width, situated on or as near as practicable to the centre line of the ship and located so as not to hinder easy access across working areas of the deck;

(2) be fitted at each side throughout its length with a footstop and guard rails supported by stanchions. Such rails are to consist of no less than 3 courses, the lowest being not more than 230 mm and the uppermost being at least 1 m above the gangway or walkway, and no intermediate opening is to be more than 380mm in height. Stanchions are to be at intervals of not more than 1.5m;

(3) be constructed of fire resistant and non-slip material;

(4) have openings, with ladders where appropriate, to and from the deck. Openings are not to be more than 40 m apart;

(5) if the length of exposed deck to be traversed exceeds 70 m, have shelters of substantial construction set in way of the gangways or walkways at intervals not exceeding 45 m. Every such shelter is to be capable of accommodating at least one person and be so constructed as to afford weather protection on the forward, port and starboard sides; and

(6) if obstructed by pipes or other fittings of a permanent nature, be provided with means of passage over such obstruction.

4.3.1.3 Alternative or modified arrangements for oil tankers with space constraint are acceptable, provided that such alternative or modified arrangements achieve an equivalent level of safety for access to the bow.

4.3.1.4 Arrangements already approved for the oil tankers constructed before 1 July 1998 may be accepted, provided that such existing arrangements achieve an equivalent level of safely for access to the bow. For oil tankers with length 100m or below, arrangements of access width not less than 600mm are acceptable, and in addition, other requirements are the same as those mentioned above.

4.3.2 Hull structural access

4.3.2.1 According to the requirements of SOLAS Convention, for oil tankers constructed on or after 1 October 1994, safe access to cofferdams, ballast tanks, cargo tanks and other spaces in the cargo area is to be direct from the open deck and such as to ensure their complete inspection. If access to double bottom spaces is from cargo pump room, pump-room, deep cofferdam, pipe tunnel or similar compartments, proper ventilation is to be considered. For access through horizontal openings, hatches or manholes, the dimensions are to facilitate the hoisting of an injured person from the bottom of the space. The minimum effective opening is not to be less than 600 mm x 600 mm.

4.3.2.2 For access through vertical openings or manholes providing passage through the length and breadth of the space, the minimum effective opening is to be not less than 600 mm x 800 mm at a height of not more than 600 mm from the bottom shell plating unless gratings or other foot holds are provided.

4.3.2.3 For oil tankers of less than 5,000 tonnes deadweight, the Administration may approve smaller dimensions for the openings, if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Administration.

4.3.2.4 Oil tankers of 500 gross tonnage and over constructed on or after 1 January 2005, safe access to cargo holds, cofferdams, ballast tanks, cargo tanks and other spaces in the cargo area is to be direct from the open deck and such as to ensure their complete inspection. Safe access to double bottom spaces may be from a pump-room, deep cofferdam, pipe tunnel, cargo hold, double hull space or similar compartment not intended for the carriage of oil or hazardous cargoes. Tanks and subdivisions of tanks having a length of 35 m or more are to be fitted with at least two access hatchways and ladders, as far apart as practicable. Tanks less than 35 m in length are to be served by at least one access hatchway and ladder. When a tank is subdivided by one or more swash bulkheads or similar obstructions which do not allow ready means of access to the other parts of the tank, at least two hatchways and ladders are to be fitted.

4.3.2.5 Each cargo hold is to be provided with at least two means of access as far apart as practicable.

In general, these accesses are to be arranged diagonally, for example one access near the forward bulkhead on the port side, the other one near the aft bulkhead on the starboard side.

4.3.2.6 Each space is to be provided with means of access to enable, throughout the life of a ship, overall and close-up inspections and thickness measurements of the ship's structures to be carried out by the Administration, the company, and the ship's personnel and others as necessary. Where a permanent means of access may be susceptible to damage during normal cargo loading and unloading operations or where it is impracticable to fit permanent means of access, the Administration may allow, in lieu thereof, the provision of movable or portable means of access, as specified in the Technical provisions, provided that the means of attaching, rigging, suspending or supporting the portable means of access forms a permanent part of the ship's structure. All portable equipment is to be capable of being readily erected or deployed by ship's personnel. The construction and materials of all means of access and their attachment to the ship's structure are to be to the satisfaction of the Administration.

4.3.2.7 A ship's means of access to carry out overall and close-up inspections and thickness measurements are to be described in a Ship Structure Access Manual approved by the Administration, an updated copy of which is to be kept on board. The Ship Structure Access Manual is to include the following for each space:

(1) plans showing the means of access to the space, with appropriate technical specifications and dimensions;

(2) plans showing the means of access within each space to enable an overall inspection to be carried out, with appropriate technical specifications and dimensions. The plans are to indicate from where each area in the space can be inspected;

(3) plans showing the means of access within the space to enable close-up inspections to be carried out, with appropriate technical specifications and dimensions. The plans are to indicate the positions of critical structural areas, whether the means of access is permanent or portable and from where each area can be inspected;

(4) instructions for inspecting and maintaining the structural strength of all means of access and means of attachment, taking into account any corrosive atmosphere that may be within the space;

(5) instructions for safety guidance when rafting is used for close-up inspections and thickness measurements;

(6) instructions for the rigging and use of any portable means of access in a safe manner;

(7) an inventory of all portable means of access; and

(8) records of periodical inspections and maintenance of the ship's means of access.

4.3.2.8 During survey to oil tankers in service, considering that hull structural accesses will deteriorate due to corrosion for a long time, ship motion force and liquid sloshing in the tank, the surveyors are to examine access prior to entering compartment/space to confirm that access is in good working condition. Survey procedures are as follows:

(1) Inspection of all accesses of the tanker is to be recorded according to requirements of ship's safety management system. The surveyors are to consult these records prior to inspecting permanent access. Access manual is attached with record form and the updated record of inspected access part is to include at least inspection date, inspector name and post, signature for confirmation, inspected access part, confirmation of service condition or any deterioration or substantial damage found. The issued license must be kept for check.

(2) To inspect access carefully. If damage, corrosion or deterioration is found, whether damage or deterioration will affect safety of access is to be evaluated. The deterioration that will affect safety of access is called substantial damage, and measures are to be taken to ensure that affected parts will not be used until proper repair is carried out.

4.3.2.9 For survey of movable means of access, refer to annex of IACS Rec.91 "Guidelines for Approval/Acceptance of Alternative Means of Access". Alternative means of access (including movable and portable) generally include but are not limited to following equipment:

(1) hydraulic lift vehicle (aerial vehicle);
(2) lift;
(3) portable platform;
(4) temporary scaffold;
(5) boat or raft;
(6) portable ladder (portable ladders more than 5 m long may only be utilized if fitted with a mechanical device to secure the upper end of the ladder);
(7) other equivalent means.

4.3.2.10 Methods for safe application of alternative means of access and methods for installing such means of access are to be clearly stated in the structural access manual. The surveyors are to check not only periodic inspection and maintenance record of portable means of access but also periodic inspection and maintenance record of movable means of access provided by the shore-based manufacturer. If problems are found, the equipment may be refused to be used.

SECTION 4 STRUCTURE REPAIR REQUIREMENTS

4.4.1 Repair Principles and Corrosion Criteria

4.4.1.1 Ship repair is generally carried out according to the principles of resuming. If it is found that parts of structure damage repeatedly, modification of node type of structure or increase of structural dimension may be considered. Modification of node type of main structure is to be approved by ISC Plan Approval Center. General principles for hull repair are as follows:

(1) principle of resuming;
(2) steel plate section and welding consumables for hull repair are to comply with relevant requirements of ISC Rules for Materials and Welding. The shipyard is to submit material qualification certificate and the grade of material is not to be lower than that of raw material;
(3) the construction technology of hull repair is to be approved;
(4) repair of each kind of structure is to avoid weld at stress concentration, the parallel butt weld of hull structure is to be such that sharp angle intersection is to be avoided;
(5) hull plate butt welds are to be double-side welded with bevel or one-side welded with back formation to ensure full thickness penetration. On completion of construction, X ray examination or ultrasonic examination is to be carried out to ensure weld quality. The weld type of such members as frame, stiffener and bracket are to be same as former weld type;
(6) it is not allowed to remove or move hull strength member or establish temporary opening on main strength members such as strength deck, side shell plating and watertight bulkhead;
(7) after repair, hull watertight structure is to be subject to tightness test;
(8) in general, repair of compensating plate of main hull structure is not acceptable and is only used in emergency to allow ship to reach appropriate port for permanent repair.

4.4.1.2 Pitting corrosion and groove corrosion are popular in oil tanker structure and the handling is important. In actual application, the assessment of pitting corrosion is to follow following principles:

(1) the reference area of pitting corrosion is single panel area. The maximum allowable corrosion limit for pitting corrosion of non-CSR oil tankers is as follows:

① For members with uniform corrosion limit of 20%, the uniform corrosion criterion should be used when the pitting corrosion density is not less than 20%. The minimum acceptable residual thickness is 70% of the as-built thickness when the pitting corrosion density is less than 20%, and the residual thickness of any point is not to be less than 6mm.

② For members with uniform corrosion limit of 25%, the uniform corrosion criterion should be used when the pitting corrosion density is not less than 20%. The minimum acceptable residual thickness is 65% of the as-built thickness when the pitting corrosion density is less than 20%, and the residual thickness of any point is not to be less than 6mm.

③The maximum allowable corrosion limit for pitting corrosion of oil tankers using special corrosion standards (not 20% or 25%)is as follows:

④ For members with uniform corrosion limit less than 25%, the uniform corrosion criterion should be used when the pitting corrosion density is not less than 20%. The minimum acceptable residual thickness is 70% of the as-built thickness when the pitting corrosion density is less than 20%, and the residual thickness of any point is not to be less than 6mm.

⑤ For members with uniform corrosion limit not less than 25%, the uniform corrosion criterion should be used when the pitting corrosion density is not less than 20%. The minimum acceptable residual thickness is 65% of the as-built thickness when the pitting corrosion density is less than 20%, and the residual thickness of any point is not to be less than 6mm.

(2) Acceptable standards for groove corrosion are to meet the requirements of pitting corrosion as well as requirements of groove width not more than 30mm;

(3) For area with only coating bubbling, corrosion will not occur inside and only random check is needed;

(4) Acceptance criteria for pitting corrosion of CSR oil tankers:

For details, please refer to 5.1.17(2)② of Section 1 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships currently in force.

(5) Acceptance criteria for edge corrosion of CSR oil tankers:

For details, please refer to 5.1.17(3) of Section 1 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships currently in force.

(6) Acceptance criteria for grooving corrosion of CSR oil tankers:

For details, please refer to 5.1.17(4) of Section 1 of Chapter 5 of PART ONE of ISC Rules for Classification of Sea-going Steel Ships currently in force.

4.4.1.3 For non-CSR oil tankers, during survey, if local pitting corrosion and grooving corrosion are found, corresponding treatment is to be carried out even the corrosion is within limit. Detailed requirements are as follows:

(1) for pitting corrosion/grooving corrosion within corrosion limit, local derusting is to be arranged and coating is to be reapplied;

(2) if pitting corrosion exceeds corrosion limit but residual thickness is more than 6mm, deposit repair is allowed. For high strength steel, input energy is to be controlled strictly during welding. The party carrying out repair is to submit approved Welding Procedure Specification (WPS), run arrangement, effective run cleaning method, starting weld tab for welding or equivalent measures; if environmental temperature for construction is below 0℃, requirements for preheating prior to welding and heat insulation after welding are to be considered. If residual thickness after pitting corrosion is less than 6mm, repair method of local change is to be adopted and the change area is to be over single panel and in no way less than Φ200mm;

(3) for structure with pitting corrosion density of 15% and thickness measurement showing entry itto substantial corrosion area, local change is to be used for repair. The change method is the same as 2);

(4) for structure with pitting corrosion density less than 15% and already within substantial corrosion area, repair polishing or sand blasting is to be used to apply hard coating. During annual survey, coating condition is to be checked and thickness measurement is to be carried out;

(5) In addition, for local corrosion caused by microorganism SRB, complete cleaning and derusting are to be required;

(6) grooving corrosion is the extension of pitting corrosion. For strength deck and side top strake, the standard for longitudinal grooving corrosion is the same as that for pitting corrosion and the standard for transverse grooving corrosion is the same as that for uniform corrosion. Once grooving corrosion of that area exceeds limit, local change is to be carried out;

(7) for continuous grooving corrosion with residual thickness not less than 50% construction

thickness and not less than 6mm and width not more than 25mm as well as discontinuous groove corrosion with residual thickness not less than 6mm, width not more than 30mm and length less than 600mm, deposit repair is allowed and polishing is needed after welding. The requirements of construction technology are to be considered during welding;

(8) welding repair is not allowed for structural high stress area.

4.4.1.4 Hull Structural Member Deformation Limit

(1) Definition

① Fold: refers to the deflection of steel plates between frames, the maximum deflection of which should be measured along the short direction among frames.

②Sagging: the joint deflection of the frames and the steel plates, the maximum deflection of which should be measured among the intact frames.

(2) Steel plate folding limit

① Deformation due to collision

a. For transverse framed strengthened deck, the maximum allowable deflection f_{max} of folding of top strake and bottom shell plating within 0.5 L midship is as follows:

when $s/t \leq 50$, $f_{max} \leq 2.6t$;

when $s/t > 50$, $f_{max} \leq 0.06s$;

b. For other locations of transverse frames and longitudinal framing, the maximum allowable deflection f_{max} of folding is:

when $s/t \leq 50$, $f_{max} \leq 3t$;

when $s/t > 50$, $f_{max} \leq 0.07s$;

where: s—framing spacing in way of folding or spacing of longitudinals of longitudinal frames, in mm;

t— thickness of shell plating in way of folding, in mm.

②Deformation due to stress

a. deformation features: the deformation of the upper deck and floor within 0.4L midship spreads across the full ship width, the plates among frames form regular wavy folds;

b. Deformation limit:

Maximum allowable deflection of transverse framed folding: $f_{max} \leq 15mm+1.5t$;

Maximum allowable deflection of longitudinal framed folding: $f_{max} \leq 20mm+2t$;

Where: t is the thickness of plates in way of folding, in mm;

c. Deformation treatment: The stress deformation should be recorded in detail. If the deformation limit is exceeded, the original plate should be replaced by a plate with greater thickness or be strengthened.

(3) Plating sagging limit:

Maximum allowable deflection of plating sagging : $f_{max} < 6L+10mm$;

Where: L is the span of mid frame, in m.

(4) other requirements:

①The displacement of free end of the framing is not to exceed 4% of its length;

② Folding of keels, frames and web plates of double bottom girders is not to exceed 4% of length of the plating;

③The bracket is not allowed to be folded and the relative displacement between the framing and the beam in way of the end should not exceed the thickness of the framing at this location.

④ Framing is not allowed to bend significantly;

⑤ Special attention should be paid to the torsional strength of ships of which the total width of deck openings is more than 0.6 times the ship's width, or the hatch length of which is more than 0.7 times the distance between the center lines of transverse deck bars at both ends of the hatch.

⑥Transverse strength members, especially the transverse strength members near one fourth of the ship length should be strengthened as appropriate when they are deformed regularly.
⑦ No cracks are allowed in the ship's stressed members, especially the side top strake, deck side plate, superstructure end, side connections and hatch corners within the 0.4L of midship;

4.4.2 Requirements for Welding

4.4.2.1 Welding is primarily to meet the requirements for safe operation, and welders are to have corresponding qualification certificate. Shipyards should have approved Welding Procedure Specification (WPS).Prior to welding, runs are to be examined, e.g. whether bevel type meets the requirements of approved WPS document, and the run surface is to be clean and dry without rust, paint or water stain. For details of welding inspection of hull structures on site, please refer to ISC Guidelines for Survey of Welding of Ships.

4.4.3 Modifications/Strengthening of Typical Structural Nodes

4.4.3.1 For repair requirements for structural fatigue damage, please refer to 4.4.6 of Section 4 - Typical Structure Details Failures and Recommended Repairs. Except for minor cracks at surface, it is not allowed to repair cracks by welding. The cracks at high- stress areas rectified directly by grinding is only a temporary repair measure, which is to be repaired / strengthened as soon as possible if condition permits.
4.4.3.2 In case of bracket toe cracks, bracket soft toe is usually to be increased with length longer 100 mm than the original one. Attention is to be paid to matching with the nearby structures, such as opposite backstay brackets is to be fitted accordingly etc. After repair, the toe welding seam and corners of welding are to be ground smooth. A lot of fatigue damages of oil tankers are reflected by bracket toe cracks. The following is a typical technical details optimized for bracket toe. When connectional bracket fitted between web frames such as girder/web cannot be extended due to lack of spaces, deep penetration welding is generally required. After welding, NDT is to be carried out. Brackets are to be cropped and renewed generally following the next two principles:
(1) The distance from any welding is not to be less than 200 mm;
(2) If possible, the length of the weld is to be increased, in order to reduce impact of weld on the hull structure;
(3) Reinforcement plate arranged at right angles should be avoided in high- stress zone.

4.4.3.3 Example 1 - Technical Requirements for Connection Bracket In Location of Web Frame / Side Longitudinal(No Bracket at Back) , as shown in the figure below:

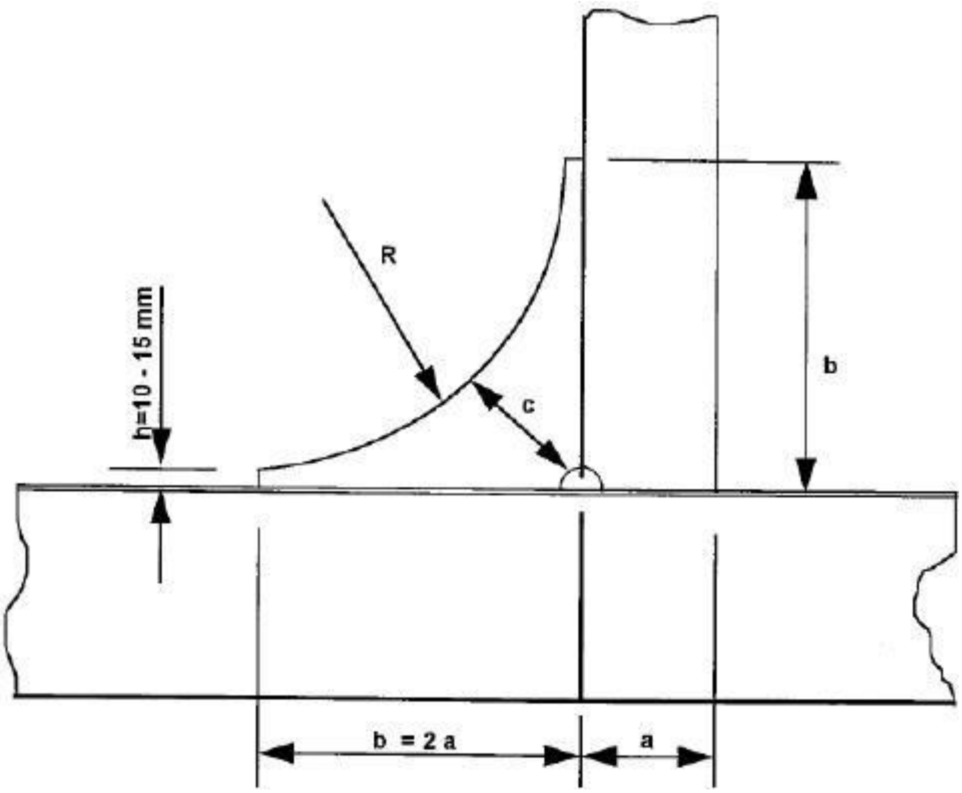


Figure 4.4.3.3 Technical Requirements for Connection Bracket In Location of Web Frame / Side Longitudinal(No Bracket at Back)

Where:
(1) For a slope at toes max. 1:3, R=(b-h)×1.6
(2) Soft toe bracket to be welded first to longitudinal
(3) Scallop in bracket to be as small as possible, recommended max. 35 mm
(4) Toe height to be as small as possible (10 -15 mm). If toes of brackets are ground smooth, full penetration welds in way to be provided
(5) Maximum length to thickness ratio = 50 : 1 for unstiffened bracket edge.

4.4.3.4 Example 2 - Technical Requirements for Connection Bracket In Location of Web Frame/Side Longitudinal(Bracket fitted at Back), as shown in the figure below:

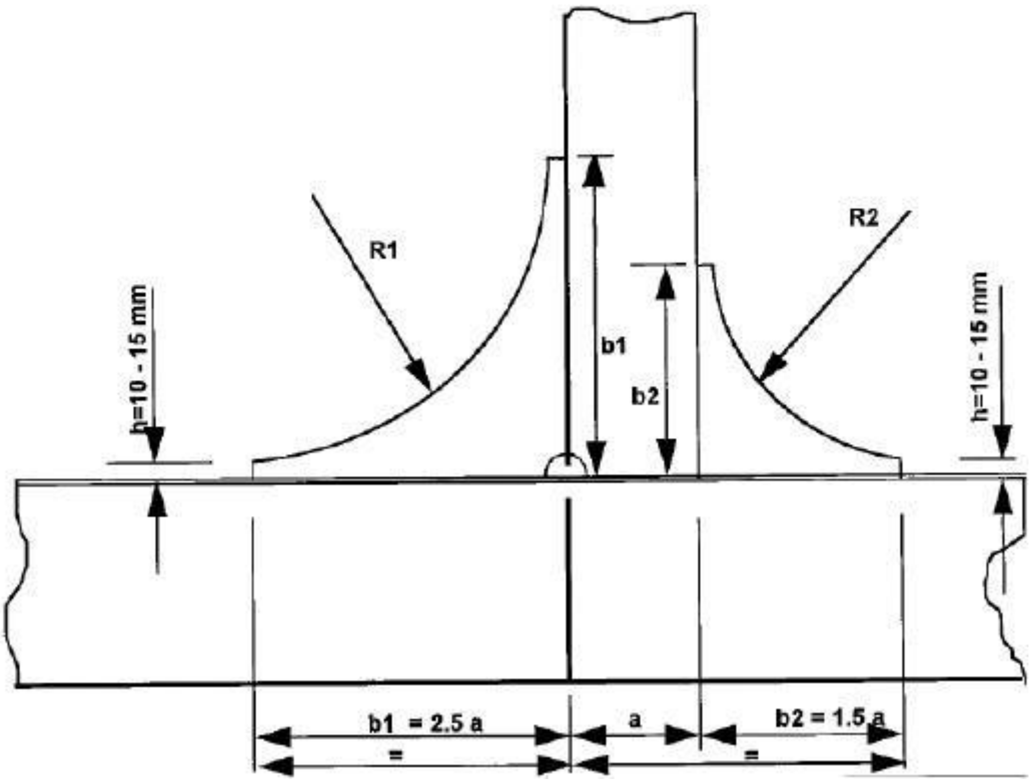


Figure 4.4.3.4 Technical Requirements for Connection Bracket In Location of Web Frame/Side Longitudinal (Bracket fitted at Back)

Where:

(1) For a slope at toes max. 1 :3, R1 = (b1 - h) x 1.6 and R2 = (b2 - h) x 1.6, back bracket b2 is not to be less than 300 mm as practicable as possible

(2) Soft toe bracket to be welded first to longitudinal

(3) Scallop in bracket to be as small as possible, recommended max. 35 mm

(4) Toe height to be as small as possible (10 -15 mm). If toes of brackets are ground smooth, full penetration welds in way to be provided

(5) Maximum length to thickness ratio = 50 : 1 for unstiffened bracket edge.

4.4.3.5 Example 3 - Technical Requirements for Connection Bracket / Reverse side of Tripping Bracket in location of Web Frame / Side Longitudinal (Stiffener fitted) , as shown in the figure below:

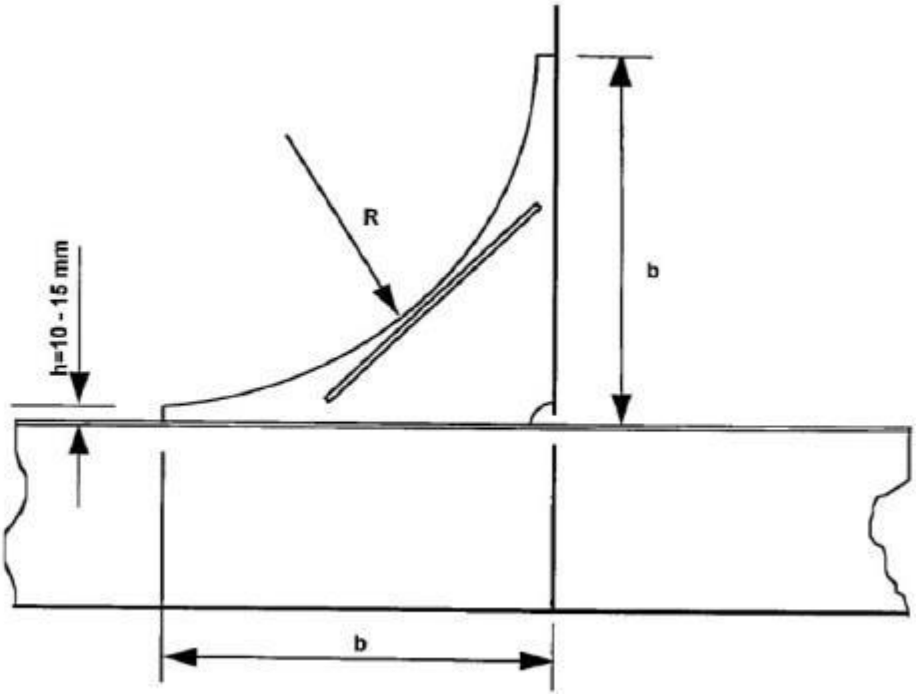


Figure 4.4.3.5 Technical Requirements for Connection Bracket / Reverse side of Tripping Bracket in location of Web Frame / Side Longitudinal (Stiffener fitted)

Where:

(1) For a slope at toes max. 1 :3, R = (b - h) x 1.6

(2) Soft toe bracket to be welded first to longitudinal

(3) Scallop in bracket to be as small as possible, recommended max. 35 mm

(4) Toe height to be as small as possible (10 -15 mm). If toes of brackets are ground smooth, full penetration welds in way to be provided

(5) Maximum length/thickness ratio of unsupported bracket edge 50: 1. Edge stiffener to be sniped

4.4.3.6 Example 4 - Technical Requirements for Web Stiffener in location of Web Frame / Side Longitudinal, as shown in the figure below:

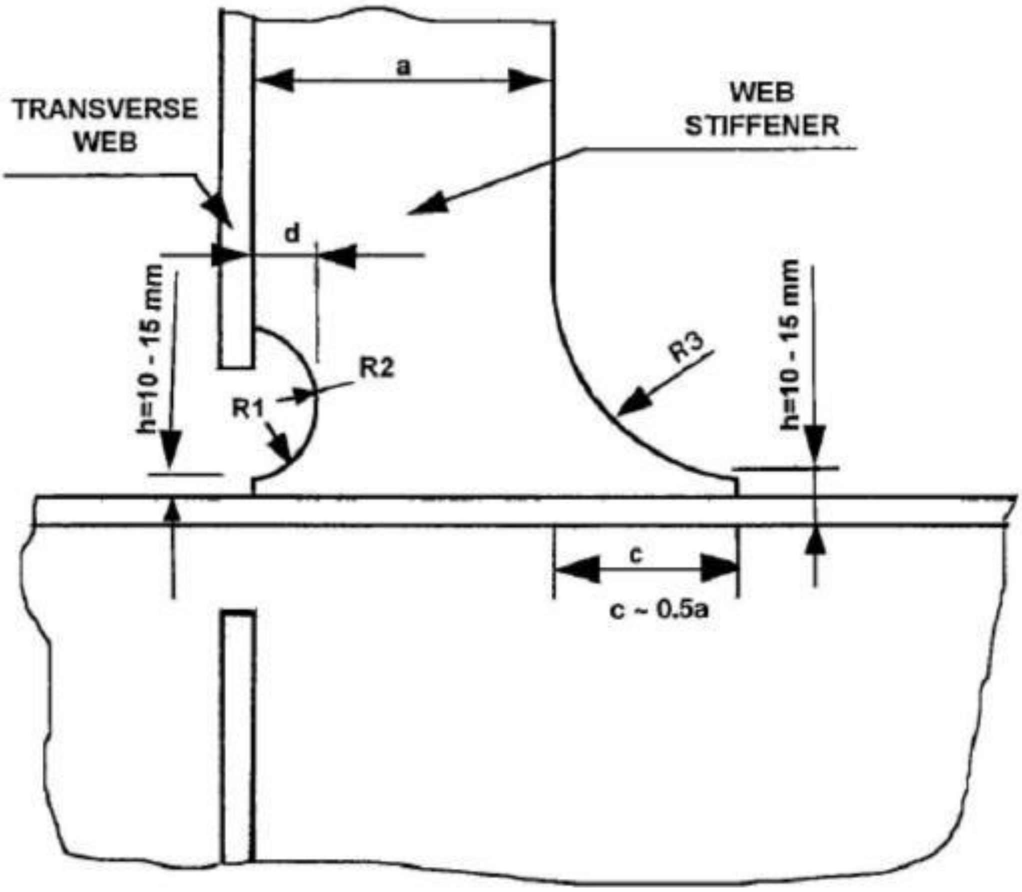


Figure 4.4.3.6 Technical Requirements for Web Stiffener in location of Web Frame / Side Longitudinal

Where:
(1) or a slope at toe max. 1 :3, R1 = 1.5 x d and R3 = 1.5 x c
(2) Soft toe bracket to be welded first to longitudinal
(3) Depth 'd' of key hole notch as small as possible, max. 30 mm

4.4.3.7 Example 5 - Detail Type of Bracket Toe, Symmetrical Flange Plate in location of Web Frame connections, as shown in the figure below:

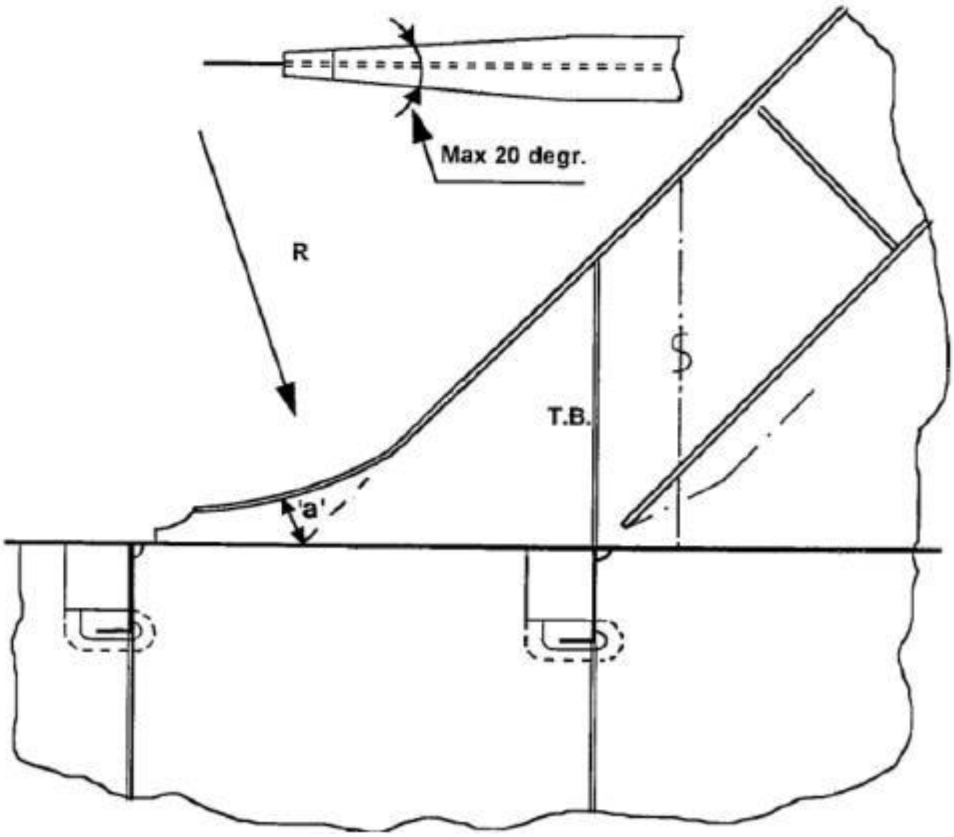


Figure 4.4.3.7 Detail Type of Bracket Toe, Symmetrical Flange Plate in location of Web Frame connections

Where:
(1) Face plate should be tampered with a total angle of 20 degree or less (i.e. taper 1 :3). Breadth of face plate at tip should be as small as possible (approx. t + 20 mm, t= toe thickness). Face plate tip should be tapered in thickness down to 10 mm with a max slope of 1:3
(2) Toe of web should be of increased thickness. Toe height should be as small as possible (10 -15 mm)
(3) Welds connecting toe web to plating and to face plate to be full penetration over the length of the snipe or radiuses part whichever is greater and grinding flush of toe recommended
(4) Toe cross sectional area, ref. measure 'a' should be approx. 60 % of flange cross sectional area
(5) Tripping bracket should be fitted as indicated to reduce flexing of the bracket and face plate
(6) Collar plates welded to the plating should be fitted in way of toe. Tip of toe clear of cut-outs 10-Slope of toe to be max 1:3 at face plate end
(7) Correct alignment of bracket with web on the other side is essential.(Deviation is not to be greater than 0.15 t as far as practicable.)

4.4.3.8 Example 6 - Detail Type of Bracket Toe, Asymmetrical Flange Plate in location of Web Frame connections, as shown in the figure below:

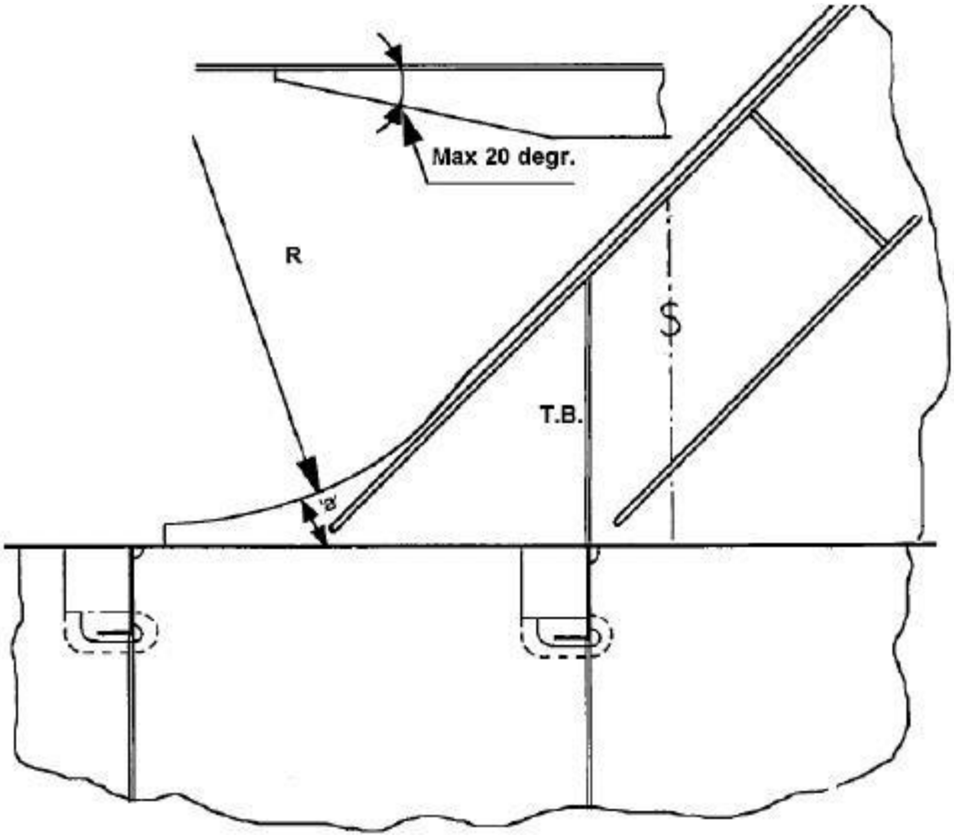


Figure 4.4.3.8 Detail Type of Bracket Toe, Asymmetrical Flange Plate in location of Web Frame connections

Where:
(1) Face plate should be tampered with a total angle of 20 degree or less (i.e. taper 1 :3).Breadth of face plate at tip should be as small as possible (approx. t + 20 mm, t= toe thickness). Face plate tip should be tapered in thickness down to 10 mm with a max slope of 1:3
(2) Toe of web should be of increased thickness. Toe height should be as small as possible (10 -15 mm)
(3) Welds connecting toe web to plating and to face plate to be full penetration over the length of the snipe or radiuses part whichever is greater and grinding flush of toe recommended
(4) Toe cross sectional area, ref. measure 'a' should be approx. 60 % of flange cross sectional area.
(5) Tripping bracket should be fitted as indicated to reduce flexing of the bracket and face plate
(6) Collar plates welded to the plating should be fitted in way of toe. Tip of toe clear of cut-outs
(7) Correct alignment of bracket with web on the other side is essential.(Deviation is not to be greater than 0.15 t as far as practicable.)

4.4.4 Other Issues to be Focused in Repair

4.4.4.1 Effect of Electro-corrosion

(1) Effect of electro-corrosion is an important factor for the aging ship, which can't be ignored. Due to various reasons, such as collisions, wear or other reasons, repair in wharf or dock is to be arranged. DC welding machine using make the hull structure occur anodic dissolution. If attention not paid, great external stray currents may occur, which cause serious electrical corrosion, and then serious accident may happen. Characteristics of Electro-corrosion are summed up as following:

① The corrosion rate is quite high, which can be determined by Faraday's law (V = 1.14I). The results of experiment showed that in case of leakage current is 1mA/cm^2, depth corroded can reach about 10mm one year later.

② Electro-corrosion is obvious local, and in sign of pitting or local hole, with sharp edges and as the same with corrosion caused by coating broken.

③ Electro-corrosion usually occur at the underwater hull where coating broken or leakage painted, protruding parts of the hull, hull welding and part where layer of coating is thin.

④ Due to large external current, cathodic protection cannot prevent this corrosion.

(2) Some shipyard supply shore power to ship lied on wharf with single-line method, so that electric is transmitted only by mooring rope and accommodation ladder between ship hull and wharf. In general, connection of mooring rope with ship hull/wharf is to be bad condition for electrical transfer, so there is great resistance between ship hull – mooring rope/accommodation ladder-wharf. A direct result of the case is that electric is to be transmit flowing through the hull - the sea - the wharf. According to Faraday's law, the worse the ship and shore contacts, the faster the hull electro-corrosion.

(3) In addition, during the voyage repair, welding machine is placed on the repair ship, inevitably there is a balance between the repair ship and ship repaired. Electrical line set irrationally may cause great current flowing through the ship hull - the water - earth, which cause severe local electro-corrosion. If the ship is fitted with a sacrificial anode protection system, the anode will be severe corroded. In the case of sacrificial anode protection system failure, hull with coating protection missed will inevitably produce corrosion to hole. When ship in docking, in fact, hull in way of docking block is to usually miss painted, the harm for the hull is particularly serious.

(4) During practical work, welding grounding should be carefully examined and can be checked in way of the hull potentiometric method. General the density of the current allowed to go through the hull underwater part is 0.1mA/m^2. In this case, the hull structural corrosion rate caused by an external electro-corrosion is 0.1mm /year, therefore the corrosion rate is safe.

4.4.4.2 Attentions to be Paid during Local Structural Replacement of Oil Tankers

Due to the weak rigidity of hull structures of oil tankers, proper strengthening is to be considered when a large area is to be cut and replaced to prevent integral deformation of the structure, otherwise it is likely to cause problems during toe end assembly.

4.4.5 Repair of Structural Damage of a Foepeak Tank

4.4.5.1 Problems found

A double-hull oil tanker with a total length of 330.00m, length between perpendiculars of 316.00m, ship width of 60.00m, moulded depth of 29.70m, design draft of 19.20m, deadweight of 297,136 tons, gross tonnage of 152,727, was built on April 22, 2010. In April 2015, during the docking survey of the ship, damage was found in the fore peak tank structural members. The damage is as follows:

(1) The bracket at the intersection of FR99 collision bulkhead and the starboard shell longitudinal L52~L55 is deformed and cracked, as shown below:

Figure 4.4.5.1(1) Crack

(2) FR100 transverse frame: root weld of brackets and stiffeners at the intersection of the port and starboard frame web and the shell longitudinals L52~L56 cracked. The frame web in the starboard side area is overall deformed, and cracked in way of the hole of penetration through the shell longitudinals, as shown in the figure below:

Figure 4.4.5.1(2) Location of defects

(3) FR101 transverse frame: Overall deformation of the frame web in the port and starboard side areas; the root weld of brackets and stiffeners at the intersection of the port and starboard frame web and the shell longitudinals L52~L56 cracked, as shown in the figure below:

Figure 4.4.5.1(3) Deformation

(4) FR102 transverse frame: web toe end at the intersection of the intersection of the port and

starboard shell longitudinals L53~L54 and FR102 cracked, as shown in the figure below:

Figure 4.4.5.1(4) Cracks

4.4.5.2 Analysis of problems

During the operation of this series of ships, it has been found that the structural members in the same position of fore peak tank have been damaged. The cause of damage is analyzed as follows:

(1) This series of ships were designed and built according to the non-CSR rules, which have different requirements for bow structures from the existing CSR rules. On the basis of the rules of individual classification societies, CSR rules further improve the strength of hull structures and promote the safety performance of ships.

(2) This series of ships are not designed with due consideration of structural nodes. For example, in some locations it is better to use brackets instead of stiffeners, some brackets should be provided with stiffeners at the free edge, and thickness of web at toes of some brackets should be increased, etc.

(3) Navigation and steering factors should also be considered. The ship was inspected before its previous voyage from the Persian gulf to Malacca and no such serious damage was found. The ship encountered surging waves in the South China Sea before reaching the repair yard for docking survey, but in order to meet the schedule, it did not slow down.

