Guidance Manual for Tanker Structures

Consolidated Edition 2022

Tanker Structure Co-operative Forum

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Consolidated text of 'Guidance Manual for Tanker Structures' incorporating IACS Recommendation No. 72: Confined Space Safe Practice – Rev.3 Dec 2018 and IACS Unified Requirements (UR) Survey and Certification: Z10.4 Hull Surveys of Double Hull Oil Tankers (Rev.16 May 2019).

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Introduction to the 1997 Edition

This manual combines in one document the various sources of information necessary for assessing the condition of ballast and cargo tank structure of tankers in service. The manual is based on the experience and practices of members of the Tanker Structure Co-operative Forum* consisting of Owners, Operators and Classification Societies.

The Forum has published three previous guidance manuals:

Guidance Manual for the Inspection and Condition Assessment of Tanker Structures, published in 1986.

Condition Evaluation and Maintenance of Tanker Structures, published in 1992.

Guidelines for the Inspection and Maintenance of Double Hull Tanker Structures, published in 1995.

This manual is a revision of the Guidance Manual and the Condition Evaluation Manual, combining both documents into one publication.

The following organisations were members of the Tanker Structure Co-operative Forum at the time of compiling this revision:

A.P. Møller
American Bureau of Shipping
Amoco Transport Company
Arco Marine Incorporated
Bergesen d.y. A/S
BP Shipping Limited
Bureau Veritas
Chevron Shipping Company
Det Norske Veritas
Exxon Company, International
Germanischer Lloyd
Gotaas Larsen Limited
Keystone Shipping Company
Lloyd's Register of Shipping
Maritime Overseas Corporation
Mobil Shipping and Transportation Company
Nippon Kaiji Kyokai
NYK Line
Shell International Trading and Shipping Co. Ltd.
Stena Rederi AB
Stolt Parcel Tankers Inc.
Texaco Marine Services Incorporated

Guidance is given first 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 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 manual incorporates, where appropriate, the results of Forum activities in areas of corrosion, defects and repairs, ultrasonic gauging and the strength of corroded structural items, as well as corrosion and maintenance evaluation of tanker structures.

The International Association of Classification Societies (IACS) has co-operated in the updating and revision of the Manual.

* Appendix I contains the background to the Forum activities.

Introduction to the 2022 Consolidated Edition

This consolidated edition combines in one guidance manual the various sources of information necessary for assessing the condition of ballast and cargo tank structure of tankers in service, while the original manual mainly addressed the conventional single hull tanker, this revision includes IACS Recommendation No. 72: Confined Space Safe Practice – Rev.3 Dec 2018 and IACS Unified Requirements (UR) Survey and Certification: Z10.4 Hull Surveys of Double Hull Oil Tankers (Rev.16 May 2019), where changes introduced in Rev.16 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2020.

Phase-Out of Single Hull Tankers

Since 2016, single hull tankers (SHTs) have been phased out of international trading. Since 1993, double hull structures are the mandatory standard for tanker design, as detailed in the 1996 requirements of MARPOL Annex 1, Regulation 19.

Phase-Out Process

Following a series of high profile tanker accidents and spills in the 1990s, MARPOL was amended to begin the process of a gradual phase-out of the SHT. Timings were based on tanker category.

Due to the impact of the sinking of the *'MV Erika'*, the IMO adopted an accelerated phase-out scheme, which entered into force on 1 September 2003, under the 'Regulation 13G' amendments of MARPOL Annex 1. The phase-out process was further accelerated by additional amendments that entered into force on 5 April 2005 (note that Regulation 13G is now incorporated as Regulation 20 in the revised MARPOL Annex I, which itself entered into force on 1 January 2007).

Under MARPOL, the final phasing out date for Category 1 tankers (pre-MARPOL) was 2005. The final phasing out date for Category 2 and 3 tankers (MARPOL tankers and smaller tankers) was brought forward to 2010, from 2015. In addition, a new Regulation (Regulation 21) for vessels carrying heavy grade oil (HGO) banned the carriage of HGO in SHT of 5,000 tons dwt and above after 5 April 2005, and in SHT of 600 tons dwt and above, but less than 5,000 tons dwt, by not later than 2009.

Exceptions from 2010

The 2010 date remained the phase-out date for most of the global SHT tonnage. However, four exceptions permitted the use of SHTs after 2010, which were:

1. If the vessel was engaged in cabotage trade i.e. trading locally and not internationally (the IMO extended this option to allow for some member States to achieve renewal for their domestic fleets, where the vessels were confined to operate only within the member State)

2. Theoretically, if the vessel was engaged in trade between States where neither were signatories to the MARPOL 1973/1978 Convention (although this is effectively nil, as 99.1% of world tonnage is under a Contracting State that has ratified MARPOL)

3. If the vessel was not engaged in the carriage of oil (*provided that the ship was in service on 1 July 2001, fitted with only double bottoms or double sides that extend to the entire cargo tank length or double hull spaces, not meeting the technical minimum distance protection requirements and that the flag State was satisfied. Again, such continued operation cannot go beyond the date on which the ship reaches 25 years of age after the date of its delivery*)

4. If the vessel operated under the Condition Assessment Scheme (CAS), as approved in IMO Resolution 94(46). However, such operation is now phased out.

Phase-Out Internationally Complete

The CAS allowed individual flag States to permit continued operation of Category 2 and 3 tankers beyond 2010, albeit subject to satisfactory inspection and results. However, the continued operation was not allowed to go beyond the anniversary of the *'date of delivery of the ship'* in 2015, or the date on which the ship reached 25 years of age after the date of its delivery, whichever was earlier (note that the CAS process was later implemented under Annex B, part B of the Enhanced Survey Programme (ESP Code)). This time limit was passed in 2016, meaning that it is not permissible for an SHT to operate internationally between MARPOL member States. Therefore, most of the global SHT fleet has now been scrapped. In addition, the IMO has amended documents to reflect the phase-out of the SHT; for example on 1 March 2018, amendments to MARPOL Annex I entered into force which removed references to SHT designs and arrangements from Form B of the International Oil Pollution Prevention (IOPP) Certificate.

Only Very Limited Numbers Remain

The number of SHT vessels remaining in the world is, therefore, very low. Those that do remain are strictly limited in their trading and operational abilities to within the national boundaries of their member State, and to those not carrying oil cargoes (subject to the other requirements specified above).

The few member states still operating SHTs, have already begun the process of full phase-out in their national legislation. Therefore, it is likely the few remaining operational SHTs will be phased out within the next few years. Double hulled vessels are, therefore, effectively considered the universal standard for new and existing tankers in international maritime operations.

Chapter One

Survey Preparation Guidelines

1.1 Survey Requirements

Surveys are considered to fall into two types—those required by Class or for compliance with other regulatory bodies, and those performed by Owners for their own purposes. Class and statutory surveys include annual and intermediate surveys, bottom/docking surveys, special or periodical surveys and occasional surveys. Owners' surveys are intended to assess general condition, corrosion rate, detailed condition or to make a repair assessment.

1.1.1 Class and Statutory Requirements

Statutory surveys for fulfilling the Convention requirements of Load Line and SOLAS (in particular Safety Construction) are very similar to Class requirements, and they should also be considered so as to avoid duplication of surveys. Statutory surveys may be carried out by the Classification Society on behalf of a particular government. As far as tank structural assessment for Class is concerned, and in terms of this manual, the Special Survey is of prime importance.

Special Surveys are generally required at five year intervals. The surveys are clearly specified in the rules for each Society concerned. In addition requirements for survey of the cargo tank area were first published in September 1982, as the 'Unified Requirements for the Special Hull Surveys of Oil Tankers', by the International Association of Classification Societies (IACS). These Requirements have since then been updated and reissued, and the last edition was issued in 2014 (Rev. 21). The Societies' respective Rules and Guidelines agree with the revision. The new Rules are termed 'Enhanced Hull Survey' and the vessels surveyed according to them will be given a Class Notation to reflect that. The Unified Requirements have been extended to cover Annual Survey and Intermediate Survey in addition to Special Survey.

The Unified Requirements specify the minimum extent of overall and Close-up Surveys, thickness measurements and tank testing, all grouped according to the age of the ship. The updated Requirements also include more specific rules with regard to survey planning and reporting. A copy of the latest IACS Unified Requirements, IACS UR Z10.1, is included as Appendix II. Section 2.5 contains an amplification of the requirements.

It is possible to do part of the survey at the fourth anniversary and the remaining part during the period up to the fifth anniversary. Societies are also prepared to do surveys at sea, i.e. a General Examination and part of the Special Survey could be done to prepare for the Special Survey that is completed up to one year later. This could advantageously be completed in conjunction with an Owners' survey.

Bottom/Docking Surveys are in general required twice in any five year period, with a maximum interval of three years between surveys. It is possible in most cases to replace alternate dockings by an In-Water Survey. It is a requirement that a survey in dry dock is part of the Special Survey.

The Annual Survey is to be carried out at intervals of approximately one year and, as the survey generally covers the annual Safety Construction and Load Line requirements that are due within a time window of three months before or after the anniversary date of these certificates, they are almost invariably combined. Most Societies harmonise the dates of expiration of these certificates with the Special Survey date to enable this to be achieved. The ballast tanks will, to an extent, be determined by the ship's age and reported condition at the preceding Special Survey or Intermediate Survey and be subject to internal survey in connection with the Annual Survey.

The Intermediate Survey is required for tankers subsequent to the first Special Survey and consists of the requirements of an Annual Survey and an examination of ballast tanks and cargo tanks, the extent being determined by the vessel's age and condition as reported at the preceding Special Survey. Thickness measurements may be required in connection with the survey. In cases where substantial corrosion has been reported at the preceding Special Survey the areas are subject to re-measuring.

Occasional surveys are not regular pre-planned surveys and may be called for after damages or other defects. The Owner is expected to inform his Society when damages due to grounding, collision or heavy weather occur, although in many cases permanent repairs (if found necessary) may be deferred to coincide with planned surveys. The same criteria apply to any modifications or repairs and to defects that may be discovered, but which may not be directly attributable to damage.

For laid-up ships surveys will be required on re-activation, but these will depend upon the maintenance, the length of time laid up and surveys that have become overdue during the period. Some Societies have requirements for General Surveys during lay-up. Statutory certificates are only required for trading, although there may be some local requirements.

1.1.2 Owner's Requirements

While concerned with ensuring compliance with Classification Society standards for overall structural strength and hull integrity, the Owner also requires information on structural condition that might affect both present and future operating and repair costs of the vessel. This information may be required at the time of Class survey or at a time outside the Class survey cycle, such as during a survey of a vessel in layup. Basically, the Owner may require more in depth knowledge of:

- The present state and estimated corrosion rates of the various structural components
- the present condition and expected rate of deterioration of existing corrosion control systems
- the existence, severity, and potential for further development of structural defects due to expected corrosion patterns and structural loadings
- the potential for cargo contamination or pollution incidents due to corrosion and structural problems.

Based on this type of information from the survey of the vessel, the Owner can then:

- Determine his present and predict his future steel renewal requirements, and/or
- study the various options for restoring or upgrading corrosion control systems to help avoid steel renewals, cargo contamination and pollution incidents over the life of the vessel.

The type of survey performed depends on the information required to meet the Owner's objective. There are various commercial types of survey, such as buyer's, insurer's or any of the classification programs for condition assessment and grading.

The surveys below are grouped into four technical types, although it is quite possible and more usual for these to overlap in practice.

(a) General Condition Surveys

These are overall surveys of limited scope and time intended to identify gross structural or corrosion related problems. They involve little or no close-up inspection or thickness determination of internal structure, but give an overall visual impression of the structural integrity and corrosion condition of the tanks inspected.

(b) Detailed Condition Surveys

Detailed condition surveys provide a more comprehensive and in depth inspection of the ship. A detailed condition survey of a ship's structure would encompass a close-up inspection and thickness measurement of a sufficient number of structural elements to accurately assess the present condition so that a course of action can be formulated.

(c) Corrosion Rate Surveys

These are limited in terms of area inspected but are of a more detailed nature, and are based on collecting representative thickness measurements of a number of structural components in various tank environments at regular intervals so that general corrosion rates can be determined for the vessel. In addition, these may identify local corrosion and/or structural problems for the more limited areas surveyed.

(d) Repair Specification Surveys

These are surveys of sufficient detail to specify precise steel renewal requirements, structural repairs and reinforcements, corrosion control measures, etc. for inclusion in a shipyard repair specification. This is the most detailed type of survey, often relying on one of the three other types of survey, particularly the detailed condition survey, to highlight areas of tanks requiring more detailed inspection.

(e) Survey and Repair Reports

Reports of structural inspections and previous repairs must be kept on board with the Supporting Documents of the Survey Report File as required by IACS UR Z10.1 6.3. (See Appendix II). These reports should follow a standardised format to simplify interpretation of the report, and analysis where necessary.

1.2 Safety and Access

1.2.1 Safety During Surveys

Before commencing any survey, the Owner and all personnel involved in the survey must ensure that appropriate safety procedures are specified. Safety standards often vary from Owner to Owner and vessel to vessel. While many Owners maintain strict onboard safety procedures, survey personnel, including Classification Society surveyors and subcontractors, must still be aware of what constitutes minimum acceptable standards for tanker inspection to protect themselves from potentially hazardous working conditions.

For basic tank entry, the 'International Safety Guide for Oil Tankers and Terminals (ISGOTT), Sixth Edition', should be followed. In particular, Section 4.7 (Permit to Work Systems), Chapter 10 (Enclosed Spaces) and Section 12.4.4 (Gas Testing and Measurement). It should be recognised that 'ISGOTT' sets standards and some Owners' practices may differ from those outlined in this Safety Guide. IACS issued Recommendation No. 72 'Confined Safe Practice', which was first published in 2000. These Recommendations have since been updated and reissued and the last edition was issued in 2018 (Rev. 3).

The types of inspection described in this manual, however, require supplemental safety procedures to cover certain aspects not addressed by 'ISGOTT'. These include limits on climbing heights, procedures for rafting, safety of ultrasonic equipment, and precautions regarding extremes of temperature. Generally, these procedures are intended to apply to surveys conducted at sea. However, where appropriate, the same procedures should be applied during other surveys.

The following are items of special importance to survey personnel and are included here to highlight the key items of onboard survey safety. These reflect the present practices of a number of Forum members and should be treated as a guide rather than a safety standard.

(a) Safety Meeting

Before beginning any survey, the survey team should ensure that a safety meeting is held to discuss all aspects of safety referred to herein, with special attention paid to gas testing procedures, command and communication links and rescue arrangements.