4.4.5.3 Treatment Measures

Through the analysis of the cause of damage, the plan approval center presented specific suggestions for the treatment of damaged structures, and the following repair plan was provided by taking into account of the repair yard's construction technology and material preparation:

(1) Replacing the bracket at the intersection of FR99 collision bulkhead and the shell longitudinal L52~L55. Replacing the original 12.5mm(AH32) bracket with a new one of 14mm(AH32), as shown below:

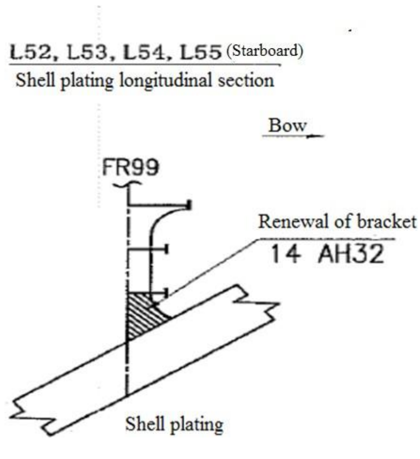


Figure 4.4.5.3(1) Repair Position

(2) For FR100 transverse frame: Replacing some starboard frame webs, replacing the original 14mm web with a new one of 17mm, and providing a new double-side soft toe bracket at the intersection of the shell longitudinals L52~L56. The new bracket should be 15 mm, stiffened at the free edge. At port side, a new double-side soft toe bracket at the intersection of the shell longitudinals L52~L56 should also be provided. The new bracket should be 15 mm, reinforced at the free edge, as shown in the two figures below:

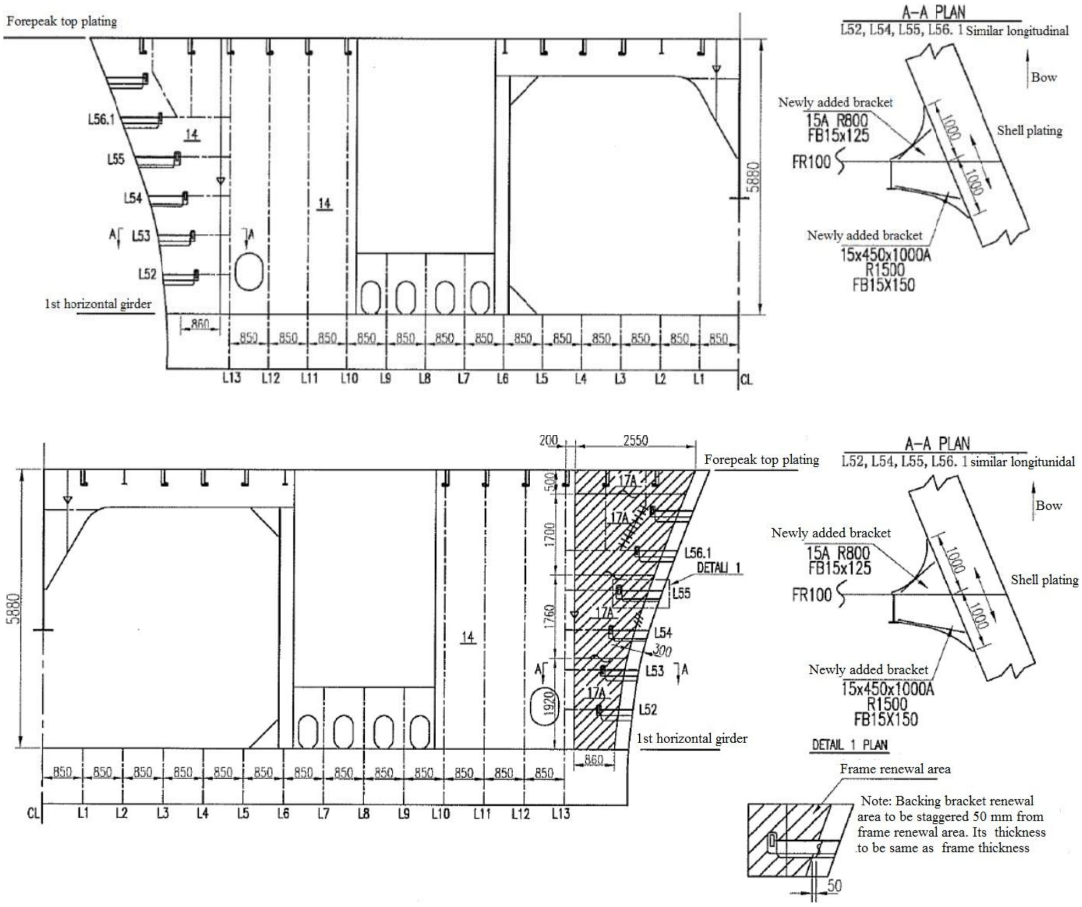


Figure 4.4.5.3(2) Repair Positions

(3) For FR101 transverse frame: frame webs and faceplates at starboard are to be replaced. The original 13.5mm web is to be replaced with a new one of 14mm, and the original 16mm faceplate replaced with a new one of 16mm. At the same time, the vertical stiffener FB14X150 is to be added to prevent buckling, and the double-side soft toe bracket is to be newly installed at the intersection with the shell longitudinals L52~L56. The newly installed bracket should be 14mm, reinforced at the free edge. The port frame web is to be cut open and leveled, and a vertical stiffener is to be added to prevent buckling, and a double-side soft toe bracket is to be newly installed at the intersection of the shell longitudinals L52~L56. The newly installed bracket should be 14mm, reinforced at the free edge, as shown in the following two figures:

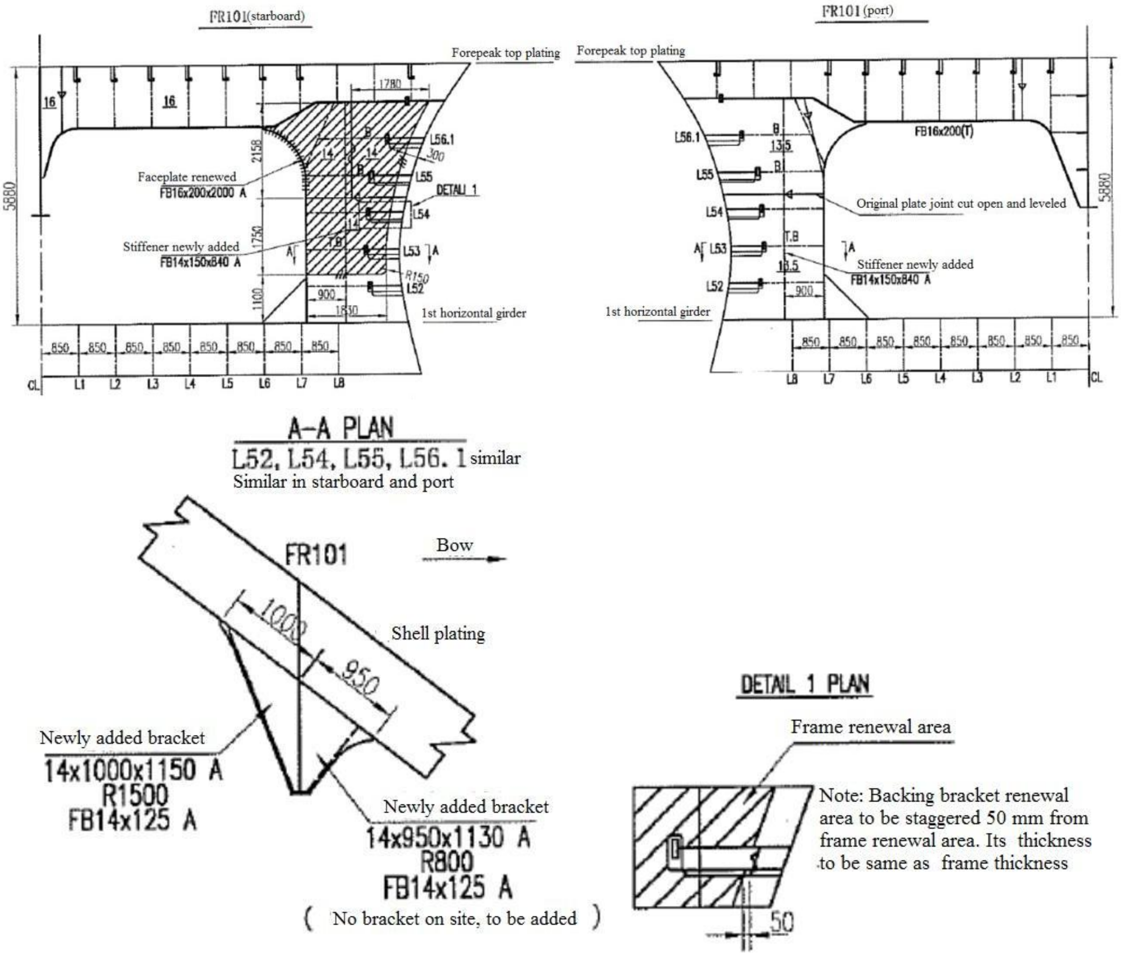


Figure 4.4.5.3(3) Repair positions

(4) For FR102 transverse frame: The web toe end at the intersection of shell longitudinals L53~L54 and FR102 is to be renewed, changed from 12.5mm to 20mm. A connecting bracket is to be newly provided, which is of 14mm, reinforced at the free edge, as shown in the following figure:

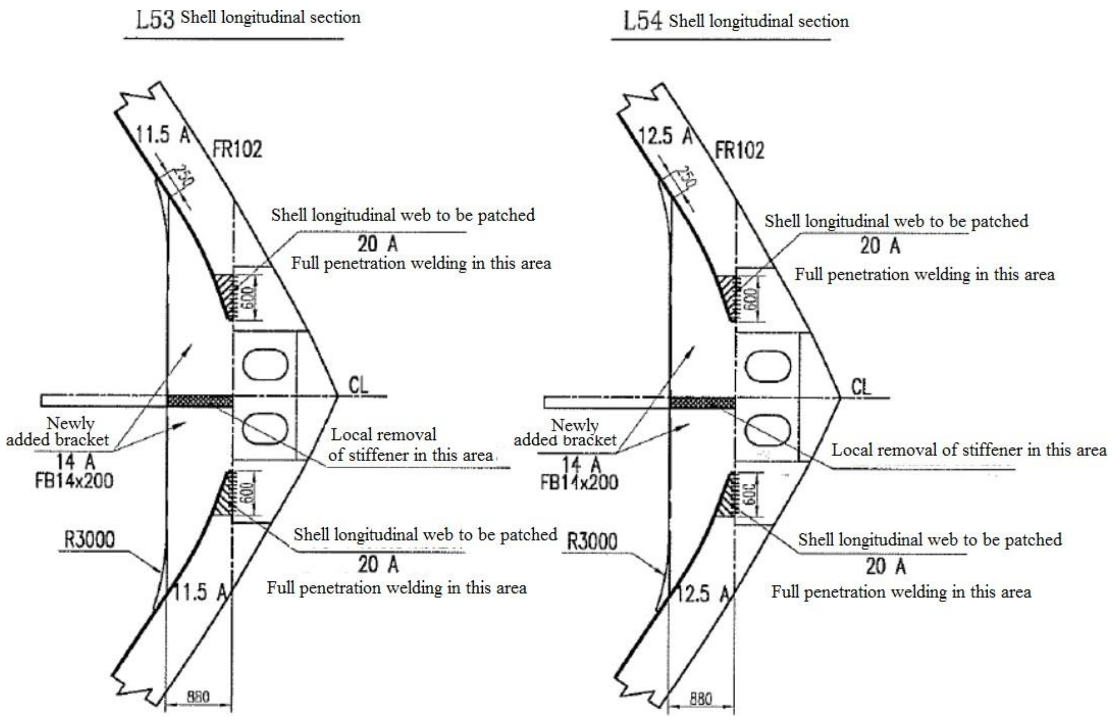


Figure 4.4.5.3(4) Repair position

4.4.5.4 Precautions and Points of Attention

(1) When reviewing drawings of hull structures, in addition to the requirements expressly provided in the rules, the surveyor should also put forward comments and suggestions on the structural arrangement and structural nodes according to his own practical experience, and communicate with the designer to urge them to modify until the best result is achieved.
(2) Suggestions are to be provided to the ship companies on safe navigation in adverse sea conditions to prevent occurrence of accidents.

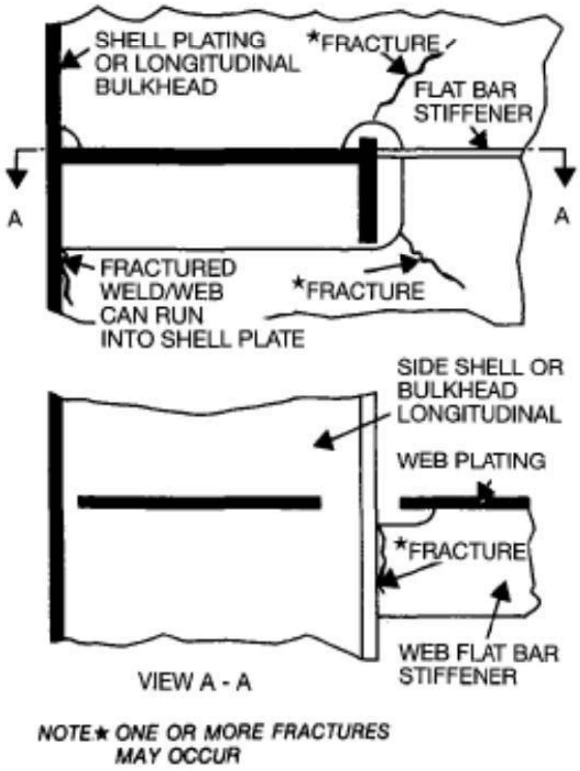
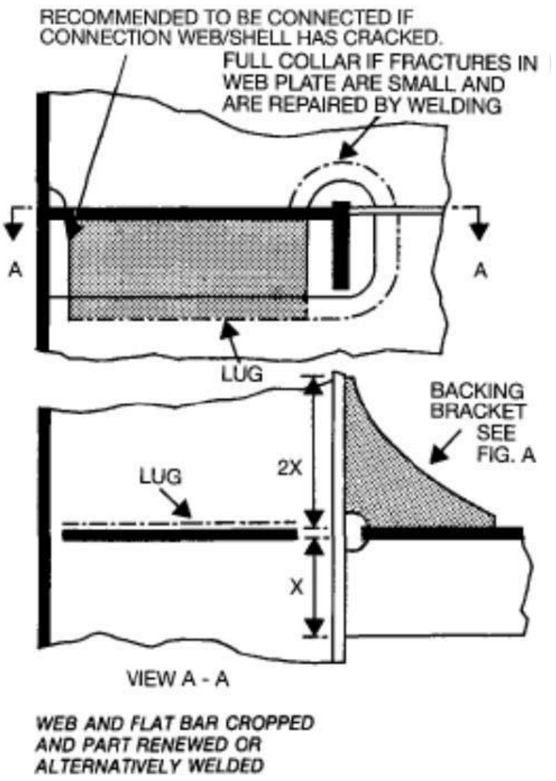
4.4.6 Typical Structure Detail Failures and Recommended Repairs

Examples of typical structure detail failures and repairs are listed below, which are divided into several groups for attention during surveys.

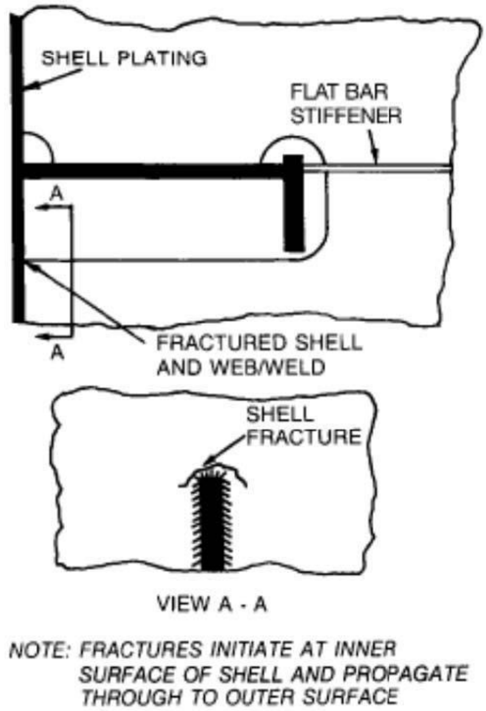
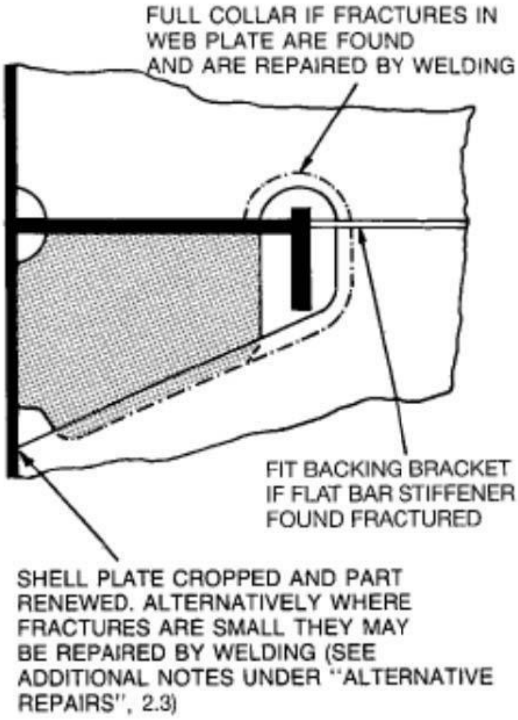
Group No.	Description	Number of examples
1	Connection of longitudinals to transverse webs	9
2	Connection of longitudinals to plane transverse bulkheads.	4
3	Connection of longitudinals to corrugated transverse bulkheads	2
4	Connection of longitudinals to floors in the double bottom	3
5	Hopper and double bottom ballast tank	3
6	Fore Peak Tank	6
7	Longitudinal girder end brackets	7
8	Transverse web frame end brackets	3
9	Primary web	3
10	Cross-ties	2
11	Transverse bulkhead horizontal stringer	5
12	Transverse bulkhead stiffener/primary web intersection	2
13	Lightening holes and openings in primary webs and swash bulkheads	3
14	Deck structure	1
15	Fore region	1

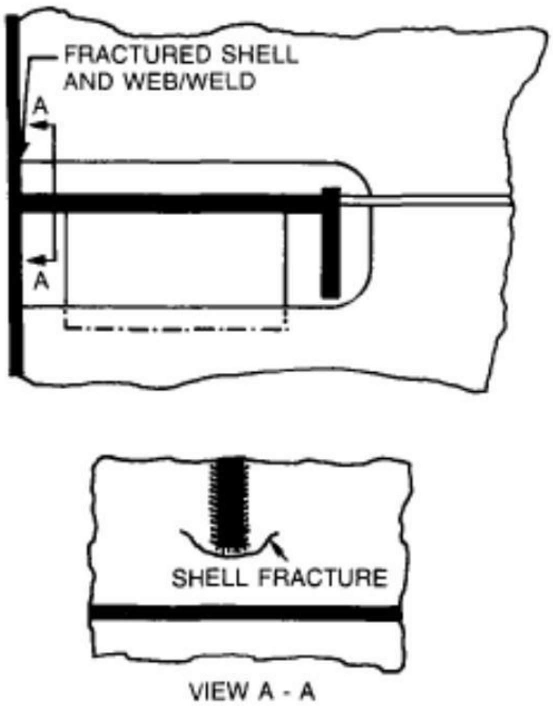
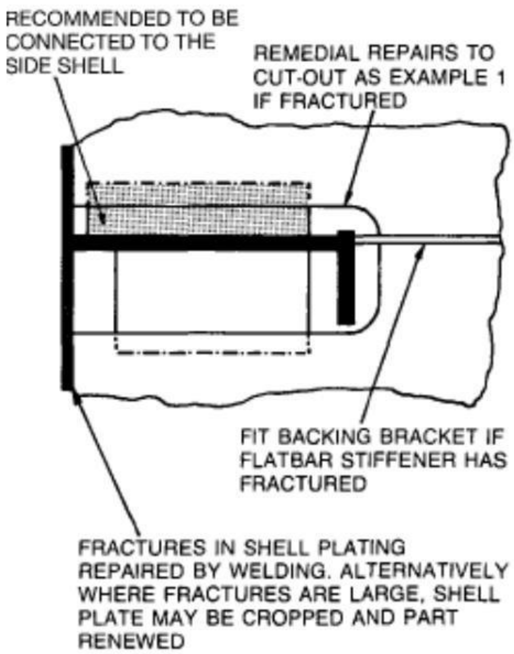
4.4.6.1 Group No.1 —— Connection of longitudinals to transverse webs

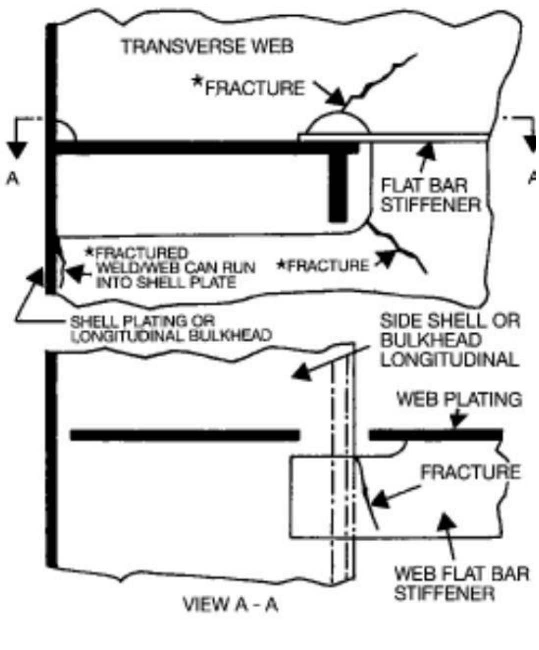
Example No.	Title
1	Web and flat bar fractures at cut-outs for longitudinal stiffener connections
2	Side shell fractures at cut-outs for longitudinal stiffener connections
3	Side shell fractures due to single lug on underside
4	Web and flat bar fractures with face plate attached to underside of web. Flat bar lap welded
5	Web and longitudinal fractures. Flat bar lap welded.
6	Web and flat bar fractures
7	Web and longitudinal fractures
8	Fractured side shell longitudinal at tripping bracket connection. No backing bracket or backing bracket too small
9	Bottom web and flat bar fractures at the cut-out for the longitudinal connections.

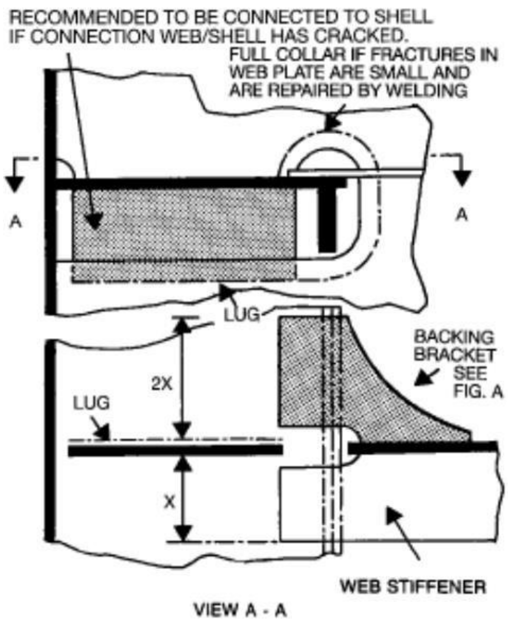
Location: Connection of longitudinals to transverse webs Example No.1: Web and flat bar fractures at cut-outs for longitudinal stiffener connections	No.1
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage: 1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener under fatigue loading. 2. Insufficient area of connection of longitudinal to web plate. 3. Defective weld at return around the plate thickness. 4. High localised corrosion at areas of stress concentration such as flat bar stiffener connections, corners of cut-out for the longitudinal and connection of web to shell at cut-outs. 5. High shear stress in the web of the transverse. 6. Dynamic sea way loads/ship motions.	Notes on repairs: 1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT. 2. Collar plates to be fitted. 3. Backing brackets to be added.

Location: Connection of longitudinals to transverse webs Example No.2: Side shell fractures at cut-outs for longitudinal stiffener connections	No.1

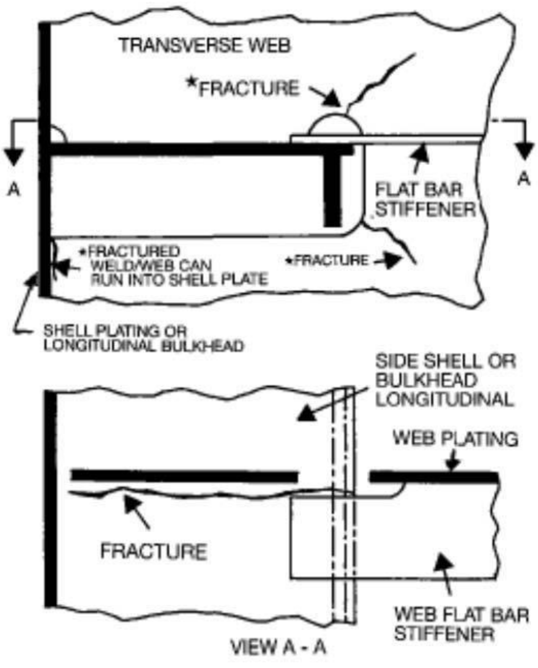
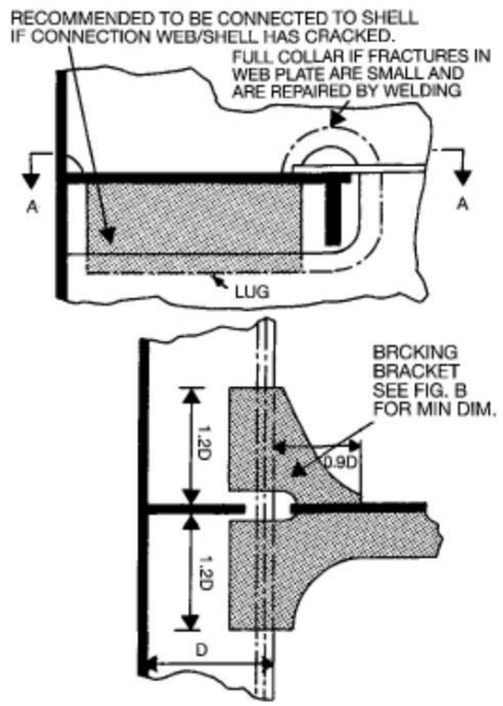
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Insufficient area of connection of longitudinal to web plates. 2. Defective weld at return around the plate thickness. 3. Localised corrosion associated with the stress concentrations in way of the longitudinal connection of web to shell. 4. Dynamic sea way loads/ship motions. 5. High shear stress in the transverse web.	Notes on repairs： 1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT. 2. Collar plates to be fitted. 3. Backing brackets to be added.

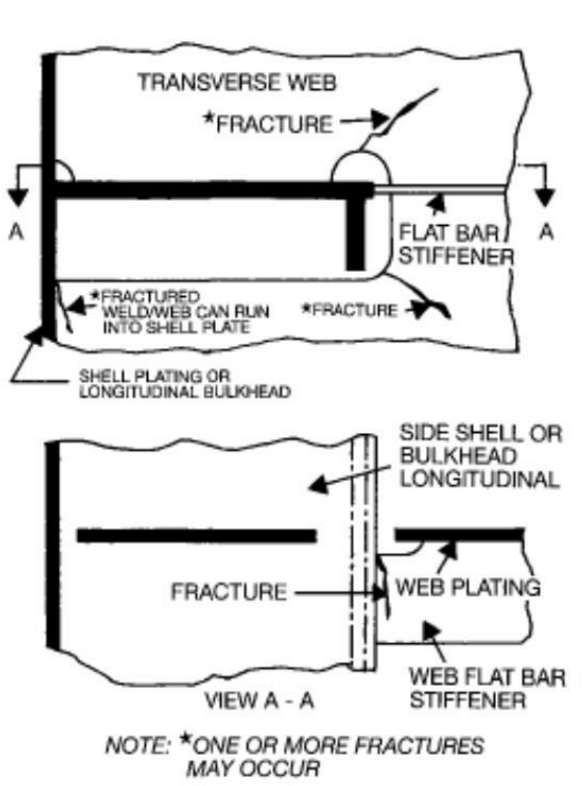
<table>
<tr><td colspan="2">Location: Connection of longitudinals to transverse webs
Example No.3: Side shell fractures due to single lug on underside</td><td>No.1</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Single lug fitted into bosom of longitudinal (instead of at. the heel side) resulting in greater deflections of the longitudinal due to dynamic loads and therefore higher stress at the upper edge of the cut-out adjacent to the shell.
2. Fracture in web flat bar stiffener connection resulting in greater deflection of longitudinal.
3. Defective weld at return around the plate thickness.
4. Dynamic sea way loads/ship motions.</td><td colspan="2">Notes on repairs：
1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT.
2. Collar plates to be fitted.
3. Backing brackets to be added.</td></tr>
</table>

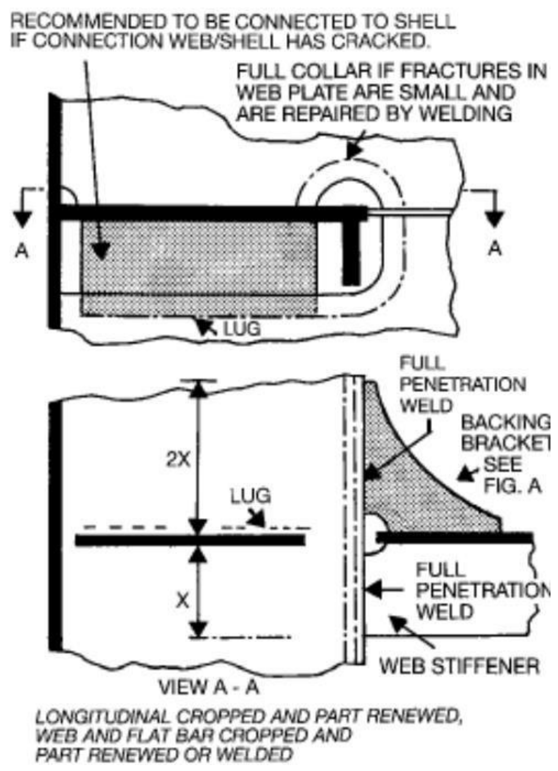
<table>
<tr><td colspan="1">Location: Connection of longitudinals to transverse webs
Example No.4: Web and flat bar fractures with face plate attached to underside of web Flat bar lap welded</td><td>No.1</td></tr>
<tr><td>Typical Damage</td><td>Proposed Repair</td></tr>
<tr><td>


NOTE: ★ONE OR MORE FRACTURES MAY OCCUR
</td><td>


LONGITUDINAL CROPPED AND PART RENEWED, WEB AND FLAT BAR CROPPED AND PART RENEWED OR WELDED
</td></tr>
<tr><td>Factors which may have caused damage：
1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener under fatigue loading.
2. Fabricated longitudinal with welding onto the exposed edge of the web resulting in poor fatigue strength of the connection of the longitudinal to the flat bar.
3. Insufficient area of connection of longitudinal to web plate.
4. Defective weld at return around the plate thickness.
5. High localised corrosion at areas of stress concentration, such as flat bar stiffener connection, corner of cut-out for longitudinal and connection of lug to shell at cut-outs.
6. High shear stress in the web of the transverse.
7. Dynamic sea way loads/ship motions.</td><td>Notes on repairs：
1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT.
2. Collar plates to be fitted.
3. Backing brackets to be added.</td></tr>
</table>

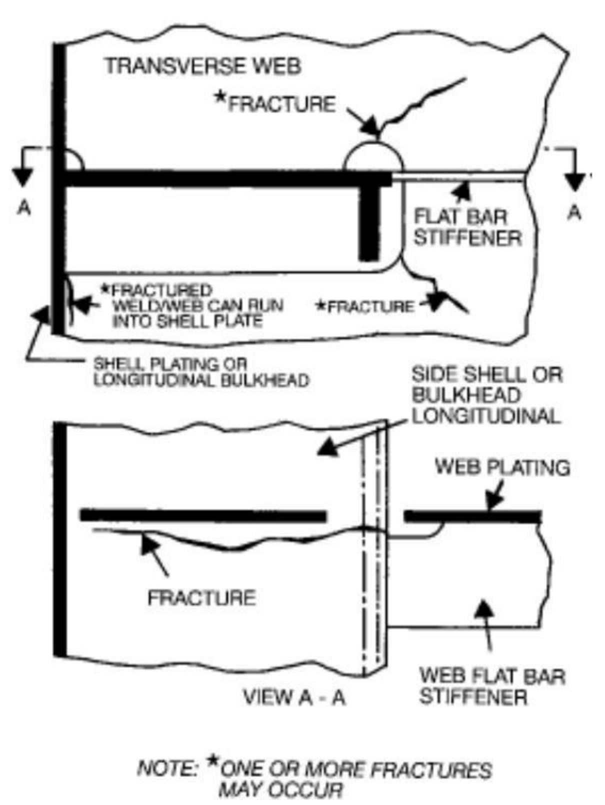
Location: Connection of longitudinals to transverse webs Example No.5: Web and longitudinal fractures. Face plate attached to underside of web. Flat bar lap welded.	No.1
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener under fatigue loading. 2. Higher tensile steel longitudinal resulting in greater stresses. 3. Fabricated longitudinal with welding onto the exposed edge of the web resulting in poor fatigue strength of the connection of the longitudinal to the flat bar. 4. Insufficient area of connection of longitudinal to web plate. 5. Defective weld at return around the plate thickness. 6. High localised corrosion at areas of stress concentration, such as flat bar stiffener connection, corner of cut-out for longitudinal and connection of lug to shell at cut-outs. 7. High shear stress in the web of the transverse. 8. Dynamic sea way loads/ship motions.	Notes on repairs： 1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT. 2. Collar plates to be fitted. 3. Backing brackets to be added.

<table>
<tr><td colspan="2">Location: Connection of longitudinals to transverse webs
Example No.6: Web and flat bar fractures as Example No.1 but with face plate attached to under side of web. Flat bar butt welded.</td><td>No.1</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>


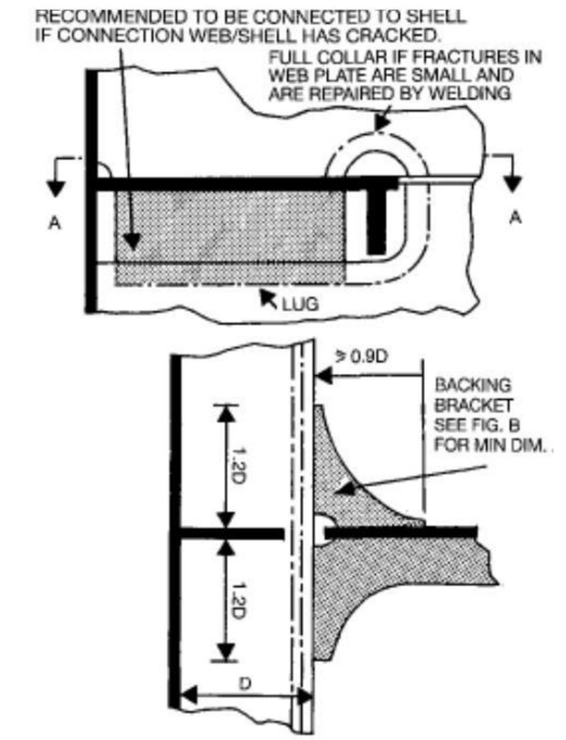
</td><td colspan="2">


</td></tr>
<tr><td>Factors which may have caused damage：
1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener under fatigue loading.
2. Fabricated longitudinal with welding onto the exposed edge of the web resulting in poor fatigue strength of the connection of the longitudinal to the flat bar.
3. Insufficient area of connection of longitudinal to web plate.
4. Defective weld at return around the plate thickness.
5. High localised corrosion at areas of stress concentration, such as flat bar stiffener connection, corner of cut-out for longitudinal and connection of lug to shell at cut-outs.
6. High shear stress in the web of the transverse.
7. Dynamic sea way loads/ship motions.</td><td colspan="2">Notes on repairs：
1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT.
2. Collar plates to be fitted.
3. Backing brackets to be added and to be full penetration welded.</td></tr>
</table>

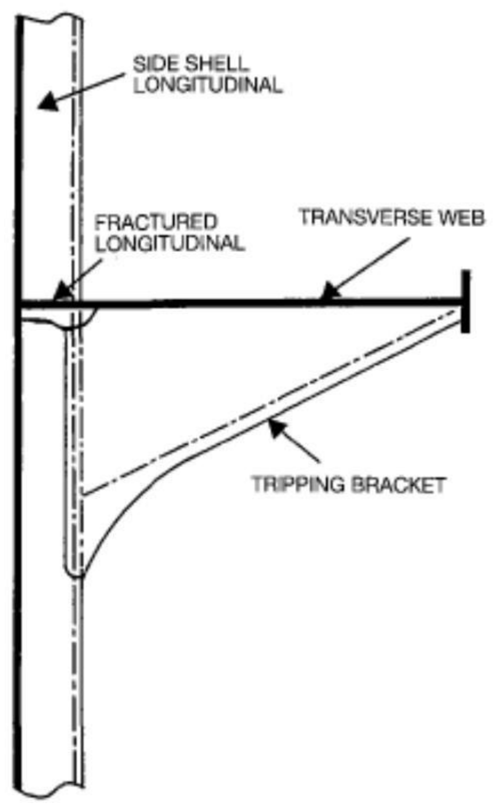
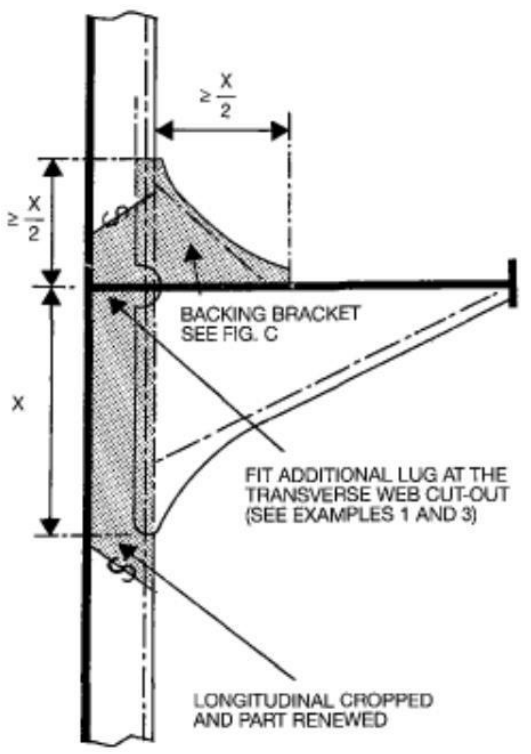
<table>
<tr><td colspan="2">Location: Connection of longitudinals to transverse webs.
Example No.7: Web and longitudinal fractures. Face plate attached to underside of web. Flat bar butt welded.</td><td>No.1</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>



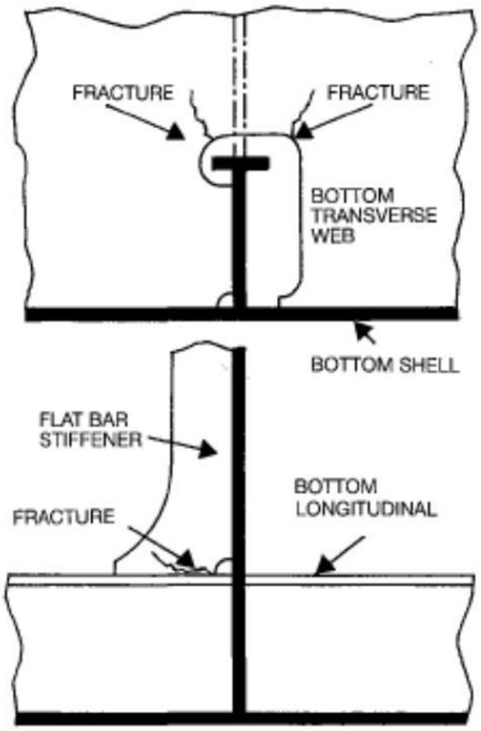
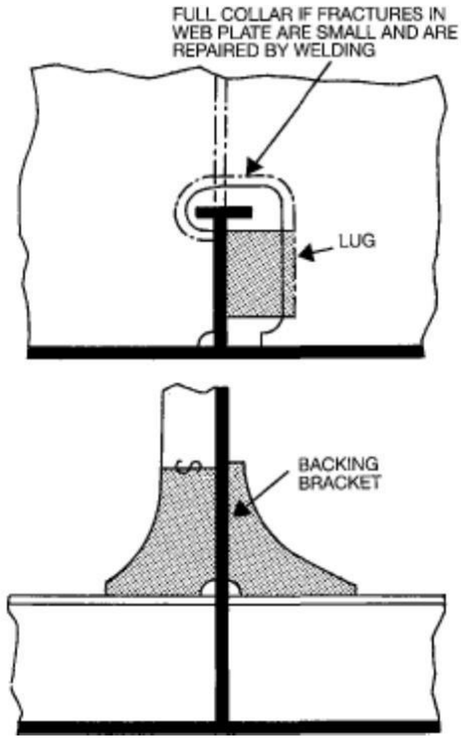
</td><td colspan="2">



</td></tr>
<tr><td>Factors which may have caused damage：
1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener under fatigue loading.
2. Higher tensile steel longitudinal resulting in greater stresses.
3. Fabricated longitudinal with welding onto the exposed edge of the web resulting in poor fatigue strength of the connection of the longitudinal to the flat bar.
4. Insufficient area of connection of longitudinal to web plate.
5. Defective weld at return around the plate thickness.
6. High localised corrosion at areas of stress concentration, such as flat bar stiffener connection, corner of cut-out for longitudinal and connection of lug to shell at cut-outs.
7. High shear stress in the web of the transverse.
8. Dynamic sea way loads/ship motions.</td><td colspan="2">Notes on repairs：
1. Web plate cropped and partly renewed, but for small fractures, the fracture can be ground, veed-out, welded-up, and examined by NDT.
2. Collar plates to be fitted.
3. Backing brackets to be added.</td></tr>
</table>

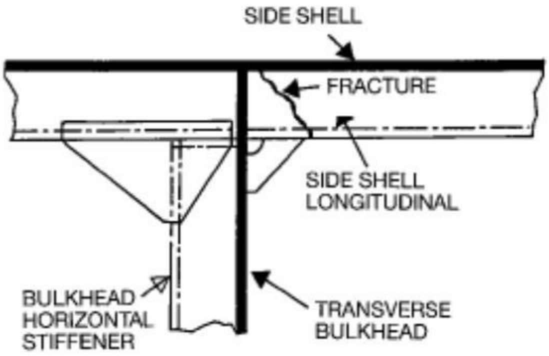
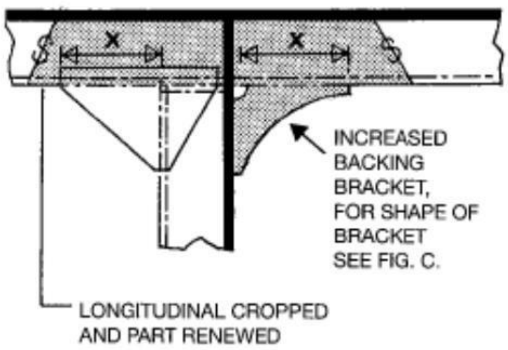
<table>
<tr><td colspan="2">Location: Connection of longitudinals to transverse webs.
Example No.8: Fractured side shell longitudinal at tripping bracket connection. No backing bracket.</td><td>No.1</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Asymmetrical connection of bracket resulting in high peak stresses at the heel of the single large bracket under fatigue loading.
2. Higher tensile steel longitudinal resulting in greater stresses.
3. Fabricated longitudinal having the face plate attached to the underside of the web (where fitted) and with welding onto the exposed edge of the web. This results in poor fatigue strength of the connection of the longitudinal web to the tripping bracket.
4. Asymmetric longitudinals resulting in additional torsional stresses.
5. Defective weld at return around the plate thickness.
6. Dynamic sea way loads/ship motion.
7. Increased stress if only a single connection is employed in way of the transverse web cut-outs.</td><td colspan="2">Notes on repairs：
1. Longitudinal to be cropped and partly renewed.
2. Backing brackets to be added.
3. Additional collar plate to be fitted at the transverse web cut-out.</td></tr>
</table>

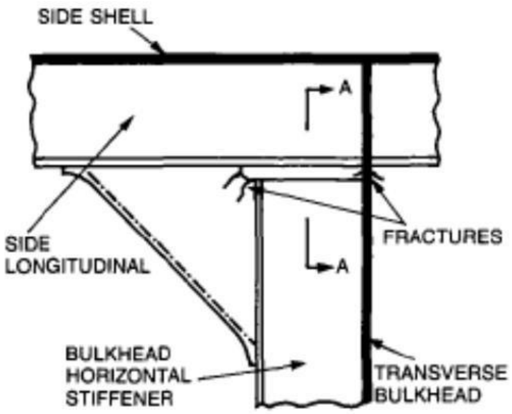
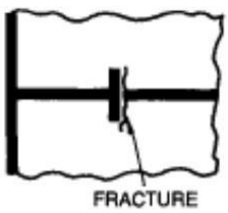
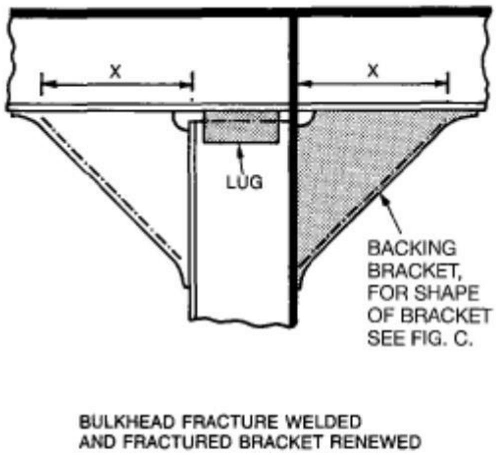
Location: Connection of longitudinals to transverse webs Example No.9: Bottom web and flat bar fractures at the cut-out for the longitudinal connections.	No.1

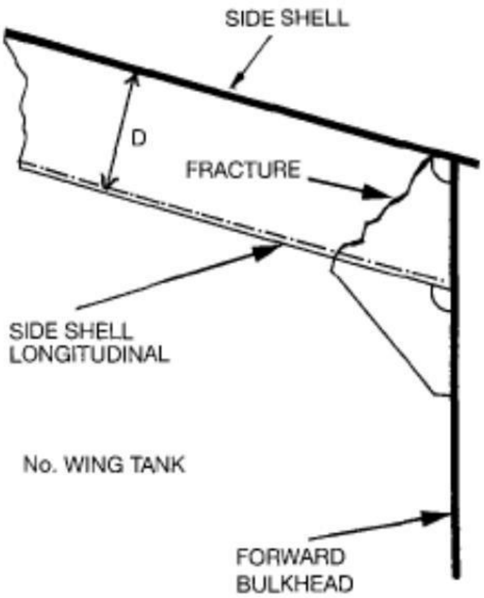
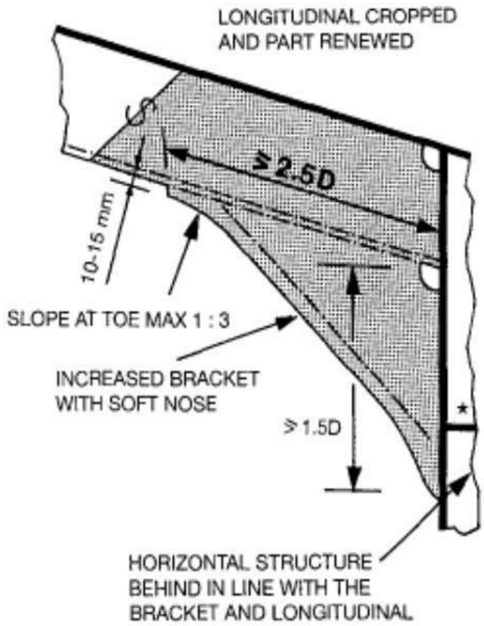
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage： 1. Asymmetrical connection resulting in high stresses at heel of stiffener. 2. Dynamic sea way loads/ship motions. 3. Insufficient area of connection of longitudinal to web plate. 4. Defective weld at return around the plate thickness. 5. High localised corrosion at areas of stress concentration such as the flat bar stiffener connection and corners of the cut-out for the longitudinal. 6. High shear stress in the web of the transverse.	Notes on repairs： 1. Flat bar stiffener to be cropped and partly renewed. 2. Additional collar plate to be fitted. 3. Backing brackets to be added.