(b) Gas Testing for Tank Entry

If gas readings are greater than 1% LEL (Explosimeter or suitable combustible gas indictor), or if other limits are exceeded, the survey team should be instructed not to enter the tank or, if already in it, to stop working and immediately vacate the tank. The Explosimeter should be calibrated with a low level full scale reading of 0 to 10% LEL.

The team should arrange, with the Master, to have the tank frequently tested for gas at several locations, say every 2-3 hours. In addition, a member of the team should verify the readings from time to time.

To aid the detection of any local pockets of gas, or lack of oxygen, team members should be encouraged to carry portable hydrocarbon and oxygen detectors with audible alarm features.

(c) Tank Preparation

Continuous forced ventilation should be supplied to the tank during the inspection. An adequate number of deck fans should be used to supply this air. The fans should, where possible, be ducted to supply fresh air to the tank bottom. The vent fans should be stopped during atmosphere checks. The inert gas fans should not be used to provide fresh air ventilation because contaminants from the inert gas lines could be introduced into the tanks. Inert gas branch lines should be blanked off and the blanking flange interlocks checked at each tank if entry is required while inerting, or gas freeing of other tanks is taking place, or if any other tanks are inerted or contain hydrocarbons. An alternative to pipe blanking would be to remove a section of the branch line.

All cargo pipelines leading to the tank should be checked for oil content and the valves secured closed, immobilised and posted. Any oil present in the lines should be removed.

All adjacent tanks should be in the same gas free condition as specified above or fully ballasted. Alternatively, and with the knowledge and approval of the Owners and the agreement of the survey team, adjacent tanks may be fully inerted or part ballasted/remainder inerted but with pressure reduced to a minimum. The survey team should be aware of the danger of potential leakage of inert gas through bulkhead fractures or faulty valves. A water seal over the level of the bell mouths may prevent IG flowing between tanks via the bottom lines.

(d) Safety Watch and Safety Equipment

The survey team should not remain in a tank unless there is a safety watch by ship's staff with at least one individual stationed at the tank hatch throughout the inspection. The safety watch should have the authority to order the evacuation of a tank and should be responsible for registering the survey team entering or leaving a tank. Communication should be maintained between personnel in the tank and the safety watch.

When underway, the safety watch should maintain communication with the bridge.

Rescue equipment, including breathing apparatus, resuscitators, smoke masks, rescue lines, a stretcher, etc. should be laid out at the tank hatch or, if more than one tank is being worked, at a suitable central location on deck.

(e) Tank Cleaning

Tanks and spaces to be surveyed must be sufficiently clean and free from water, scale, dirt and oil residues to reveal excessive corrosion, significant deformation, fractures, damages and other structural deterioration. Tank cleaning can be performed with an existing crude oil washing (COW) system.

Generally, tank surveys should be avoided in tanks in which de-sludging operations are taking place since these operations can potentially raise gas levels.

(f) Ballast Transfer

The survey team should not enter or remain in any tank if the tank is being ballasted. If the tank is being de-ballasted while personnel are rafting in that tank, the program for ballast changes must be fully agreed and communication must be assured with the vessel's staff (See 1.2.2). Consideration should also be given to ballast movement in adjacent tanks.

(g) Entry into Tank while Ship is Manoeuvring

The survey team should not enter or remain in any tank while the ship is manoeuvring in congested or confined waters.

(h) Use of Electrical and Electronic Equipment in Cargo Tanks

The use of electrical and electronic equipment (such as radios, lights, ultrasonic thickness measuring equipment and video equipment) that is not certified as explosion proof or intrinsically safe is allowed only in tanks with a gas-free certificate certifying it safe for hot or, alternatively, where agreed by the Owner/Master, in tanks with air quality meeting the requirements of 'ISGOTT' Chapter 10. In this case, surfaces within cargo tanks that are not sufficiently cleaned of cargo residues are unacceptable for inspection and should be avoided by the survey team. If ultrasonic measurements are essential in such areas, the surfaces must be cleaned free of all residues for a radius of 1 metre around each reading point.

(i) Climbing

In general, the free climbing height should be limited to about 3 metres above the bottom or any large stringer platform. If it is necessary to exceed this height, there should be a water bottom to provide a 'cushion' or other provisions such as safety lines. The free climbing height above the water surface should not exceed 6 metres. Climbing should only be attempted where the structure provides adequate hand and foot holds and is not slippery.

When climbing in tanks containing water, the surveying personnel should wear 'flotation' aids. A flotation aid is a simple form of lifejacket that does not impede climbing.

(j) Temperature Extremes

When temperature extremes are expected during a survey, the inspection team should review the procedures that the Master or Safety Officer will follow to monitor the exposure of the team to guard against hypothermia, frostbite, heat fatigue, heat stroke, etc.

When working in a hot environment, the surveying personnel may have to reduce work periods.

High humidity increases the effective temperature and work periods should be reduced accordingly.

The team, in consultation with the Master or Safety Officer, should adjust its work/rest periods to the conditions encountered. In hot climates, the surveys should be scheduled to avoid the midday heat. Water and salt should be available to the team so that they can drink a small amount every 15–20 minutes. Some cooling can be achieved by spraying the decks with water during very hot weather.

(k) Lighting

Whenever possible, natural lighting should be provided in the tank during surveys by opening all tank hatches. Suspended lighting should also be provided to supplement any natural lighting. Each person should carry a torch of the high intensity beam type such as a Wolflite or halogen light. Torches and lights should be of an intrinsically safe or explosion proof design.

(l) Rafting Surveys

Inflatable or rigid rafts should be of a type with sufficient compartmentation that adequate buoyancy and stability is provided even with one compartment ruptured.

Rafting should not be carried out in narrow wing tanks where the raft may be damaged by the structure. At no time should the water level be allowed to be within one metre of the deepest underdeck web face flat.

Under no circumstances should the raft be used so that it is isolated from a tank hatch. In the case of tanks with swash bulkheads, where two tank hatches are not fitted, the survey may be carried out using two rafts.

One raft will be in use while the other is secured at the swash bulkhead for emergency escape.

Rafting should not be attempted if there is more than a thin sheen of oil on the water.

Rafting or boating should be discontinued if the rise and fall of the raft or boat within a cargo tank (due to the motion of ballast water caused by rolling) makes the operation difficult or hazardous. In making this decision, the team should consider the degree and period of roll, the proximity of rafting to the deckhead or other structure (that could damage the raft), and expected manoeuvring that could add to excessive motion of the ballast water. While the actual limit will vary, a general guide is that the rise and fall of ballast water should not exceed about one metre, equivalent to about 1.5 to 2 degrees of roll per side on a V/ULCC.

The tank should not be filled beyond a level approximately 1 metre below the deck transverses so that the survey team is not isolated from a direct escape route to the tank hatch. This will mean that on larger vessels with deep deck transverses the inspector will still be some distance from the deckhead which may preclude Close-up Survey.

1.2.2 Access to the Structure

Once the type of survey has been decided upon, it is necessary to consider the means of access available to achieve the goals of the survey.

The need for reasonable access to the upper parts of a tank structure have recently been reinforced by the introduction of the IACS 'Unified Requirements for the Enhanced Survey Program for Oil Tankers'. These requirements do not stipulate how access is to be achieved, but have specific requirements for close-up surveys of deckhead structure and primary ring structure coupled with thickness determination in these areas.

The following options are available to aid access to the structure for condition assessment:

(a) Permanent Arrangements

Much can be achieved at the design stage of a vessel by the provision of manholes and ladders. The width of face plates, the location of stringers, the provision of manholes etc., can all contribute to the ease with which a structure may be surveyed and the condition monitored in service.

Some shipbuilders fit limited permanent walkways at the upper parts of the tank, either for their own use or at the request of an Owner. Often, use of an existing structure is made for permanent walkways with handrails added. Walkways can provide sufficiently close access to obtain a general assessment of the condition of the structure and identify suspect areas for closer examination.

When permanent arrangements exist, inspections to check their safety should be carried out prior to other inspections.

(b) Temporary Staging

Conventional temporary staging within a tank, to gain access to deckheads and bulkheads structure, is an option that may be attractive in some circumstances but, as the vessel gets older and survey requirements more stringent, the cost of such staging methods could become prohibitive.

The use of temporary staging restricts the survey to being carried out within the repair yard and does not facilitate a survey at sea for preparation of repair specifications and planning the work.

(c) Mobile Platforms

The most common form of temporary staging other than conventional scaffolding is the mobile platform. This can consist of a portable, self-elevating platform suspended from wires (through holes drilled in the upper deck or otherwise fixed to the deck structure). If a sufficiently extensive grid of attachment points is provided, reasonable access to deckhead areas can be achieved.

Alternative designs of mobile platform are mostly based upon an articulated or telescopic arm principle. Such designs would typically incorporate a support turret suspended from a tank cleaning opening or from the tank bottom. The articulated or telescopic arm is supported by the turret and is usually operated hydraulically or pneumatically to bring the inspection platform to the desired position. The movement of the platform can usually be controlled by the inspector on the platform and should be capable of carrying two persons.

All forms of mobile platform are highly susceptible to the motions of the vessel and are, therefore, more readily usable in drydock or sheltered conditions than at sea. It should be noted that these platforms may have to be certified as complying with local regulations and International Labour Organization (ILO) requirements, particularly when used within a repair yard.

(d) Rafting

Although limited in use for some structural configurations, the survey of deckheads, side shell and bulkheads from a raft or boat within a partially filled tank is fairly common practice with some operators and is likely to become even more popular as more stringent survey requirements are introduced. Rafting is often used in conjunction with limited climbing.

Close-up inspection of the deck transverse web frame is often possible by climbing from the raft onto the stiffened side of the web.

Filling to levels above the deck transverses should only be contemplated if a deck access manhole is fitted in the bay being examined to provide access to the raft and direct escape to the deck in an emergency. Fitting of additional deck manholes (with access ladders and platforms) for this purpose should possibly be considered on future designs if rafting is planned as the main means of deckhead survey. Safety is of prime importance during rafting surveys and likely motions of the vessel must be taken into account at all times (see 1.2.1).

(e) Remotely Operated Devices

Underwater remotely operated vehicles (ROVs) can be used for the inspection of ballasted tanks. The vehicle is small enough to fit through a standard access hatch opening, is powered by at least two electrically driven thruster units and is controlled from a location outside the tank, such as the cargo control room.

While the method depends on the initial cleanliness of the tank and the clarity of the ballast water, the use of a monochrome camera for general scanning and navigation together with a colour camera, principally for close-up work, makes the device a good alternative survey device under the right conditions. The systematic approach needed means that the survey can be time consuming and operator and inspector fatigue from continuously monitoring a video screen may be a problem.

(f) Use of Divers

Surveys may be conducted using divers with handheld cameras and ultrasonic probes. As with the ROV, the inspector monitors and controls the diver from a control station outside the tank. Good communication between the diver and the control station is therefore essential. Orientation within the tank and identification of structural elements must be carefully considered.

In cases where diving is undertaken in water depths over 10 metres, the duration of the dive and the possible provision of decompression equipment may need to be considered.

At least two divers should be available for a tank survey for safety reasons.

(g) In Tank Camera

A remotely controlled deckhead camera which is lowered though a Butterworth plate on the upper deck. The camera can rotate and angle upwards to view the underdeck structure. Illumination is provided by a light attached to the mounting. The operator controls the orientation of the camera from the deck as well as a zooming control for the camera lens. The images are recorded on video tapes. The unit is not intrinsically safe.

The clarity of images is sufficient for most defects to be identified such that a decision can be made as to whether a close-up inspection is required by a surveyor.

(h) Industrial Rope Access

Certified climbers use mountaineering techniques to access the structure. As the climbers do not always have the qualifications for steel inspection, cameras may be used to show surveyors the condition of the structure.

(i) Other Devices

From time to time various devices such as image intensified viewers, telescopes etc., have been suggested for use in surveying deckheads from the bottom of tanks. While the resolution on some of these devices is reported to be very good, perspective and image distortion problems can make defect identification difficult. Commercially available equipment such as binoculars and video cameras may be used to inspect specific areas.

1.3 Ultrasonic Thickness Determination

An essential part of most types of survey is the determination of the remaining thickness of the structure in critical areas. Ultrasonic thickness gauging is used almost exclusively for this purpose. This section discusses the various aspects of the techniques involved, with specific reference to the accuracy achievable and resulting confidence levels in the data produced for assessing structural integrity. The accuracy levels are also of particular relevance for surveys intended to determine corrosion rates in particular locations.

1.3.1 Survey Team Qualifications

The survey team is responsible for carrying out the survey plan. The composition of this team could be company personnel, contract personnel, or a combination of the two.

Whatever the composition, it is important that the team provides the Owner and the Classification Society with an accurate assessment of the structural condition of the hull.

The level of experience and the degree of training of the survey team has a significant influence on the accuracy of the survey data.

The team leader should be a qualified steel inspector since it is his duty to survey the hull and detect areas where corrosion is occurring and locate structural defects such as fractures. The team leader can also function in other capacities, such as a repair superintendent, but his skill as a steel inspector is the most significant in terms of the structural survey.

The thickness measurements for classification purpose are normally to be made under the supervision of the Class surveyor. However, the Class surveyor may accept thickness measurements not made under his supervision. The Class surveyor should re-check the measurements as deemed necessary to ensure acceptable accuracy.

The minimum requirements for thickness measurements are specified in the following sections of IACS UR Z10.1 (see Appendix II):

> Sections 2.4 (Special Survey), 3.2.5.1. (Annual Survey) and Tables II and IV.
> The sections and structures subjected to thickness measurements are to be nominated in a planning document as requested in Annex I.

The thickness measurements are to be performed by qualified personnel belonging to the specialised company certified by the Classification Society according to procedures for certification described in Table VII of IACS UR Z10.1, see Appendix II. The certificate of approval is subjected to renewal/ endorsement at intervals not exceeding 3 years. The approval may be cancelled in particular cases of deficiencies.

Operator experience is not enough to ensure a consistent level of gauging accuracy. It is necessary that all the operators used by the Owner are also trained to use a standard gauging procedure so that all gauging data will be comparable. The procedure should specify the technique that is to be used for operation of the equipment. The specification will cover items such as calibration interval, recommended equipment and probe combinations, environmental constraints on equipment usage and surface preparation requirements. This procedure can also describe recommended gauging patterns that will provide the Owner with sufficient data for his steel condition analysis. This procedure is to be approved by the Classification Society according to IACS UR Z10.1 Table VII 2(1) e and f.

The gauging team should be familiar with the shipboard gauging environment. Many of the hull surveys are made while the vessel is at sea on a ballast voyage. In this environment the operator has to contend with a rolling vessel, dimly lit tanks and surfaces covered with scale and pits that are only accessible by a combination of rafting and climbing. This environment would hamper an operator experienced only in a land based environment.