4.4.6.2 Group No.2：Connection of longitudinals to plane transverse bulkheads

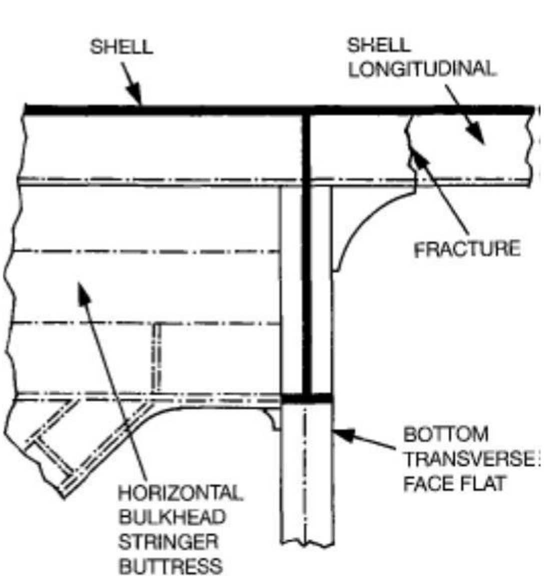
Example No.	Title
1	Fractured side shell longitudinal
2	Fractured bulkhead end bracket at side shell.
3	Fractured side shell longitudinal at forward transverse bulkhead
4	Fractured side shell longitudinal at transverse bulkhead buttress

<table>
<tr><td colspan="2">Location: Connection of longitudinals to plane transverse bulkheads.
Example No.1: Fractured side shell longitudinal. Bulkhead horizontally stiffened.</td><td>No.2</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Asymmetrical connection of bracket in association with a backing bracket which is too small. This results in high stress at the toe of the smaller bracket under fatigue loading.
2. Higher tensile steel longitudinal resulting in greater stresses.
3. Dynamic sea way loads/ship motions.
4. Fabricated longitudinal having the face plate attached to the underside of the web (where fitted) and with welding onto the exposed edge of the web. This results in poor fatigue strength of the connection of the longitudinal web to the bracket.
5. Asymmetric longitudinal resulting in additional torsional stresses.
6. Horizontally stiffened transverse bulkhead causing increased end moments at the side shell longitudinal connection resulting from loading on the transverse bulkhead.
7. Deflection of the adjacent side shell transverse under load.
8. Defective weld at return around the plate thickness.</td><td colspan="2">Notes on repairs：
1. Longitudinal to be cropped and partly renewed.
2. Backing brackets to be added.</td></tr>
</table>

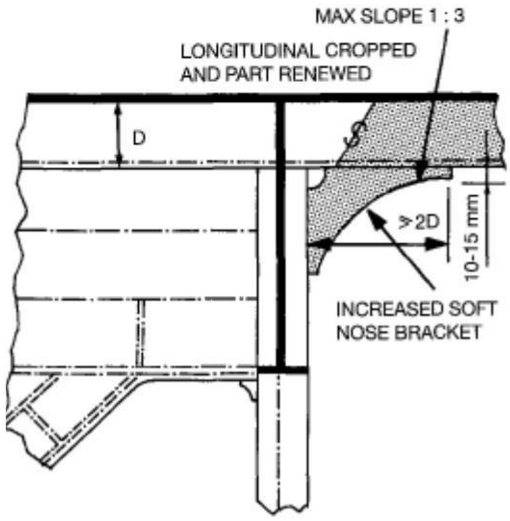
Location: Connection of longitudinals to plane transverse bulkheads Example No.2: Fractured bulkhead end bracket at side shell. Bulkhead horizontally stiffened.	No.2
Typical Damage	**Proposed Repair**
  VIEW A - A	
Factors which may have caused damage： 1. Large unconnected ending of bulkhead stiffener associated with an asymmetrical connection resulting in high stresses at the heel of the stiffener and the bracket. 2. Horizontally stiffened transverse bulkheads causing increased end moment at the side shell longitudinal connection resulting from loading on the transverse bulkhead. 3. Deflection of the adjacent side shell transverse under load. 4. Defective weld at return around plate thickness. 5. Dynamic sea way loads/ship motions.	Notes on repairs： 1. Fractured bulkhead repaired by weld and fractured bracket partly renewed. 2. Additional collar plate to be fitted. 3. Backing brackets to be added.

Location: Connection of longitudinals to plane transverse bulkheads Example No.3: Fractured side shell longitudinal at forward transverse bulkhead	No.2
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage： 1. Under-designed end bracket. 2. Higher tensile steel side shell longitudinal resulting in greater stresses. 3. Fabricated longitudinal having the face plate attached to the underside of the web (where fitted) and with welding onto the exposed edge of the web. This results in poor fatigue strength of the connection of the longitudinal to the bracket. 4. Deflection of the adjacent side shell transverse under load. 5. Defective weld at return around the plate thickness. 6. Dynamic sea way loads/ship motions of forward end of ship.	Notes on repairs： 1. Longitudinal to be cropped and partly renewed. 2. Increased bracket with soft toes.

<table>
<tr><td colspan="2">Location: Connection of longitudinals to plane transverse bulkheads.
Example No.4: Fractured side shell longitudinal at transverse bulkhead buttress</td><td>No.2</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>



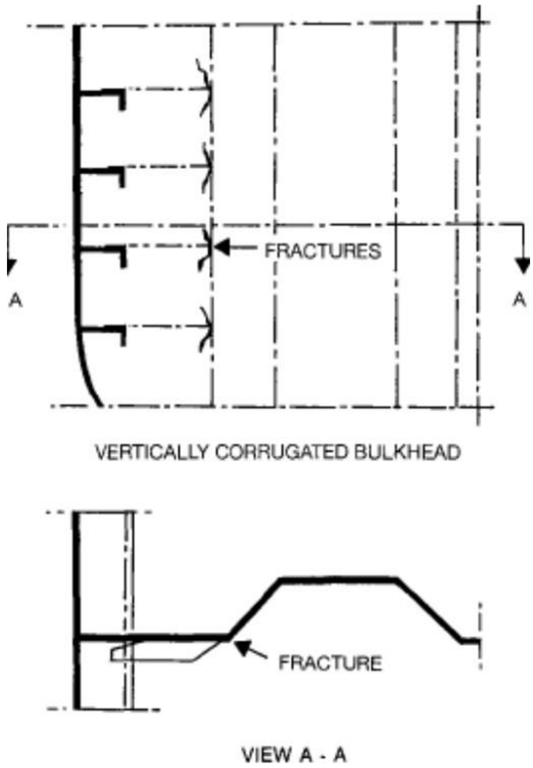
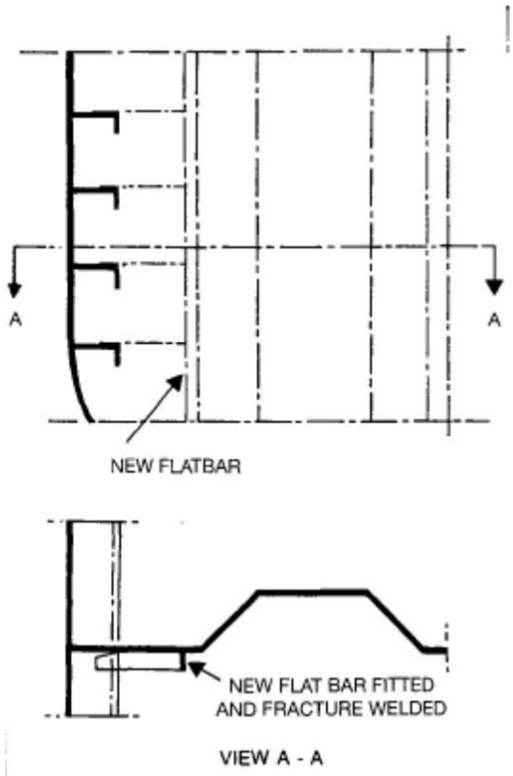
</td><td colspan="2">



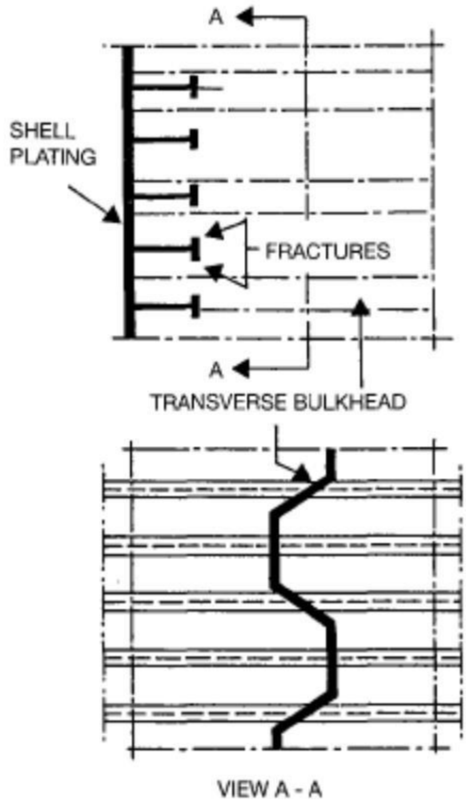
</td></tr>
<tr><td>Factors which may have caused damage:
1. Under-designed end bracket.
2. Higher tensile steel side shell longitudinal resulting in greater stresses.
3. Fabricated longitudinal having the face plate attached to the underside of the web (where fitted) and with welding onto the exposed edge of the web. This results in poor fatigue strength of the connection of the longitudinal web to the bracket.
4. Deflection of the adjacent transverse web frame under load.
5. Defective weld at return around the plate thickness.
6. Dynamic sea way loads/ship motions.
7. Asymmetric longitudinal resulting in additional torsional stresses.</td><td colspan="2">Notes on repairs:
1. Longitudinal to be cropped and partly renewed.
2. Increased bracket with soft toes.</td></tr>
</table>

4.4.6.3 Group No.3：Connection of longitudinals to corrugated transverse bulkheads

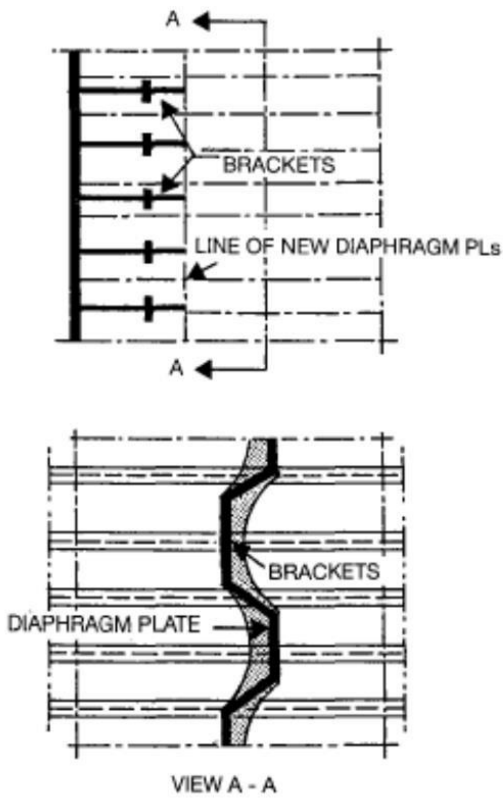
Example No.	Title
1	Bulkhead fracture at toe of horizontal flat bar stiffener.
2	Bulkhead fractured at passage of side longitudinal.

Location: Connection of longitudinals to corrugated transverse bulkheads Example No.1: Bulkhead fracture at toe of horizontal flat bar stiffener. Vertically corrugated bulkhead.	No.3
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Sniped stiffener ending close to corrugation knuckle forming a hard spot under deflection of the corrugation and rotation of the longitudinal. 2. Insufficient stiffener end connection at the knuckle in the corrugation. 3. Dynamic seaway loads/ship motions.	Notes on repairs： 1. Bulkhead to be cropped and partly renewed or repaired by weld. 2. New flat bar stiffener to be fitted.

<table>
<tr><td colspan="2">Location: Connection of longitudinals to corrugated transverse bulkheads
Example No.2: Bulkhead fractured at passage of side longitudinal. Bulkhead horizontally corrugated.</td><td>No.3</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>



</td><td colspan="2">



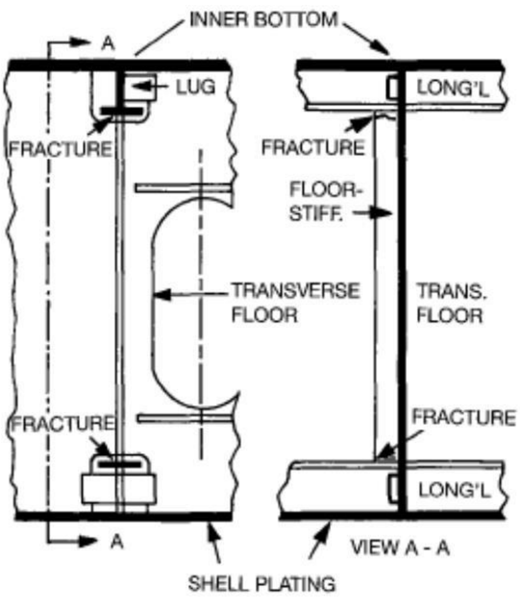
</td></tr>
<tr><td>Factors which may have caused damage：
1. Inadequate connection between side longitudinal and horizontal corrugation.
2. Large span of horizontal corrugation.
3. Dynamic seaway loads/ship motions.</td><td colspan="2">Notes on repairs：
1. Backing brackets to be added.
2. Additional collar plate with increased thickness (125%) to be fitted at cut-outs.</td></tr>
</table>

4.4.6.4 Group No.4：Connection of longitudinals to floors in the double bottom

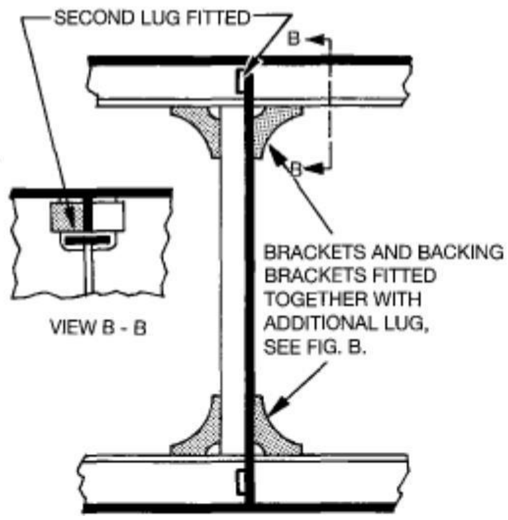
Example No.	Title
1	Fractured stiffener connection to bottom and inner bottom longitudinals
2	Connection of longitudinals to ordinary floors
3	Cut-outs on floors

Location: Connection of longitudinals to floors in the double bottom Example No.1: Fractured stiffener connection to bottom and inner bottom longitudinals	No.4

Typical Damage



Proposed Repair

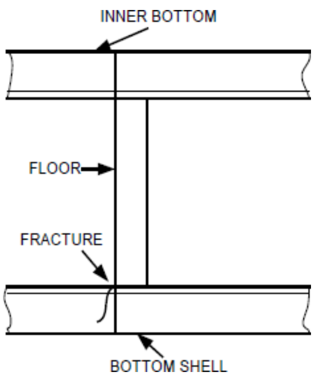
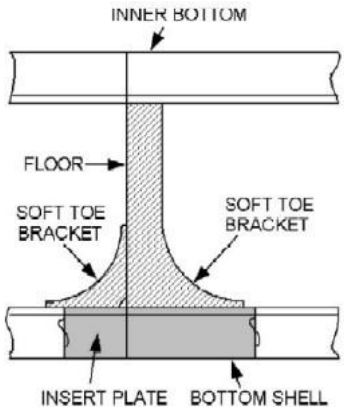


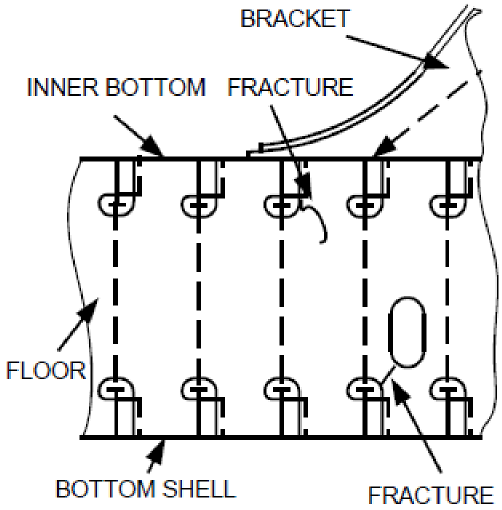
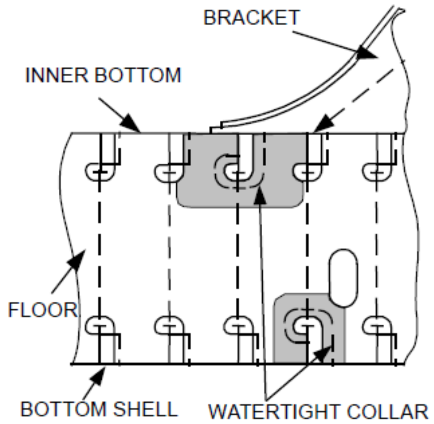
Factors which may have caused damage：

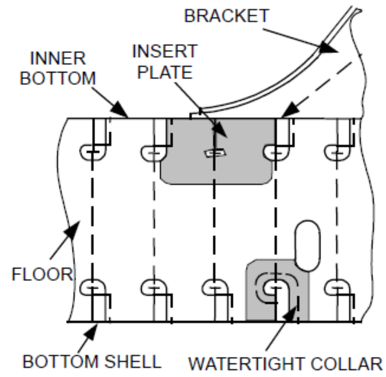
1. Asymmetric connection leading to high local stresses at the connection of vertical stiffeners of the transverse floors to the inner and outer bottom longitudinals.
2. Wide slot for longitudinal leads to inefficient lug connection.
3. Sharp corners or flame-cut edges producing a notch effect.
4. Incomplete/defective weld at stiffener connection to the longitudinals.
5. Dynamic sea way loads/ship motions.

Notes on repairs：

1. Additional collar plate to be fitted.
2. Backing brackets to be added.

<table>
<tr><td colspan="2">Location: Connection of longitudinals to floors in the double bottom
Example No.2: Connection of longitudinals to ordinary floors</td><td>No.4</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
Stress concentration at the connection of bottom longitudinal and stiffener on floor.</td><td colspan="2">Notes on repairs：
See Sketch.
1. Butt welds in bottom longitudinal should be kept clear of the soft toe bracket toes.
2. If possible soft toe bracket and vertical stiffener should be integral.</td></tr>
</table>

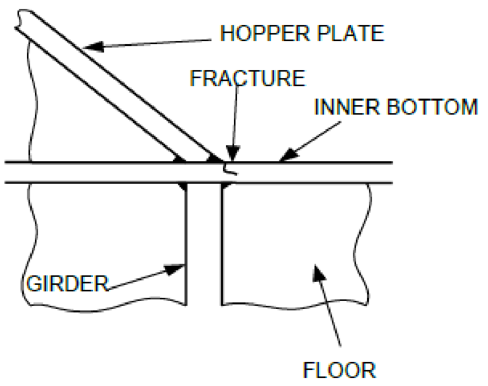
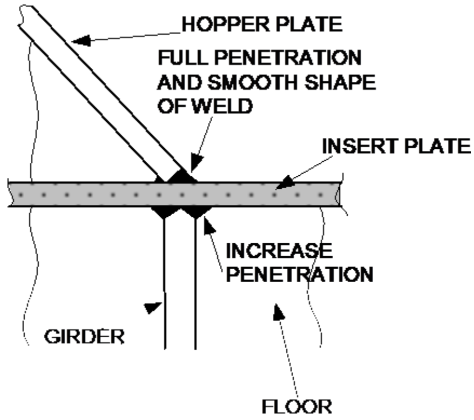
<table>
<tr><td colspan="2">Location: Connection of longitudinals to floors in the double bottom
Example No.3: Cut-outs on floors</td><td>No.4</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">

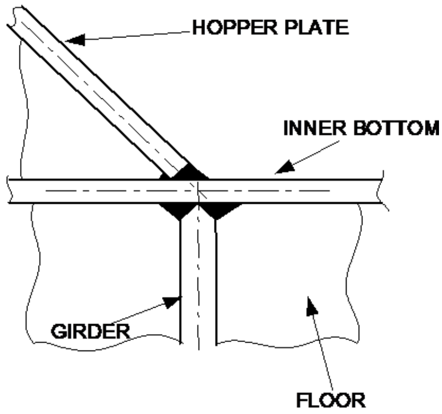
Above for relatively small fractures.


Above method for larger fractures.</td></tr>
<tr><td>Factors which may have caused damage:
1. High stress in the vicinity of the transverse web frame bracket toe.
2. Lack of material between manhole and cut-out for bottom longitudinals</td><td colspan="2">Notes on repairs:
1. Top sketch: Gouge and reweld fractures then fit WT collars.
2. Bottom sketch: As an alternative to rewelding and fitting collar, crop and insert.</td></tr>
</table>

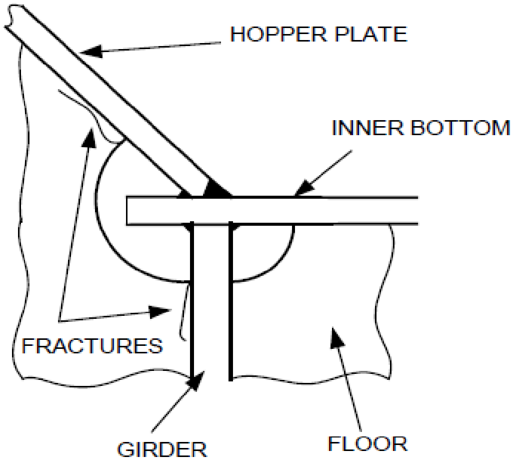
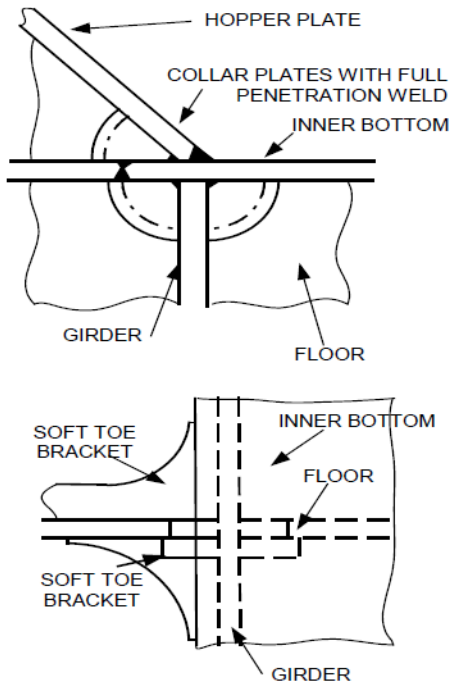
4.4.6.5 Group No.5: Hopper and double bottom ballast tank

Example No.	Title
1	Fracture on the inner bottom plating at the connection of hopper plate to inner bottom
2	Fracture at connection of bilge hopper plate and inner bottom
3	Fracture in gusset plate in line with inner bottom

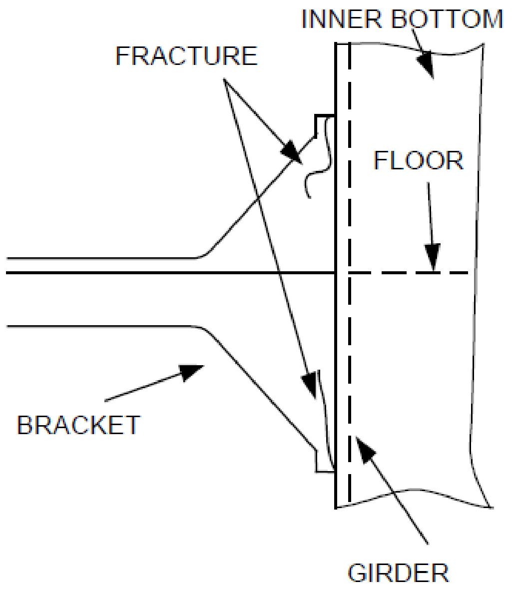
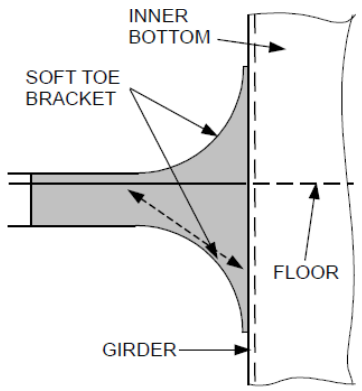
<table>
<tr><td>Location: Hopper and double bottom ballast tank
Example No.1: Fracture on the inner bottom plating at the connection of hopper plate to inner bottom</td><td>No.5</td></tr>
<tr><td>Typical Damage</td><td>Proposed Repair</td></tr>
<tr><td>
</td><td>

NEW CONSTRUCTION

</td></tr>
<tr><td>Factors which may have caused damage：
1. Stress concentration at juncture of hopper plate to inner bottom.
2. Insufficient welding connection.
3. Misalignment between hopper plate, inner bottom and girder.</td><td>Notes on repairs：

See Sketch.</td></tr>
</table>

<table>
<tr><td>Location: Hopper and double bottom ballast tank
Example No.2: Fracture at connection of bilge hopper plate and inner bottom</td><td>No.5</td></tr>
<tr><td>Typical Damage</td><td>Proposed Repair</td></tr>
<tr><td>
</td><td>

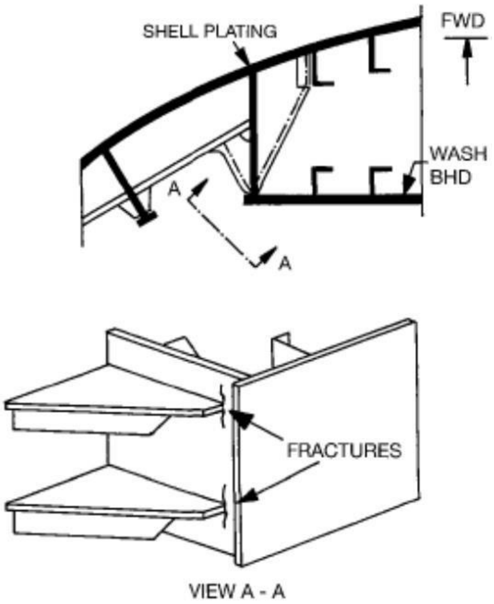
Notes: Plate midlines intersect</td></tr>
<tr><td>Factors which may have caused damage：
Stress concentration at the knuckle.</td><td>Notes on repairs：
See Sketch.</td></tr>
</table>

<table>
<tr><td colspan="2">Location: Hopper and double bottom ballast tank
Example No.3: Fracture in gusset plate in line with inner bottom</td><td>No.5</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td></td><td colspan="2">
Notes: Bracket radii as large as practicable.
Bracket same thickness as inner bottom stiffener.
Toe height should be small as possible while still allowing return weld (wrapped weld).</td></tr>
<tr><td>Factors which may have caused damage：
1. Stress concentration due to small radius and abrupt toe.
2. Insufficient welding.
3. Insufficient sectional area (thickness x breadth) of the connecting bracket.</td><td colspan="2">Notes on repairs：
See Sketch.</td></tr>
</table>

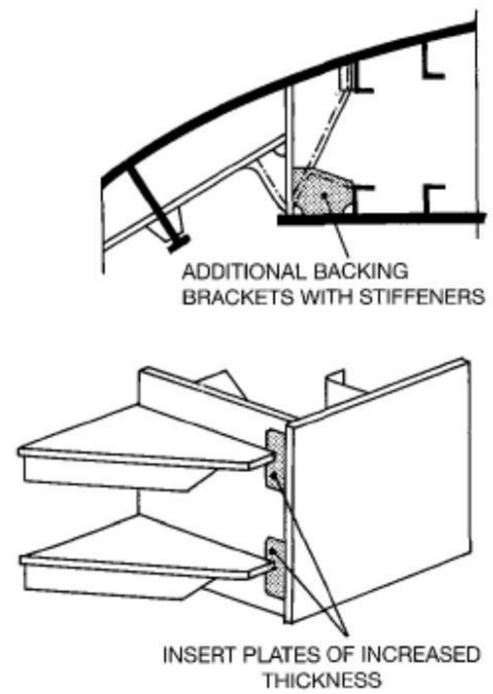
4.4.6.6 Group No.6: Fore Peak Tank

Example No.	Title
1	Fractured vertical web at the longitudinal stiffener ending in way of the parabolic bow structure
2	Fractured stringer end connection in way of the parabolic bow structure
3	Fracture at end of longitudinal at bow structure
4	Fracture at toe of web frame bracket connection to stringer platform bracket
5	Fracture and buckle of bow transverse web frame in way of longitudinal cut-outs
6	Buckled and tripped breast hooks

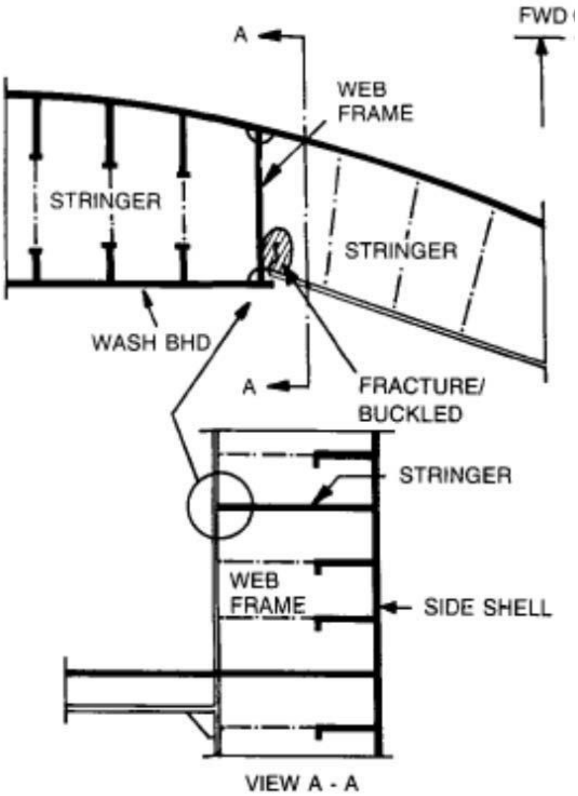
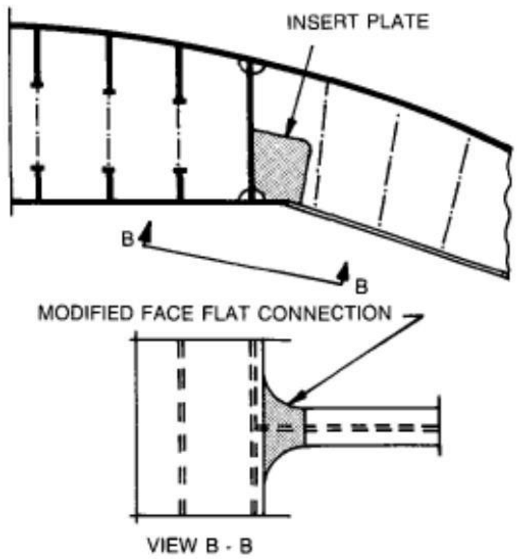
<table>
<tr><td colspan="2">Location: Forepeak structure.
Example No.1: Fractured vertical web at the longitudinal stiffener ending in way of the parabolic bow structure</td><td>No.6</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>

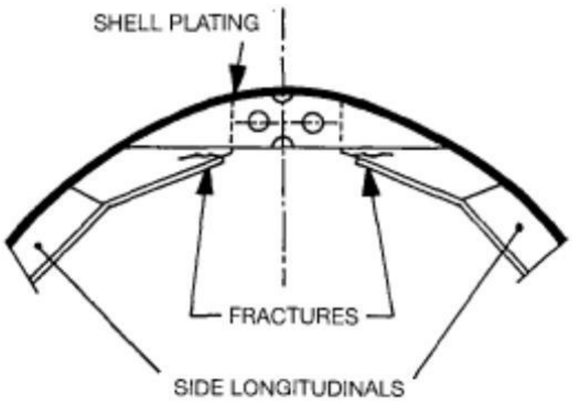
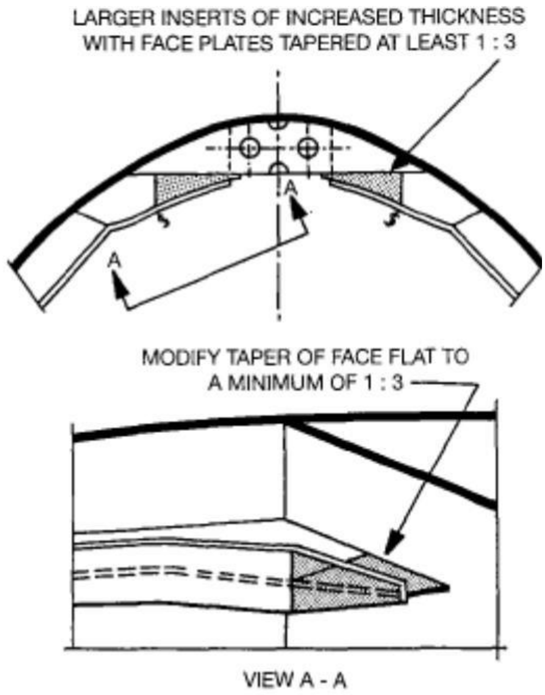


</td><td colspan="2">



</td></tr>
<tr><td>Factors which may have caused damage：
1. Stress concentrations at bracket ending due to inadequate support at bracket toes in way of connection to web frame members.
2. Localised thinning in way of coating failure at bracket endings due to flexing of the structure.
3. Dynamic seaway loadings at bow causing flexing at bracket endings.</td><td colspan="2">Notes on repairs：
1. Insert plates with increased thickness below bracket ending.
2. Additional backing brackets with stiffeners to be added.</td></tr>
</table>

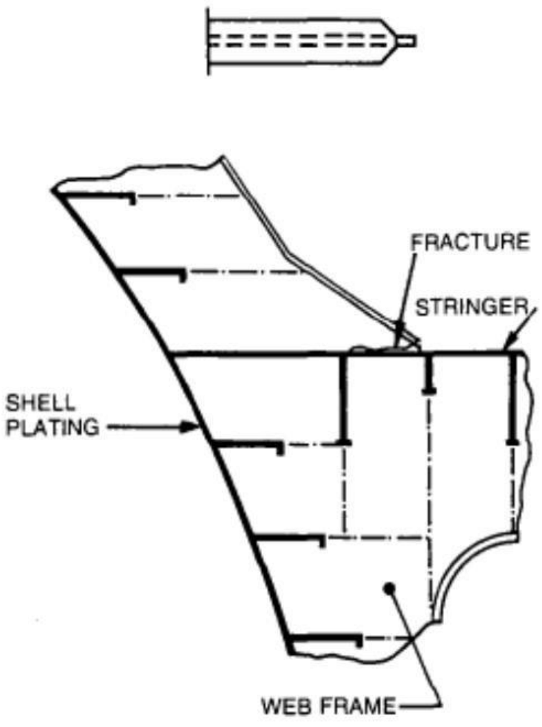
<table>
<tr><td colspan="2">Location: Forepeak structure
Example No.2: Fractured stringer end connection in way of the parabolic bow structure</td><td>No.6</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. High stress concentration at connection of stringer to stiff girder/deep web intersection due to discontinuity of face plate.
2. Localised thinning in way of coating failure at stringer connection due to flexing of the structure.
3. Dynamic seaway loadings at bow causing flexing in way of detail</td><td colspan="2">Notes on repairs：
1. Insert plate with increased thickness at connection.
2. Modified face plate connection.</td></tr>
</table>

Location: Forepeak structure Example No.3: Fracture at end of longitudinal at bow structure	No.6
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Inadequate brackets forming the longitudinal endings at bow structure. 2. Localised thinning in way of coating failure at longitudinal endings due to flexing of the structure. 3. Dynamic seaway loadings at bow causing flexing at longitudinal endings.	Notes on repairs： 1. Modified taper of toes to a minimum of 1:3. 2. Insert web plate with increased thickness with soft toes. 3. Modified taper of face plate to a minimum of 1:3.

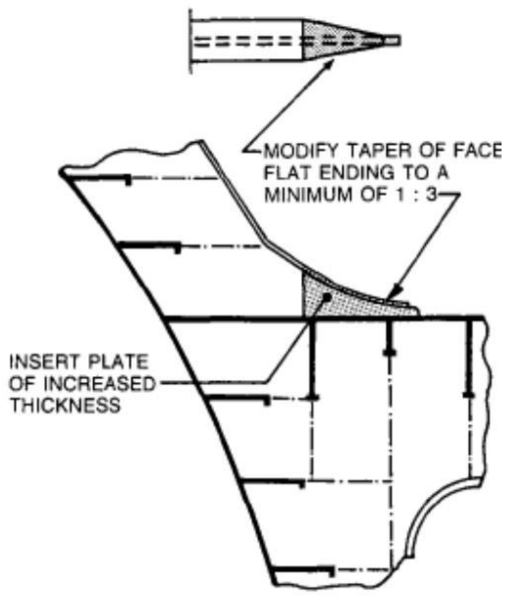
Location: Forepeak structure
Example No.4: Fracture at toe of web frame bracket connection to stringer platform bracket

No.6

Typical Damage



Proposed Repair

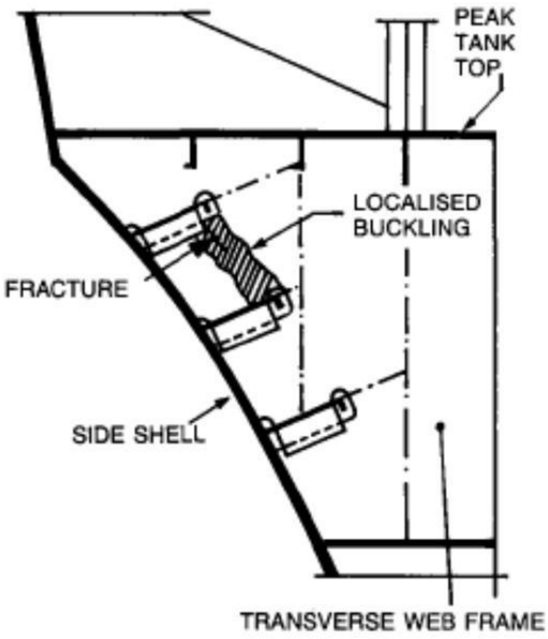
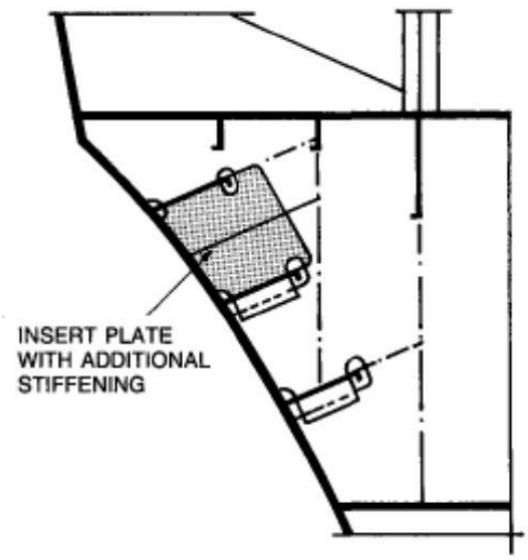


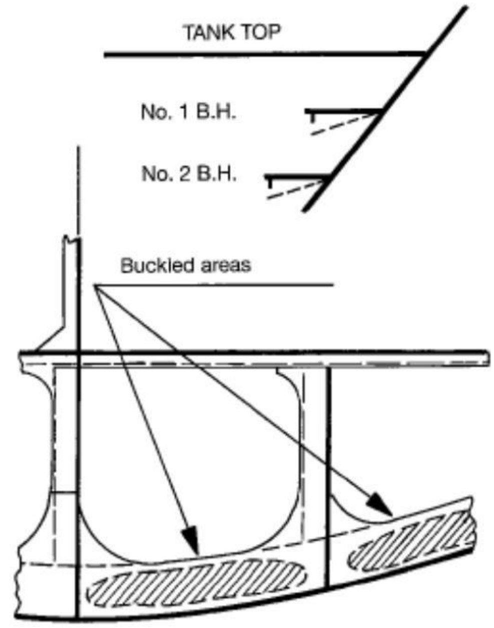
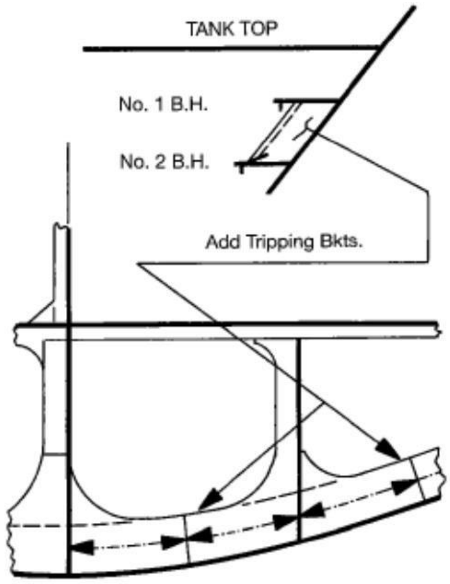
Factors which may have caused damage：

1. Inadequate bracket forming the web frame connection to the stringer.
2. Localised thinning in way of coating failure at bracket due to flexing of the structure.
3. Dynamic seaway loadings in way of bow flair.

Notes on repairs：

1. Modified taper of toes to a minimum of 1:3.
2. Insert web plate with increased thickness with soft toes.
3. Modified taper of face plate to a minimum of 1:3.