The gauging team should also be familiar with the scope of the hull survey to ensure that the gauging data is obtained in an efficient manner. For example, when the hull survey is made at sea the vessel crew and gauging team will develop a ballasting pattern to efficiently reach the selected gauging locations. If the ballast pattern is not carefully planned, time and fuel would be wasted and the survey could end up only partially complete.

1.3.2 Basic Equipment Types

Ultrasonic wall thickness measuring devices work on the principle that a pulse generator causes a probe to oscillate and transmit ultrasonic compression waves through the medium being gauged. The waves are reflected from the front and back surfaces of the object or from any flaw in the material. These echoes are picked up by the receiving probe and, after amplification, the signal delay can be interpreted as a measure of the thickness of the material (given the density of the material and the sound velocity through it).

Two basic instrument types are widely available for marine use, i.e. screen image instruments and digital readout instruments. The screen image instrument incorporates an oscilloscope cathode ray tube screen (CRT) on which the full echo pattern can be displayed with associated amplitudes.

The single echo digital instrument incorporates a pre-set discrimination level and will automatically make a thickness assessment based upon the first arriving back wall echo to exceed that discrimination level.

Although the direct reading digital instrument has advantages of compactness and portability, it has certain drawbacks compared with the CRT instrument. The single echo digital instrument cannot discriminate between echoes from the back wall and those from inclusions or flaws in the material and can therefore cause errors in thickness determination that the operator has no means of checking. In the case of the CRT instrument, the operator determines the thickness after evaluation and interpretation of the echo pattern displayed. Intermediate echoes can be located and an assessment made as to whether these are from laminations, inclusions or pits. Similarly, on heavily corroded plates the slope of the echo can be poorly defined, leading to errors with both instrument types, but the CRT instrument has the advantage that the operator can verify the quality of the reflected signal and make adjustments accordingly.

Digital units that read multiple echoes are available as an alternative to the CRT, which should overcome the drawbacks mentioned above. These units have a microprocessor circuit that allows it to make the digital measurement between echoes instead of the conventional unit that measures between the pulse and echo. Digital units are also offered in intrinsically safe models.

Various types of probes may be selected depending upon the type of work being undertaken and the output required from the probe. The probes can be single or twin crystal types and the coupling fluid between the probe and the surface of the material is usually oil or water. Proper selection of the probe will improve the operator's ability to obtain thickness measurements on corroded steel. The single probe uses the same crystal for both transmitting and receiving while the twin probe has the transmitting signal electrically and acoustically separated from the receiving signal. The single probe is commonly used with CRT units because it will receive multiple echoes. The single probe is not used with digital equipment since this equipment is not designed to read multiple echoes.

The twin probe is used when additional signal strength is needed to overcome the loss of signal caused by surface roughness scattering the sound energy. The twin probe uses a focused beam and the focal length should be chosen near to the expected wall thickness for maximum sensitivity.

For both probe types there are several frequencies and diameters from which to choose. The frequency affects the sound transmission characteristics and under conditions where echo strength is marginal, the selection of a probe with a different frequency may improve the echo strength. Most operators use probes that have a frequency between 2.25 MHZ and 5.0 MHZ. The probe diameter affects the shape of the sound beam and therefore the signal strength. The smaller the diameter the narrower the beam. Diameters between 10 mm and 25 mm are preferred by most operators.

The use of single echo instruments should normally be avoided. Classification Societies generally do not accept single echo type devices. Multiple echo instruments are preferred as they provide a more accurate assessment of steel thicknesses. A unit that reads multiple echoes eliminates the thickness of the coating as the time difference between the first and second echoes is measured and hence the steel thickness. Therefore, no correction is necessary for coating thickness. Should a single echo reading device be used, paint film must be removed by grinding.

Some digital instruments are also now offered with memory that relieves the operator from writing. In this case, the identification of each measurement sequence is to be carefully prepared and indicated to avoid mixing of gauging series.

The improvement of the digital units and their advantages of compactness and portability make them more and more preferred to the CRT for thickness measurements.

1.3.3 Thickness Measurement Accuracy

When ultrasonic thickness measurement data is used to evaluate structural integrity or predict corrosion rates, the accuracy of the measurements must be taken into consideration. The accuracy of ultrasonic measurements is a function of the equipment accuracy and the operator technique in using that equipment.

All equipment types will have an inherent inaccuracy associated with their design. The internal equipment accuracy can be determined by procedures laid down in standards such as ASTM E317. All equipment types are considered to be capable of measuring within ± 0.2 mm on uncorroded plate using these standard test procedures.

These standard test procedures do not, however, provide a means for determining equipment accuracy on corroded surfaces. To analyse the accuracy achievable on corroded material a series of tests were undertaken by Forum members. Based upon these comparative tests with various instrument/probe combinations and using various operators, the best achievable accuracy was ± 0.5 mm ranging to ± 3.0 mm in the worst cases. The accuracy levels quoted statistically represent a 95% probability that the actual residual thickness will fall within the range quoted, i.e. for the best results there is a 95% chance that the true thickness is within a range of ± 0.5 mm from the measured thickness.

These accuracy levels hold for both the CRT and digital equipment. Within a given instrument group an operator may achieve consistently better accuracy levels with certain instrument/probe combinations. This accuracy level depends on the operator. A different operator using the same instrument/probe combination is not assured of achieving the same accuracy levels. The technique that is used to obtain thickness measurement data varies depending upon the operator's skill and experience. Tests have shown that gauging experience in a shipboard environment can influence the accuracy level the operator can achieve to a greater degree than in a shop environment. Tests, however, have also shown that accuracy can be significantly improved by standardising the gauging procedure for all operators. This is of particular importance when historical data is being reviewed so that any bias in the data due to operator technique at different surveys is minimal.

The overall accuracy with which a set of gaugings represent the true wastage is a function of the local accuracy of the single reading plus the number and pattern of measurements taken. If only one measurement is used to determine the wastage of a structural member then the local accuracy level applies. However, if additional measurements are taken then the average of these measurements can be used to represent the overall wastage of the member. Statistically it can be shown that, based upon accuracy levels determined for single measurements, the overall accuracy can be improved by increasing the number of measurements.

1.3.4 Measurement Procedures

As stated earlier, tests have shown that accuracy levels of approximately ± 0.5 mm are the best that can be achieved on corroded plates diminishing to ± 3.0 mm if careful control is not exercised. Therefore, it is necessary to carefully consider procedures for thickness determination to increase confidence levels in the data produced.

According to IACS UR Z10.1 Chapter 7 'Procedures for thickness measurements', these procedures are to be approved by the Classification Society while certifying of the qualified company that makes the gauging.

If the measurements are carried out for classification purposes, reference is made to IACS UR Z10.1 Table VII 2(1) c, d, e and g in addition to Table IV, in addition to the following aspects:

(a) Equipment Type

Instruments should comply with a recognised industrial standard such as BS 4331 or ASTM E317. Selection of instrument type, i.e. digital or CRT, will depend upon factors such as expected level of wastage, surface condition for gauging etc., but the generally preferred instrument for a gauging survey would be the CRT type except where tine portability of the compact digital gauge outweighs all other considerations.

The probe type and frequency will depend upon the level of sensitivity required for the particular application.

(b) Operator Qualification

At least one member of the gauging team should be qualified to ASNT Level II or equivalent. The operator should have experience of gauging in a shipboard environment.

The qualification of the operators is to be agreed by the Classification Society.

(c) Operator Technique

A standard technique should be followed by the gauging team. There are several aspects of the gauging technique, such as sensitivity setting selected, the signal echoes used for measurement, the frequency of calibration etc., which might influence the data produced. The important point is to follow the technique found to give the best accuracy and be consistent in applying that technique.

On corroded surfaces, it is often difficult to keep the face of the transducer parallel to the walls of the plate because of the roughness. By changing probe diameters, the operator may improve his chances of keeping the probe face parallel to the walls. An experienced operator will usually carry a variety of probes to ensure that he will be able to obtain the required thickness measurement data as efficiently as possible.

It is essential that good acoustic contact is achieved between the probe and the surface of the plate being measured. To achieve this all scale, dirt and, in some cases, paint must be removed from the surface. In some locations, because of access or lack of cleanliness, it is desirable to take shell plate readings externally through the paint film. This can be done satisfactorily provided the paint film is reasonably smooth and uniform and due allowance is made for the paint film thickness when assessing residual steel thicknesses. The sound velocities in steel and paint are about 5,900 m/sec and 1,600 m/sec respectively, and therefore the steel thickness equivalent of the paint film will be approximately 3.7 times the film thickness. In CRT instruments the paint can be allowed for by measuring between the pulse and the first echo or second echo and correcting for the paint 'thickness equivalent' having determined the average coating thickness mechanically. Alternatively, the measurement can be taken between the first and second echo, eliminating the need for a manual paint correction. With single echo digital instruments the measurement must always be corrected for the 'steel equivalent' thickness of the paint film.

The technique to be followed is to be specified in writing in a guide for operators, which is to be approved by the Classification Society.

Consistency of technique is of particular importance if the data is being used to assess corrosion rates by comparison with historical data.

(d) Gauging Patterns

Given the accuracy probable with a single ultrasonic thickness measurement, the precision with which a set of gauging data accurately reflects the wastage levels in a particular plate or location will be a function of the number of readings taken. The required accuracy will depend on the use to which the data will be put (e.g. determination of corrosion rates) and how critical the data is in terms of structural integrity.

Within Section 2 of the manual, guideline locations have been identified for ultrasonic thickness determination during corrosion rate or detailed condition assessment surveys. The purpose of specified gauging patterns would be to ensure that representative thicknesses are measured in these areas. The gauging patterns would also typically increase the density of readings at locations where improved accuracy will contribute to better maintenance decisions, and reduce the number at locations where the maintenance decision would not be affected by the level of gauging accuracy.

For example, the gauging team should be aware that few readings are required where wastage is less than half the permissible limit or is well beyond that limit. Elsewhere a higher density of readings would be requested to define better the actual wastage as the permissible limit is approached. Typically, a five point pattern of readings would be sufficient at critical locations. The actual number of readings at particular locations may have to be increased if the surface is heavily pitted or irregularly corroded.

Minimum gauging patterns are specified in IACS UR Z10.1 Table IV Requirement for extent of thickness measurement at those areas of substantial corrosion at special surveys.

(e) Miscellaneous Instruction

The gauging teams should not confine themselves to simply recording and reporting ultrasonic data. Visual observations should be made and any defects reported. These should include fractures, heavy local wastage such as holes, knife edging, grooving, pitting etc. All data should be accompanied by a photographic record when appropriate.

Apparently spurious readings showing increases in thickness over original scantling should be treated with caution. 'As fitted' plans indicate the nominal plate thicknesses without any allowance for rolling tolerance limits set down by industrial standards. This could mean, according to some standards, a variation of up to about + 2.0 mm between plates of the same nominal thickness. Similarly, actual thickness can vary across the width of a plate by up to about 1.0 mm and still be within tolerance. Gauging readings should be taken clear of plate edges.

These variations in original thickness are of particular importance if the gauging is carried out as part of a corrosion rate monitoring programme. For establishing corrosion rates it is essential that the base line thickness is determined initially. It has been suggested that this can only realistically be done by carrying out a gauging survey before a new building enters service to establish actual as opposed to nominal thicknesses at critical locations.

(f) Reporting

The reporting format is to be approved by the Classification Society. This format is established according to the IACS 'Recommended Procedures for Thickness Measurements of Oil Tankers', see Z10.1 Appendix II.

The reports are to be signed by the operator and stamped by the gauging company. They are also to be verified and stamped by the Classification Society surveyor.

1.4 Technical Background for Surveys

The purpose of carrying out a structural survey of any tank is to determine the extent of corrosion wastage and structural defects present in the tank. To help achieve this and to identify key locations in the tank that might warrant special attention, the surveyor should be familiar with the service record of the tank and any historical problems of the particular vessel or other vessels of a similar class.

An experienced surveyor will be aware of typical structural defects likely to be encountered and some knowledge of the contributing factors to corrosion (including the effectiveness of corrosion control systems) will assist him in assessing the corrosion patterns he finds.

1.4.1 Nomenclature

For clarity of definition and reporting of inspection data, it is recommended that standard nomenclature for structural elements be adopted. A sketch showing generally accepted nomenclature for structure within the cargo tank length is incorporated for reference as Figures 1.1 and 1.2.

1.4.2 Structural Load Descriptions

(a) Structural Aspects

A tanker must maintain its structural integrity and watertight envelope when exposed to internal static and dynamic liquid loads, including sloshing loads, to external hydrostatic and dynamic sea loads, and to longitudinal hull girder bending. Longitudinally stiffened plate is typically the primary structure of a tanker. This stiffened plate is supported by web frames, girders and bulkheads. The hydrostatic and hydrodynamic pressures flow from the plate through the stiffeners into the web frames, girders and bulkheads, where they balance other loads or contribute to accelerations.

Most loads are cyclic with many different frequencies. The cyclic loads affecting fatigue are described in 1.4.4. The following describe the loads that the major structural elements must resist.

(b) Tank Bottom Structures

The bottom structure must resist the axial loads from hull girder bending plus local bending from cargo, ballast and sea water pressure and structural loads from adjacent tanks. The hull girder bending loads are generally the highest and combine with the hydrostatic loads to generate the maximum stresses. The hydrostatic loads on the bottom are the highest in the vessel but generally vary less than the side shell frame external wave loads, whereas the hull girder bending loads are cyclic.

The loads in the subject tank and adjacent tanks often put relatively small transverse forces on the bottom web frames. This is especially true of tanks used for alternate ballasting side by side, such as with departure ballast in the wing tanks followed by arrival ballast in the centre tanks and cargo centre tanks followed by segregated ballast in the wing tanks.

(c) Side Shell, Longitudinal and Transverse Bulkheads

The side shell longitudinal and transverse bulkheads maintain each tank's integrity and resist hydrostatic pressures as well as internal sloshing and external wave loads. The side shell and longitudinal bulkheads are also the webs of the hull girder and transmit the shear loads from tank to tank and along the length of the vessel. These members also contribute somewhat to resisting the longitudinal bending near the deck and bottom. The transverse bulkheads transmits the transverse shear loads and maintains the hull girder's form along with the transverse web frame rings.

The girders, stringers and vertical web frames that support the bulkheads resist bending and shear loads as they transmit the local pressure loads into the hull girder.

The hydrostatic loading increases linearly with depth and is often balanced with another liquid on the opposite side of the structure. The wave loading on the side shell is cyclic and is the most severe area on the vessel for fatigue, see Section 1.4.4.

(d) Deckhead Structures

The main load on the deck is axial due to hull girder bending and transverse due to tank loading and waves. The axial stresses in the deck are the highest in the vessel as the upper deck is farthest from the neutral axis. While local loads are generally small on a tanker deck, equipment foundation loads, green water on deck and sloshing loads must be considered.