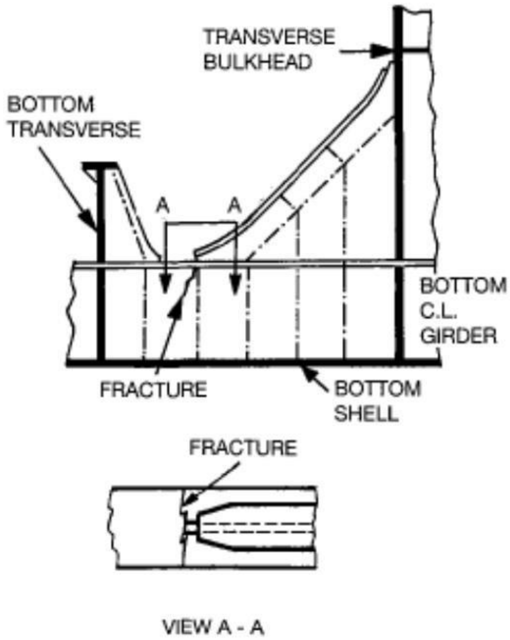
<table>
<tr><td colspan="2">Location: Forepeak structure
Example No.5: Fracture and buckle of bow transverse web frame in way of longitudinal cut-outs</td><td>No.6</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Localised thinning in way of coating failure at cut-outs and sharp edges due to working of the structure.
2. Dynamic seaway loadings in way of bow flair.</td><td colspan="2">Notes on repairs：
Insert web plate with additional stiffeners and increased thickness.</td></tr>
</table>

Location: Fore peak structure Example No.6: Buckled and tripped breast hooks	No.6
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage: 1. Bow impact load. 2. Low buckling resistance	Notes on repairs: Tripping brackets to be added at breast hooks

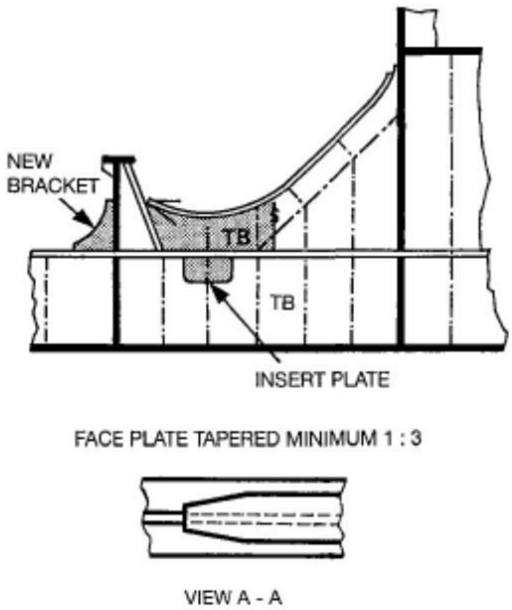
4.4.6.7 Group No.7：Longitudinal girder end brackets

Example No.	Title
1	Fractured bottom centre line girder at the end bracket connection to O.T. bulkhead
2	Fractured and buckled buttress in way of bracket connection to O.T. bulkhead.
3	Fractured vertical web bracket connection to bottom centerline girder
4	Buckled and fractured vertical web and bottom centre line girder bracket connection
5	Fractured bottom girder brackets in way of pipe opening
6	Fractured and buckled bottom side girder in way of end connections to O.T. bulkhead
7	Fractured intercostal bottom girder fitted without an end bracket in way of the wash bulkhead

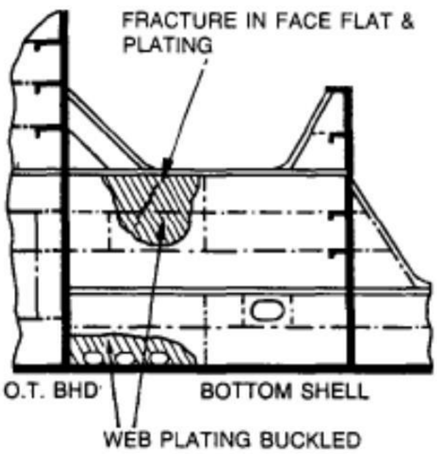
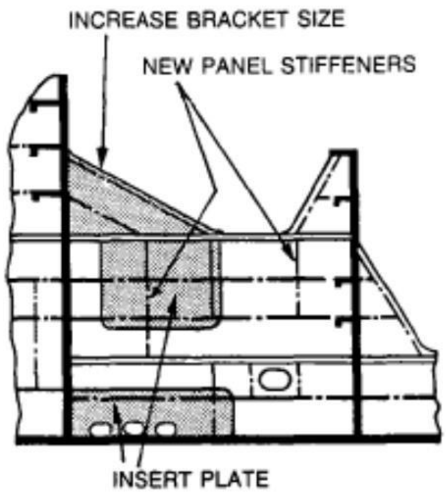
<table>
<tr><td colspan="2">Location: Longitudinal girder end brackets
Example No.1: Fractured bottom centre line girder at the end bracket connection to O.T. bulkhead</td><td>No.7</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>

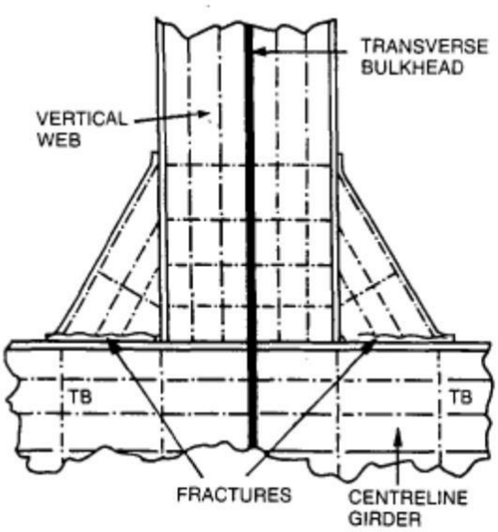
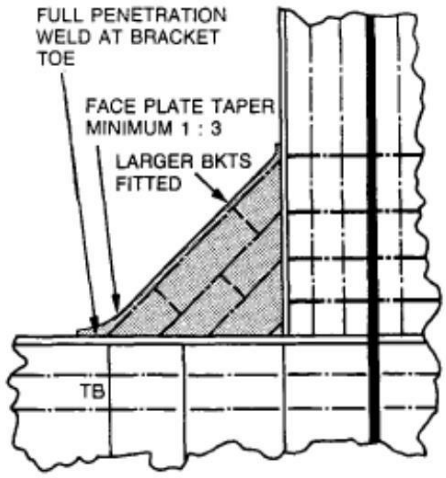


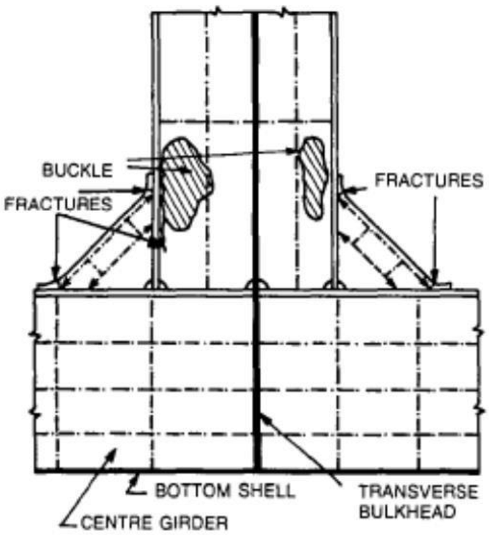
</td><td colspan="2">

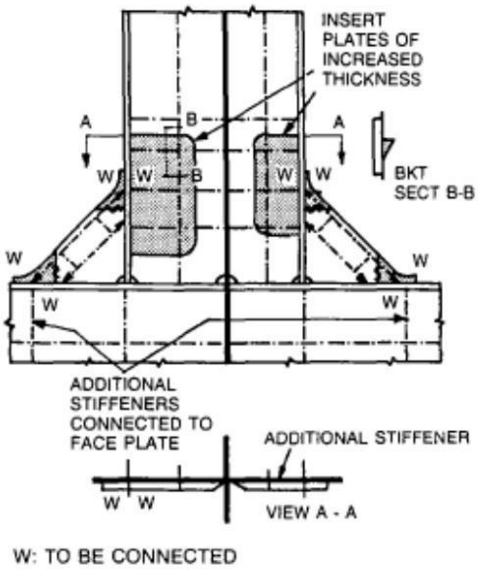


</td></tr>
<tr><td>Factors which may have caused damage：
1. Stress concentration at bracket toe.
2. Insufficient taper on sniped end of bracket face plate.
3. High shear stress level in the longitudinal girder due tostringer reaction.</td><td colspan="2">Notes on repairs：
1. Modified taper of face plate to a minimum of 1:3.
2. Insert plate at cut-outs below bracket toes.
3. Backing brackets to be added.</td></tr>
</table>

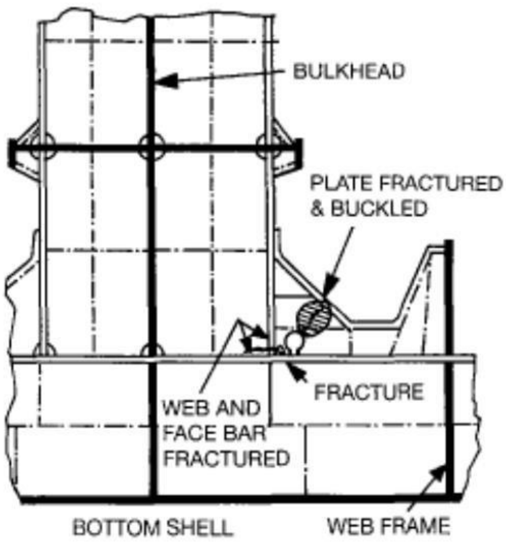
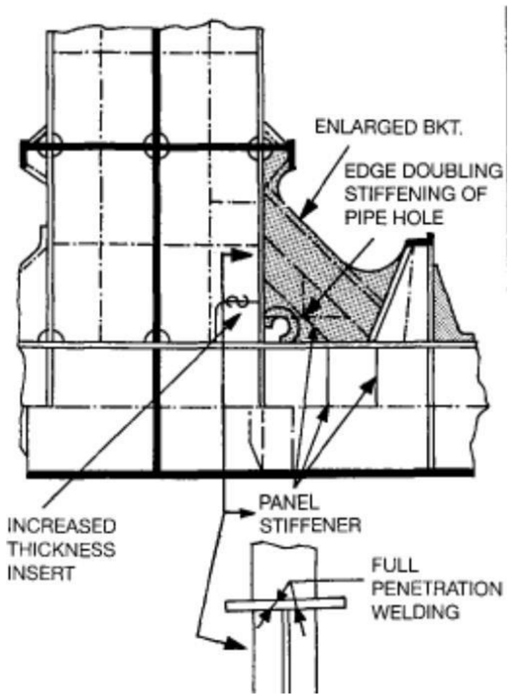
<table>
<tr><td colspan="2">Location: Longitudinal girder end brackets
Example No.2: Fractured and buckled buttress in way of bracket connection to O.T. bulkhead.</td><td>No.7</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Panel stiffening on girder web not fitted in way of bracket toe.
2. Stress concentration at bracket toe.
3. Local dry-docking loads.</td><td colspan="2">Notes on repairs：
1. Increased bracket size.
2. Additional panel stiffeners to be fitted.</td></tr>
</table>

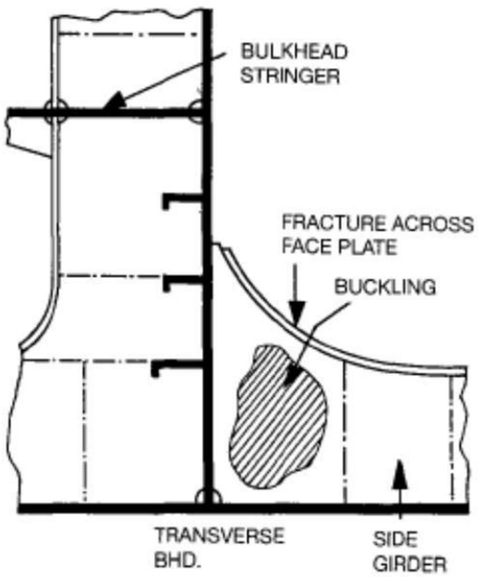
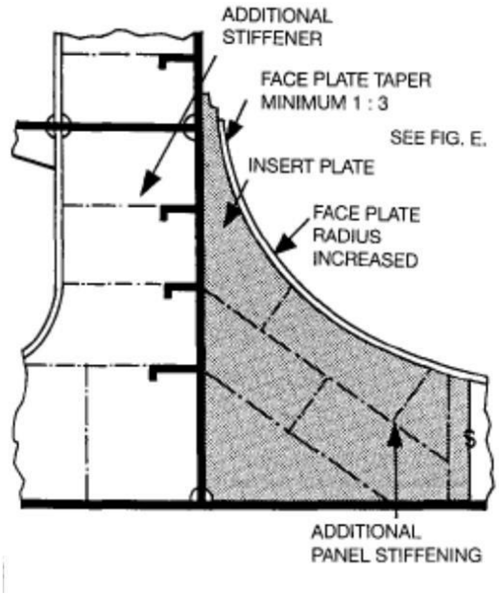
<table>
<tr><td colspan="2">Location: Longitudinal girder end brackets
Example No.3: Fractured vertical web bracket connection to bottom centerline girder</td><td>No.7</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Inadequate end bracket to vertical web resulting in high nominal stress.
2. Bracket toe having inadequate taper resulting in stress concentration.
3. Insufficient buckling strength of the bracket face plate.</td><td colspan="2">Notes on repairs：
1. Increased bracket size with soft toes.
2. Full penetration weld at bracket toes.</td></tr>
</table>

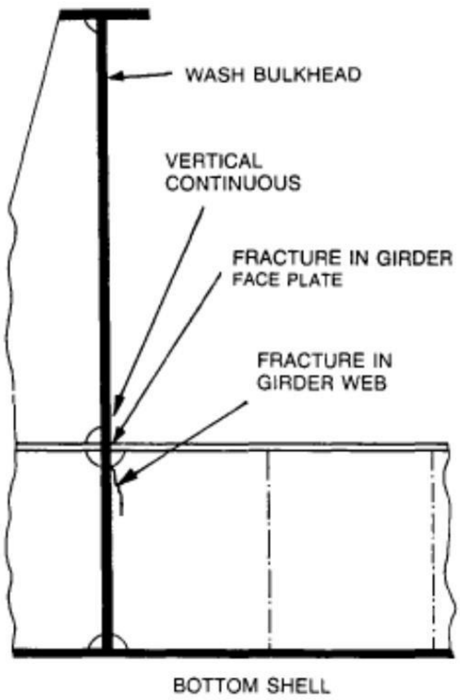
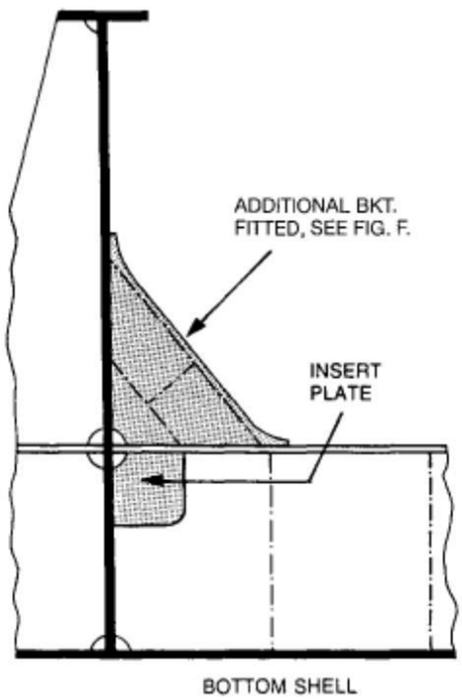
<table>
<tr><td colspan="2">Location: Longitudinal girder end brackets
Example No.4: Buckled and fractured vertical web and bottom centre line girder bracket connection</td><td>No.7</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>


</td><td colspan="2">


</td></tr>
<tr><td>Factors which may have caused damage：
1. Insufficient panel stiffening on vertical web.
2. Stress concentration at bracket toes with sniped face plate.</td><td colspan="2">Notes on repairs：
1. Insert web plate with increased thickness.
2. Bracket toes partly renewed.
3. Additional stiffeners connected to face plate.</td></tr>
</table>

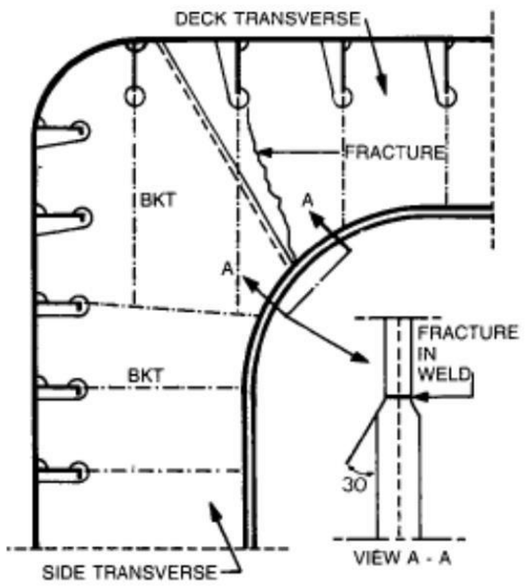
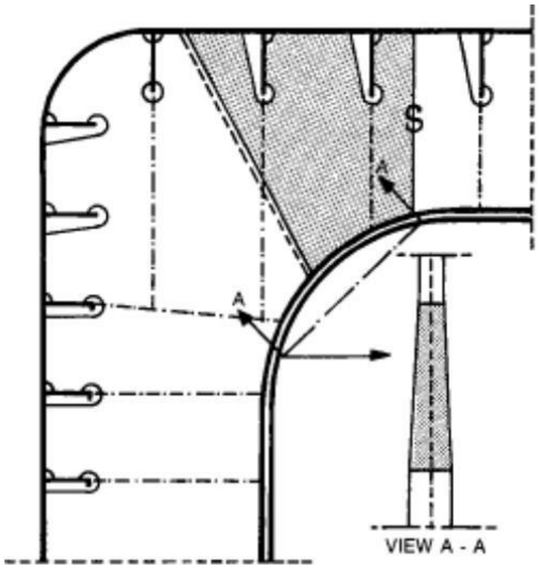
<table>
<tr><td colspan="2">Location: Longitudinal girder end brackets
Example No.5: Fractured bottom girder brackets in way of pipe opening</td><td>No.7</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Insufficient throat through bracket in way of pipe opening.
2. Stress concentration at pipe opening.</td><td colspan="2">Notes on repairs：
1. Enlarged bracket.
2. Additional stiffeners of bracket to be fitted.
3. Insert web plate with increased thickness/additional stiffeners
4. Full penetration weld at bracket.</td></tr>
</table>

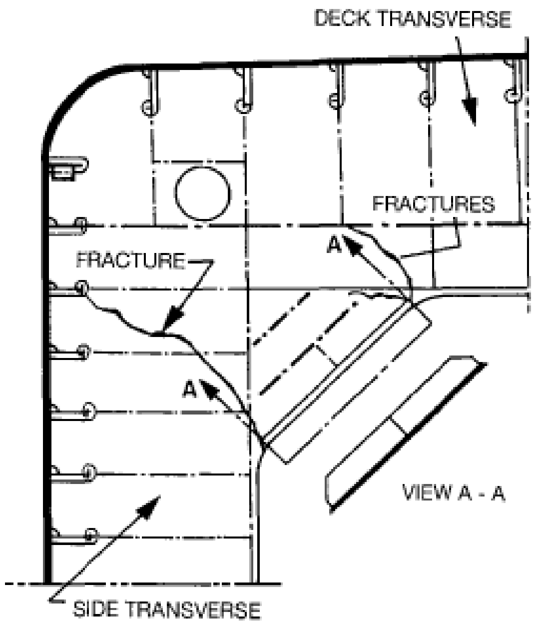
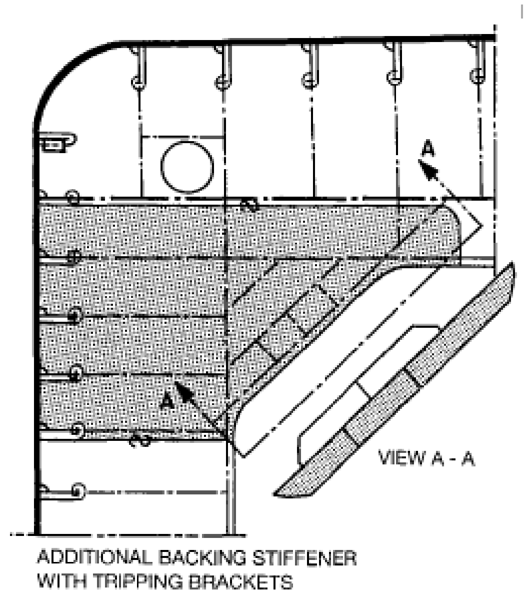
Location: Longitudinal girder end brackets Example No.6: Fractured and buckled bottom side girder in way of end connections to O.T. bulkhead.	No.7
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage: 1. Inadequately sized bracket connection at end of girder. 2. Insufficient panel stiffening on girder web in way of end bracket.	Notes on repairs: 1. Additional panel stiffeners to be fitted. 2. Enlarged bracket and increased face plate radius.

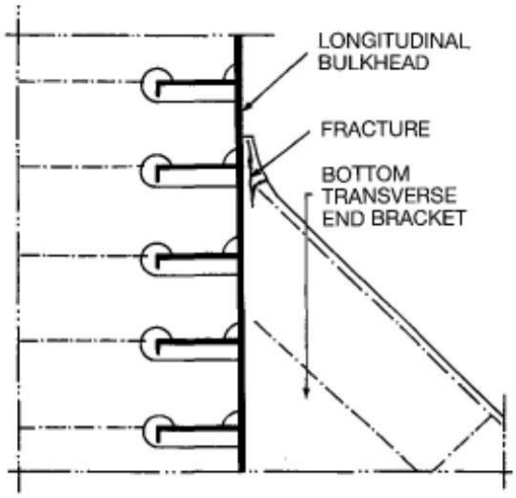
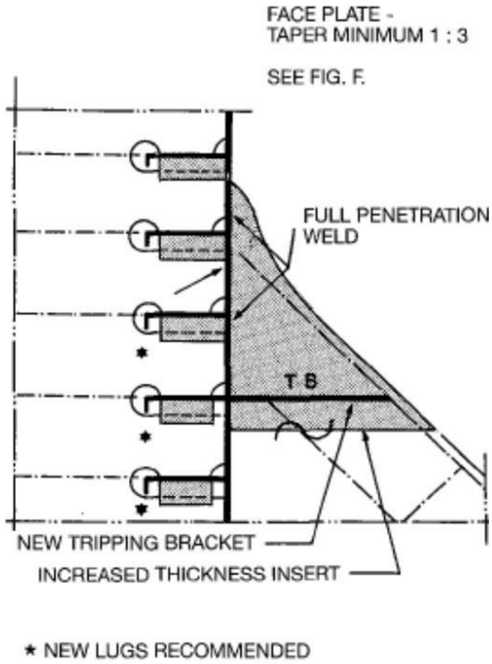
<table>
<tr><td colspan="2">Location: Longitudinal girder end brackets
Example No.7: Fractured intercostal bottom girder fitted without an end bracket in way of the wash bulkhead.</td><td>No.7</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Inadequate end connection of girder to the washbulkhead.</td><td colspan="2">Notes on repairs：
1. Insert web plate with increased thickness.
2. Additional bracket to be fitted.</td></tr>
</table>

4.4.6.8 Group No.8：Transverse web frame end brackets

Example No.	Title
1	Fractured wing tank deck transverse bracket. Continuous face plate
2	Fractured wing tank deck transverse bracket. Face plate sniped
3	Fractured centre tank bottom transverse end brackets. Asymmetrical face plate

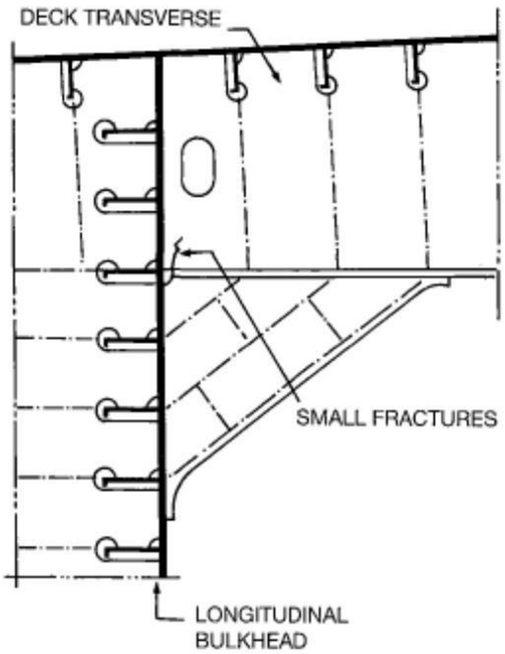
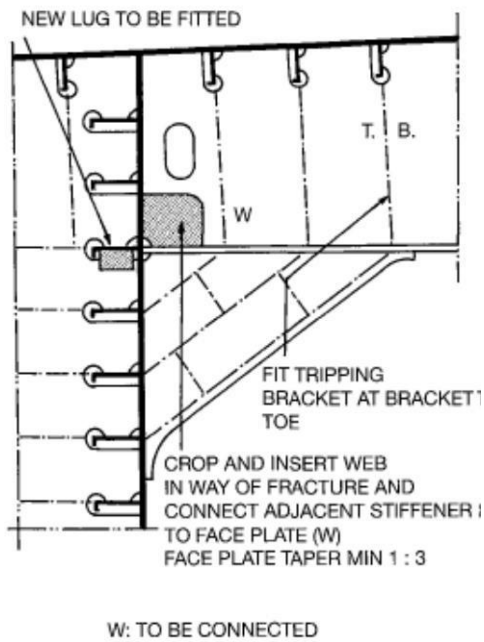
Location: Transverse web frame end brackets Example No.1: Fractured wing tank deck transverse bracket. Continuous face plate.		No.8
Typical Damage	**Proposed Repair**	
	 WEB CROPPED AND PART RENEWED. FACE PLATE CROPPED BACK AND PART RENEWED WITH LONG TAPER	
Factors which may have caused damage： 1. Abrupt reduction of face plate thickness and width. 2. Taper and butt weld in face plate located in corner radius where high stresses exist. 3. Stress concentration due to scallop in the web plate. 4. Defective butt weld at face plate taper.	Notes on repairs： 1. Web plate and face plate to be cropped and partly renewed. 2. Modified taper of face plate.	

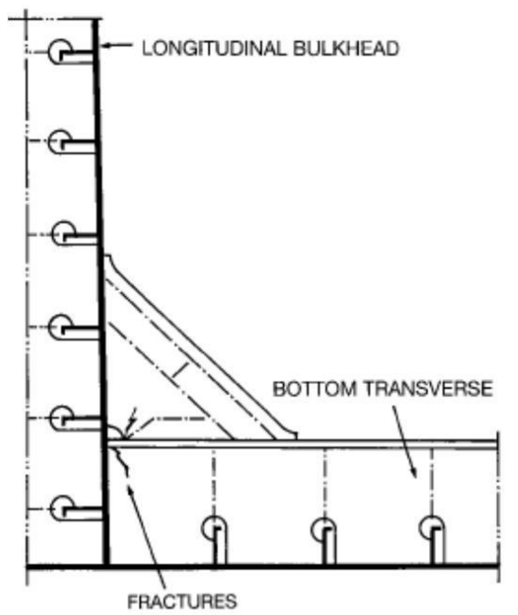
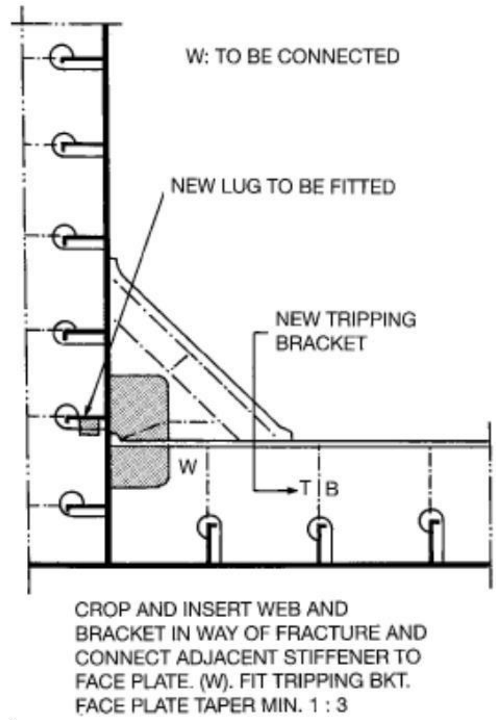
Location: Transverse web frame end brackets Example No.2: Fractured wing tank deck transverse bracket. Face plate sniped.	No.8
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Stress concentration at bracket face plate sniped end. 2. Defective weld or material at the face plate snipe.	Notes on repairs： 1. Web plate and face plate to be cropped and partly renewed. 2. Additional backing stiffeners with tripping brackets to be fitted.

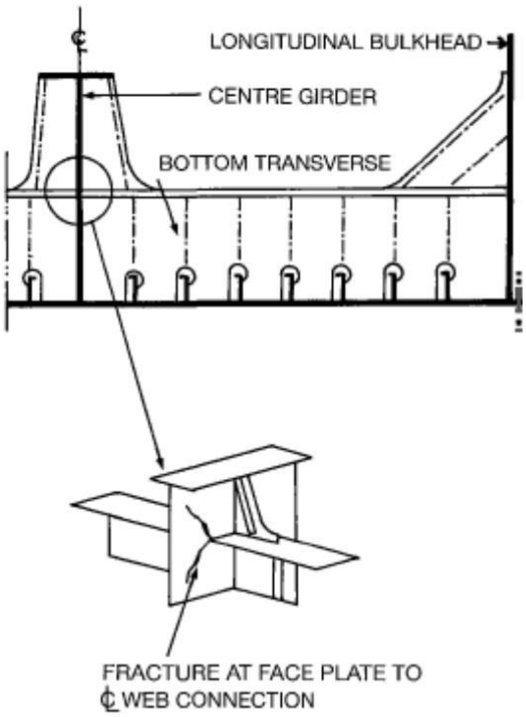
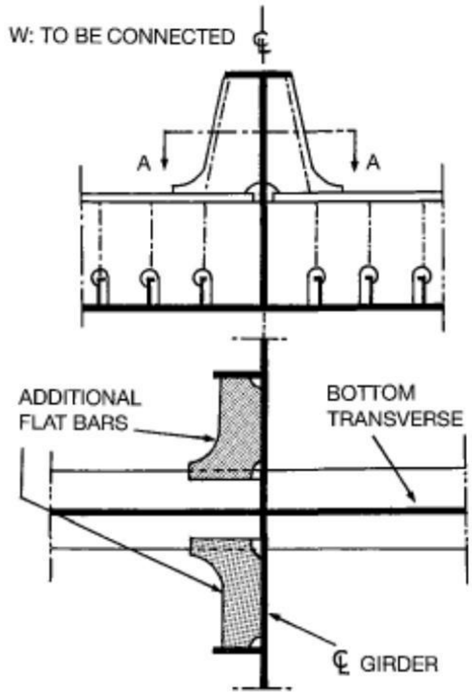
Location: Transverse web frame end brackets Example No.3: Fractured centre tank bottom transverse end brackets. Asymmetrical face plate.	No.8
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage: 1. Bracket face plate in way of toe with insufficient taper. 2. Localised corrosion at bracket toe. 3. Insufficient bracket size resulting in high nominal stress. 4. Deficient weld around bracket toe.	Notes on repairs: 1. Web plate and face plate to be cropped and partly renewed with increased thickness and soft toes. 2. Additional stiffeners to be fitted. 3. Additional collar plate to be fitted at cut-outs.

4.4.6.9 Group No. 9：Primary web

Example No.	Title
1	Fractured centre tank deck transverse.
2	Fractured centre tank bottom transverse.
3	Fractured centre girder at intersection with the bottom transverse.

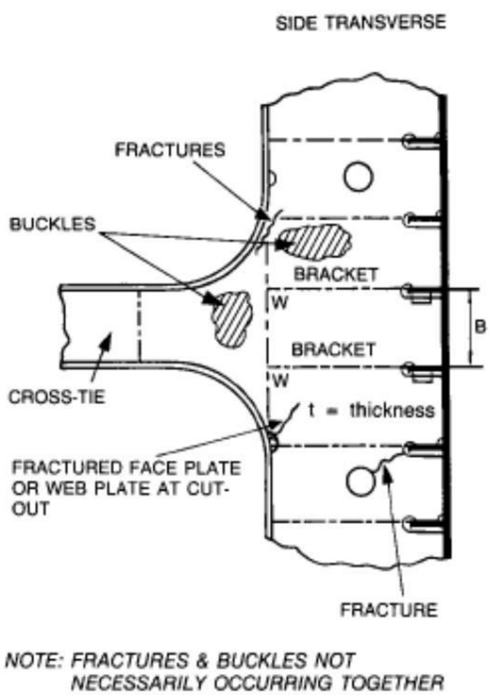
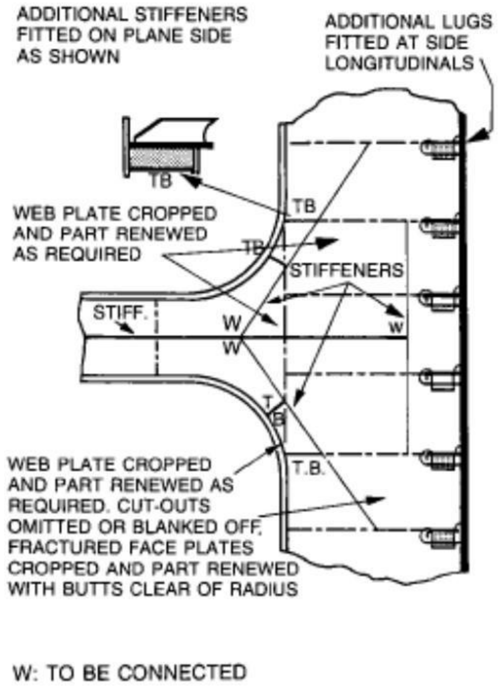
<table>
<tr><td colspan="2">Location: Primary web, face plate end connection.
Example No.1: Fractured centre tank deck transverse.</td><td>No.9</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Sloshing loads on deck transverse.
2. Distance between the longitudinal bulkhead and the deck transverse tripping bracket too long.
3. Insufficient taper at deck transverse face plate.
4. Defective weld at the face plate taper.</td><td colspan="2">Notes on repairs：
1. Crop and insert web plate in way of fracture and connect adjacent stiffeners to face plate.
2. Additional tripping brackets to be fitted.
3. Additional collar plate to be fitted at cut-outs.</td></tr>
</table>

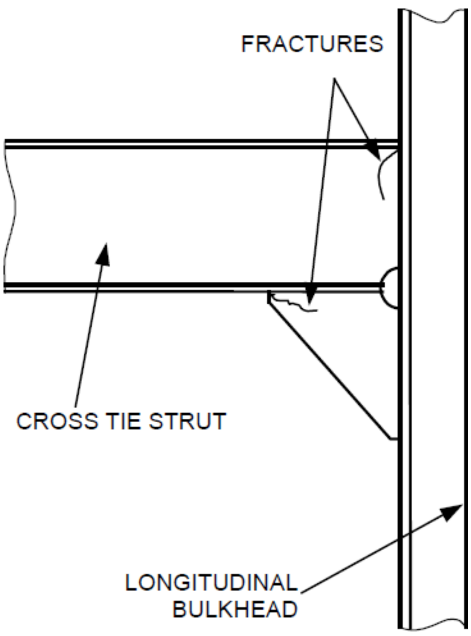
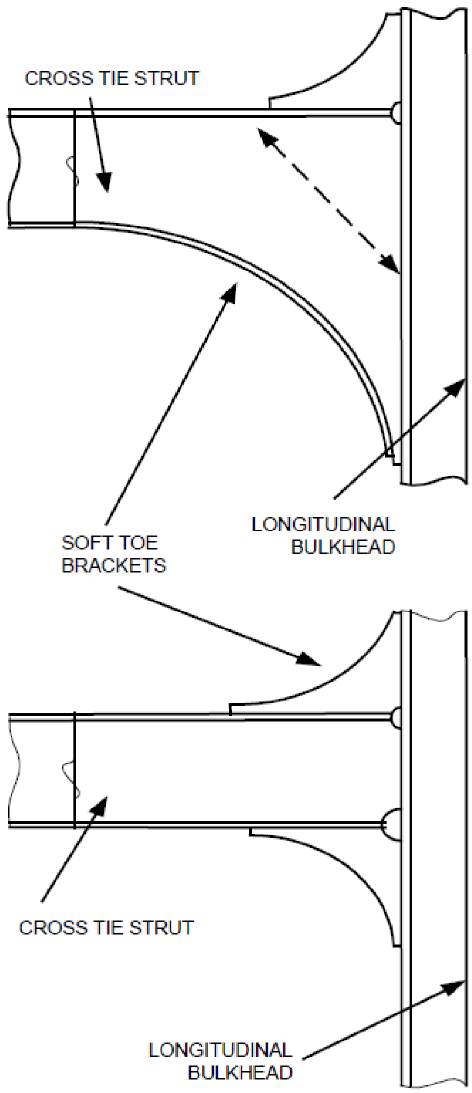
<table>
<tr><td colspan="2">Location: Primary web, face plate end connection.
Example No.2: Fractured centre tank, bottom transverse.</td><td>No.9</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Distance between longitudinal bulkhead and the bottom transverse tripping bracket too long.
2. Defective weld at the face plate taper.
3. Insufficient taper of the bottom transverse face plate.</td><td colspan="2">Notes on repairs：
1. Crop and insert web plate in way of fracture and connect adjacent stiffeners to face plate.
2. Additional tripping brackets to be fitted.
3. Additional collar plate to be fitted at cut-outs.</td></tr>
</table>

<table>
<tr><td colspan="2">Location: Primary web, face plate end connection.
Example No.3: Fractured centre girder at intersection with the bottom transverse.</td><td>No.9</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage:
1. Hard spot at welded connection of transverse face plate to girder web.
2. Vibration.
3. Distance from girder to tripping bracket on bottom transverse too great.
4. Misalignment of face plates.
5. Defective weld of face plate to girder web.</td><td colspan="2">Notes on repairs:
Additional flat bars to be fitted and connected to face plate.</td></tr>
</table>

4.4.6.10 Group No. 10：Cross-ties

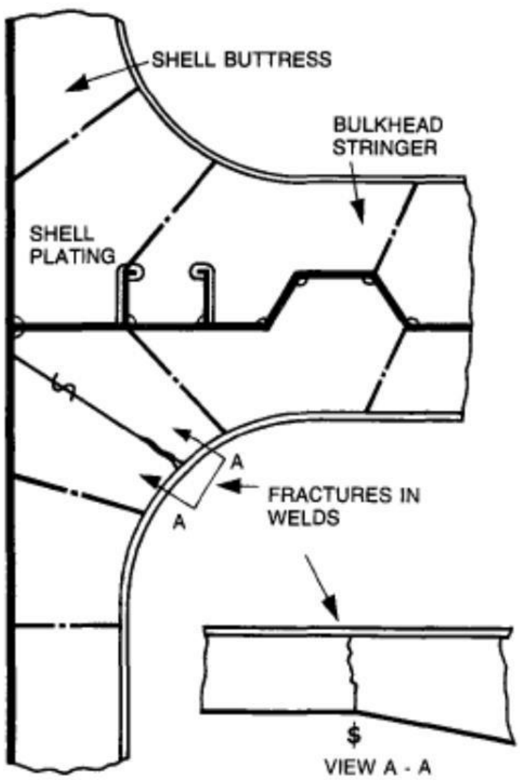
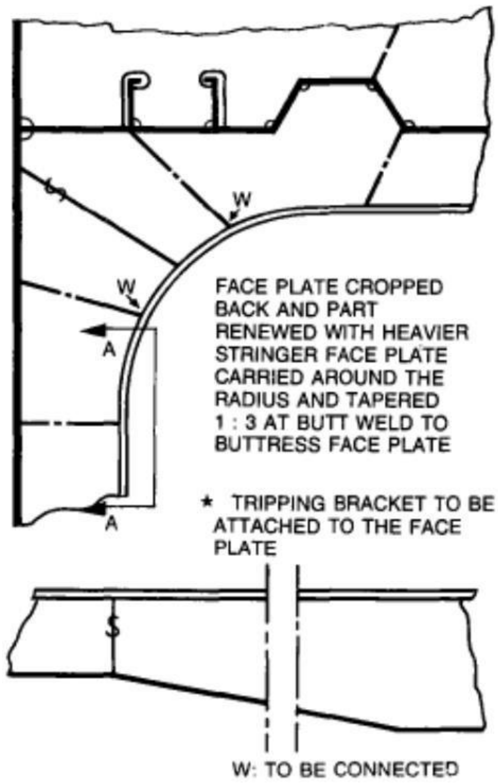
Example No.	Title
1	Fractured and buckled web plate and fractured face plate
2	Cross ties and their end connections

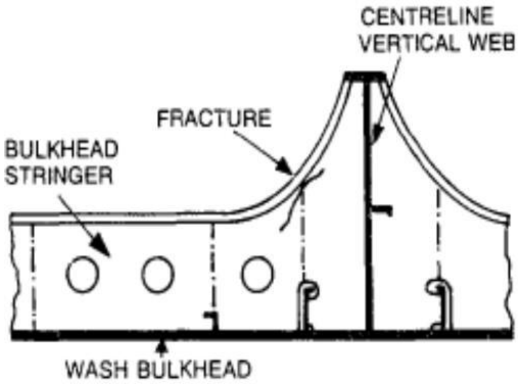
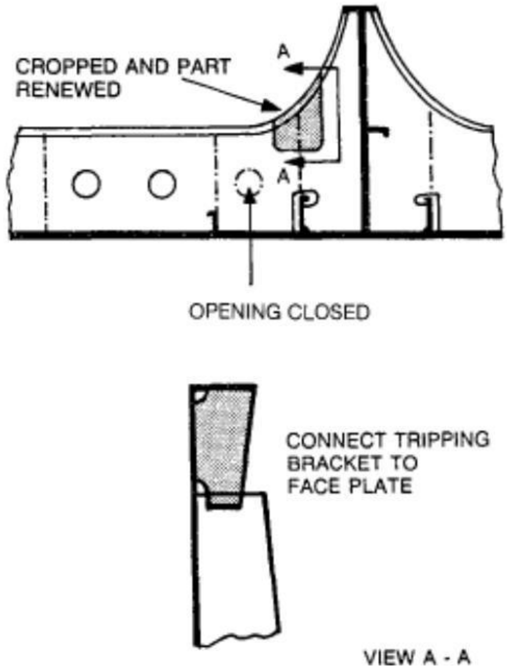
<table>
<tr><td colspan="2">Location: Cross-ties and their end connections
Example No.1: Fractured and buckled web plate and fractured face plate</td><td>No.10</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Face plate radius in way of the cross-tie too small leading to high stress under bending of vertical web and cross-tie.
2. Stress concentration at notches in web plate.
3. Localised corrosion of web plate particularly in ballast tanks leading to panel flexing and fractures.
4. Inadequate panel stiffening of web plate.</td><td colspan="2">Notes on repairs：
1. Web plate cropped and partly renewed, fractured face plate cropped and partly renewed with butts clear of radius.
2. Cut-outs omitted or blanked off.
3. Additional stiffeners to be fitted.</td></tr>
</table>

Location: Cross-ties and their end connections Example No.2: Cross ties and their end connections	No.10
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage: 1. Stress concentration due to unsuitable bracket shape at juncture of cross tie to longitudinal. 2. Inadequate panel stiffening of web plate of cross-tie.	Notes on repairs: See Sketch.