1.4.3 Structural Defects

Structural defects include weld defects, buckling and fractures, see also 1.4.4 Fatigue. Fractures initiating at latent defects in welding more commonly appear at the beginning or end of a run, or at rounding corners at the end of a stiffener or at an intersection. Special attention should be paid to welding at toes of brackets and cutouts or intersections of welds. Fractures may also be initiated by undercutting in way of stress concentrations. Although now less common, intermittent welding may cause problems because of the introduction of stress concentrations. Corrosion of welds may be rapid because of the influence of the deposited metal or the heat affected zone, and this may lead to stress concentrations.

Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or damage. Elastic buckling will not be directly obvious but may be detected by coating damage, stress lines or shedding of scale.

Fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of inspection. It is therefore important to identify and closely inspect potential problem areas. Fractures will normally initiate at notches, stress concentrations or weld defects. If these initiation points are not apparent, the structure on the other side of the plating should be examined.

For examples of defects that have occurred in service, attention is drawn to the Catalogue of Structural Detail Failures in Appendix IV. It is suggested that surveyors should be familiar with the contents of this catalogue before undertaking a survey.

The following areas where structural defects might occur should have special attention at the survey:

1. Ends of principal girders, stringers, transverses and struts with associated brackets. Particular attention should be paid to toes of brackets.

2. Bracketed ends of shell, deck and bulkhead stiffeners.

3. Connection of shell, deck and bulkhead longitudinals to transverse web frames. Particular attention should be paid to the side shell connections between full load and ballast waterlines.

4. Any discontinuities in the form of misalignment or abrupt change of section.

5. Plating in way of cutouts and openings.

6. Areas that show any evidence of damage or buckling.

1.4.4 Fatigue

Fatigue is the most common cause of cracking in the structure of large tankers. The cracks generally develop at structural intersections or discontinuities where detailed design has led to a stress raiser and there is a material or welding defect, or some other type of notch.

Fatigue failures are caused by repeated cyclical stresses that individually would not be sufficient to cause failure but can initiate cracks, in particular in way of in built defects, which can grow to sufficient size to become significant structural failures.

If the crack remains undetected and unrepaired it can grow to a size where it can cause sudden fracture. However, it is unusual for a fatigue crack to lead directly to a catastrophic failure.

Fatigue failures can be considered to have three stages:

1. Initiation – due to a stress raiser or notch, e.g. material or weld defect.

2. Stable crack growth – due to cyclic loading arising from vessel response in waves. Typical cyclic loading mechanisms:

   » hull girder bending

   » local pressure variation

   » cargo or ballast internal pressure variation

3. Unstable crack growth - at the critical crack length.

Critical crack length can be predicted using fracture mechanics methods.

To develop structural designs that will minimise the amount of fatigue cracking, and ensure that fatigue cracking does not cause a catastrophe, it will be necessary to carry out greater investigation of fatigue strength than has traditionally been the case for large tankers.

Fatigue strength can be calculated using 2 methods:

- Compare calculated numbers of cyclic stress ranges with established fatigue criteria (S-N data)

- calculate crack growth rates based on above stress range data and material properties.

(a) Typical Locations for High Sensitivity to Fatigue Failure

Deck, bottom and side shell connection of a longitudinal stiffener to a transverse web or bulkhead are shown in Figure 1.3. Of these locations the side shell is the most sensitive due to the combined actions of all three loading mechanisms with the addition of horizontal bending.

The effects of hydrodynamic pressure variations within the wave are most significant just below the load waterline. This results in a distribution of fatigue damage, as shown in Figure 1.3.

The overall effect is to make the zone between load and ballast waterlines most sensitive to fatigue damage. Internal loadings from the ballast and external loadings from wave passage cause deflections in the side shell structure that are concentrated at the connections of the longitudinal stiffeners to the webs and bulkheads.

The Classification Societies have, in recent years, introduced rules to cover the effect of fatigue loads on ship structures and guidelines on how to carry out proper fatigue calculations.

For many years the Class rules have included requirements to deck and bottom detail design, i.e. continuity of longitudinal elements, shape of openings and similar. These rules were introduced in order to obtain good fatigue properties for the mild steel hull girder and have in general proved satisfactory even after the introduction of higher tensile steels (HTS) in the deck and bottom. However, with the increased use of HTS, combined with ever more optimised designs, proper fatigue evaluations and calculations are becoming more important.

(b) The Effect of Higher Tensile Steel

The higher yield strength of HTS has enabled a structure to be designed with higher stresses, resulting in lighter scantlings. This does, however, also lead to an increase in the dynamic stress range. The fatigue damage is proportional to the stress range cubed, and HTS materials in welded connections, when exposed to corrosive environments, have similar fatigue properties as mild steel. Therefore, it follows that the risk of fatigue damage may increase for welded HTS connections in tankers when the increased strength capabilities are utilised.

The use of lighter scantlings often leads to higher deflections, which are particularly important at the side shell connections. In some HTS designs it is possible that the deflections of the side shell web frames may be larger than in mild steel designs due to the ability of the HTS material to accept higher stress levels, in combination with structural arrangement such as wider web frame spacing and lack of cross ties. Such deflections add to the stress levels in the longitudinals at the intersections between the longitudinals and the transverse bulkheads, the additions being proportional to the deflections.

Where dynamic stresses are prevalent, the use of symmetrical profiles, such as 'T' - section, will substantially reduce fatigue damage caused by torsional loads on asymmetrical profiles.

The notch toughness properties of all HTS used in the ship are verified by testing, whereas mild steel A-grade is not. The notch toughness is an important parameter in the evaluation of resistance to brittle fracture. However, this would not have significant effect on the risk of crack initiation or the stable crack growth, but would have significant effect on the final unstable crack propagation.

The above factors have to be considered when designs of HTS are made, and today it is normal practice to improve the detail design to reduce the stress concentrations in areas where calculations show that high dynamic stress levels are expected. Figure 1.3 indicates where the higher dynamic stress levels are found. The ship side is particularly prone.

The overall effect when the higher strength of HTS is utilised can be to significantly increase the risk of fatigue damage. By improving the detail design, it will usually be possible to obtain a fatigue life comparable to that for ordinary mild steel designs.

1.4.5 Typical Corrosion Patterns

In addition to being familiar with typical structural defects likely to be encountered during a survey, the surveyor must also be aware of the various forms and possible location of corrosion that may have occurred in the tank.

The main types of corrosion pattern which may be identified include the following:

(a) General Corrosion

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

(b) Pitting Corrosion

Pitting corrosion is a localised corrosion that occurs on bottom plating, other horizontal surfaces and at structural details that trap water, particularly the aft bays of tank bottoms. For coated surfaces the attack produces deep and relatively small diameter pits that can lead to hull penetration in isolated random places in the tank, with consequential pollution risk. Pitting of uncoated tanks, as it progresses, forms shallow but very wide scabby patches (e.g. 300 mm diameter); the appearance resembles a condition of general corrosion. Severe pitting of uncoated tanks can affect the strength of the structure and lead to extensive steel renewals.

(c) Grooving Corrosion

Grooving corrosion is a localised, linear corrosion which occurs at structural intersections where water collects or flows. This corrosion is sometimes referred to as 'inline pitting attack' and can also occur on vertical members and flush sides of bulkheads in way of flexing.