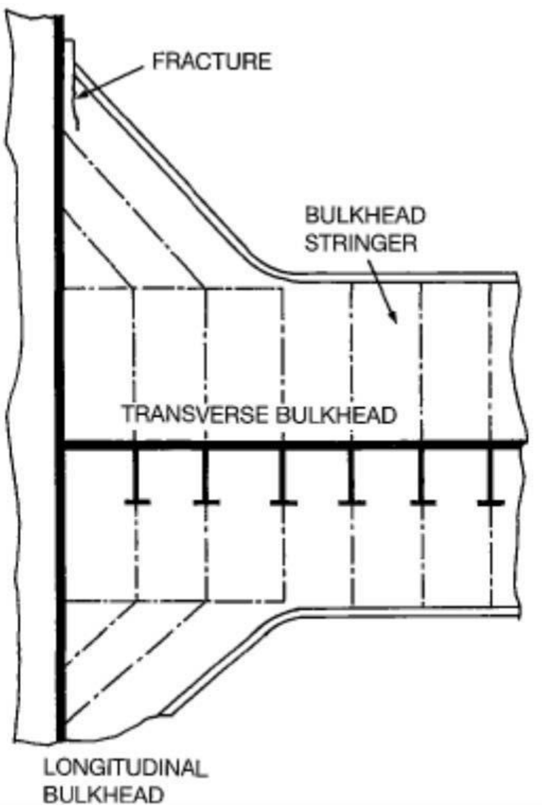
4.4.6.11 Group No. 11：Transverse bulkhead horizontal stringer

Example No.	Title
1	Fractured face plate and web at the radiused end brackets. Vertically corrugated bulkheads.
2	Fractured web of stringer at the radiused bracket in way of centre line vertical web
3	Fractured centre tank stringer bracket connection to the longitudinal bulkhead.
4	Fractured wing tank stringer bracket and side shell longitudinal in way
5	Fractured web of buttress at connection to shell

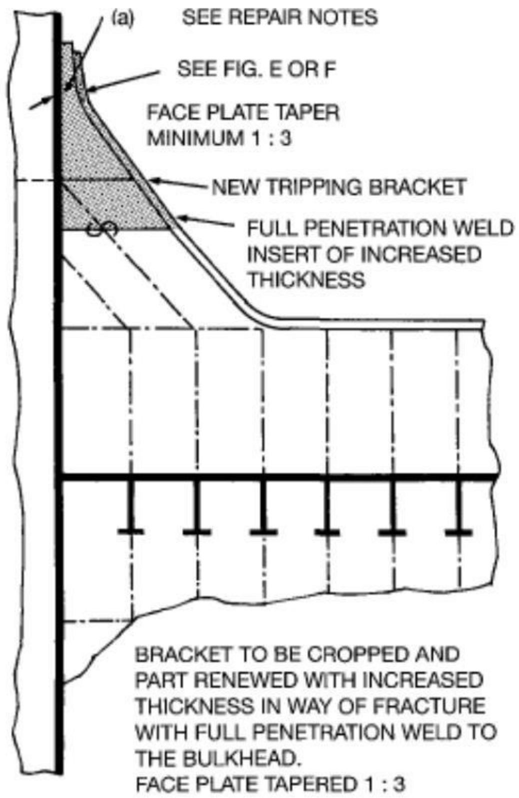
<table>
<tr><td colspan="2">Location: Transverse bulkhead horizontal stringer
Example No.1: Fractured face plate and web at the radiused end brackets. Vertically corrugated bulkheads.</td><td>No.11</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
1. Stress concentration in the web plate due to discontinuity in the face plate size and to increased general stress level at the radius.
2. Butt welds and notches in area of high stress concentration.
3. Inadequate size of stringer end bracket resulting in high general stress levels.
4. Dynamic loads on the bulkhead.
5. Localised corrosion at area of stress concentration.</td><td colspan="2">Notes on repairs：
Face plate cropped and partly renewed with heavier stringer, face plate carried around the radius and taper.</td></tr>
</table>

Location: Transverse bulkhead horizontal stringer Example No.2: Fractured web of stringer at the radiused bracket in way of centre line vertical web.	No.11
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Sloshing loads where tanks are partially filled. 2. Stress concentration in the web plate due to snipe at the tripping bracket and high general stress levels in way of the radiused end bracket.	Notes on repairs： Web plate and face plate cropped and partly renewed, face plate carried around the radius and taper.

<table>
<tr><td colspan="2">Location: Transverse bulkhead horizontal stringer.
Example No.3: Fractured centre tank stringer bracket connection to the longitudinal bulkhead.</td><td>No.11</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>

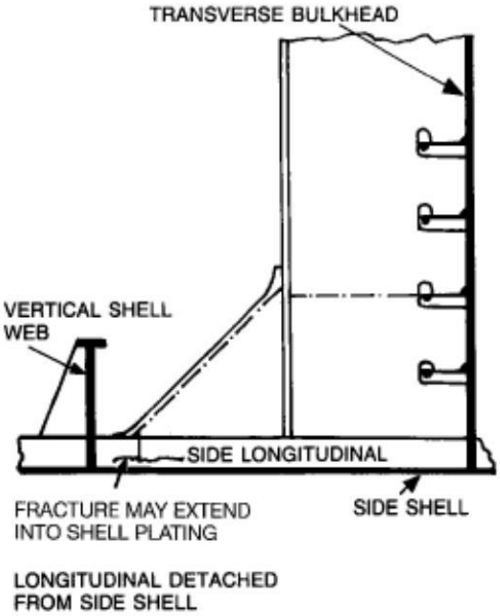


</td><td colspan="2">

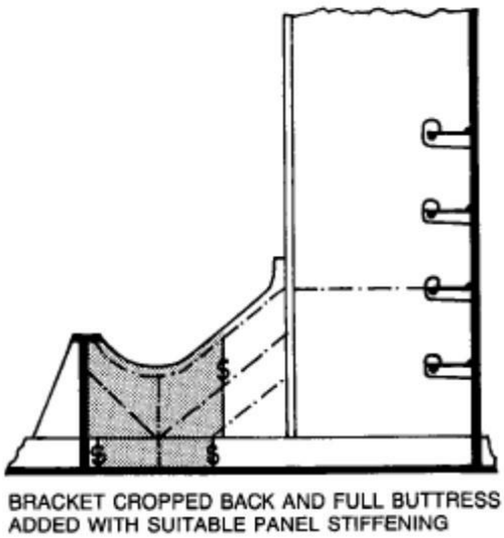


</td></tr>
<tr><td>Factors which may have caused damage:
1. Stress concentration in the web of bracket where face plate is sniped, particularly where taper is inadequate.
2. Insufficient radius of bracket toe.
3. Insufficient thickness of web plating.
4. Dynamic loads on the bulkhead.
5. Localised corrosion at bracket toe in area of stress concentration.
6. Misalignment of bracket toe in way of longitudinal bulkhead.
7. Defective weld around plate thickness at bracket toe and at face plate snipe.</td><td colspan="2">Notes on repairs:
1. Bracket to be cropped and partly renewed with increased thickness in way of fracture.
2. Full penetration weld insert of increased thickness.</td></tr>
</table>

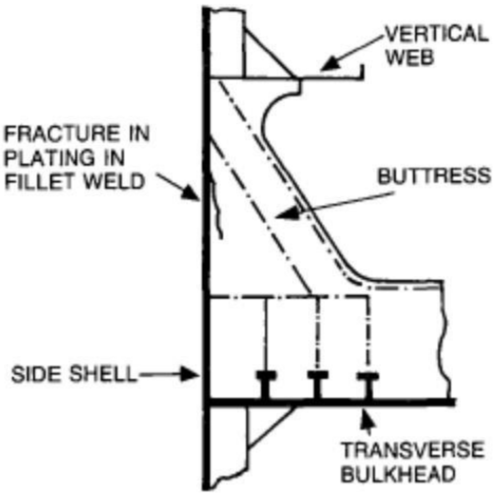
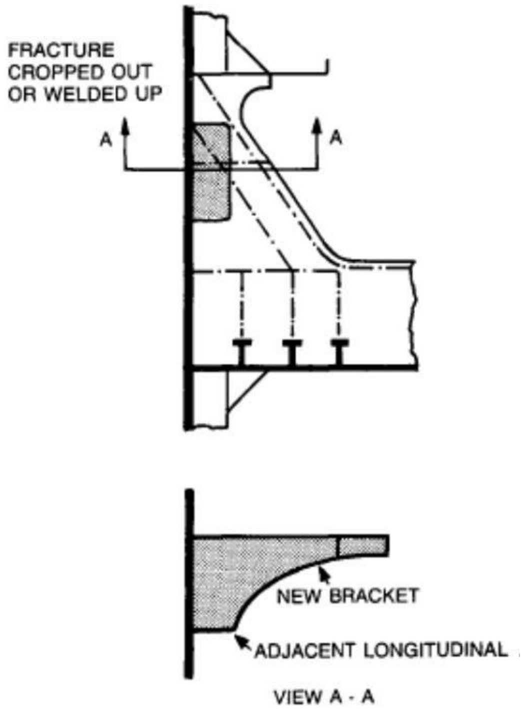
<table>
<tr><td colspan="1">Location: Transverse bulkhead horizontal stringer
Example No.4: Fractured wing tank stringer bracket and side shell longitudinal in way</td><td>No.11</td></tr>
<tr><td>Typical Damage</td><td>Proposed Repair</td></tr>
<tr><td>



</td><td>

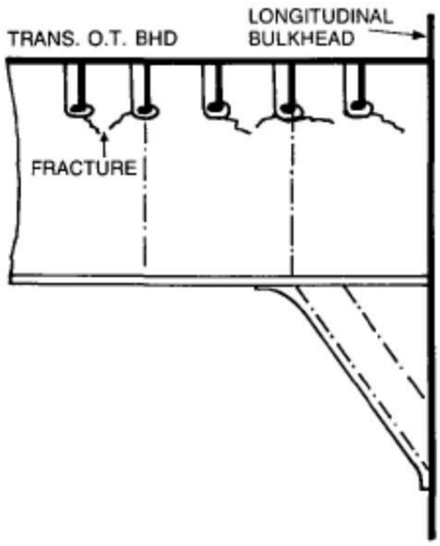
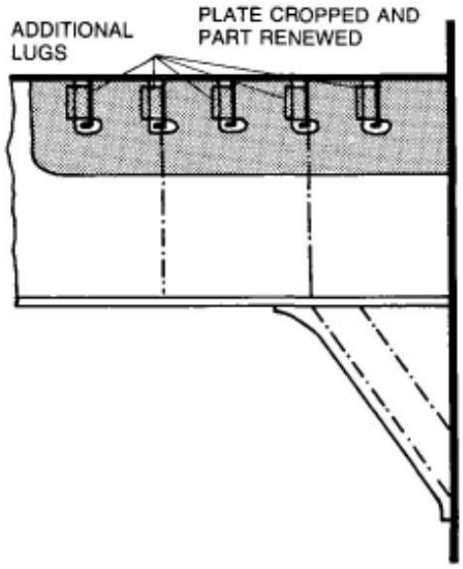


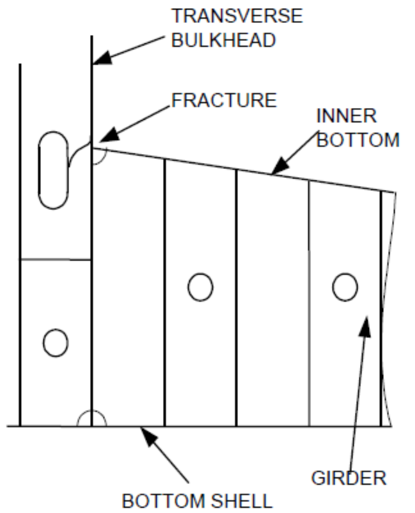
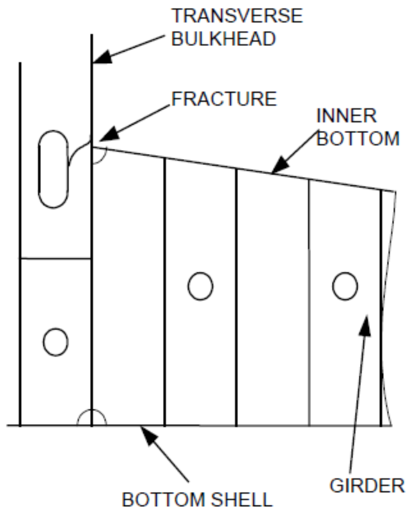
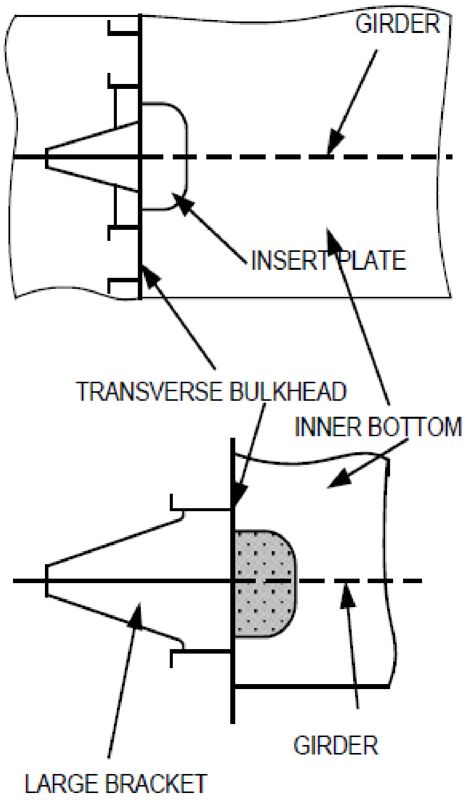
</td></tr>
<tr><td>Factors which may have caused damage:
1. Bad design of stringer connection to web frame with inadequate buttress size to absorb stringer end loads. This results in high stresses in the side shell longitudinal. This is the major contributory factor with the design illustrated.
2. Stress concentration in the web of bracket where face bar is sniped.
3. Dynamic loads on the bulkhead and side shell.
4. Localised corrosion of bracket toe at area of stress concentration.</td><td>Notes on repairs:
1. Bracket cropped and partly renewed, and modified the Bkts to U type.
2. Added with suitable panel stiffeners.</td></tr>
</table>

<table>
<tr><td colspan="2">Location: Transverse bulkhead horizontal stringer
Example No.5: Fractured web of buttress at connection to shell</td><td>No.11</td></tr>
<tr><td>Typical Damage</td><td colspan="2">Proposed Repair</td></tr>
<tr><td>
</td><td colspan="2">
</td></tr>
<tr><td>Factors which may have caused damage：
Vibration of stringer web.</td><td colspan="2">Notes on repairs：
1. Bracket cropped and partly renewed, and modified the Bkts to U type.
2. Additional bracket to be fitted in way of fracture.</td></tr>
</table>

4.4.6.12 Group No. 12：Transverse bulkhead stiffener/primary web intersection

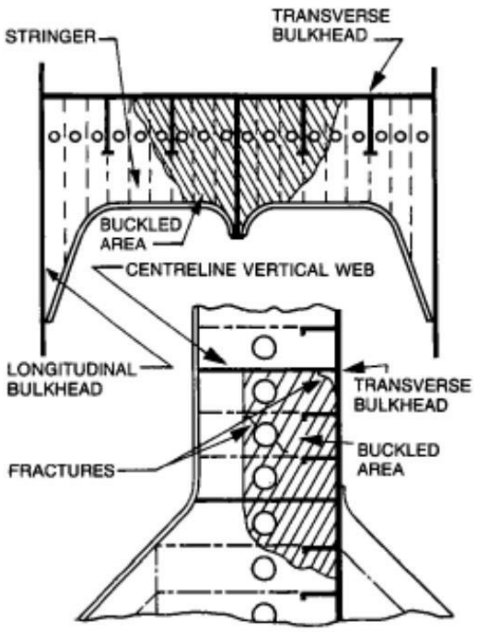
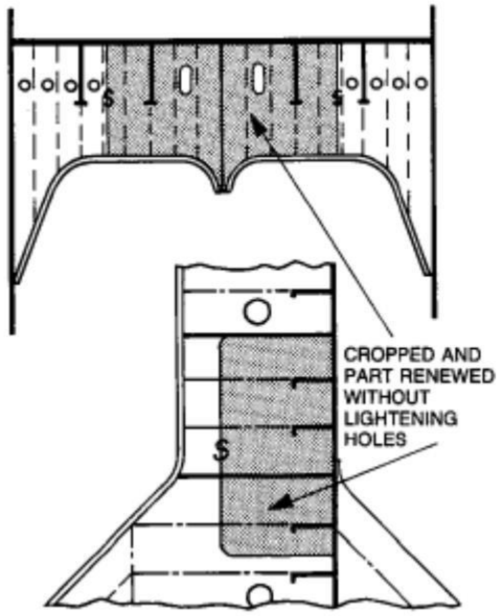
Example No.	Title
1	Fractured web at cut-outs for vertical stiffeners
2	Fracture at connection of transverse bulkhead to knuckle inner bottom/girder

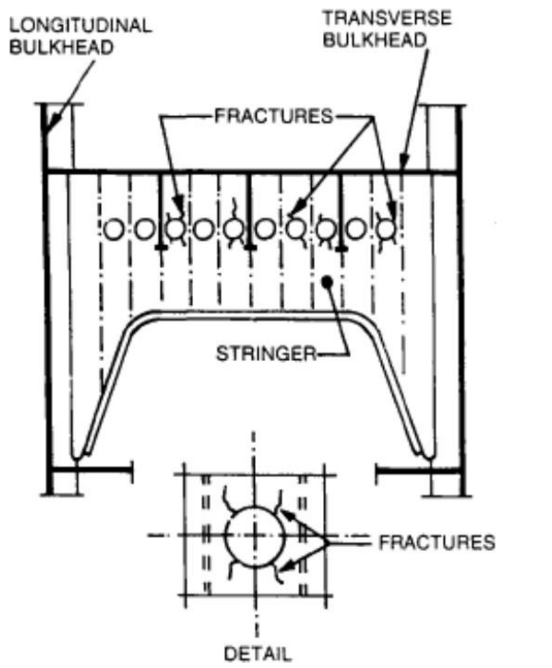
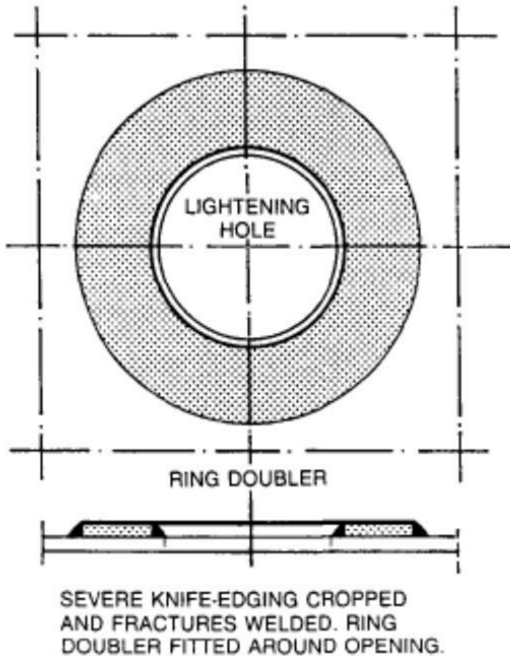
Location: Transverse bulkhead stiffener/primary web intersection Example No.1: Fractured web at cut-outs for vertical stiffeners.		No.12
Typical Damage	**Proposed Repair**	
 	 	
Factors which may have caused damage： 1. Dynamic internal loads in full tanks due to ship motion. 2. High peak stresses in way of cut-out corners. 3. Insufficient area of connection for vertical stiffener. 4. Localised corrosion at areas of stress concentration. 5. High shear stress in the horizontal stringer web plate.	Notes on repairs： 1. Web plate to be cropped and partly renewed. 2. Additional collar plates to be fitted at cot-outs.	

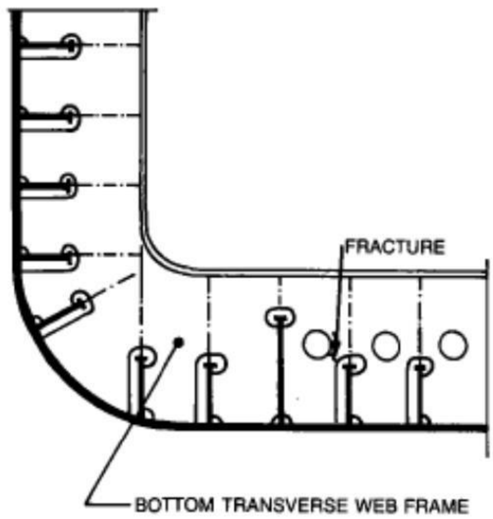
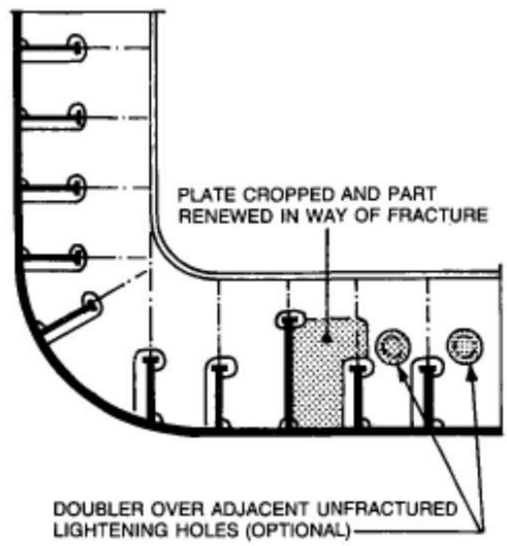
Location: Transverse bulkhead stiffener/primary web intersection Example No.2: Fracture at connection of transverse bulkhead to knuckle inner bottom/girder	No.12
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1 High stress concentration. 2. Discontinuity of structural members at knuckle joint.	Notes on repairs： See Sketch

4.4.6.13 Group No. 13： Lightening holes and openings in primary webs and swash bulkheads

Example No.	Title
1	Buckled and fractured centre line vertical web and stringer in way of intersection
2	Fractures in way of lightening hole in stringer
3	Fractured web of bottom transverse in way of lightening holes

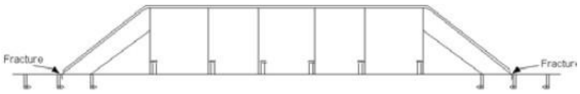
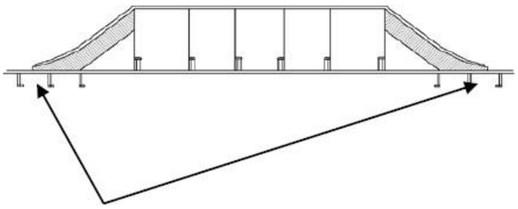
<table>
<tr><td>Location: Lightening holes and openings in primary webs and swash bulkheads
Example No.1: Buckled and fractured centre line vertical web and stringer in way of intersection</td><td>No.13</td></tr>
<tr><td>Typical Damage</td><td>Proposed Repair</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Factors which may have caused damage：
1. Corrosion losses in way of openings, leading to buckling of stringer and centre line girder, with fracturing in way of openings.
2. Stress concentrations in way of lightening holes.
3. Inadequate shear area in the vertical web.</td><td>Notes on repairs：
Web plate to be cropped and partly renewed without lighting holes.</td></tr>
</table>

Location: Lightening holes and openings in primary webs and swash bulkheads Example No.2: Fractures in way of lightening hole in stringer	No.13
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： 1. Corrosion losses causing thinning and knife-edging of plating surrounding holes. 2. Lack of material associated with too many holes close together leading to stress concentrations.	Notes on repairs： Severe knife-edging plate to be cropped, fractures to be repaired by weld, and ring doublers to be fitted around opening.

Location: Lightening holes and openings in primary webs and swash bulkheads Example No.3: Fractured web of bottom transverse in way of lightening holes	No.13
Typical Damage	**Proposed Repair**
 	
Factors which may have caused damage: 1. Unstiffened lightening holes too close to longitudinal cutouts causing stress concentrations in web plating. 2. Corrosion losses on edges of openings.	Notes on repairs: 1. Web plate cropped and partly renewed in way of fracture. 2. Double plate to be fitted over adjacent lighting hole.

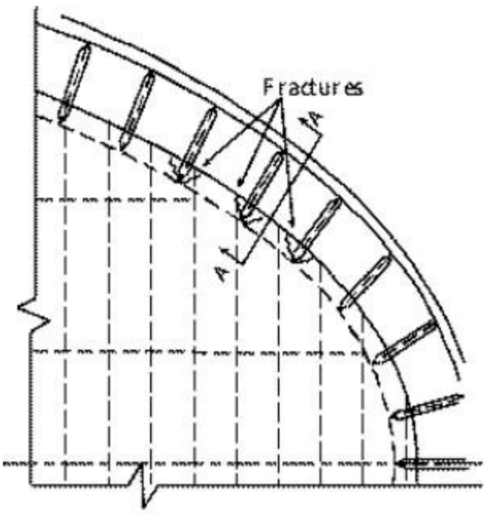
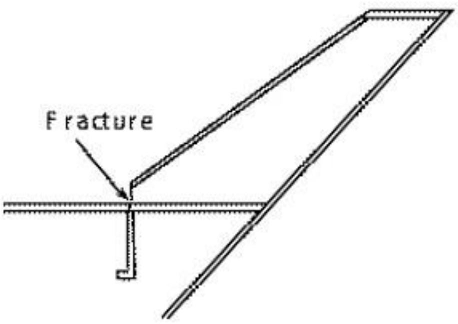
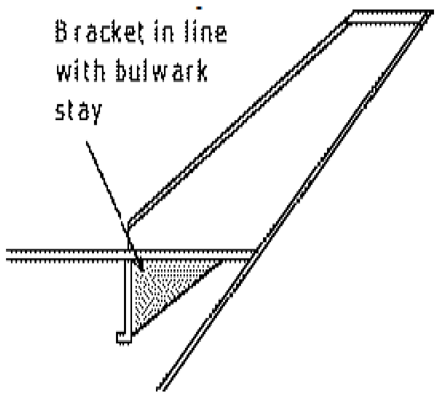
4.4.6.14 Group No.14: Deck Structure

Example No.	Title
1	Fracture at ends of deck transverse

Location: Deck Structure Example No.1: Fracture at ends of deck transverse	No.14
Typical Damage	**Proposed Repair**
	
Factors which may have caused damage： High stress due to toes bracket ending at cut out for longitudinal.	Notes on repairs： See Sketch. 1. Increase bracket length to end between underdeck longitudinals and align end to underdeck transverse. 2. Install fitted collar rather than lapped collar. 3. Insert deck plating if fracture extends into deck.

4.4.6.15 Group No.15: Fore region

Example No.	Title
1	Fracture in forecastle deck plating at bulwark

Location: Fore region Example No.1: Fracture in forecastle deck plating at bulwark	No.15
Typical Damage	**Proposed Repair**
  View A-A	 View A-A
Factors which may have caused damage： 1. Bow Flare effect in heavy weather. 2. Stress concentration due to poor design.	Notes on repairs： 1. Fractured deck plating should be cropped and renewed. 2. Bracket in line with the bulwark stay to be fitted to reduce stress concentration.

CHAPTER 5 FIRE PROTECTION, FIRE DETECTION AND FIRE EXTINCTION

For oil tanker, the requirement for setting the fire safety and fire-fighting facilities is under its various deadweight, including effective fire integrity and insulation separation, oil spill prevention impacting on the safety of the ship, the cargo area cooling system (sprinkler system), static electricity elimination, cargo inerting requirements (IGS system), reasonable procedures for cleaning, purging and gas free operation, foam extinguishing system, fire water system, emergency towing arrangement, to achieve the fire safety objectives and functional requirements. Ship structural fire protection and fire-fighting facilities are to refer to the approved fire control plans.

The requirements mentioned in this Chapter apply to oil tankers carrying petroleum products with a flashpoint not exceeding 60℃ (closed cup test, as determined by an approved flashpoint apparatus). Tankers carrying petroleum products with a flashpoint exceeding 60℃ shall comply with the requirements for cargo ships other than tankers, except for installation position of isolation valve, provision of four sets of fireman’s outfit and installation of fixed deck foam system complying with IMO Fire Safety System Code.

According to the requirements of petroleum companies, oil tankers also need to meet additional requirements, please refer to ISC Guidelines for Implementing Requirements for Structure and Equipment of Tanker by Petroleum Industry Organization.

All ships which undergo repairs, alterations, modifications and outfitting related thereto are to be possible to meet the requirements of the current Convention，at least need to meet the requirements previously applicable to these ships.

SECTION 1 FIRE STRUCTURAL PROTECTION

5.1.1 Fire structural protections mainly include the following five areas：

5.1.1.1 To divide the ship into machinery space of Category A, stern superstructure area, cargo area and stem area by fire division;

5.1.1.2 To separate accommodation spaces and spaces with greater fire risk by fire division;

5.1.1.3 To effectively maintain the integrity of fire division in case of various openings and penetrations;

5.1.1.4 To restrict use of combustible materials;

5.1.1.5 To protect means of escape

5.1.2 The effectiveness of structural fire protection of hull cannot be destroy by repair of structural fire protection, attention is to be paid to following contents:

5.1.2.1 Structural fire protection materials, including non-combustible materials, are to be approved by ISC;

5.1.2.2 The integrity of fire structure cannot be destroyed, especially various opening and penetration areas.

5.1.2.3 The size of stairways（including doors） is not to be less than that required in ship design.

5.1.2 Isolation of cargo tanks

5.1.2.1 For all tankers carrying crude oil or petroleum products having a flashpoint not exceeding 60℃，cargo pump-rooms, cargo tanks, slop tanks and cofferdams are to be positioned forward of machinery spaces. Cargo tanks and slop tanks are to be isolated from machinery spaces by cofferdams, cargo pump-rooms, oil bunker tanks or ballast tanks.

5.1.2.2 Except for permit by the Administration, main cargo control stations, control stations, accommodation and service spaces are to be positioned aft of cargo tanks, slop tanks and spaces which isolate cargo or slop tanks from machinery spaces, and shall be arranged in such a way that a single failure of a deck or bulkhead will not permit the entry of gas or fumes from the cargo tanks into main cargo control stations, control stations, accommodation or service spaces.

5.1.2.3 Machinery spaces other than those of category A, such as thruster room，may be permitted forward of the cargo tanks, provided they are isolated from the cargo tanks or slop tanks by cofferdams, cargo pump-rooms, oil fuel bunker tanks or ballast tanks.

5.1.2.4 Where the fitting of a navigation position above the cargo area is shown to be necessary, it can be with a height of at least 2 m.

5.1.2.5 Means are to be provided to keep deck spills away from the accommodation and service areas. They can be positioned fore of superstructure, and in some tanker，the forward bulkhead of superstructure will be an effective part of the continuous coaming. The continuous coaming at the end of deck is to have a height of at least 300mm, extending from one side to another side and passing through the whole ship width. According to updated requirements of some foreign oil terminals,

(1) for oil tankers less than 100,000DWT, the height of continuous coamings at bow deck edge is to be at least 150 mm away from bow and progressively rise to the transverse coaming separating the rear end of cargo tank from living area, and the height of transverse coaming is 300mm.

(2) For oil tankers over 100,000DWT, the height of continuous coamings at bow deck edge is to be at least 250 mm away from bow and progressively rise to the transverse coaming separating the rear end of cargo tank from living area, and the height of transverse coaming is 400mm.

5.1.2.6 Accesses, air inlets and openings to superstructure/aft deckhouse are not to be arranged to face cargo area and within the range of 4%L at both sides (not less than 3 m but need not exceed 5 m). Wheelhouse doors may be located within such area so long as they are designed to ensure that the wheelhouse can be made rapidly gas and oil gas tight. The windows of superstructure and deckhouse within the area (including wheelhouse) are to be of non-opening type. The access to main cargo control stations and to such service spaces used as provision rooms, store-rooms and lockers can be arranged in such area, but such accesses cannot directly or indirectly lead to any other spaces including or used as accommodation spaces and control stations, or service spaces such as kitchen, pantry or workroom, or similar spaces having oil gas ignition source. The boundary of such spaces is to be insulated to "A-60" standard, but except for boundary facing cargo area.

5.1.2.7 In some oil tankers, there are access doors facing the cargo area and directly to fore castle. For access doors directly to forecastle, it is to confirm that there is no ignition source in the forecastle, i.e. all electrical installations in the forecastle are to be explosion-proof type, and it is not necessary for the forecastle end wall to be insulated to "A-60" standard.

5.1.2.8 It is not permitted to have ignition source in cargo area, i.e. any electrical installations in cargo area are not allowed to be directly exposed to the atmosphere. All cables in cargo area are to be of sleeve type or intrinsically safe type, with insulation gasket in way of sleeve flange connections. Switches and lights are required to be intrinsically safe. It is not necessary for the forecastle end wall to be insulated to "A-60" standard. For tankers carrying crude oil or petroleum products having a flashpoint not exceeding 60℃, any parts of the forecastle is not allowed to be arranged directly above the cargo oil tank.

5.1.3 Fire protection in accommodation spaces

5.1.3.1 For oil tankers of which the keels were laid on or after 1 September 1984, method IC is to be used in aft superstructure/deckhouse, i.e. in accommodation spaces and service spaces of “B” or “C” class division, combustible material cannot be used in corridor and stairway enclosure, and all materials in accommodation spaces and service spaces are to be of non-combustible type (except for small amount of inlaying strips). Smoke detectors are to be provided in corridors, stairways and escape routes, and manual alarm button is to be provided on each layer of deck. A smoking room with electrically heated cigarette lighter is specially arranged in the superstructure, and in some companies, smoking is prohibited on board.

5.1.3.2 Exterior boundaries of superstructures/deckhouses enclosing accommodation spaces, including any overhanging decks which support such accommodation spaces, are to be insulated to A–60 standard for all parts which face the cargo area and for 3 m aft or forward thereof (except for bridge).
For oil tankers of which the keels were laid on or after 1st July 1998, the windows in above mentioned area are also to be insulated to A–60 standard. For first layer superstructure/deckhouse, it is prohibited to arrange the windows to face cargo area.
5.1.3.3 Within superstructure, doors and door frames on A class fire division are to be constructed of steel, and doors on B class division are to be constructed of non-combustible material, their fire resisting performance is to be equivalent to that of the bulkhead where the doors are located. Doors are not to be fitted with hold-back hooks, except for hold-back arrangements fitted with remote release devices. It is not required to be insulated for watertight doors.
5.1.3.4 On corridor bulkheads within superstructure, ventilation openings may be permitted on and under the doors of cabins and public spaces. Ventilation openings are also permitted on "B" class doors leading to lavatories, offices, pantries and store rooms. The openings are to be provided only in the lower half of a door.
5.1.3.5 In general, penetrations of fire division in superstructure are to be tested and approved in accordance with Fire Test Procedures Code. However, where the penetration sleeve is made of steel material having a thickness of 3mm or greater and a length of not less than 900 mm, it is considered to be equivalent to A class division. Where the penetration is made of a steel sleeve having a thickness of not less than 1.8 mm and a length of not less than 900 mm for pipe diameter of 150 mm or more and not less than 600 mm for pipe diameter of less than 150 mm, and the pipe has good connection, it is considered to be equivalent to B class division. Where a thin plate duct with an effective cross-sectional area not more than 0.02 m^2 passes through A class division, the opening is to be lined with a steel sleeve having a thickness of at least 3 mm and a length of at least 200 mm.

5.1.4 Escape route

5.1.4.1 Unless expressly provided otherwise by the Administration, at least two widely separated means of escape are to be provided for all accommodation spaces, service spaces, machinery spaces and special spaces. Lifts cannot be considered as means of escape.
5.1.4.2 For tankers of which the keel were laid on or after 1 July 2002, stairways and corridors used as means of escape are to be not less than 700 mm in clear width and with a handrail on one side. Stairways and corridors with a clear width of 1,800 mm and over are to have handrails on both sides. The inclination angle of stairways is to be not greater than 50°, and in machinery spaces or small spaces, it can be not more than 60°. Doorways which give access to escape route are to be not less than 700 mm in clear width.
5.1.4.3 Two means of escape as far apart as possible are to be provided in machinery space of category A. Except for un-enclosed steel ladders one of these means of escape is to provide continuous fire shelter to a safe position outside the machinery space, and the steel ladders are to be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The enclosure is to have internal dimension of at least 800 mm x 800 mm, and steel ladders and frames can be set in this net opening provided there is no problem when passing. It may be accepted for escape from machinery space of category A by passing a steel door capable of being operated from each side, and providing access to a safe escape route from the lower part of the space to the open deck. In a ship of not more than 1,000 gross tonnage, the Administration may dispense with one of the means of escape.
5.1.4.4 For machinery spaces, the inclination angle of inclined ladder/stairway as part of means of escape or leading to means of escape but not located within enclosed machinery spaces is not to be greater than 60º and the net width is not to be less than 600mm.
5.1.4.5 For ships of which the keels were laid after 1 January 2016, all inclined ladders and stairways within machinery space are required to use steel material, with steel plate at bottom to

prevent heat and flame damage. At the same time, main workroom within machinery space is to be provided with two means of escape, at least one of which is to provide continuous fire shelter to a safe position outside the machinery space. For engine control room within category A machinery space of cargo tankers, two means of escape are to be provided, at least one of which is to provide continuous fire shelter to a safe position outside the machinery space.

5.1.4.6 A single escape route may be accepted for other spaces that are entered only occasionally and where the maximum travel distance to the door is 5 m or less. In the steering gear space, a second means of escape is to be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

5.1.4.7 For tankers of which the keel were laid on or after 1 July 2002, the number, width and inclination angle of escape routes are to be in accordance with the requirements of the Administration.

5.1.4.8 On all ships, within the machinery spaces of category A, emergency escape breathing devices are to be provided ready for use, the location of emergency escape breathing devices is to fully take into account the layout of the machinery space and the number of persons normally working in the spaces. The number and location of these devices are to be indicated in the approved fire control plan. Also one emergency escape breathing device for training purpose need to be placed on board.

SECTION 2 FIRE DETECTION SYSTEM

5.2.1 Fire detection arrangement in accommodation spaces

5.2.1.1 The oil tanker is to adopt IC method to install and arrange a fixed fire detection and fire alarm system so as to detect smoke in all corridors, stairways and escape routes within accommodation spaces.

5.2.2 Fire detection arrangement in cargo pump rooms

5.2.2.1 For cargo pumps, ballast pumps and stripping pumps installed in pump room and driven by the shaft passing through pump room bulkhead, the bulkhead shaft the stuffing gland, bearing and pump case are to be provided with temperature sensing devices. Continuous audible and visual alarm signals are to be activated automatically in cargo control room or pump control station.

5.2.2.2 A system continuously monitoring hydrocarbon gas concentration is to be installed. The sampling points or detection heads are to be positioned in adequate position to detect potential dangerous leak at any time. If the hydrocarbon gas concentration has reached preset level (which is not to be higher than 10% lower explosion limit of combustible gas), continuous visual and audible alarm signals shall be motivated automatically in pump room, engine control room, cargo control room and wheelhouse to cause alertness of relevant personnel to potential danger. For installation position of combustible gas probes, please refer to the requirements of Section 6 of this Chapter.

5.2.3 Fire detection arrangement in double hull spaces and double bottom spaces of oil tankers

5.2.3.1 Oil tankers of 20,000 DWT and above which were constructed on or after 1 January 2012 are to be provided with a fixed hydrocarbon gas detection system complying with Chapter 16 of Fire Safety System Code. The system is used for measuring hydrocarbon gas concentration of all ballast tanks and void spaces in double hull spaces and double bottom spaces adjacent to cargo oil tank, and these spaces include forepeak tank as well as any other tanks and spaces below bulkhead deck and adjacent to cargo oil tank. For oil tankers adopting fixed inert gas system for inerting protection in spaces mentioned above, fixed carbon gas detection equipment is not necessary.

5.2.4 Portable gas measuring instrument in oil tankers

5.2.4.1 According to the requirements of SOLAS Convention, at least one set of portable gas measuring instrument for measuring oxygen concentration and one set of portable gas measuring instrument for measuring concentration of combustible gas in the air as well as sufficient spare parts and proper calibration devices are to be provided for oil tanker. According to unified interpretation of MSC.1/Circ.1456, if sufficient spare parts and proper calibration devices are not provided, two sets of portable gas measuring instrument for measuring oxygen concentration and two sets of portable gas measuring instrument for measuring concentration of combustible gas in the air may be provided instead.

5.2.4.2 According to the requirements of ISC Rules for Classification of Seagoing Steel Ships, at least two sets of portable gas measuring instrument for measuring concentration of combustible gas in the air and two sets of portable oxygen content analysis instrument shall be provided on board each oil tanker. In addition, for oil tanker with inert gas system, at least two sets of portable gas detector measuring concentration of combustible gas in inert air are to be provided.

SECTION 3 FIRE EXTINCTION SYSTEMS

5.3.1 Water fire-fighting system

5.3.1.1 Water fire-extinguishing system is a kind of fire-fighting system which must be equipped on board all ships, and is one of the most basic and effective fire-extinguishing systems. Water fire-extinguishing system includes fire pump, fire pipe, hydrant, fire hose and fire nozzle. Water fire-fighting system is often used for deck wash, chain flush, ejector supply and other purposes, and sometimes it is also used as ballast pipe.

5.3.1.2 For oil tankers of 500 gross tonnage and upwards, two fire pumps are to be provided, and the total capacity of fire pumps (except for emergency fire pump) is not to be less than four thirds of the capacity of each independent bilge pump for bilge water drainage, but need not exceed 180 m^3/h. For cargo ships of 1,600 gross tonnage and upwards and with a periodically unattended machinery space, one of the main fire pumps can be of remote start from the outside of machinery space. For ships of 1,000 gross tonnage and upwards, independently-driven power source must be provided for two main fire pumps.

5.3.1.3 For ships of 500 gross tonnage and upwards but less than 1,000 gross tonnage, one fire pump is allowed to adopt non-independently-driven power source.

5.3.1.4 Fire main is to be provided in machinery space to outside machinery space, and isolation valves are to be fitted in an easily accessible and tenable position outside the machinery spaces. Within cargo areas, isolation valves are to be fitted at protected positions of fire main with interval of not more than 40 m, one of which is to be fitted at fire pipe branch, to preserve the integrity of the fire main system in case of fire or explosion.

5.3.1.5 The number of fire hoses to be provided is to be one for each 30 m length of the ship and one fire hose for each hydrant in machinery space of category A. In open deck area within cargo area, fire hose connection cannot be made of aluminum alloy or other plastics. All fire hoses are to have a length of at least 10 m, but not more than 15 m in machinery spaces and not more than 20 m in other spaces. For ships with moulded width in excess of 30m, the maximum length of fire hose on the open deck may be extended to 25 m.

5.3.1.6 Each fire hose is to be equipped with a fire nozzle and necessary connection, and the fire nozzle is to be of approved dual-purpose type with closing device (spray/spout type). In open deck area within the cargo area, fire nozzle cannot be made of aluminum alloy.

5.3.2. Fixed deck foam fire-extinguishing system

5.3.2.1 The principle of foam extinguishing is to produce foam layer by mixing mixed liquid of sea water and foam concentrate with air, so that combustion is isolated from air, and then cooling to achieve the purpose of fire extinguishing. It is especially suitable for extinguishing oil fires.

5.3.2.2 The expansion ratio of the deck foam fire-extinguishing system is generally not more than 12:1. If the expansion ratio is slightly in excess of 12, it is to be deemed as 12 for capacity calculation. When medium expansion ratio foam is employed, the calculation and arrangement are to be specially approved by ISC. By proportioner, the foam concentrate is mixed with seawater in accordance with the proportion of 3% -6%, forming a complete mixture through the pipe, then spraying the mixture by pressure and forming air bubbles by mixing air. The following is schematic diagram of typical fixed deck foam fire-extinguishing system.

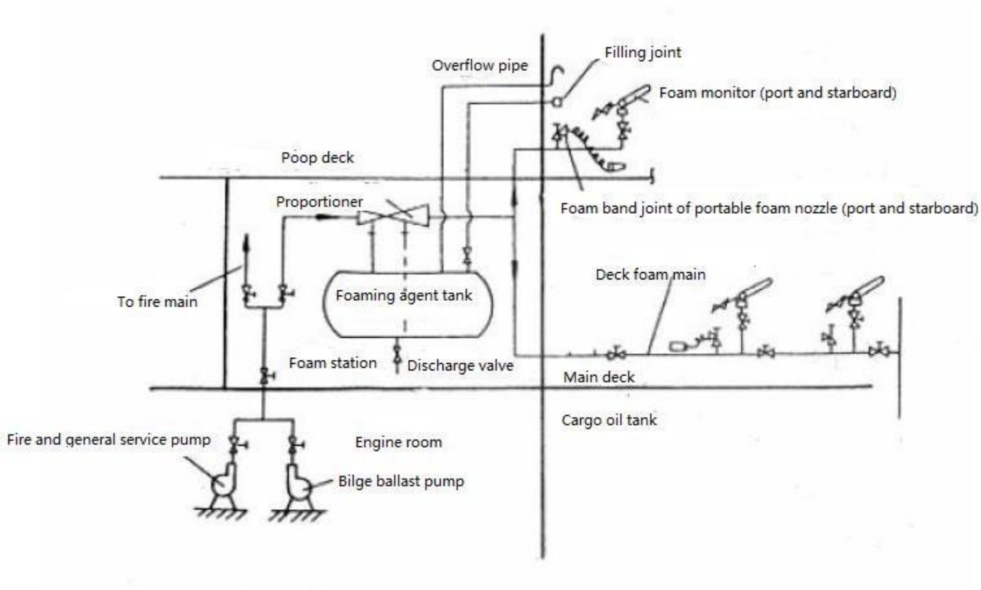


Figure 5.3.2.2 Schematic diagram of typical fixed deck foam fire-extinguishing system

5.3.2.3 There are two common methods to mix seawater and foam concentrate for fixed deck foam fire-extinguishing system, i.e.

(1) Pressure mixing

(2) Mixing in the pipeline

5.3.2.4 Oil tankers of 4000 DWT and above (regardless of flash point) are required to be provided with fixed deck foam fire-extinguishing system complying with the requirements of Chapter 14 of FSS Code. Oil tankers below 4000 DWT may be provided with fixed deck foam fire-extinguishing system without foam monitor complying with the requirements of paragraph 2.2.2.1, Chapter 14 of FSS Code. For oil tankers of less than 2000 gross tonnage and carrying petroleum products having a flashpoint exceeding 60°C, according to interpretation of IACS UI SC48, the cargo space can be not fitted with a fixed deck foam fire-extinguishing system.

5.3.2.5 The arrangements for providing foam are to be capable of delivering foam to the deck of entire cargo tank area as well as into any cargo tank of which the deck has been ruptured. The rate of foam supply is not to be less than the following:

(1) for deck in cargo oil area, 0.6L/min/m^2 for ;
(2) for deck in single cargo oil tank, 6L/min/m^2; or
(3) in front of single foam monitor/foam nozzle, 3L/min/m^2 but not less than 1,250L/min.

5.3.2.6 Sufficient foam concentrate is to be supplied to ensure that:
(1) at least 20 minutes of foam supply in tankers fitted with IGS system,
(2) at least 30 minutes of foam supply in tankers not fitted with IGS system.

5.3.2.7 The deck foam system is to be capable of simple and rapid operation. The main control station for the system is to be suitably located outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the protected area.

5.3.2.8 When the fire main is an integral part of the deck foam system, valves are to be provided in the foam main and fire main , and immediately forward of any foam monitor position.

5.3.2.9 The foam used for fire-fighting in cargo area is generally category B low-expansion foam concentrate. According to the requirements of MSC.1/Circ.1312 Guidelines for Performance, Test Criteria and Inspection of Foam Concentrate for Fixed Fire-extinguishing System, foam is to be subject to periodical inspection with interval requirements as follows: one inspection at third year after ship delivery and one inspection each year thereafter. For foam extinguishing agent conducting national standards, GB15308-2006 provides relevant provisions for storage life of each type of foam extinguishing agent, i.e. performance of product within storage life is to comply with the requirements of standards, and the foam extinguishing agent beyond the storage life is to be subject to annual fire-extinguishing performance test to determine whether the product is working. In addition, please pay attention to the requirements of the Administration and foam manufacturer.

SECTION 4 VENTILATION SYSTEM

5.4.1 Ventilation system is divided into natural ventilation and power ventilation, and power ventilation can be divided into mechanical ventilation and air condition system. As ventilation ducts penetrate the fire division and extend to different tanks, which will directly affect the effectiveness of the fire division if the fire occurs.

5.4.2 ISC Rules for Construction of Seagoing Steel Ships provide specific fire protection requirements for the ventilation system of the ship, which is mainly reflected in:

5.4.2.1 According to the degree of fire risk, set up several individual ventilation systems, such as category A machinery spaces, accommodation spaces and service spaces, kitchen, cargo areas, etc.;

5.4.2.2 Ventilation system is to be subject to effective control, including stopping the ventilation fan and closing the main inlets;

5.4.2.3 The ventilation ducts are to be made of non-combustible material, except for short ducts.

5.4.2.4 When the ventilation ducts pass through fire division, the penetration is not to impair the integrity of fire division, and fire dampers are to be provided for ventilation ducts with bigger sectional area.

5.4.2.5 For tankers carrying products having a flashpoint not exceeding 60℃, the fixed mechanical ventilation system is to be fitted in the cargo pump room and ballast pump tank within cargo area. The ventilation system is to be isolated from other ventilation system, using fans of non-sparking type (with sufficient spare), and the oil gas discharged from the exhaust fans is to be led to a safe place on the open deck, which will not affect original dangerous gas zone division of the ship.

5.4.2.6 All ventilation fans are to be capable of being stopped from an easily accessible position outside the space being served. The ventilation stop arrangement serving machinery space and other spaces is to be independent. The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the spaces being ventilated.

5.4.2.7 When the ventilation ducts passing through A class division have a cross-sectional area exceeding 0.075m^2, or the ventilation ducts in A class machinery space or kitchen pass through accommodation spaces, service spaces or control stations, or vice versa, fire dampers which can be closed automatically are to be fitted. Fire dampers are not required if ventilation ducts pass through spaces surrounded by A class enclosure without openings, provided those ducts have the same fire integrity as the divisions which they pass through.

SECTION 5 SPECIAL REQUIREMENTS FOR CARGO AREA

5.5.1 Typical hazardous zones

5.5.1.1 According to the provisions of IEC60092-502, typical hazardous zone of oil tanker is divided into zone 0, zone 1 and zone 2.

5.5.1.2 Following zones or spaces are to belong to zone 0:

(1) cargo oil tank, slop tank and any pressure vacuum piping system or other venting system of cargo oil tank and slop tank;

(2) interiors of piping and equipment containing cargo oil.

5.5.1.3 Following zones or spaces are to belong to zone 1:

(1) cofferdams and ballast tanks adjacent to cargo tanks;

(2) cargo pump room of which mechanical ventilation is to comply with following requirements:

① Visual and audible alarm is to be given from manned space when there is failure of mechanical ventilation in cargo pump room;

② If there is failure of mechanical ventilation, measures are to be taken immediately to recover ventilation;

③ If mechanical ventilation cannot be recovered for a long time, in addition to following equipment, other electrical equipment is to be capable of being closed in safe area and measures are to be taken to prevent unauthorized reconnection:

(a) Intrinsically safe equipment;

(b) Explosionproof lamp;

(c) Explosionproof general emergency alarm sounder without contact producing spark inside;

④ If the mechanical ventilation is stopped for a long time or it is used for the first time, electrical equipment (except for intrinsically safe equipment, explosionproof lamp and explosionproof general emergency alarm sounder) can only be powered on after the cargo pump room is subject to air exchange for at least five times;

(3) Enclosed or semi-enclosed spaces immediately above the cargo tanks (such as tween deck spaces), or having bulkhead above and in line with the cargo tank bulkheads;

(4) Spaces other than cofferdam, adjacent to and below the top of a cargo tank (e.g. trunk, passage and grocery tank), and the double bottom and pipe tunnel under the cargo tank;

(5) Open deck area within 3m of cargo tank opening, gas or vapors outlet[①], cargo oil distribution valve, cargo oil pipe flange, cargo pump room ventilation outlet and cargo tank pressure/vacuum valve which allows slight gas or vapor flow due to temperature change, or semi-enclosed spaces on the open deck;

(6) Above cargo tank outlet intended for the passage of large volumes of gas vapor mixture during cargo loading, ballasting or degasing, with a vertical cylinder of unlimited height and 6 m radius; and the open deck area below the outlet and within the hemisphere of 6m radius, or semi-enclosed space on the open deck;

(7) Open deck area 1.5m away from cargo pump room inlet, cargo pump room ventilation inlet, cofferdam inlet or other zone 1 opening space, or semi-enclosed space on the open deck;

(8) Open deck area above all cargo tank (including all ballast tanks in cargo hold area), of which the structure limits natural ventilation and the width is the full width of the ship, plus 3m fore and aft of the forward -most and aft-most cargo tank bulkhead ,up to height of 2.4m above the deck;

(9) Open deck area within overflow damper below cargo oil distribution valve, extending horizontally outward with damper as boundary and within height of 2.4m away from deck;

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① These openings include observation hole, tank washing opening, oil level void volume (tank expansion residual) measurement opening, sounding pipe, cargo oil vapor outlet, etc.

(10) Tank for storing oil hose;
(11) enclosed or semi-enclosed spaces with cargo oil pipes;
(12) The fore peak tank and its vent opening specified in paragraph 3.4.14.1, Chapter 3, PART SIX of ISC Rules for Classification of Seagoing Steel Ships.
5.5.1.4 Following zones or spaces are to belong to zone 2:
(1) If there is no special provisions, the area within 1.5m away from the periphery of open spaces or semi-enclosed spaces in zone 1 specified in 5.5.1.3;
(2) Spaces 4m away from the area defined in 5.5.1.3(6);
(3) Open deck area within 3m of cargo tank outlet and cargo tank pressure/vacuum valve having slight gas or vapor flow due to temperature change, or the area 2m beyond semi-enclosed spaces on the open deck;
(4) Within airlock leading to zone 1;
(5) If there is continuous coaming on the deck (so as to keep the overflow on the deck and far away from accommodation spaces and service spaces), the open deck area extending 3m outward within and out of this boundary and within 2.4m above the deck;
(6) Open deck area above all cargo tanks (including all ballast tanks within cargo tank area), i.e. the open deck area ensuring natural ventilation with width of full width of ship, extending horizontally 3m outward fore and aft bulkheads of cargo tank respectively and within 2.4m height away from periphery of open or semi-enclosed spaces belonging to zone 1;
(7) The space is adjacent to open deck area defined in 5.5.1.3(8) and 5.5.1.4(6), but lower than main deck and having an opening on the main deck or not higher than 0.5m above main deck, unless:
① The access to such spaces and all other openings (including ventilation exit and air inlet) do not face cargo tank area and at least 5m away from foremost bulkhead of cargo tank, with horizontal distance of at least 10m away from cargo tank exit or gas or vapor exit; and
② The space is provided with mechanical ventilation.
5.5.1.5 For the oil tanker dangerous area division plan, please refer to approved plan on board ship.

5.5.2 Cargo tank venting

5.5.2.1 General requirements
(1) The venting systems of cargo tanks are to be entirely different from the air pipes of the other compartments of the ship.
(2) The venting arrangements in each cargo tank may be independent of or combined with other cargo tanks, and may be incorporated with the inert gas piping.
(3) The venting arrangements are to be connected to the top of each cargo tank and be capable of self-draining the liquid to the cargo tanks under all normal trim and list conditions of the ship. Where it may not be possible to provide self-draining lines, permanent arrangements are to be provided to drain the liquid in vent lines to a cargo tank.
(4) The arrangements and positions of openings on the cargo tank deck from which emission of flammable vapors can occur are to minimize the possibility of flammable vapors being admitted to enclosed spaces containing source of ignition, or gathering in the vicinity of deck machinery and equipment which may constitute ignition hazard.
5.5.2.2 Safe arrangement of venting system (commonly known as main venting system)
(1) The venting system is to be provided with the arrangement to prevent flame entering cargo tank. The venting outlets for cargo handling and ballasting are to:
① make free flow of vapor mixtures. The arrangement is to be such that the outlet is not to be less than 6 m above the cargo tank deck or fore and aft gangway if situated within 4 m of the gangway and located not less than 10 m measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard. The inert gas main may be used for such ventilation;
② make the throttling of the discharge of the vapor mixtures to achieve a velocity of not less than

30 m/s, and these outlets are to be approved high speed arrangements, which are to be arranged as not less than 2m above cargo tank deck and not less than 10 m measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard. The detailed arrangements are also to comply with the requirements of dangerous zone division plan;

(2) It is to be so arranged that the vapor mixture is discharged vertically upwards.

5.5.2.3 Pressure or vacuum structure protection of cargo tank (commonly known as secondary venting system or auxiliary venting system)

The venting arrangements are to be so designed and operated as to ensure that neither pressure nor vacuum in cargo tanks will exceed design parameters and be such as to provide for:

(1) the flow of the small volumes of vapor, air or inert gas mixtures caused by thermal variations in a cargo tank in all cases through pressure/vacuum valves; and

(2) the passage of large volumes of vapor, air or inert gas mixtures during cargo loading and ballasting or discharging.

(3) Pressure release openings are to

① have as great a height as is practicable above the cargo tank deck to obtain maximum dispersal of flammable vapors，but in no case less than 2 m above the cargo tank deck;

② be arranged at the furthest distance as far as possible but not less than 5 m from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard. The positions of windlass and chain locker opening are treated as fire hazard spaces.

(4) Safety precautions in cargo tank (measures against liquid rising to the venting system)

Precautions are to be taken to prevent liquid in venting system to rise to the height which may exceed the design pressure in cargo tank. It is to be realized by adopting high level alarm or overflow control system or other equivalent measures together with independent measuring arrangements and cargo tank filling procedures. For the purpose of this paragraph, overflow valves cannot be regarded as equivalent to overflow system.

(5) Auxiliary pressure/vacuum release device

① Auxiliary devices allowing full release of vapor, air or inert gas mixture are to be provided. In order to prevent overpressure or underpressure due to failure of main venting system during cargo handling, pressure sensor can be installed in each cargo tank as alternative to preventive measures, and sensor monitoring system is to be fitted in cargo control room or the position where cargo is generally operated;

② Alarm device is to be provided on the monitoring device to be activated when overpressure or underpressure in cargo tank is detected.

(6) Pressure/vacuum disconnecting device

① One or more pressure/vacuum disconnecting device is to be provided to prevent cargo tank suffering from:

② a positive pressure in excess of the test pressure of the cargo tank if the cargo is loaded at the maximum rated capacity and all other air outlets are left shut; and

③ a negative pressure in excess of 700 mm water pressure if cargo is unloaded at the maximum rated capacity of the cargo pumps and the inert gas blowers fail.

(7) Size of venting outlet

Considering the released gas, in order to prevent pressure of any cargo tank in excess of design pressure, the design of venting outlet for cargo handling and ballasting is to comply with multiplication of maximum design loading speed by coefficient of at least 1.25.

(8) Documents regarding maximum allowable loading speed of each cargo tank are to be provided to the shipmaster. For combined venting system, documents of each group of cargo tank are to be provided.

5.5.3 Requirements for anti-explosion of oil tanker

5.5.3.1 Definition of explosionproof equipment

(1) Explosionproof enclosure (Exd): an enclosure which can withstand internal explosion of flammable gas or vapor placed in it but will not be damaged, and of which internal combustion cannot ignite external flammable gas or vapor through contact surface or structure pores. Explosionproof equipment which is commonly used on board is generally of explosionproof type.

① Common equipment: for explosionproof equipment, with Ex signs, and with explosionproof category and temperature groups on the nameplate. The lamp category is ExdIIBT4, and enclosure is fixed by hex bolts. For details, see the Figures below.

Figure 5.5.3.1(1)(1) Explosionproof equipment mark

Figure 5.5.3.1(1)(2) Explosionproof lamp cover

Figure 5.5.3.1(1)(3) Explosionproof fluorescent lamp

Figure 5.5.3.1(1)(4) Explosionproof lamp and explosionproof motor

Figure 5.5.3.1(1)(5) Explosionproof electrode

(2) Pressurized enclosure (Exp): an enclosure of electrical installation, which is filled with air or other inflammable gas so that pressure inside the enclosure is higher than atmospheric pressure to prevent ingress of external inflammable gas or vapors. It is rarely used on board ship.

① Following figure shows a positive pressure ventilation type explosionproof tank. When positive pressure value is below the lower limit (70Pa), power is automatically cut off, and the signal light ‘P lower limit’ is turned on. When positive pressure value is over the upper limit (1600Pa), the signal light ‘P upper limit’ is turned on, and if necessary, the duty officer may open the spare exhaust valves for emergency venting.

Figure 5.5.3.1(2)① Positive pressure ventilation type explosionproof tank
(explosionproof mark: EXpdibIIBT4)

(3) Intrinsically safe (Exia;ib): the circuit or a part of the circuit in which any electric arc or thermal effect produced in the specified test conditions, which includes normal operation such as opening and closing and fault conditions such as short circuit or earthing, is not capable of causing ignition of specified inflammable gas or vapour. PT-100 temperature sensors are commonly used intrinsically safe equipment. See the figure below.

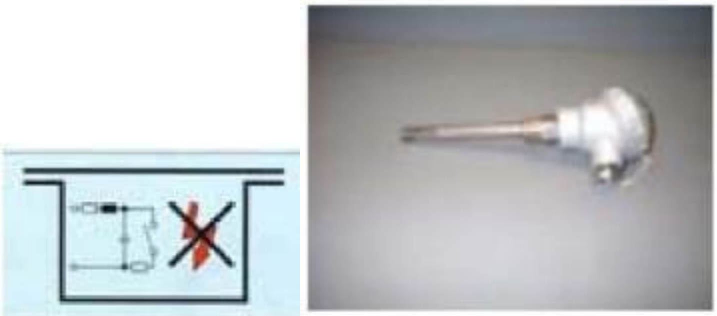


Figure 5.5.3.1(3)① Intrinsically safe and PT-100 temperature sensor

① Work principle of PT-100: temperature is the physical parameter that represents cold and hot engineering of an object, it microscopically reflects intensity of thermal motion of molecule inside object or the average kinetic energy. At present, temperature sensors usually adopt platinum resistance of standard 4 wire to measure temperature. The measurement is based on the characteristics that the resistance value of platinum conductor increases with temperature;

(4) Sand filled type (Exq): all live parts are completely buried in powder material, and the electrical arc produced cannot cause the ignition of external inflammable mixture through flame spread or overheating of enclosure wall when it is used according to the condition specified by the design. It is rarely used on board ship.

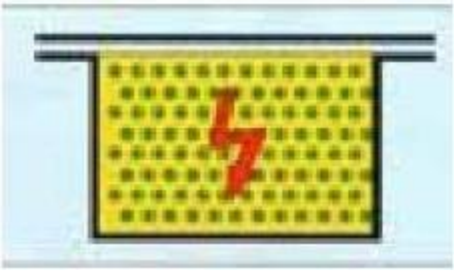


Figure 5.5.3.1(4) Sand filled type electrical equipment (Exq)

(5) Oil immersed type (Exo): the electrical equipment in which all parts likely to produce arc under normal operation condition are immersed in oil of adequate depth so as not to cause ignition of the explosive gas mixture above the oil. The live parts of such equipment which cannot produce arc under normal condition may be immersed in oil or adopt other approved explosion-proof type. It is rarely used on board ship.

Figure 5.5.3.1(5) Oil immersed type electrical equipment (Exo)

(6) Increased safety type (Exe): a type of protection applied to general industrial electrical apparatus in which additional measures are applied so as to give increased security against the possibility of excessive heat and occurrence of arcs and sparks under normal operation condition.

Figure 5.5.3.1(6) Increased safety type (Exe)

(7) Sintered flame arrestor: an explosionproof enclosure, made by atomic sintering procedure, external flammable gas can penetrate into the enclosure and cause combustion and explosion inside, however, the generated energy is insufficient to detonate the external flammable gas. It is mainly used for flammable gas detection.

Figure 5.5.3.1(7) Sintered flame arrestor

The sintered metal oxide inductor is substantially polycrystalline multiphase structure similar to ceramic structure. After sintering, lattice defects are produced, cation distribution is in a non-equilibrium state, despite aging, such non-equilibrium state is not completely eliminated. For long-term use, the unstable non-equilibrium state is slowly transformed to stable equilibrium, the crystal size, pore diameter and depth, grain boundary barrier, etc. will be changed, causing drift phenomena of gas-sensitive characteristics, i.e. detection sensitivity is reduced.

5.5.3.2 Precautions for equipment in hazardous areas - static electricity protection

(1) The metal casings of all electrical equipment in any hazardous zones or spaces are to be reliably earthed.
(2) All cargo piping and inert gas lines and ventilation ducts are to ensure continuous electrical connection with the hull. Copper/white steel sheets between flanges or bonding gasket below connecting bolts can be used, or it can be ensured that bolt connection can guarantee continuous electrical connection.
(3) All tanks are to ensure reliable electrical earthing of relevant processing unit with hull.
(4) The fans are to be of non-sparking type, and when air and fire dampers are closed/open, no spark will occur (non-ferrous metal/other gaskets are generally used at points of contact).
(5) Reliable electrical connection with hull is to be ensured during rigging replacement.

Figure 5.5.3.2 Pipe connection against static electricity

5.5.3.3 Requirements for laying cable in hazardous areas

(1) For cables laid in deck or pump room, a non-metallic impervious sheath is to be applied over the metal meshwork. Protective casing is necessary when cables are laid at positions liable to mechanical damage. If cables are laid on the deck, cable ducts may be used, or cable trays with cover can be used for main cable, but it is to be noted that cables on the deck pass through cable duct if tray is used, and it is suggested that cable trays be used for main cables during ship building, as considering the duct corrosion is significant and for replacement is a trouble in the future operation.
(2) Electrical appliances powered by flexible cables are not to be used in hazardous zones or spaces, with the exception of flexible cables or wires of intrinsically safe type.
(3) The distance of cables with steam pipes having a diameter equal to or less than 75 mm is to be more than 450mm/300mm to prevent the cables being burned by the steam.
(4) Cables of intrinsically safe circuits are to be laid separately with other cables with a distance of at least 50mm, because intrinsically safe cables transmit mA analog signal. In order to prevent interference of other cables to intrinsically safe cables, they are not to be laid in the same duct or on

the same cable tray as far as possible.

(5) Marine cables

Cables laid outdoor are generally with impervious sheath, as shown below

Figure 5.5.3.3(1) B-C insulated marine power cable

(6) Cables of intrinsically safe circuits

In addition to characteristics of low capacitance and low inductance, strengthening shield is also adopted so that cables have excellent shielding properties and strong resistance to external electromagnetic interference, radio frequency interference and electric coupling, thus can be used as transmission cable to transit weak signal in intrinsically safe circuits of distribution and control systems and automatic detection control systems (with rated voltage of 450/750) of industrial sectors in explosive atmospheres such as chemical and petroleum.

Figure 5.5.3.3(2) Intrinsically safe cable

5.5.3.4 The type of explosion-proof electrical equipment in hazardous zones

(1) The explosion-proof electrical equipment in oil tankers is to meet at least following requirements:
Temperature class T3; Equipment group IIA.

(2) The sensors are to be of type ia or ib and intrinsically safe.

(3) The lamps are to be Exd, Exp or Exe type, normally Exd or EExd, or Exde or EExde type.

(4) The electrical motors are generally to be EExde type.

(5) The non-suction type sensor of flammable gas detection system are generally divided into ionic type or chemical combustion type, for the position of which high accuracy is not required, the ionic type is often used, and for the position of which high accuracy is required, the chemical combustion type is often used.

(6) The internal of general alarm generator is to be without sparks, i.e. electronic contactor.

(7) For the electrical equipment with voltage not exceeding 1.2V, current not exceeding 0.1A and energy not more than 20 mJ or power not exceeding 25 mW, it is not necessary to be authenticated or identified in accordance with IEC79 publications, which can be considered as intrinsically safe circuit. If this type of electrical equipment is connected with the power or energy storage component capable causing above electrical parameters, the requirements of IEC79 publications are to be complied with. The circuit with working voltage not exceeding 24V and current not exceeding 20mA is considered as intrinsically safe circuit by EU. A simple end circuit under 24 V without energy storage component after explosion-proof barrier is considered as intrinsically safe circuit.

(8) An ordinary PT-100 senor with working voltage less than 24 V and current less than 20mA may be considered as intrinsically safe equipment.

5.5.3.5 Precautions

(1) To make sure that electrical transfer is continuous in pipelines of cargo, inert gas and stripping, i.e. check good connection of ground lug or wire or pad.

(2) To make sure that non-metallic outer sheath of the cable in dangerous zone is not injured.

(3) To make sure that explosion-proof lamp power is less than maximum power marked on lamp in dangerous zone, but it is necessary to confirm that the type and temperature class is above IIA and T3.

(4) To confirming that type and temperature class in battery room is not below IIC and T1, and it is not below IIC and T2 in acetylene room.

(5) To make sure that explosion-proof cloth core of cable wiring for explosion-proof equipment is in good condition, junction boxes are airtight, cables and cloth core are matched well and cables are not loose.

(6) To make sure that shell of devices in dangerous zone is in good earthing condition.

(7) To make sure that in case of replacement, the explosion-proof type and temperature class of

electrical devices in dangerous zone is not below the original equipment.

(8) Interlock between fan and lighting in pump room is to be noted. Fan and main lighting (including lighting powered from emergency switchboard, under normal circumstances, the emergency switchboard is distributor of the main switchboard) are to be interlocked under normal condition. The lighting is not interlocked with fan in case of emergency, for example, when an emergency generator is started.

5.5.4. Cargo tank level detection and alarm device

5.5.4.1 Requirements of Rules and Conventions

(1) Each cargo tank is to be fitted with a high-level alarm system to give alarm when the level reaches 95% of tank capacity. Paragraph 15.3.3, Chapter 15, PART THREE of ISC Rules for Classification of Seagoing Steel Ships requires that each cargo tank connected with vapor collection system is to be provided with a intrinsically safe overflow alarm system so as to notify the operator to stop loading operation as early as possible. In general, the setting value of cargo tank overflow alarm is not more than 98.5% of tank capacity, and the duration between alarm and overflow is not to be less than 1 min.

(2) SOLAS Reg.II-2/4.5.5.3.2 also specifies that closing type level measurement systems also is to be provided for oil tankers fitted with fixed inert gas system. At present, radar level remote measurement system is commonly used for ship design, which can show the level, volume and pressure of cargo tank.

5.5.4.2 Precautions

(1) The system is intrinsically safe equipment, transmission signal is 4-20mA, a dedicated cable with compensation core wire is used, which is to be separated with other cable to prevent interference to its transmission signal. It is not to damage the cable during laying;

(2) Note that the lower part of the sensor is not to be damaged during installation;

(3) Cable connection sequence must be correct, otherwise it may result in damage of the sensor or control parts;

(4) Relevant components are to be well fixed, cable entry position and the upper cover of the sensor is to be well fixed to prevent damage of the equipment due to flooding;

(5) After installation, it is to adjust tank capacity according to the tank capacity table and check the level setting according to oil-water interface detector;

(6) Because the difference between pressure in the tank and external air pressure is displayed, pressure check is generally by means of comparison with inert gas system pressure or display value of 0 or close to 0 when the hatch cover is open;

(7) During operation, attention is to be paid whether there is a big discrepancy between displayed tank capacity and tank capacity table, and whether the displayed level is consistent with the level checked by oil-water interface detector, calibration is to be carried out if the error exceeds the requirements of the specification

(8) Attention is to be paid not to damage the sensor and cable during ship repair.

SECTION 6 SPECIAL REQUIREMENTS FOR CARGO PUMP ROOM

5.6.1 Pump rooms with cargo oil transfer pumps, or pump rooms with pumps and their accessories for ballasting those spaces situated adjacent to cargo tanks and slop tanks and pump rooms with oil fuel transfer pumps are to be considered as cargo oil pump rooms provided that such pump rooms have the same safety standard as that required for cargo pump rooms. Pump rooms intended solely for ballast or oil fuel transfer, however, need not comply with the requirements of this section. The cargo oil pump room is located between machinery space and cargo tank space, and the lower portion of the pump room may be recessed into machinery spaces of category A to accommodate pumps, provided that the deck head of the recess is in general not more than one third of the molded depth above the keel, except for ships of not more than 25,000 tonnes deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangements, this is impracticable, the Administration may permit a recess in excess of such height, but not exceeding one half of the molded depth above the keel.

5.6.2 Each cargo pump room is to be provided with fixed CO_2, high-expansion foam or pressure water-spraying fire-extinguishing system. As CO_2 can cause characteristics of electrostatic detonation, it is only used for fire-fighting forgather than inerting. Steel skylight of pump room can be closed outside.

5.6.3 The cargo oil pump room is to be provided with mechanical suction type ventilation system complying with the requirement of SOLAS Reg.II-2/4.5.4. The fans are to be non-sparking type (fans are to have spare parts), and the gas discharged from the fans is to be led to a safe place on the open deck. The ventilation of these rooms is to have sufficient capacity to minimize the possibility of accumulation of flammable vapors. The number of air changes is to be at least 20 per hour. For ships of which keels were laid on or after 1st July, 2002, lighting system is to be interlocked with ventilation so that failure of the ventilation system will not cause the lighting to go out. Main lighting of all cargo pump rooms is to be interlocked with ventilation, i.e. ventilation before turning on the light. For ships of which the construction contract is signed after 1st July 2017, ventilation system is required to run at least 5 minutes, and after the light is turned on, it will not be turned off due to failure of the ventilation system.

5.6.4 The cargo oil pump room is to be fitted with flammable gas detection equipment. According to the requirements of MSC.1/Circ.1321, it is suggested to install flammable gas sensor at following positions in the cargo pump room: vertical to the upper part of main cargo pump or between two cargo umps, within the height of 30cm above lowest part of cargo pump bottom, every 10m length or width.

5.6.5 Cargo pumps, ballast pumps and stripping pumps installed in pump rooms and driven by shafts passing through pump room bulkheads are to be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. A continuous audible and visual alarm signal is to be automatically motivated in the cargo control room or pump control station.

5.6.6 Sliding watertight doors are to be provided if cargo pump room has an access to tunnel, and the door is to be kept closed and can be remotely controlled at bridge and be closed at pump room entrance. Where this tunnel is used as a passageway for pump room, if there are requirements for damage stability, regardless where an opening is arranged for tunnel, the watertight doors are to be fitted.

5.6.7 For the requirements for cargo pump room double bottom arrangement, please see relevant contents of Section 3, Chapter I of the Guidelines on cargo pump room double bottom protection.

SECTION 7 INERT GAS SYSTEM

5.7.1 For tankers with cow system, tankers of 20,000 DWT and upwards which was constructed after 1st May 1981 and tankers of 8,000 DWT and upwards of which the keels were laid after 1st January 2016, the protection of cargo area is to be achieved by an IGS system.

5.7.2 Inert gases are mainly from the flame-retardant gas by boiler exhaust gas passing through scrubbers or directly from the inert gas generator such as N2. Inert gas in the tank is to ensure that oxygen content is less than 8%, i.e. the gas will not be ignited even though it is within the scope of explosion.

5.7.3 IGS system and cargo oil pipe arrangement are as follows:

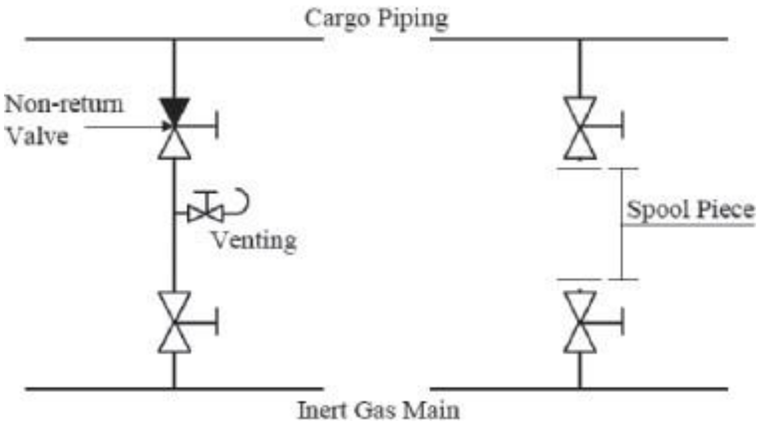


Figure 5.7.3 IGS system and cargo oil pipe arrangement

5.7.3.1 Typical IGS system arrangement is shown as follows:

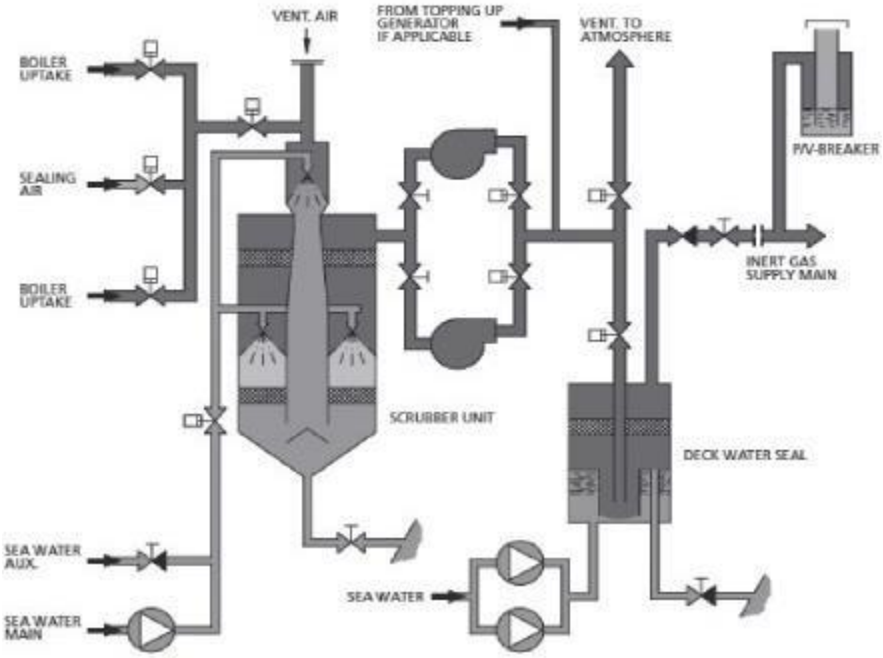


Figure 5.7.3.1 Typical IGS system arrangement 1

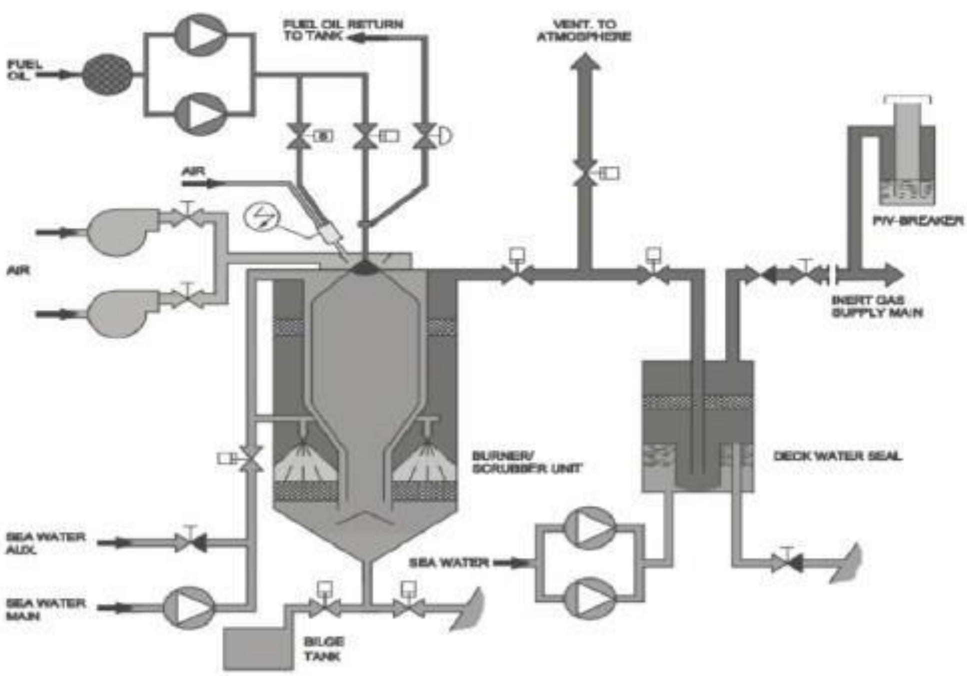


Figure 5.7.3.1 Typical IGS system arrangement 2

5.7.4 The most dangerous state of IGS system is oil gas backflow, which generally occurs in the following situations:

5.7.4.1 Inert gas blower failure

5.7.4.2 The scrubber pump stops

5.7.4.3 Cargo vapor pressure is too high (when loading)

5.7.4.4 Check valve failure

5.7.4.5 Failure control of item 5.7.4.1 and 5.7.4.2 is achieved by the gas throttling valve, and excessive gas can be discharged to the atmosphere by the ventilation system which is water-sealed on the deck.

5.7.4.6 Failure control of item No. 5.7.4.3 and No. 5.7.4.4 is achieved by gas pressure adjustment valve.

5.7.5 IGS system is divided into dry, semi-dry and wet three types according to deck water seal, shown as follows:

※ Dry seal tank is located at upper part of deck water seal, automatically adjusting the tank switch (only one non-return valve is provided on the pipeline between deck water seal and cargo tanks) by means of pressure sensor, once the sensor fails, the backflow occurs, this situation is most dangerous. At present, this arrangement is not used on the oil tanker, and OCIMF does not accept dry type.

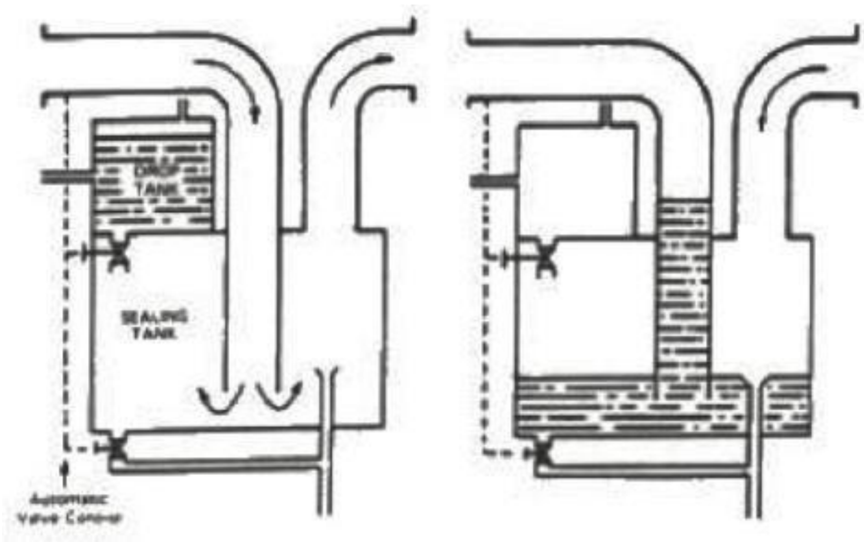


Figure 5.7.5(1) Dry type IGS

※ Semi-dry type, the pipe blockage will cause separation/semi-separation of IGS system with cargo tank. When IGS system stops operation, the residual pressure difference in the pipeline will cause small backflow, then the deck mechanical check valve certainly fail. Attention is to be paid whether there is serious corrosion inside pipeline, this can be achieved through pipe irrigation test.

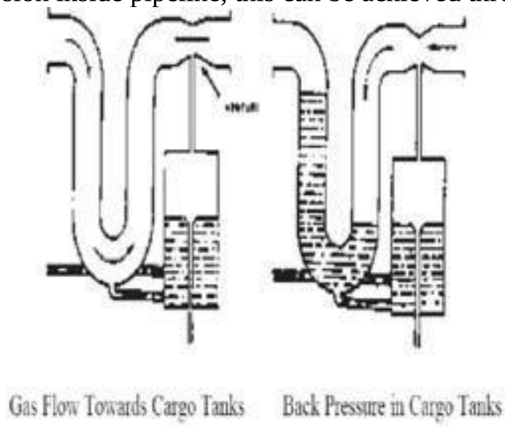


Figure 5.7.5(2) Semi-dry type IGS

※ Wet type is most commonly used at present, and internal corrosion (including bottom rubber) is mainly focused on during inspection.

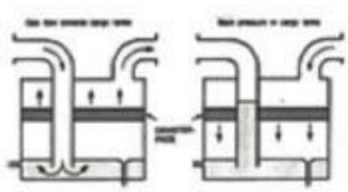


Figure 5.7.5(3) Wet type IGS

5.7.6 On-site inspection is to be carried out in accordance with specific requirements of Inert Gas Operation Manual, usually including following:

5.7.6.1 Check pipe corrosion, particularly in way of flange, to make sure that there is no pipe

leakage;
5.7.6.2 Test 2 blowers to make sure of normal operation;
5.7.6.3 Test scrubber fan to make sure of normal operation;
5.7.6.4 Know automatic filling and discharging condition of deck water seal, check for water and confirm bottom rubber condition;
5.7.6.5 Test all remotely or automatically controlled valves, including smoke isolation valve;
5.7.6.6 Test normal function of soot blower, when boiler is soot blowing, the smoke isolation valve is to be closed, and when the valve is open, boiler soot blowing cannot be carried out;
5.7.6.7 Check the gas pressure regulating valve, when the blower pressure is insufficient or the blower stops working, the valve is to be closed;
5.7.6.8 Check the inert gas alarm system, including simulation test of high oxygen content in inert gas main, low gas pressure in inert gas main, low water supply pressure of deck water seal, high gas temperature in inert gas main, low scrubber water pressure or low water speed, high level in scrubber, failure of inert gas blower, automatic control of gas pressure regulating valve and power failure of display and recorder of high oxygen content in inert gas main and high pressure in inert gas main;
5.7.6.9 Test accuracy of oxygen content measuring equipment by using standard gas;
5.7.6.10 During special survey, following inspection and test are to be completed:
(1) overhauling inert gas generator, blower, inert gas adjusting valve and stop valve on inert gas distribution piping, deck seal check valve and cooling pumps of cooling water system;
(2) Inspecting inside scrubber;
(3) overhauling and checking pressure/vacuum equipment of inert gas distribution piping, if fitted.

SECTION 8 FIRE-FIGHTING APPLIANCES

5.8.1 Machinery spaces of category A are to be provided with at least one set of portable foam applicator unit complying with FSS Code as well as approved foam extinguisher or equivalent extinguisher with capacity of at least 45L, which is sufficient to shoot foam or its equivalent to fuel oil and lubricating oil pressure system, transmission gear and any part with fire hazard. In addition, there are to be enough portable foam extinguishers or equivalent extinguishers which are so arranged that the walking distance between any point in the space and a set of extinguisher is not more than 10m, and at least two sets of such extinguishers are to be provided at each space. Yellow sand box provided in boiler room can be replaced by portable extinguisher.
5.8.2 There are to be 4 sets of fireman's outfit on each oil tanker. Each fireman's outfit is to consist of personal equipment and self-contained breathing apparatus, for each breathing apparatus, a fireproof lifeline 30m in length which can bear 3.5KN load strength for each 5m length is to be provided. The free air storage volume of each set of self-contained breathing apparatus is to be at least 1,200L, at least two sets of spare cylinders are to be provided for each breathing apparatus, and the cylinders are to be interchangeable. If self-charging system is provided on board ship, one spare cylinder may be provided for each breathing apparatus.
5.8.3 For ships constructed on or after 1 July 2014, when the storage volume of self-contained compressed air of fireman's outfit in the cylinder is decreased to not less than 200L, audible and visual alarm or other device is to be used to notify the user. According to the interpretation of MSC.1/Circ.1499, audible alarm and traditional pressure gauge (the dial is generally divided into three areas, i.e. red, yellow and green, red indicates alarm) can be deemed as meeting requirements. Ships constructed before 1 July 2014 are to comply with the requirements no later than 1 July 2019.
5.8.4 For ships constructed on or after 1 July 2014, each fire brigade is to be provided with at least 2 sets of two-way portable radio telephone for firemen's communication. These two-way portable radio telephones are to be explosion-proof or intrinsically safe type. Ships constructed before 1 July 2014 are to comply with the requirements no later than the first survey after 1 July 2018.

SECTION 9 MAINTENANCE OF FIRE-FIGHTING EQUIPMENT

5.9.1 Manual of Training, Excising, Safe Operation and Maintenance of Fire-fighting Facilities complying with the requirements of Conventions is to be provided on board ship. The manual can be written separately or in one volume, in the working language of the ship. For oil tankers, Fire Safe Operation Manual is to include instructions on fire-fighting and emergency cargo loading in IMDG Code, provisions of preventing fire spreading to cargo area due to ignition of flammable vapors and procedure of cargo tank degassing.

5.9.2 A Fire Safe Operation Manual is to be provided in each crew mess room and recreation room or in each crew cabin. All the crew are to arrange the inspection and maintenance in time strictly in accordance with the manual provisions, and arrange necessary testing and survey strictly in accordance with relevant requirements of each flag Administration.

SECTION 10 ALTERNATIVE FIRE-FIGHTING ARRANGEMENTS AND DESIGN

5.10.1 According to relevant provisions of SOLAS Convention, fire safety design and arrangements may deviate from the prescriptive requirements set out in Convention, provided that the design and arrangements meet relevant fire safety objectives and the functional requirements. In addition, the documents approved by the Administration or ISC are to be kept on board ship.

CHAPTER 6 POLLUTION PREVENTION OF OIL TANKERS

SECTION 1 CRUDE OIL WASHING SYSTEM

6.1.1 Requirements for crude oil washing

6.1.1.1 According to regulation 33, Annex 1 of MARPOL Convention, crude oil tankers of 20,000 dwt and above delivered after 1 June 1982 as defined in Regulation 1.28.4 are to be equipped with cargo oil tank washing system by using crude oil washing, which is to be subject to satisfactory crude oil washing survey after a period of service and certified.

6.1.1.2 The crude oil washing apparatus and associated equipment and arrangement are to comply with the provisions of Technical Specifications for the Design, Operation and Control of Crude Oil Washing Systems adopted by IMO.

6.1.1.3 IMO adopted Technical Specifications for the Design, Operation and Control of Crude Oil Washing Systems by Resolution A.446 (XI) on 15th November 1979.

6.1.1.4 IMO adopted Resolution A.497 (XII), the amendments to Resolution A.446 (XI), on 19th November 1981.

6.1.1.5 Attention is to be paid that it is highly dangerous to enter the oil tank which is not subject to washing or gas free inspection. According to existing concepts, it may be deemed as no entry. Realizing such kind of risk, IMO defined that inspection inside tank by the inspector should not be treated as mandatory requirements during inspection of all crude oil washing systems by Resolution A.897(21) adopted on 25th November 1999.

6.1.1.6 Every oil tanker adopting crude oil washing system is to be provided with an Operation and Equipment Manual detailing the system and equipment and specifying operational procedures. The format is to meet Standard Format of Crude Oil Washing Operation and Equipment Manual adopted by Resolution MEPC.3(XII) and revised by Resolution MEPC.81(43). If the Manual is not compiled in English or French, the text is to include a translation into one of these languages.

6.1.2 COW effectiveness verification (IMO Resolution A.897(21))

6.1.2.1 Basic survey requirements

(1) In order to verify whether COW system installed and used on board ship has reached technical specifications of design, operation and control of COW system in IMO Resolutions A.446(11), A.497(XII) and A.897(21), in addition to comprehensive and strict initial survey, additional survey is to be carried out to cargo tank subject to COW according to the provisions of regulation 4.2.10 of above resolutions, i.e. effectiveness survey of COW system (initial survey specified in paragraph 3.2 of Resolution A.446(XI) is not necessary).

(2) Such survey is carried out within one year after the tanker was first engaged in crude oil transportation or by the end of the third voyage carrying crude oil suitable for crude oil washing (whichever occurs later), and serves as the basis of effectiveness survey to verify COW system and final certification (IOPP).

(3) If the Administration thinks that some ships are similar in every respect, only one ship of such kind is required to implement the requirements of regulation 4.2.10 of Resolution A.897(21). (i.e. effective test of sister ships can be exempted with the consent of the Administration).

(4) Every oil tanker adopting COW system is to be provided with an Operation and Equipment Manual detailing the system and equipment and specifying operational procedures. The Manual uses standard formats in the Appendix of Resolution MEPC.3(12) as revised by MEPC.81(43), which are approved by the Administration. The Manual provides not only guidance to correct operation of the system by the crew, but also relevant information on the system and operational procedure for the port inspector. If the Manual is not compiled in English or French, the text is to include a translation into one of these languages.

(5) When applicable, Operation Manual for Oil Gas Recovery and Inert Gas Operation Manual are to be provided for reference.

6.1.2.2 According to the requirements of regulation 4.2.10 of Resolution A.897(21), in order to confirm the effectiveness of COW system and stripping system, the crude oil washing operation is to be witnessed to the satisfaction of the Administration.

(1) For ships that comply with regulation 19.3, Annex I of MARPOL Convention,

① the crude oil washing operations are to be carried out using the approved crude oil washing equipment and as specified in the approved Operation and Equipment Manual. For at least one tank of a group of tanks of similar configuration, the Administration is to:

a. confirm the operation of the stripping system by observing the monitoring devices and monitoring the oil level (by dipping or other means) during bottom washing.

b. monitor the proper operation of the washing machines with particular reference to supply pressure, cycle times and machine function.

c. on completion of washing and final draining, the tanks are to be hand dipped, as close as practical to the forward end, center and aft end in each tank, certain ships are specially equipped with dipping holes for use, and a record of these dips is to be made in the COW Manual. The Administration may require an internal examination as described in subparagraph a of this section, or by an alternative method acceptable to the Administration, if deemed necessary.

② Survey contents and details

a. The contents of former regulation 13F(3) of Resolution A.897(21) may refer to existing regulation 19.3, i.e. applicable to ships delivered on or after 6th July 1996.

b. Because crude oil washing must be carried out under inert state, residual oil at tank bottom must be hand dipped, and remotely measured level by CARGO MASTER cannot be treated as alternative data, and finally, the remaining oil in each tank is calculated by checking tank capacity table.

c. When measurement is carried out to selected tank, if fore, middle and aft points on the deck of oil tanker have special Vapor Lock holes, measurement can be completed under inert state. If it is necessary to open other holes such as portable washing machine hole/cover, only antistatic measuring tools are allowed and safety precautions are to be taken (e.g. tools must be reliably earthed before entering the tank).

- Note 1: For dipping, tools are selected according to the order of:

a) Dedicated instruments specially designed for dipping;
b) Antistatic safe ruler, such as UTI or MMC approved by the authority;
c) A homemade copper measuring stick.

- Note 2: UTI is a dedicated tool having three functions of U, T and I, i.e. U (Ullage)/T(Temperature)/I(Interface).
- Note 3: During practical operation, measurement is to be carried out at Vapor Lock (semi-enclosed gastight measuring hole) as far as possible, if the dipping holes are not fitted with Vapor Lock, measurement such as using observation hole is also acceptable, provided that tanks must be under satisfactory inert state with oxygen content less than 8%.

d. In order to judge tank washing effects, the surveyor is to:

(i) check that tank washing plan and implementation record on board ship has been carried out according to Operation and Equipment Manual.

(ii) verify Table 6.1.2.2(1)②e Verification Record of Bottom Washing Effects and Table 6.1.2.2(1)② f Dipping Record on site.

(iii) use all effective means to ascertain that selected cabins do not have obvious adhesives and sediments. (It is ascertained that there is no obvious big or large area adhesives and sediments in the tank by checking through inherent openings on the deck or other equivalent methods).

(iv) In order to meet Convention requirements for pollution prevention, washing effects are judged according to the sum of oil slick, and additional washing effect verification is to be carried out in the tank which is defined as cargo and ballast tank on board ship, i.e. further washing after crude oil washing, and verification is carried out by measuring oil slick. For symmetrical ballast tanks, one can be selected and verified according to following Table 6.1.2.2(1)②g and Figure 6.1.2.2(1)②j.

(v) If the internal structure of slop tank is very complicated, individual verification is also to be carried out after washing.

e. Witness Report of Bottom Washing Effectiveness is shown as follows:

Witness Report of Bottom Washing Effectiveness Table 6.1.2.2(1)②e

M/T：

Port： Berth：

Date Cargo name：

Tank	Machine No	Washing Pressure (Mpa)	Cycle Time(m)	Stripping Pump (Y/N)	Result (Pass/Fail)

Note: “Stripping Pump” Y/N(Used/No use)

Draft forward (m) Trim (m)

Draft aft (m) List Deg

Chief officer Surveyor

f. Dipping Record is shown as follows:

Dipping Record Table 6.1.2.2(1)②f

M/T：

Port： Berth：

Date： Cargo name：

1	2	3			4	5
Tank	Capacity(m^3)	Sounding(cm)			Observed vol. (m^3)	Ratio=Item 4/Item 2 <0.085%
		F	M	A		

Note:

Draft forward (m) Trim (m)

Draft aft (m) List Deg

Chief officer Surveyor

g. Record of Oil Floating on Top of Tanks is shown as follows：

Record of Oil Floating on Top of Tanks Table 6.1.2.2(1)②g

1	2	3	4	5	6	7	8
Cargo tank with WB	Tank Vol. (m^3)	Ull. to top of oil layer (M)	Vol. of oil + water (m^3)	Ull. to top of water (m)	Volume of water (m^3)	Volume of oil (m^3)	Ratio Vx/Vx
X	V_x	UX	Vw+x	Uw	Vw	v_x	

h. For bilaterally symmetrical cargo and ballast tanks and/or slop tanks, one of them can be selected.
i. When cargo and ballast tanks are washed, if method of washing tank while sweeping tank to the sewage tank is adopted, verification can be carried out by measuring sum of oil slick in sewage tank, but such method is to adopt other supplementary measures and have relevant records and explanations.
j. Oil volume in tank and ratio of oil to tank volume are to be carried out by following methods, and reference can be made to following figure:
(i) measuring Ullage to top of oil layer (column 3);
(ii) measuring Ullage to top of water (column 5);
(iii) checking capacity table.
★ filling total volume of oil water in each tank (column 4);
★ filling water volume of each tank (column 6);
★ subtracting water volume from total volume of oil water to get oil volume of each tank.
(iv) Calculating oil volume of each individual tank by subtracting column 6 from column 4, i.e. Vw+x – Vw = vx.
(v) Calculating ratio of residual oil volume to capacity, with the result less than 0.085%.

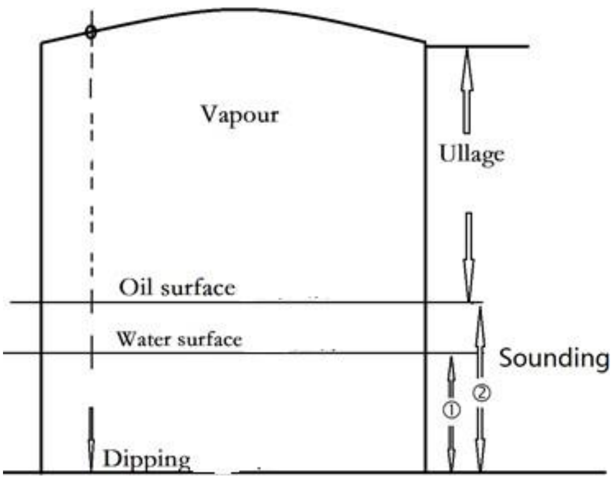


Figure 6.1.2.2(1)②j Measurement of Oil floating

③ Personnel safety precautions:

a. During measurement, the personnel is to stand in a position perpendicular to the wind to avoid inhalation of cabin exhaust gas as far as possible.
b. It is to carry portable or personal toxic gas detector according to the nature of cargo, so as to protect against harmful gases such as hydrogen sulfide and benzene.
c. Though inspection of above cargo and ballast tanks has certain difficulties in terminal operation, it is also practicable, i.e. it is required to connect washing heater in the pump room on board ship, and tank can be washed by hot water in the terminal under inerting state. If it is not allowed in particular terminals, in order to speed up ship turnover, measuring oil slick while sailing and washing tank after leaving the terminal can be agreed, of course all steps are to be checked by the surveyor.

(2) For ships not complying with regulation 19.3,
Such ships are usually early single hull oil tankers or crude oil tankers below 20000 DWT without Convention’s mandatory requirements for providing COW equipment, and they are omitted here.

6.1.2.3 Safety checklist used on board ship
Sheets such as Crude Oil Washing Checklist, Checklist for Use before COW Operation, During COW Operation and After COW Operation are to be completed on board ship, and the surveyor is to check their effectiveness.

6.1.2.4 Important reminder
(1) New verification method is based on onboard operation and surveyor witness, therefore, main work is crew operation.
(2) Verification is mainly based on ratio of residual oil to capacity after COW below 0.085% as required by the Convention, not measurement of area inside tank.
(3) Key points are as follows:
① To check the washing plan which is to be prepared by the ship master according to Operation and Equipment Manual approved by ISC, whether relevant records (using sheets recommended by the Instructions) are prepared according to the requirements, whether selected oil tanks meet relevant requirements, and whether ship trim meets the requirements of Operation and Equipment Manual;
② Whether washing system and stripping system work properly, whether relevant requirements of Operation and Equipment Manual are met;
③ Whether preparation of safety inspection work on board ship meets relevant requirements of COW safe operation;
④ Visual inspection is carried out at corresponding opening after tank washing; (It is not encouraged to enter the tank for inspection, if tank entry is necessary, it is to report to ISC Headquarters and ship company Headquarters and take corresponding safety measures);
⑤ For the selected ordinary oil tank, dipping measurement is carried out at fore, middle and aft part of oil tank by means of UTI or other effective measurement after COW, and the final ratio of residual oil quantity to oil tank is not more than 0.085%;
⑥ For the oil tank requiring further measurement of oil slick after washing (may be cargo and ballast or slop tank), under the condition that entry into oil tank for inspection is not possible, ratio of oil slick after washing to oil tank capacity can be not more than 0.085%.

SECTION 2 OIL DISCHARGE MONITORING AND CONTROL SYSTEM

6.2.1 Oil discharge monitoring and control system

6.2.1.1 Oil tankers of 150 gross tonnage and above are to be equipped with an oil discharge monitoring and control system approved by the Administration. The oil discharge monitoring and control system is to be designed and installed in compliance with the guidelines and technical specifications for oil discharge monitoring and control system for oil tankers developed by IMO, including:

(1) For oil content meters installed on oil tankers built prior to 2 October 1986, refer to Recommendation on International Performance and Test Specifications for Oily-water Separating Equipment and Oil Content Meters adopted by IMO by resolution A.496(XII);
(2) For oil content meters as parts of discharge monitoring and control systems installed on oil tankers built on or after 2 October 1986, refer to the Guidelines and Technical Specifications for Oil Discharge Monitoring and Control Systems for oil tankers adopted by the Organization by resolution A.586(14);
(3) For oil content meters as part of discharge monitoring and control systems installed on oil tankers constructed on or after 1 January 2005, refer to Revised Guidelines and Specifications for Oil Discharge Monitoring and Control Systems for Oil Tankers adopted by IMO by resolution MEPC.108(49).

List of Implementation Requirements for Oil Discharge Monitoring and Control Systems

Table 6.2.1.1

Feature	Category							
		I	II	III	IV(a)	I	V(a)	V(b)
Application	After 1 January 2005	New ≥4k	New ≥4k	New <4k	Existing ≥20k		Existing <20k	
Input data	A	A	A	A	A	A	A	A
Input data	A	A	M	M	M	M	A/M	A/M
Input data	A	A	M	M	M	M	A/M	A/M
Input data	A	A	A	A	A	A	M	M
Input data	A	A	A		A			
Input data PPm Discharge flow rate	A	A	A					
Output data	A	A	A	A	A	A	A/M	A/M
Input data	A	A	A	A	A	A	AM	M
Input data	A	A	A	A	A	A	M	M
Input data Litres/Knot Total quantity of oil	A		A	A	A	A	A	A
System type	Control unit		Computing unit				Checking unit	
After 2 October 1986		A	B					

Note:
New—Ships delivered after 31 December 1979 as defined in Convention
Existing—Ships delivered before 31 December 1979 as defined in Convention
K---1,000 DWT
A---Automatic function
M---Manual input from unit data

6.2.2 Operation manual for oil discharge monitoring and control systems

6.2.2.1 The operational instruction book of oil discharge monitoring and control system is to comply with approved operation manuals.
6.2.2.2 The Operational Manual for Oil Discharge Monitoring and Control System is to contain all details necessary to operate and maintain the system and is also to include at least following information. The information may be combined as indicated, or in an equivalent manner.
(1) Introduction: Particulars of the ship, together with the date on which the system was/is to be installed and index to remainder of manual.
(2) Section 1: Manufacturer's equipment manuals for major components of the system. These manuals may include installation, commissioning, operation and failure finding procedures for the oil content monitor.
(3) Section 2: Operation Manual comprises description of following items: ship's cargo ballast system, dedicated overboard discharge with sampling points, normal operation procedures,

automatic inputs, manual inputs (as applicable), starting interlock and discharge valve control (as applicable), override system, audible and visual alarms, record outputs and, where required for manual input, flow rate when discharging by gravity and pumping ballast overboard. The Manual is also to include instructions for discharge of oily water following mal-function of the equipment. Above information is to be supported by copies of relevant approved diagrams. Reference may be made to Section 1, where applicable.

(4) Section 3: Technical manual comprises failure finding schedules, maintenance record and electrical, pneumatic and hydraulic schematic diagrams and description of the complete system. Reference may be made to Section 1, where applicable.

(5) Section 4: Test and inspection procedures include a functional test at installation and guidance notes for the Surveyors carrying out initial and in-service surveys. Reference may be made to Section 1, where applicable.

(6) Appendix I: Technical installation specifications include location and mounting of components, arrangements for maintaining integrity of 'safe' zones, safety requirements for electrical equipment installed in hazardous zones and supported by copies of approved drawings, sample piping layout and sample delay calculations, design and arrangements of sampling probes, flushing arrangements and zero setting. Reference may be made to Section 1, where applicable.

(7) Appendix II: Copy of Type Approval Certificate and Works Approval Certificate for major components.

6.2.3 Installation requirements for oil discharge monitoring and control system

6.2.3.1 Basic principles

(1) The basic safety principle for the installation of cargo oil discharge monitoring and control system on board oil tankers is that the parts of the system containing cargo oily-water mixture and oil vapor, including the parts of the system containing electric and electronic components, are to be separated from all sources of ignition.

(2) The parts of the system containing cargo oily-water mixture and oil vapor are to be entirely contained within cargo area (for instance, cargo pump room), unless expressly provided otherwise in the Guidelines.

(3) The electric and electronic components are to be entirely contained in gas safe spaces, unless they are of certified intrinsically safe type.

6.2.3.2 Application

At present, the following types of systems are known to be available and are considered for the purpose of the Guidelines as far as their installation on board is concerned:

(1) Systems utilizing light transmission through bulkhead between dangerous spaces and gas safe spaces and with the measuring instrument located in gas dangerous spaces.

(2) The light transmission may be made by means of:

① optic fibres, or

② window fitted on the above bulkhead;

(3) systems of which the measuring instrument is located in gas safe spaces.

6.2.3.3 Fire safety provisions

(1) Systems utilizing optic fibers

When being suitable for installation according to the characteristics, these systems meet the basic principle stated in 6.2.3.1.1.

(2) Systems utilizing bulkhead window

The bulkhead lens are to comply with F9 in so far its protection against mechanical damage, strength and resistance to fire are concerned. Additionally, the bulkhead window and the parts of the system located in gas safe spaces are to be protected by a steel casing constructed to at least A-0 standard with gas-tight doors. These doors are to be provided with a notice requiring to be kept closed at all times when the system is not in use.

(3) Systems where the measuring instrument is located in gas safe spaces

① Sampling lines passing through bulkhead or deck between gas dangerous and gas safe spaces are to have, as a rule, a maximum inside diameter of 12 mm. If such a diameter needs to be greater, the arrangement is to be specially considered on case by case basis. The relevant pipes are to be heavy steel tube or of other metallic material resistant to sea water corrosion.
② Any pipe passing through bulkhead is to be welded on both sides.
③ Any shaft driving pump passing through bulkhead is to comply with F13.
④ The entire measuring instrument is to be located as close as possible to the bulkhead and the sampling lines are to be kept as short as possible.
⑤ The entire measuring instrument which is directly connected with the sampling lines is to be fitted with a gastight casing.
⑥ The casing is to be fitted with exhaust type mechanical ventilation arranged to the satisfaction of ISC. Provisions are to be made to ventilate the casing prior to putting the system into operation, and a warning notice requiring the use of such a ventilation is to be placed outside the casing.
⑦ The compartment with the instrument containing the oily-water components is to be separated from the compartment containing the electric and electronic components by means of a gastight division.
⑧ Stop valves are to be fitted inside the sampling lines (both suction and return line) in gas safe space as close to the bulkhead penetration as possible. The following notice is to be fitted on the valves: "To be closed when the measuring instrument is not in use." In addition, a water-seal device is to be provided for return line in the gas dangerous space.
⑨ The casing is to be fitted with a system suitable for detecting oily gas. The arrangement of the system is to be to the satisfaction of ISC.
⑩ Whenever the casing is open, the oily-water sampling pumps are to be automatically stopped.
⑪ Oily-water samples taken from gas dangerous spaces are to be returned to these spaces.
⑫ If fitted, the safety valve in the sampling line is to be located in gas dangerous space.
⑬ The system is to be hydrostatically tested with pressure not less than the opening pressure of the safety valve. If safety valve is not arranged, the whole system is to be hydrostatically tested with at least 1.5 times the work pressure of cargo/ballast pump.

6.2.4 Others

6.2.4.1 The accuracy of oil discharge monitoring equipment complying with MEPC.108 (49) is to be tested by manufacturer or organization authorized by the manufacturer every 5 years and verified at IOPP renewal survey. The calibration certificate certifying date of last calibration check is to be kept on board for inspection purposes.
6.2.4.2 The recording device of a control section is to include a digital printer which can be formatted electronically. The recorded parameters are to be explicitly displayed on the printout. The printout is to be legible, remain so once removed from the recording device and be kept for at least three years.

SECTION 3 OIL/WATER INTERFACE DETECTOR

6.3.1 Oil tankers of 150 gross tonnage and above are to be provided with effective oil/water interface detectors approved by the Administration for a rapid and accurate determination of oil/water interface in slop tanks and be available for use in other tanks where the separation of oil and water is effected and from which it is intended to discharge effluent direct to the sea.
6.3.2 The common oil/water interface detectors are potable, and type UTI or MMC is usually used on board ship as shown below:

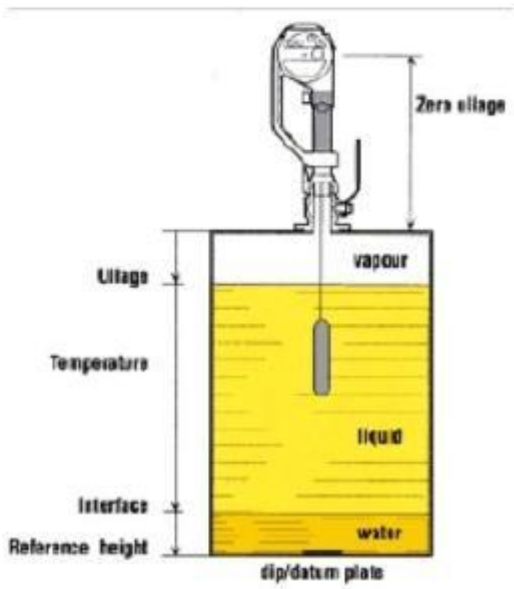


Figure 6.3.2 Schematic diagram

SECTION 4 OILY DISCHARGE CONTROL

6.4.1 Oily water discharge

6.4.1.1 Discharge outside special areas (not including areas specified in International Polar Code)

(1) Any discharge of oil or oily mixture into the sea, except for exceptional cases and compliance of clean and dedicated ballast water with following conditions, is to be prohibited:

① the tanker is not within a special area;

② the tanker is more than 50 nautical miles from the nearest land;
③ the tanker is proceeding en route;
④ the instantaneous oil discharge rate does not exceed 30 litres per nautical mile;
⑤ for oil tankers delivered on or before 31 December 1979, as defined in regulation 1.28.1, Annex I of MARPOL Convention, the total quantity of oil discharged into sea is not to exceed 1/15,000 of the total quantity of the particular cargo to which the residue oil belongs, and for tankers delivered after 31 December 1979, as defined in regulation 1.28.2, Annex I of MARPOL Convention, the total quantity of oil discharged into sea is not to exceed 1/30,000 of the total quantity of the particular cargo to which the residue oil belongs ; and
⑥ the oil discharge monitoring and control system and slop tank meeting the requirements of Annex I of MARPOL Convention are in operation.

6.4.1.2 Discharges in special areas (not including areas specified in International Polar Code)
Any discharge of oil or oily mixture from the cargo area of an oil tanker into the sea, except for discharge of clean or dedicated ballast, is to be prohibited while the oil tanker is in a special area. Nothing in this regulation is to prohibit a ship on a voyage only part of which is in a special area from discharging outside the special area in accordance with above paragraph 1.1.

6.4.1.3 Polar area defined in Polar Code
Any discharge of oil or oily mixture into sea, except for discharge of clean or dedicated ballast, is to be prohibited while the oil tanker is in Arctic waters. Under special conditions, implementation can be approved by the Administration and with reference to paragraph 1.1.3, PART II-A of Polar Code.

6.4.1.4 For oil tankers of less than 150 gross tonnage, oil discharge control under this regulation is to be effected by retention of oil on board ship with subsequent discharge of all contaminated washings to reception facilities. All oil and water used for washing and returned to a storage tank is to be discharged to reception facilities, unless adequate arrangements are made to ensure that any effluent which is allowed to be discharged into the sea is effectively monitored to ensure that the provisions of this regulation are complied with.

6.4.1.5 The oil residues which cannot be discharged into the sea in compliance with the provisions are to be retained on board ship or discharged into reception facilities.

6.4.2 Oil Record Book (Cargo/ballast operation)

6.4.2.1 Every oil tanker of 150 gross tonnage and above is to be provided with an Oil Record Book Part II (Cargo/Ballast Operation). The Oil Record Book Part II, whether as a part of the ship's official logbook or otherwise, is to be in the form specified in Appendix III to MARPOL Annex I. IMO MEPC74 adopted Resolution MEPC.312(74) “Amendments to MARPOL Annexes I, II and V on Using Electronic Record Book”. As of 1 October 2020, electronic record book can be used instead of paper record book according to relevant requirements, and at the same time, requirements of the flag Administration for such documents are to be complied with.

6.4.2.2 Oil Record Book Part II is to be completed on a tank-to-tank basis if appropriate, whenever any of the following cargo/ballast operation takes place in the ship:
(1) loading of cargo oil;
(2) internal transfer of cargo oil during voyage;
(3) unloading of cargo oil;
(4) ballasting of clean ballast tanks of cargo oil tanks;
(5) cleaning of cargo oil tanks, including crude oil washing;
(6) discharge of ballast water, except discharge from dedicated ballast tanks;
(7) discharge of water from slop tanks;
(8) closing of all applicable valves or similar devices after slop tank discharge operation;
(9) closing of valves necessary for isolation of clean ballast tanks from cargo and stripping lines after slop tank discharge operation; and
(10) disposal of residues.

6.4.2.3 For oil tankers with COW equipment, the total quantity of oil and water used for washing

and returned to a storage tank is to be recorded in Oil Record Book Part II.
6.4.2.4 In the event of exceptional cases as is referred to in MARPOL Annex I or in the event of accidental or other exceptional discharge of oil not excepted by exceptional cases, a statement is to be made in the Oil Record Book Part II of the circumstances of, and the reasons for, the discharge.
6.4.2.5 Each operation described in above paragraph 2.2 is to be fully recorded without delay in the Oil Record Book Part II so that all entries in the book appropriate to that operation are completed. Each completed operation is to be signed by the officer or officers in charge of the operation concerned and each completed page is to be signed by the ship master. The entries in the Oil Record Book Part II are to be at least in one of English, French or Spanish. Where entries in an official language of the flag State are used at the same time, this is to prevail in case of dispute or discrepancy.
6.4.2.6 Any failure of the oil discharge monitoring and control system is tol be recorded in Oil Record Book Part II.
6.4.2.7 Oil Record Book Part II is to be kept in such a place as to be readily available for inspection at all reasonable times and, except in case of unmanned ships under tow, be kept on board the ship. It is to be preserved for a period of three years after the last entry has been made.
6.4.2.8 The competent authority of the Party to the Convention may inspect Oil Record Book Part II on board any ship to which this Annex applies while the ship is in its port or offshore terminals, make a copy of any entry in that book, and require the ship master o certify that the copy is a true copy of such entry. Any copy so made which has been certified by the ship master as a true copy of an entry in the ship's Oil Record Book Part II is to be made admissible in any judicial proceedings as evidence of the facts stated in the entry. The inspection of an Oil Record Book Part II and the taking of a certified copy by the competent authority under this paragraph are to be performed as expeditiously as possible without causing the ship to be unduly delayed.
6.4.2.9 If the ship is provided with facilities receiving slops from engine room to slop tank in cargo hold area with special approval, synchronous record is to be made on deck record book and engine room record book during operation.
6.4.2.10 If the ship will sail to Polar Code area, corresponding consideration is to be made to operation in polar area involved in oil record book.

SECTION 5 VAPOR CONTROL SYSTEM

The vapor control system is only required by particular ports, and ISC Rules has given detailed technical requirements. Taking into account that the system will be required by more ports, a brief introduction is made here.

6.5.1 Plan and documents

Plans and documents are to be submitted for approval by ISC and kept on board for inspection of relevant port. Main plan and documents are as follows:
6.5.1.1 Vapor pipe diagram, which is to indicate pipe material specification, size, grade, connection details and accessories.
6.5.1.2 Measurement and overflow system diagram, which is to indicate equipment or instrument manufacturer and type, dangerous zone, position of electrical equipment in gas dangerous spaces and safety certificate of electrical instrument intended for dangerous zones, power supply circuit of alarm system and intrinsically safe equipment circuit.
6.5.1.3 Venting system diagram, which is to indicate data necessary for verifying pressure/vacuum valve venting capacity.
6.5.1.4 Pressure drop calculation, in comparison with cargo transfer rate and pressure drop between farthest cargo hold and vapor connector (including possible hose).

6.5.1.5 To calculate time between alarm setting and overflow at maximum loading speed of each cargo hold.
6.5.1.6 Operation manual.

6.5.2 Requirements

6.5.2.1 The arrangement of vapor control system is not to interfere with proper operation of the cargo tank venting system and effective isolation with IGS system which may be realized by valve setting. A draining and recovery device is to be fitted for vapor control system. If a tanker carries several incompatible cargoes, vapor control system is to be separated correspondingly.
6.5.2.2 Shore connection is to be as close to the side area of loading station as possible, where a manual quick-close valve is to be installed. The shore connection flange is to comply with the requirements of standard ANSI B16.5 Class 150, and be fitted with a protruding stud (diameter 12.7mm, length not less than 25.4mm) for good alignment with steam hose, correspondingly, a round hole 16mm in diameter is provided at vapor hose flange. Vapor hoses are to be installed with hose bracket to prevent twist and squash of hose. Each vapor manifold is to be painted on the pipe 1m in front of external connection flange and its exterior surfaces with red/yellow/red. The red bands are 100 mm wide, and the yellow in the center is 800mm wide and labeled “VAPOUR” in black letters at least 50 mm high. Each hose is comply with following technical requirements:
(1) a maximum work pressure of at least 0.035 MPa;
(2) the capacity of withstanding at least 0.014 MPa vacuum without collapsing or constricting;
(3) burst pressure not less than 0.175MPa;
(4) with electrical continuity and maximum resistance of 10kΩ;
(5) resistance to abrasion and kinking.
6.5.2.3 The closed gauging arrangement is to be fitted in the cargo tank, if the portable gauging system is used, the quantity is to meet the needs of all cargo tanks with simultaneous loading and unloading and two extra spares.
6.5.2.4 The high level alarm system and overfill alarm system are to be fitted in cargo tanks, which are to be capable of giving audible and visual alarm indications at the cargo control station, and the overfill alarm system is to provide corresponding alarm points at the cargo deck area.

SECTION 6 STABILITY INSTRUMENTS

6.6.1 IMO MEPC66 adopted Amendments to MARPOL Annex I on mandatory provision of stability instruments for oil tanker (Resolution MEPC.248(66)), which took effect on 1 January 2016.

6.6.2 Main contents
6.6.2.1 All oil tankers are to be provided with stability instruments which can check intact stability and damage stability. The stability instruments are to comply with relevant performance standards, i.e. Chapter 4, Part B of 2008 International Intact Stability Code, Section 4 of Annex of Revised MSC.1/Circ.1229 “Guidance Notes on Approval of Stability Instruments” and Part 1 of MSC.1/Circ.1461 “Guidance Notes on Verifying Requirements for Damage Stability of Cargo Tanker”, and be approved by the Administration.

6.6.3 Implementation date
6.6.3.1 Oil tankers constructed before 1 January 2016 are to comply with the requirements at first planned renewal survey on or after 1 January 2016, but not later than 1 January 2021.
6.6.3.2 Despite of the requirements mentioned in above paragraph 6.6.1.1, the stability instruments which have already been installed on the oil tanker constructed before 1 January 2016 need not be

replaced provided that the Administration confirms that the stability instruments can check intact stability and damage stability.

6.6.3.3 The Administration is to issue approval documents for stability instruments of all ships.

6.6.4 Ships complying with following conditions can be exempted from installation of stability instruments.

6.6.4.1 Special-purpose ships, which have limited loading quantity so that all anticipated loading conditions are included in approved stability information which is provided to the ship master.

6.6.4.2 Ships whose stability is verified by remote method approved by the Administration.

6.6.4.3 Ships which carry out loading within the range of approved loading condition.

6.6.4.4 Oil tankers which are constructed before 1 January 2016 and have approved limit KG/GM curve covering all applicable intact stability and damage stability requirements.

6.6.4.5 Oil tanker exemption conditions are to be recorded in Annex of IOPP Certificate as revised by above amendments.

6.6.5 Implementation

6.6.5.1 Damage stability instruments with ISC class are to be inspected according to the requirements of Appendixes 1 and 2, Chapter 2, PART TWO of ISC Rules for Seagoing Steel Ships.

CHAPTER 7 ADDITIONAL REQUIREMENTS RELATED TO OIL TANKERS

SECTION 1 REQUIREMENTS FOR STEERING GEAR

7.1.1 For every oil tanker of 10,000 gross tonnage and above, the main steering gear is to be composed of two or more identical power units complying with the provisions of SOLAS Convention. Following requirements are to be complied with:

7.1.1.1 The main steering gear is to be so arranged that when any part of a power execution system of main steering gear (except for tiller, quadrant or parts of same purpose) has single failure, or when the steering capacity is lost because the rudder actuator is jammed, steering capacity is to be recovered within 45s after a power execution system is failed.

7.1.1.2 The main steering gear is to include:

(1) Two independent and separate power execution systems, each system is to meet the requirements of putting the rudder over from 35°on one side to 30°on another side when the ship is under deepest sailing draught and at maximum service speed, and putting the rudder over from 35°on one side to 30°on another side within 28s under same condition; or

(2) At least two identical power execution systems are to meet the requirements of putting the rudder over from 35°on one side to 30°on another side when the ship is under deepest sailing draught and at maximum service speed, and putting the rudder over from 35°on one side to 30°on another side within 28s under same condition. If it is required to comply with the requirements, the hydraulic power execution system is to be provided with cross link. Liquid loss in the system is to be found and the defective system is to be separated automatically so that other one or more execution system can keep in full operation.

7.1.1.3 Steering gear other than hydraulic type is to reach equivalent standard.

(1) For oil tankers of 10000 gross tonnage and above but less than 100000 DWT, if equivalent safety standards can be reached, solutions other than those mentioned above are allowed, i.e. single failure criteria is not necessary for one or more rudder actuators, and

① If steering capacity is lost due to single failure of piping system or any part of a power equipment, it is to be recovered within 45s; and

② If the steering gear only includes single rudder actuator, special attention is to be paid that stress analysis including fatigue analysis and fracture mechanics analysis (if applicable) is to be carried out for the requirements of the material used in the design, installation of sealing device, test check and effective maintenance.

SECTION 2 EMERGENCY TOWING ARRANGEMENTS

7.2.1 According to the provisions of SOLAS Reg.II-1/3.4.1 and 3.4.2, ships of 500 gross tonnage and above are to be provided with a copy of emergency towing procedure for emergency condition. For details of the procedure, refer to Guidelines for Owners/Operators on Preparing Emergency Towing Procedures (MSC.1//Circ.1255).

7.2.2 An emergency towing arrangement is to be fitted at both ends on board oil tankers of not less than 20,000 tonnes deadweight as shown below. For oil tankers the keels of which are laid before 1 July 2002, the design and construction of emergency towing arrangements are to comply with Revised Guidelines for Emergency Towing Arrangements on Tankers adopted by Resolution MSC.35(63).

7.2.3 For oil tankers the keels of which are laid on or after 1 July 2002, the arrangements are to be always capable of being quickly expanded and easily connected with tug when the main power of towed vessel fails. At least one set of emergency towing arrangement is to be preset to standby state for quick expansion. Emergency towing arrangements at both ends are to have enough strength, and ship size and deadweight as well as anticipated force action under severe weather conditions are to be taken into account. For oil tanker, bow emergency towing arrangements fitted at fore are usually used as bow single point mooring.

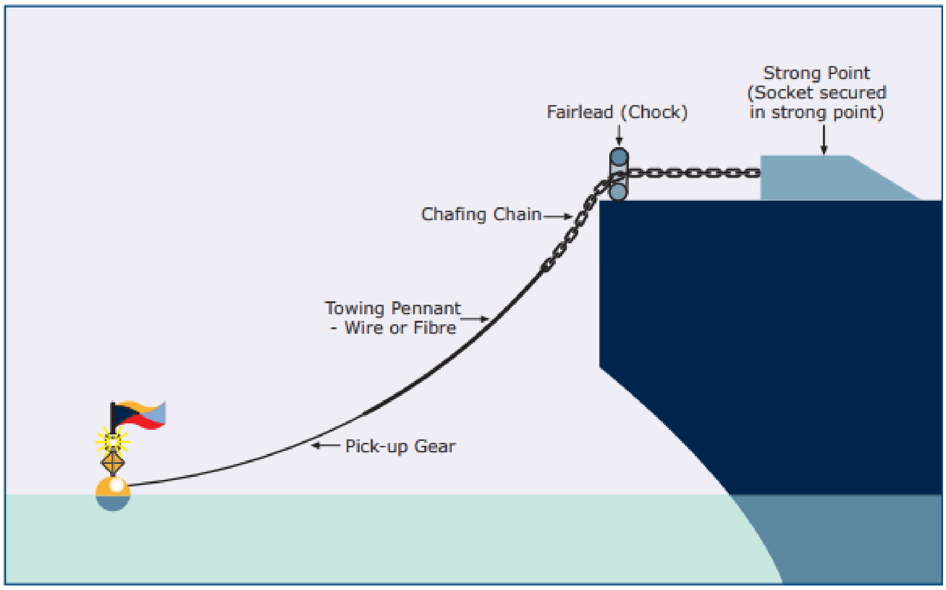


Figure 7.2.1(1) Typical composition of stern emergency towing arrangements

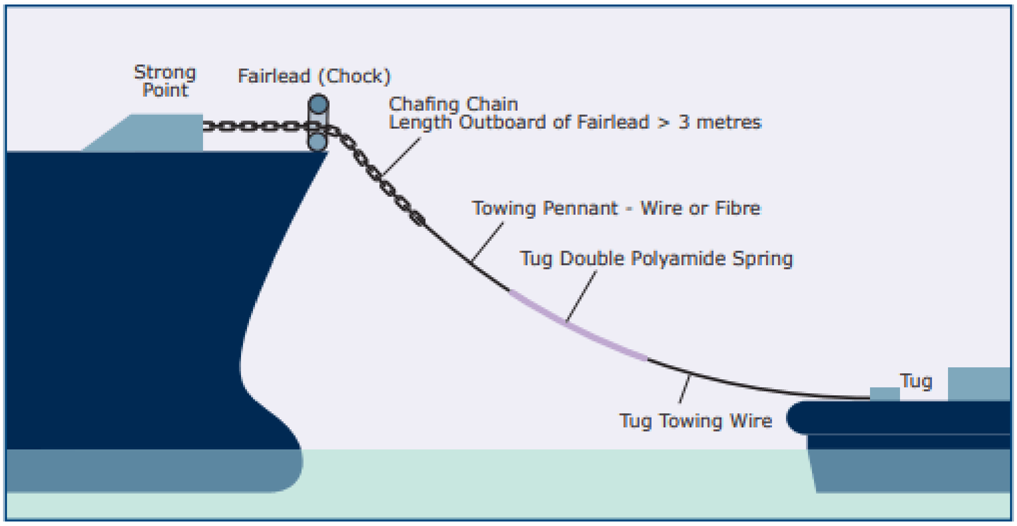


Figure 7.2.1(2) Typical composition of bow emergency towing arrangements

7.2.4 The pick-up gear of stern emergency towing arrangement is for the convenience of picking up the short towing rope of tug.

7.2.5 Requirements for components of towing arrangements by ISC Rules for Seagoing Steel Ships are shown as follows:

Requirements for Major Components Table 7.2.5(1)

Major components	Location		Strength requirements
Major components	Forward of ship	Aft of ship	
Pick-up gear	Optional	Yes	/
Towing pennant	Optional	Yes	Yes
Chafing gear	Yes	Depending on design	Yes
Fairlead	Yes	Yes	Yes
Strongpoint	Yes	Yes	Yes
Roller pedestal	Yes	Depending on design	/

Safe Work Load of Components **Table 7.2.5(2)**

Deadweight of ship (t)	Safe work load (KN)
20,000 to 50,000	1000
≥50,000	2000

7.2.6 During survey in service of oil tanker, the components of emergency towing arrangements are to be inspected according to ship design drawings to confirm that the components are consistent with the drawings and maintained effectively. The reinforced sides of emergency towing arrangements and their reinforced members under deck are to be inspected and kept in good condition without serious corrosion or excessive surface defects.

SECTION 3 OBSERVATION HOLE ON BALLAST TANK COVER OF OIL TANKER

7.3.1 In accordance with the requirements of oil companies, observation holes are to be fitted on the manhole cover of ballast tank of oil tanker. From technical angle of observation holes, they are not to destroy the strength and watertight integrity of manhole covers. No specific provisions have been made in ISC rules, and the actual design is generally based on CB/T 3981-2008 Ballast Tank Manhole Cover with Inspection Holes. The specific parameters of the observation holes which were fitted on the manhole cover with coaming are as follows:

Example of standard specific parameter—stud fixed type (in mm) Table 7.3.1.1

Nominal diameter	Inner diameter of hole	Inner diameter of cover groove	Outer diameter of cover	Thickness of cover	Height of coaming	Thickness of coaming	Diameter of stud	Number of stud	Locking means
250	230	300	350	As manhole cover	20	--	M16	8	Center spiral, locking downward

Example of standard specific parameter—clip swivel type (in mm) Table 7.3.1.2

Nominal diameter	Inner diameter of hole	Inner diameter of cover groove	Outer diameter of cover	Thickness of cover	Height of coaming	Thickness of coaming	Diameter of stud	Number of stud	Locking means
250	230	320	--	As manhole cover	100	As manhole cover	M16	3	Center spiral, locking downward

SECTION 4 OTHERS

7.4.1 For oil tankers the keels of which were laid on or after 1 October 1994, the flammable gas is to be capable of being detected in the dedicated ballast tanks within double hull of cargo area. The means of detection can be fixed flammable gas detection system installed in dedicated ballast tank or portable flammable gas detector which is capable of being used in wet environments.

7.4.2 According to the requirements of SOLAS Reg.II-2/4, oil tankers are to be equipped with at least one portable instrument for measuring oxygen and one for measuring flammable vapor concentrations, together with a sufficient set of spares. Suitable means are to be provided for the calibration of such instruments.

7.4.3 Taking into account the gas risk of cargo area, the self-igniting light of lifebuoy in cargo area is to be battery type as required by SOLAS, and aluminum gangway is to avoid direct connection with the hull.

CHAPTER 8 BRIEF INTRODUCTION OF OIL COMPANY INSPECTION

8.1 Brief introduction of the major oil companies' inspection

8.1.1 At present, OCIMF (The Oil Companies International Marine Forum) has 108 members worldwide to carry out audit and check system for chartered ships or third party tankers which will carry company's cargo or lay alongside company's dock or carry cargo of interest to the company (bulk oil tanker, shuttle tanker, chemical tanker and liquefied gas carrier), except for individual members, check objects include two parts, i.e. tanker management company and ship.

8.1.2 For tanker management company, the Tanker Vessel Management and Self-Assessment is adopted, and TMSA3 of 2017 version is used at present.

8.1.3 Unified ship inspection system SIRE (Ship Inspection Report Exchange) Programme is adopted, and the inspector carries out inspection through Vessel Inspection Questionnaires, and at present, VIQ7 of February 2019 is used.

8.1.4 Check standards and contents include:

8.1.4.1 Management of ship company;

8.1.4.2 Ship design and construction;

8.1.4.3 Ship construction and equipment

8.1.4.4 Crew qualification;

8.1.4.5 Ship management and maintenance;

8.1.4.6 Class and statutory documents and certificates.

8.1.5 Personnel carrying out audit and inspection can be auditors of each petroleum company, or professional third party inspection organization. The inspectors are usually ship masters and chief engineers with rich experience in navigation, who have got the qualification of inspector after professional training and examination and evaluation of senior inspector.

8.1.6 The petroleum company adopts the concept of BPG (Best Practice Guidance) for inspection. Any industrial standards or guidelines and recommendations are adopted by the petroleum company and required to be implemented by the inspected company and ship, therefore, there is no mandatory standard or suggestion, as long as deviation between those found during audit and best practice, they are called observation, and those involving fire and explosion protection, safety of life or pollution prevention are highly possible as high risk items, typically such as explosionproof lamp shade, if one screw is not fastened, it is highly likely that this inspection will not succeed.

8.1.7 Inspection by petroleum companies mainly has three characteristics:

- Wide range—about 50 conventions and oil tanker special publications.
- High standard—USCG Code and COSWP, etc. exceeding the requirements of conventions or guidelines are to be observed.
- Strict requirements—OCIMF has its own serial publications with fast updating, e.g. oil tanker inspection questionnaire has changed 6 versions from 1993 to current VIQ7.

8.1.8 The latest survey status provided by ISC is to be capable of being downloaded from ISC website by ship company within 15 days since the date of SIRE inspection.

8.2 For survey of ships in service, in addition to conventions and codes, main publications are based on:

8.2.1 International Safety Guidelines for Oil Tankers and Petroleum Terminals (ISGOTT 5th version)

8.2.2 Oil tanker inspection questionnaire 7th version (VIQ7)

8.2.3 USCG Code (latest version)

8.2.4 ISC 2019 Guidelines for Ship-to-ship Lighterage

8.2.5 OCIMF Guidelines for Mooring Equipment (4th version) (MEG4)

8.2.6 OCIMF Guidelines for Effective Mooring (4th version) (EM4)

8.2.7 2017 Code of Safe Practice for Merchant Ship Seafarer (COSWP)

8.2.8 ISC 2019 Guidance Notes for Documents of Compliance for Issuing OCIMF Recommendations for Oil Tanker and Chemical Tanker Manifold and Relevant Equipment.

8.3 Main contents of survey in service to be carried out by petroleum company inspection
8.3.1 Maritime security
8.3.1.1 Whether the ship is provided with enhanced anti-piracy arrangement (harden vessel).
8.3.1.2 Whether the company and ship are provided with cyber security system documents.
8.3.2 Pollution prevention or safety protection equipment on board oil tanker are generally of double set or double way.
8.3.2.1 Requirements for double way
(1) All oil (including fuel oil) outlet valves are to be installed with blind plates with same thickness as flange.
(2) Stop valves are provided in the middle of pressure gauge at manifold and sampling pipe at lower part respectively, and header (or pipe cap) is to be provided at port.
(3) Portable washing machines on fuel oil/washing pipelines are to have cover.
(4) Blind arrangements are to be provided in front of ODME outlet and in blind state when oily sewage is not discharged.
8.3.2.2 Requirements for double set
(1) Pump room ventilation of single form is to be provided with spare motor.
(2) If emergency generator starts with only one energy source, spare motor is to be provided.
(3) Two sets of portable instruments to measure oxygen/flammable gas/H_2S/CO respectively, extraction pump and sampling pipe suitable for cabin depth, two sets of anoxic detonator (applicable to IGS ship) and at least two sets of personal (e.g. pocket type) four-in-one detector are to be provided. Above equipment are to be calibrated and inspected regularly according to the requirements of the manufacturer.
8.3.3 Ship maneuverability chart
8.3.3.1 Oil tankers of which the length between perpendiculars is more than 100m as well as chemical and gas carriers are to be provided with ship maneuverability chart, and except for items which are not applicable, all data on the chart are to be filled in.
8.3.4 Visual inspection holes of ballast tank with height less than 600mm are to be kept watertight. Type A or type B can be selected with reference to ship industry standard CB/T 3981-2008 Ballast Tank Manhole Cover with Inspection Hole and at shipowner's option.
8.3.5 When the protective cover of explosionproof intercom antenna is damaged, it must be replaced.
8.3.6 Loading instrument
8.3.6.1 During annual survey, the surveyor is to ask the chief officer or pilot in charge of cargo operation to input several hold data at random on site, then turn out status display results and compare with standard values in Loading Manual. The error value is to be within acceptable tolerance band. For details, refer to following table:

Error value of Loading Instrument Testing Table 8.3.6.1

Calculation item	Tolerance (percentage of approved value)
Still water shear force (SWSF)	±5%
Still water bending moment (SWBM)	±5%
Still water torsional moment (SWTM)	±5%

8.3.7 Oil pipelines are to be subject to a test under 100% nominal work pressure at least every year. Within any five year period, the oil system is to be subject to two tests under 1.5 times work pressure.
8.3.8 All lifting parts of more than one ton are to have annual testing record, and SWL mark on board ship is to be treated according to following principle.
8.3.8.1 For statutory equipment (e.g. emergency towing arrangements ETA and associated attachments—bollard and chock), kN must be used. If the unit of identification of relevant

equipment of real ship is not international standard unit and t or T is used, two unit values of corresponding kN and ton (t or T) are to be marked at the same time in Emergency Towing Manual.

8.3.8.2 For non-statutory equipment such as deck winch and food crane, random selection can be made from ton (t or T) and kN, and capital form can be used for the sake of beauty.

8.3.9 FPD device is not to be used during navigation at sea.

8.3.10 The ends of lifeboat, lifting equipment and main bearing wire of gangway are not to use U type bolt bulldog grips for fastening, and only permanent terminations or wedge sockets are allowed.

8.3.11 The self-igniting buoy light on ship buoy is to be of battery type (not seawater battery type), and the self-igniting light in cargo area is to be of explosionproof or intrinsically safe type.

8.3.12 The pointer indicating minimum breaking force of 60%~80% of mooring rope is to be provided on the brake lever on the winch. The arrangement and provision of mooring rope is to coincide with Mooring System Management (MSMP) on board ship.

8.3.13 Any memo or condition in ship certificate will be transferred to oil company inspection report. Where condition permits, early coordination or reminding the shipowner to eliminate is to be made, e.g. requirements for initial compliance inspection for COW.

8.3.14 Paints and chemicals (such as furnace medicine) used on board ship must have MSDS and translation of working language.

8.3.15 If liquid flange joints are above switchboard, spill shield is to be provided.

8.3.16 Any equipment damage, water leakage as well as temporary wrapping and all soft patches on board ship, such as epoxy resin or cement box are to be treated as observations, even if they are not key equipment.

8.3.17 Functional test is to be carried out to cargo control computers or other similar electronic devices, especially pressure sensors within cargo hold and venting system belonging to SOLAS Convention and IBC Code, observation must be made if abnormality is found.

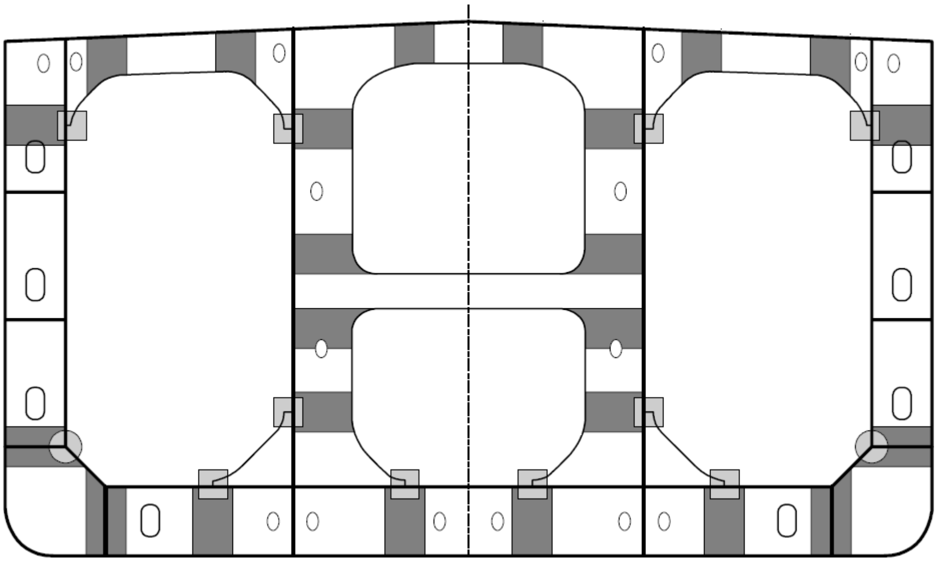
8.3.18 Portable gangway also belongs to statutory inspection item, and service inspection is to check whether there are marks for maximum load and allowable angle.

8.3.19 If the designated smoking room has openings towards open deck, such openings are to be closed or parts are to be so fastened that the openings cannot be opened manually.

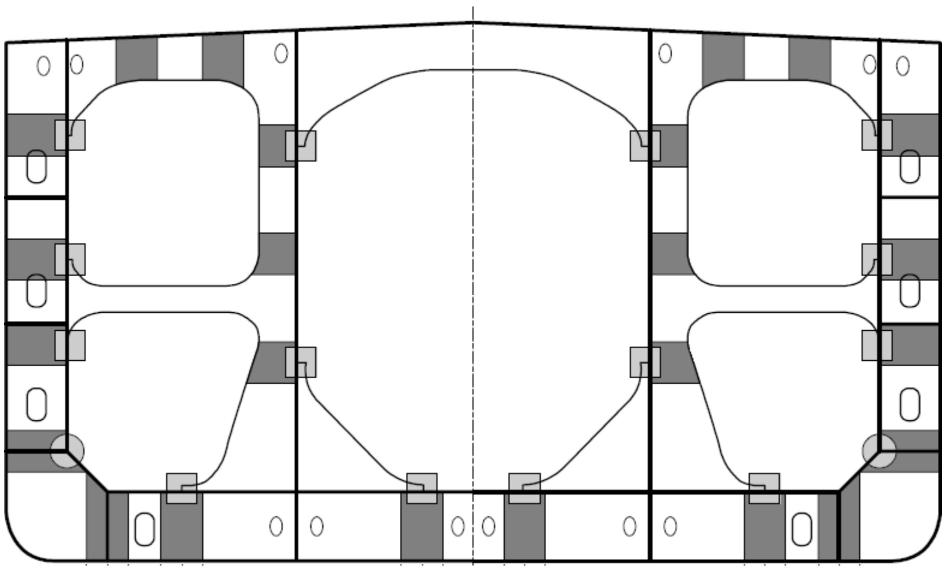
APPENDIX

APPENDIX: INSPECTIONS OF KEY STRUCTURAL AREAS

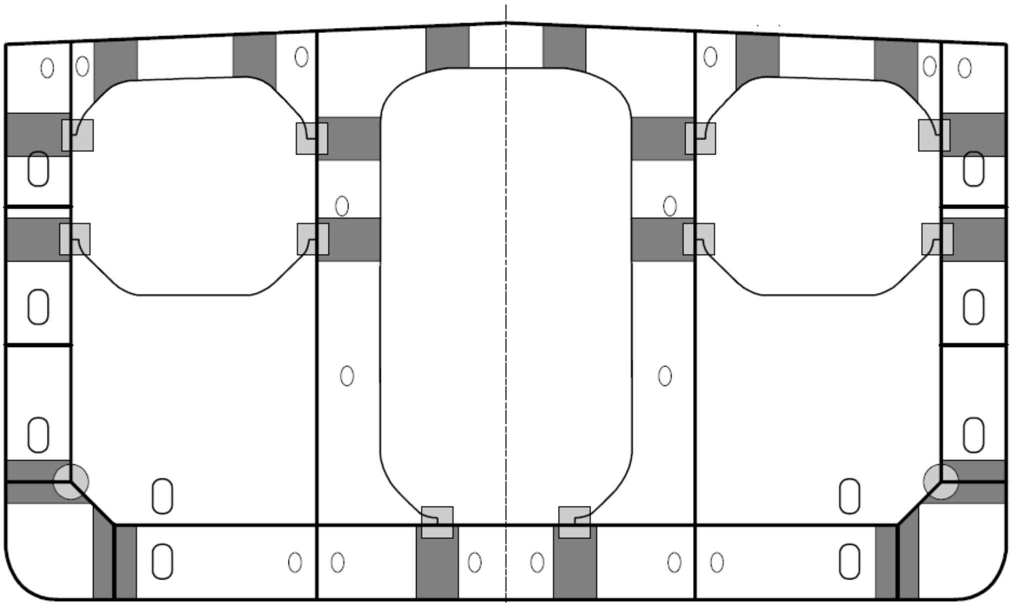
1. **According to CSR Rules, for oil tankers with two longitudinal bulkheads, if horizontal braces are provided in the middle cargo hold, high stress parts of strong frame are as follows:**



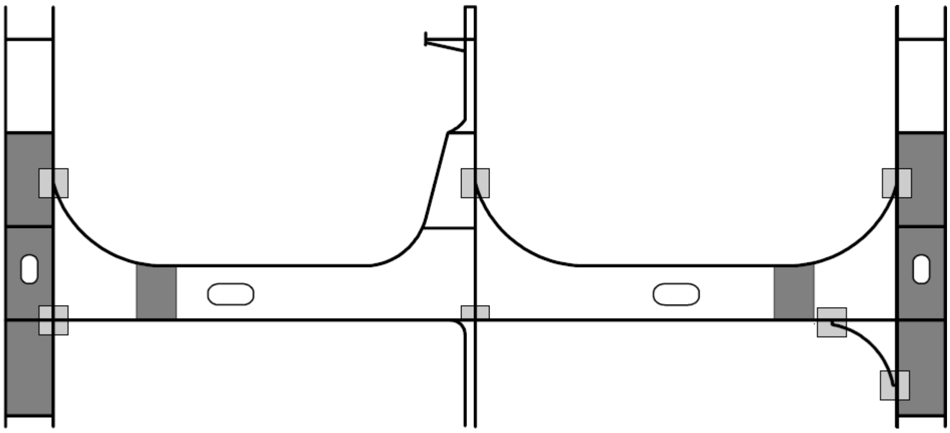
2. **According to CSR Rules, for oil tankers with two longitudinal bulkheads, if horizontal braces are provided in the side cargo hold, high stress parts of strong frame are as follows:**

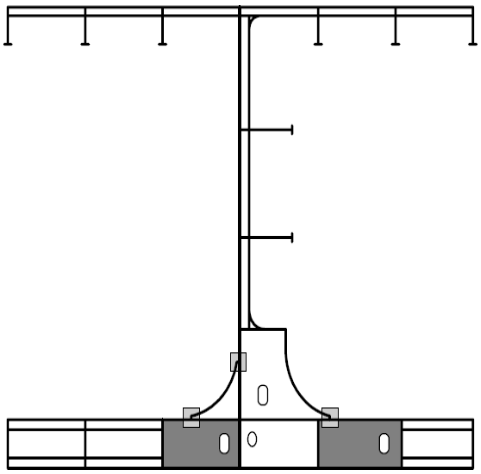


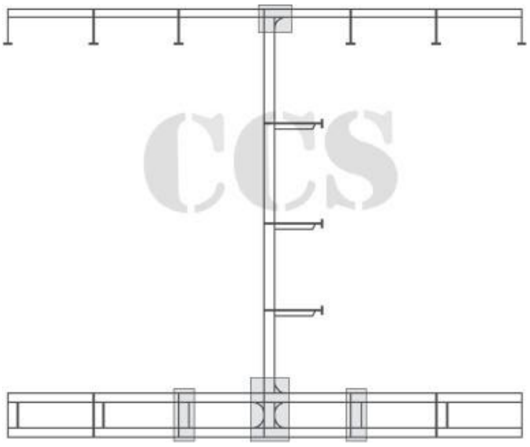
3. **According to CSR Rules, for oil tankers with two longitudinal bulkheads, high stress parts of swash bulkhead are as follows:**

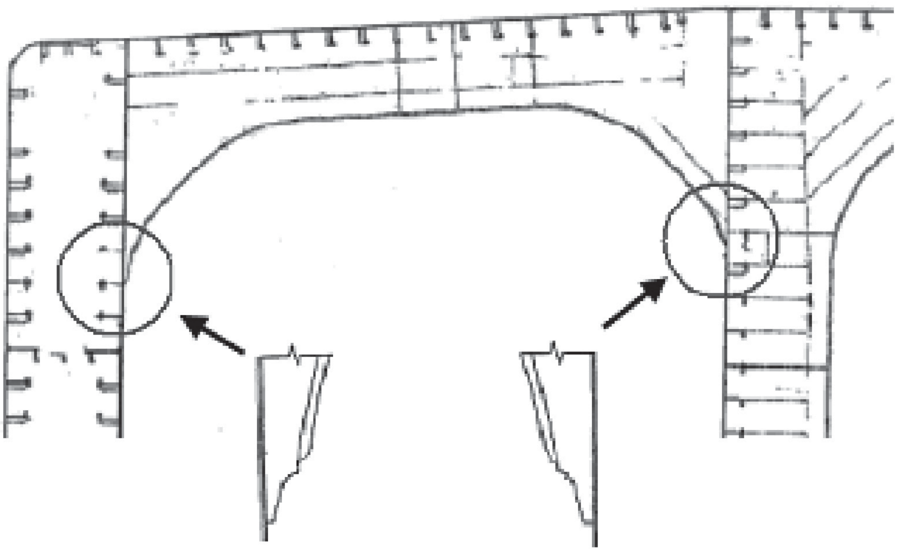


4. **According to CSR Rules, high stress parts of horizontal girder and vertical girder are as follows:**

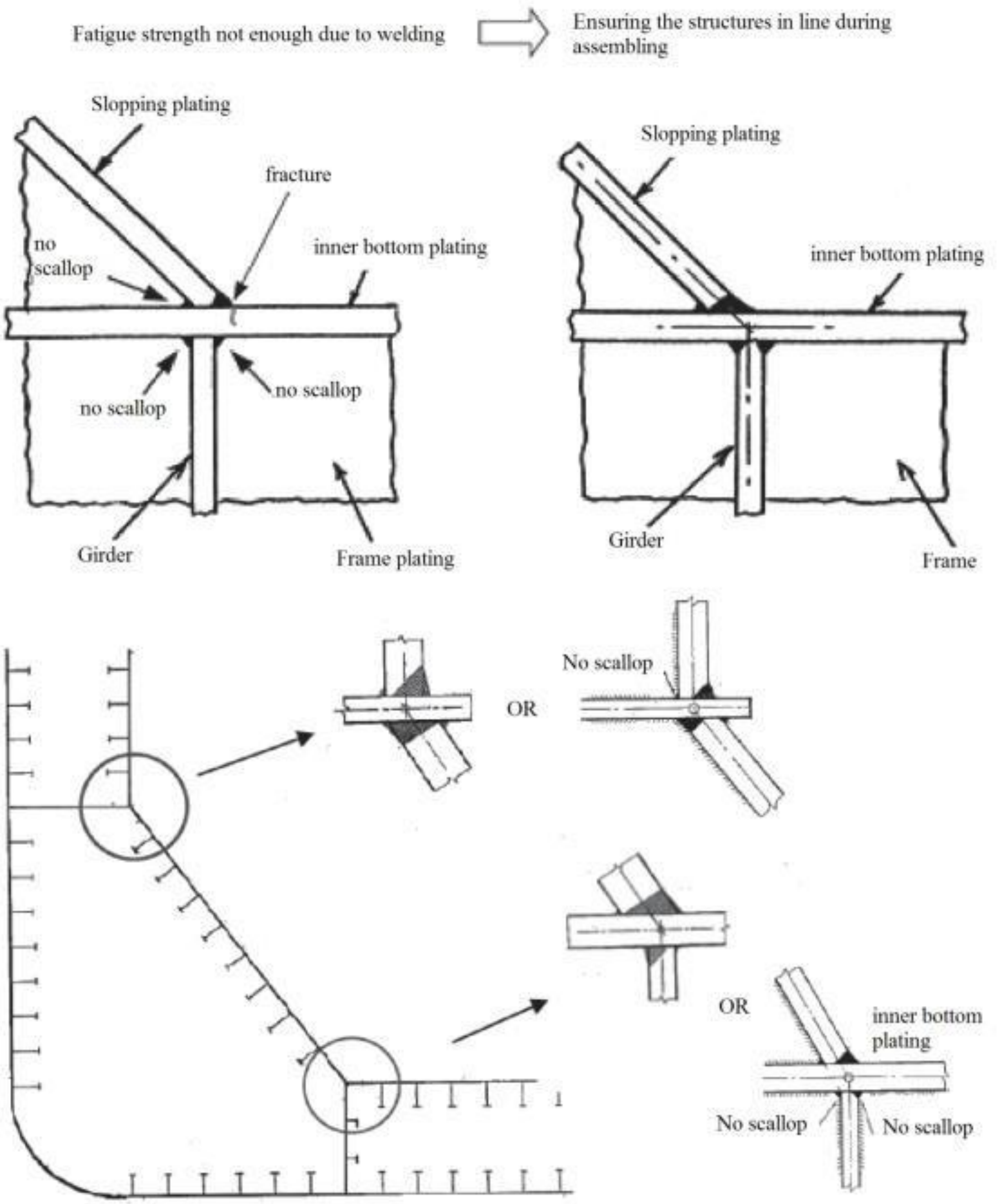




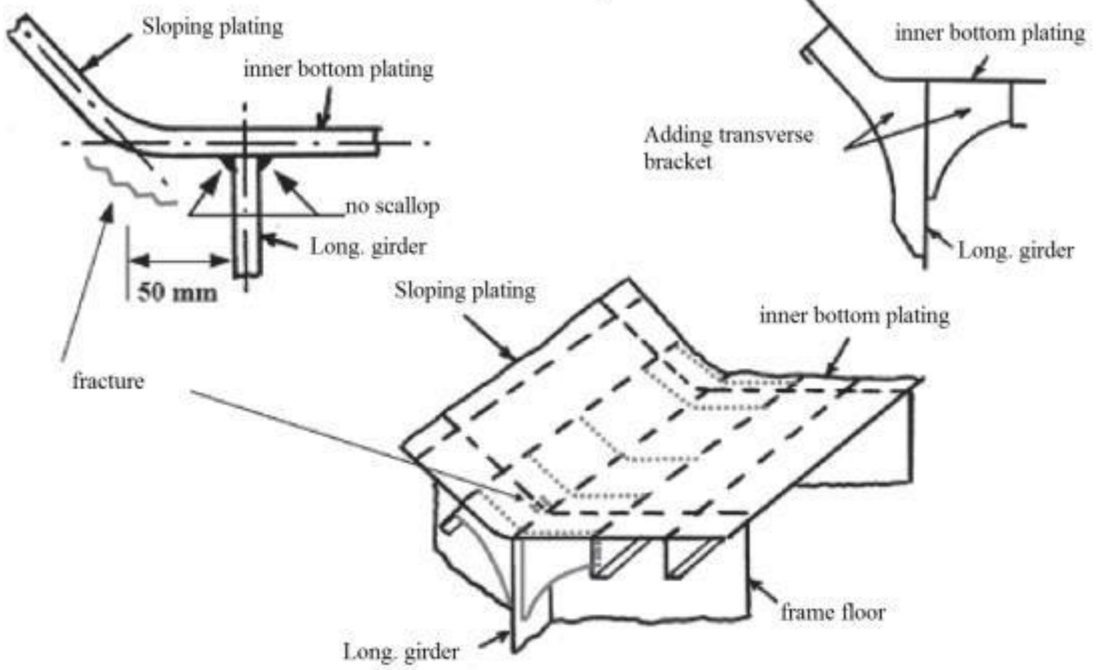


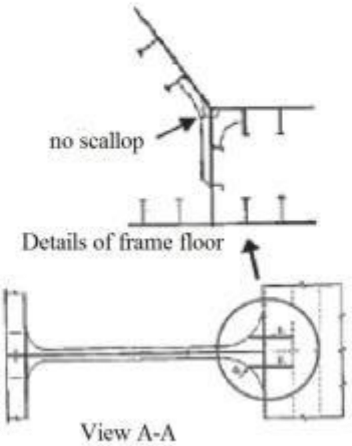


5 Key structural areas of double bottom structures of slop tanks(with special attention to inspection of not-in-line area)

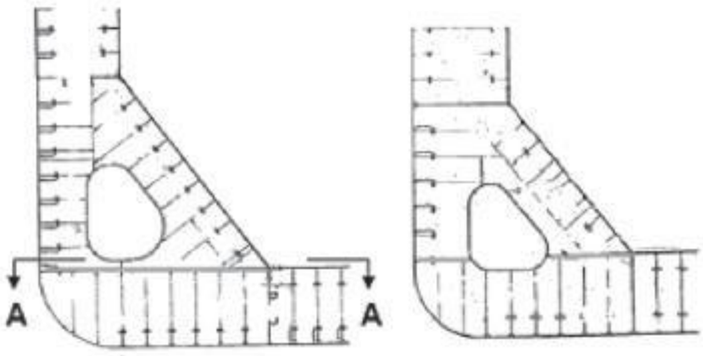

Fatigue strength not enough due to welding
Ensuring the structures in line during assembling
Slopping plating
fracture
no scallop
inner bottom plating
no scallop
no scallop
Girder
Frame plating
Slopping plating
inner bottom plating
Girder
Frame
OR
No scallop
OR
inner bottom plating
No scallop
No scallop

Lower hopper tank sloping plating defect at knuckle ⇨ Means be taken to lessening the defects

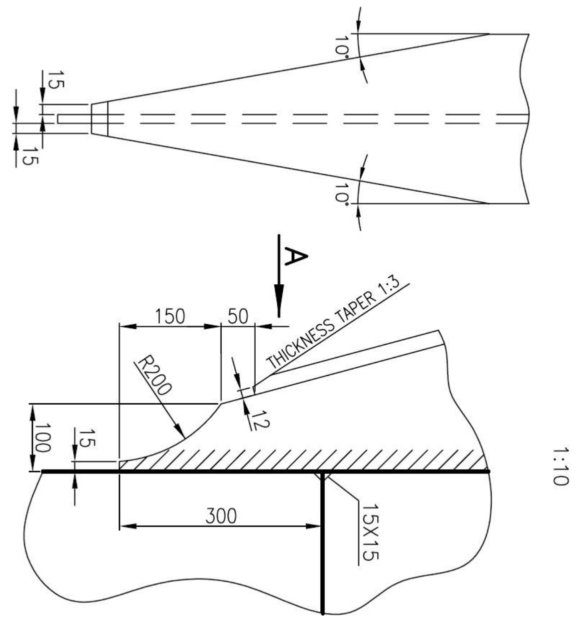


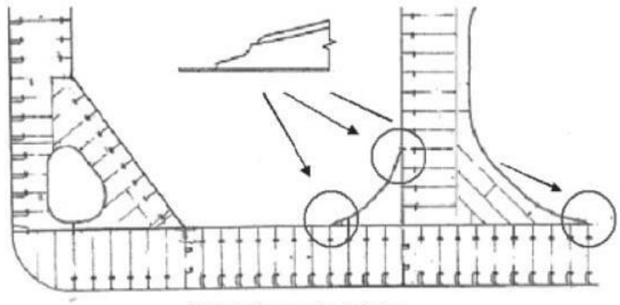


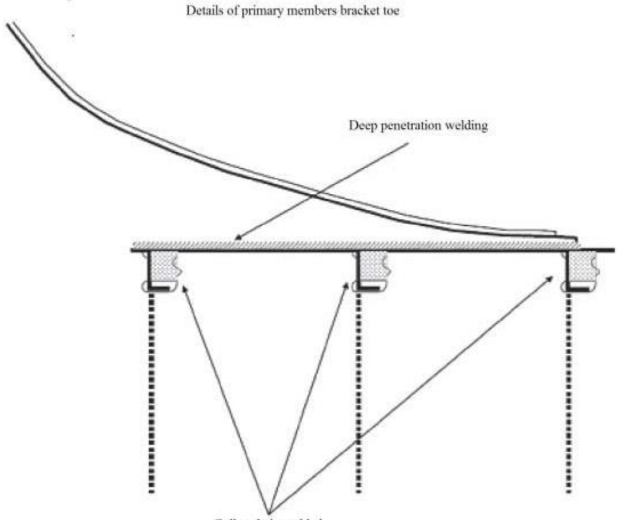
View A-A

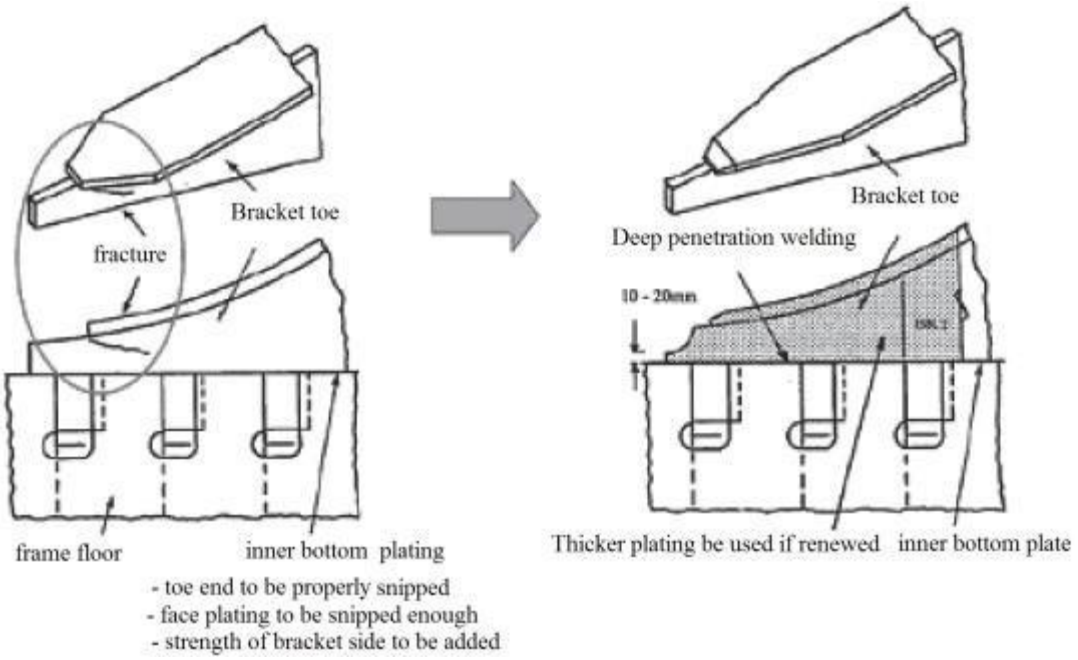


Inner bottom designed on the left drawing is better than the right one

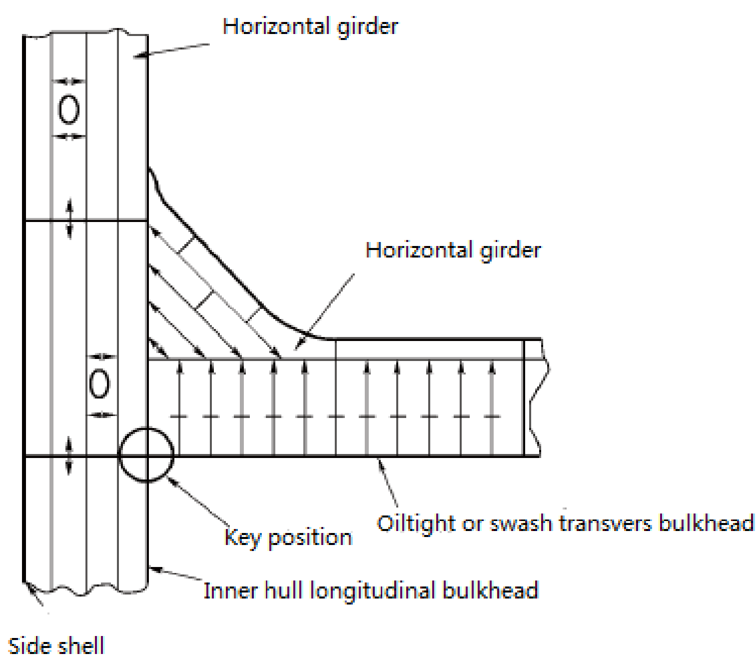


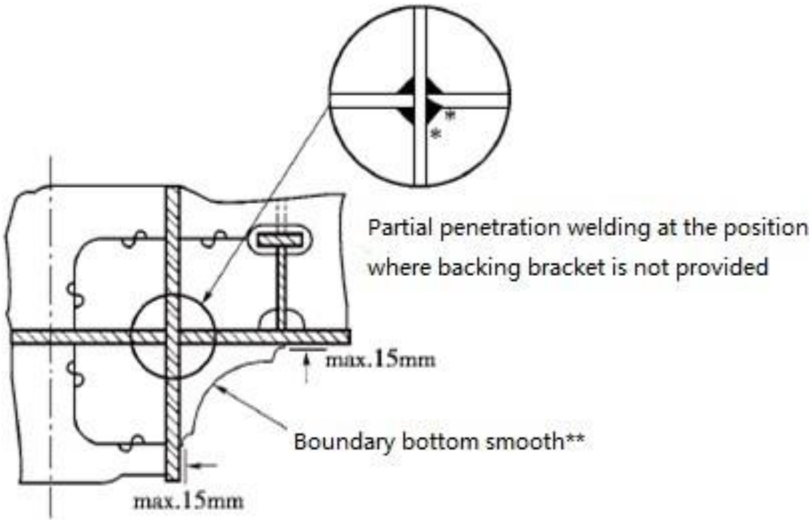

Details of primary members bracket toe





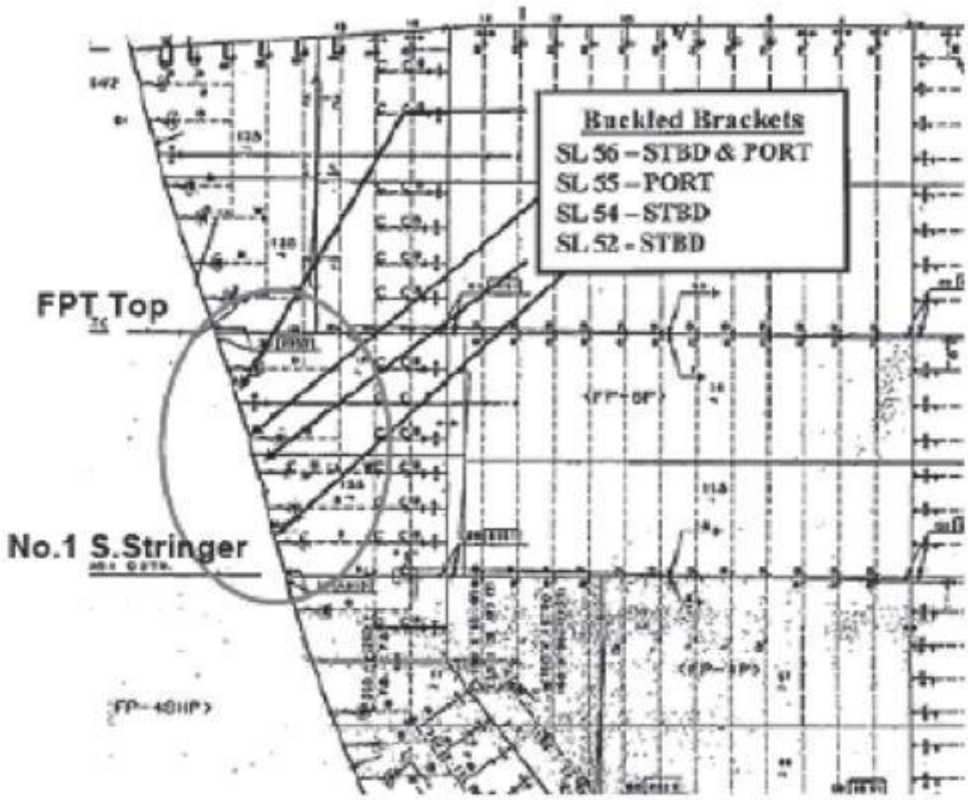
6. **Key structural areas at connection of horizontal girder of transverse bulkhead and inner shell**

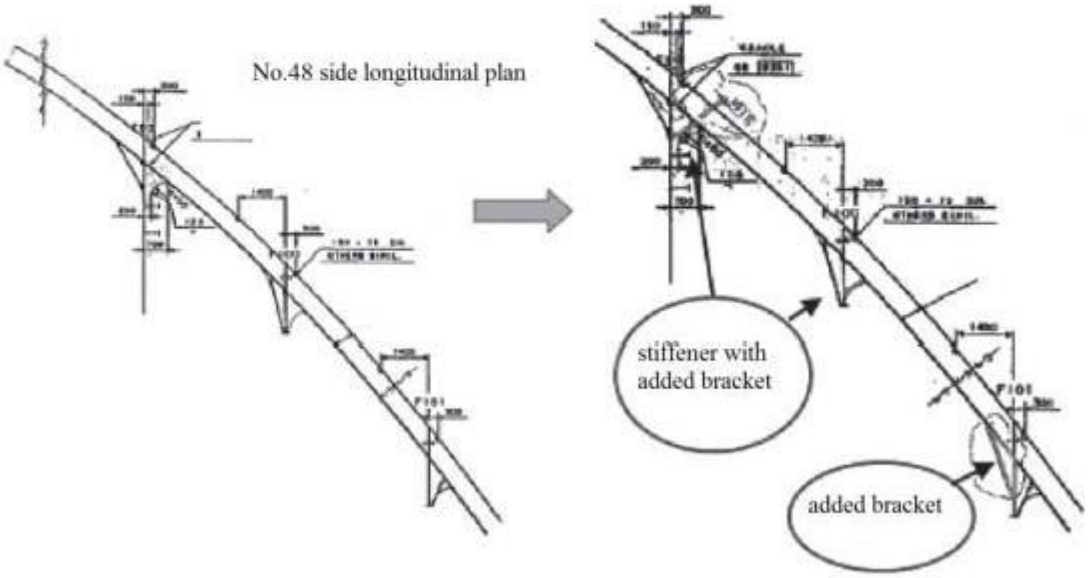


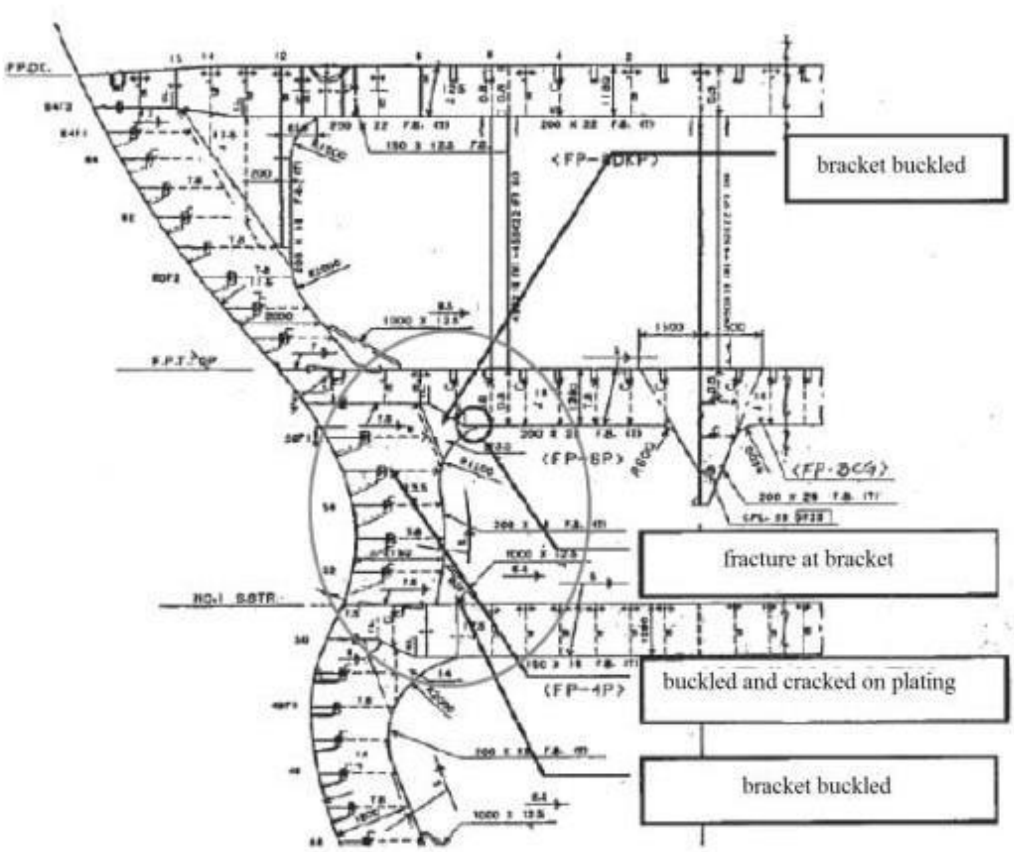


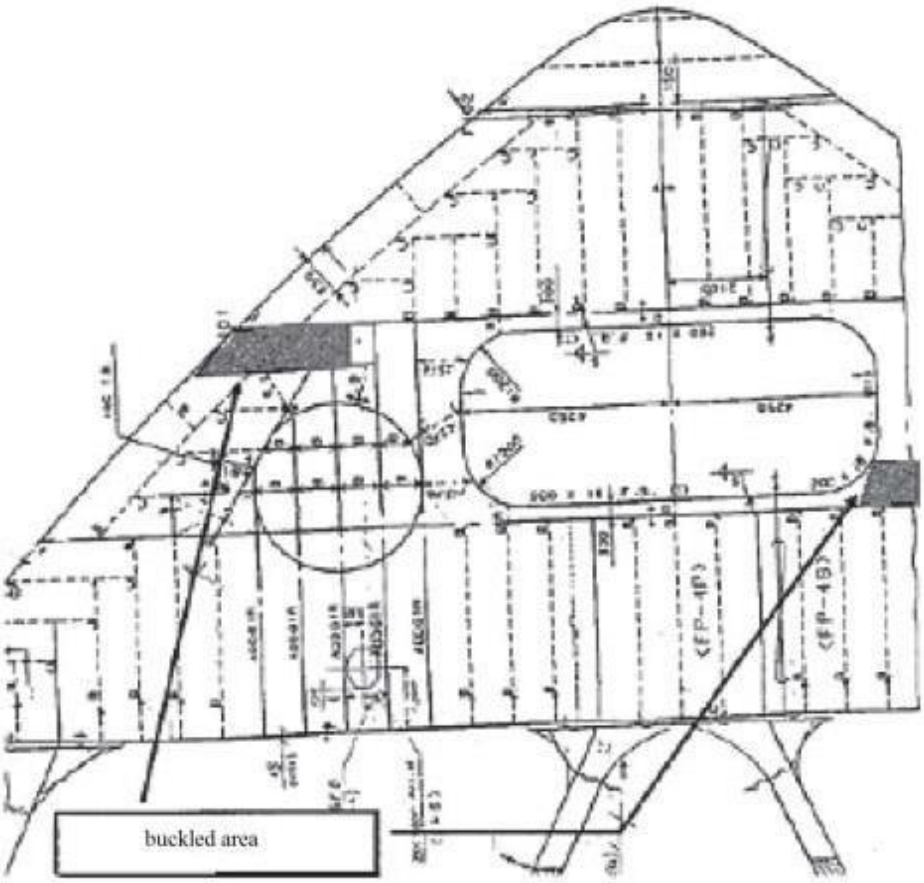
Notes: * The weld toes are grounded smoothly, and notches at which bracket is not provided are to be removed.
** For the position where face plate must be installed, it is suggested to use certain design method to reduce stress concentration at face plate end (e.g. bevel and soft nose).

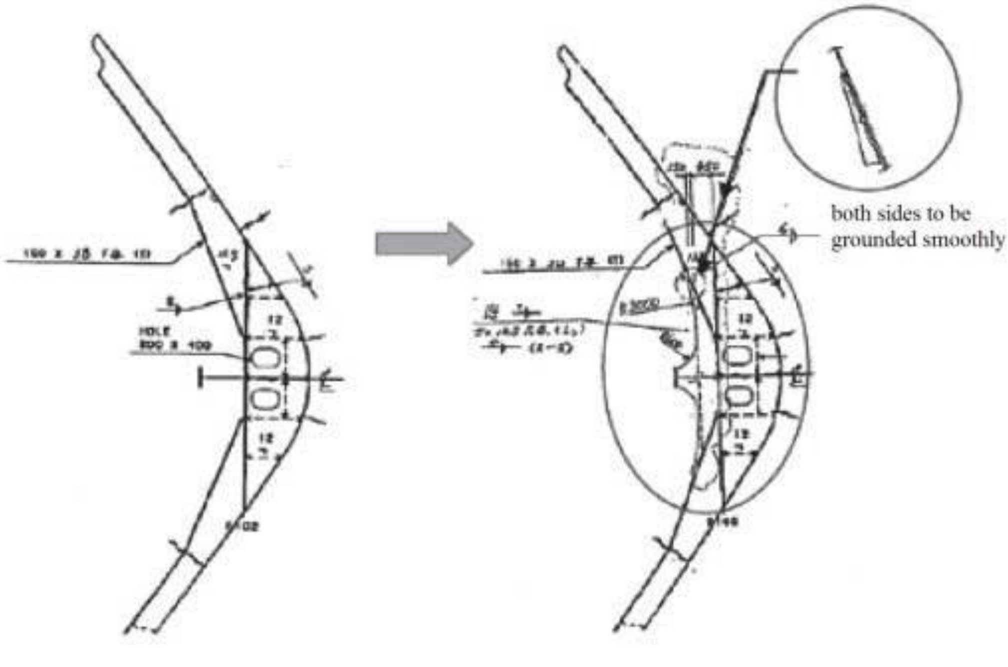
7. **Key structural area of bow structure (Above lightload waterline to freeboard deck)**


Buckled Brackets
SL 56 – STBD & PORT
SL 55 – PORT
SL 54 – STBD
SL 52 – STBD
FPT Top
No.1 S.Stringer


No.48 side longitudinal plan
stiffener with added bracket
added bracket


bracket buckled
fracture at bracket
buckled and cracked on plating
bracket buckled


buckled area


both sides to be grounded smoothly