(d) Weld Metal Corrosion

Weld metal corrosion is defined as preferential corrosion of the weld deposit. The most likely reason for this attack is galvanic action with the base metal, which may start as pitting and often occurs in hand welds rather than machine welds.

1.4.6 Factors Influencing Corrosion

When corrosion problems occur it is important to have some understanding of the possible contributing factors to the corrosion so that remedial action taken will minimise the possibility of future repetition. The significance of each of these factors will vary depending upon the tank service. For example, for cargo/ballast tanks the length of time in ballast, the effectiveness of coating or anode systems and sourness of the crude could all be relevant major factors. Similarly, for ballast tanks the effectiveness of the protection system and high humidity could be major factors. For cargo only tanks the method and frequency of tank washing and the sulphur content of the cargo could be factors of particular significance.

The following is a list of possible factors that may be relevant in evaluating corrosion patterns being experienced:

(a) Frequency of Tank Washings

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.

(b) Tank Washing Medium

In order of decreasing effect, the mediums affecting tank corrosion are: hot seawater, ambient seawater and crude oil washing.

All washing mediums can remove protective oily films residual from crude oil carriage. Tank coatings may deteriorate more rapidly in a tank that is regularly crude oil washed.

(c) Carriage of Arrival Versus Departure Ballast

Although modern tankers will be fitted with segregated ballast tanks (SBT), it is recognised that some existing tankers may be operated with cargo/arrival and cargo/departure ballast tanks. On these vessels, due to the removal of residual protective oily films by tank washings, arrival ballast service can lead to higher corrosion rates than departure ballast service provided that the corrosion control systems are equivalent. In practice, however, tanks designed for departure ballast service have minimal, if any, corrosion control systems and, due to the frequency and extent of tank washing, they may show higher corrosion rates than tanks designed as arrival and segregated ballast tanks, which usually have more extensive corrosion control systems.

(d) Composition and Properties of Cargo

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

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

- carriage of cargoes with high water content can increase corrosion rates

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

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

(e) Time in Ballast

For unprotected tanks, corrosion increases with the time in ballast.

For tanks protected by anodes, the corrosion rate can be high for a short time while initially in ballast; oily film residue from carriage of crude oil can restrict the level of cathodic protection until the oily film dissipates from the anode surface and the anodes activate to designed current densities.

(f) Microbial Induced Corrosion

Microbial influenced corrosion is the combination of the normal galvanic corrosion processes and the microbial metabolism. The presence of microbial metabolites generates corrosive environments that promote normal galvanic corrosion.

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.

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 collects.

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. Proper maintenance of coating integrity, or blasting and coating the uncoated surfaces, would be an effective method to deal with microbial induced corrosion.

(g) Humidity of Empty Tank

Empty tanks, e.g. segregated ballast tanks during laden voyages, can have high humidity and are therefore susceptible to general atmospheric corrosion, especially if corrosion control is by anodes that are ineffective during these periods.

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.

(h) Temperature of Cargo in Adjacent Bunker or Cargo Tanks

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.

(i) Coating Breakdown

Intact coatings prevent corrosion of the steel surface. However:

- 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
- holidays in coating can lead to pitting corrosion rates higher than for unprotected steel.

Periodic inspections at appropriate intervals and repair of coating as required are effective in minimising corrosion damage.

(j) Locations and Density of Anodes

- Anodes immersed in bottom water can afford protection against bottom corrosion
- anodes are not effective in reducing underdeck corrosion rates
- properly designed systems with high current densities may afford greater protection against corrosion
- electrical isolation or coatings, oily films, etc., on anodes can make anodes inoperative (see (e)); abnormally low wastage rates of anodes may indicate this condition.

(k) Structural Design of Tank

- High velocity drainage effects can lead to increased corrosion in the vicinity of cutouts and some other structural details for uncoated surfaces
- horizontal internals and some details can trap water and lead to higher corrosion rates for uncoated surfaces
- 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
- sloping tank bottoms (e.g. as with double bottom tanks) to facilitate drainage may reduce bottom corrosion by permitting full stripping of bottom waters.

(l) Gas Inerting

- Decreased oxygen content of ullage due to gas inerting may reduce corrosion of overhead surfaces
- sulphur oxides from flue gas inerting can lead to accelerated corrosion due to formation of corrosive sulphuric acid.

(m) Navigational Route

- Solar heating of one side of a ship due to the navigational route can lead to increased corrosion of affected wing tanks
- anodes used to protect crude oil/ballast tanks on voyages of short duration may not be effective due to insufficient anode polarisation period when high corrosion may occur (see (e)).

Taking into account all the possible factors which may be relevant to a particular tank, the surveyor should pay special attention to the following areas when looking for signs of serious corrosion:

- Horizontal surfaces such as bottom plating, face plates and stringers, particularly towards the after end of the structural element. The wastage may take the form of general corrosion or pitting. Accelerated local corrosion often occurs at the after bays and particularly in way of suctions
- deck heads and ullage spaces in uncoated ballast or cargo/ballast tanks (where anodes may not be effective) or non-inerted cargo tanks
- structure in way of lightening holes or cutouts where accelerated corrosion may be experienced due to erosion caused by local drainage and flow patterns. Grooving may also take place on both horizontal and vertical surfaces
- areas in way of stress concentrations such as at toes of brackets, ends of stiffeners and around openings
- surfaces close to high pressure washing units where localised wastage may occur due to direct jet impingement

- bulkhead surfaces in ballast tanks adjacent to heated cargo or bunkers
- areas in way of local coating breakdown.

1.4.7 Corrosion Trends in Tank Spaces

Depending on the tank function and location in the tank, some structural components are more susceptible to corrosion than others.

The following are some phenomena of corrosion observed in each type of tank space:

(a) Segregated (Water) Ballast Tank Spaces

Necking occurs at the junction of the longitudinal bulkhead plating and longitudinals. The deflection of the bulkhead plating and longitudinals due to reverse, cyclic loading from cargo oil and water ballast, plus the accumulated mixtures of water, mud and scale at their junctures, accelerates the corrosion rate. As the steel thins and weakens, the flexing consequently increases and hence corrosion accelerates (see Figures 1.4 and 1.5). It should be noted that the level of corrosion shown in Figure 1.5 has generally exceeded the allowable loss as permitted by the Classification Societies for this type of structure. A similar necking effect could also occur in the transverse bulkhead plating and stiffeners, or in the inner bottom plating and longitudinals inside the double bottom space. In the uncoated water ballast tank, the longitudinals are the most affected (see Figures 1.6 and 1.7). In the coated water ballast tanks, the plating is the principally affected area due to local corrosion in way of coating failure (see Figures 1.8 and 1.9).

Corrosion reduces not only the strength capability but also the stiffness (to resist the deflection) of the structural components as corrosion progresses during tanker ageing. The deflection tends to crack the hard scale formation on the steel surface and to expose the fresh steel to the water. Since the loading on corroded structural components remains unchanged, as the structure becomes weaker, the deflection becomes larger and the corrosion rate accelerates (see Figure 1.5).

The vertical girders on the longitudinal bulkhead and the horizontal cross ties in the web frames are subjected to higher shear stress and have a higher corrosion rate in the uncoated water ballast tank (see Figure 1.10).

For partially filled ballast tanks, the water level is constantly surging in the splash zone due to the ship's motion. This accelerates the corrosion rates in uncoated ballast tanks and accelerates coating breakdown in coated ballast tanks.

If the intake ballast water is contaminated, the lower part of the ballast tank and bottom plating in particular, might be subjected to microbial influenced corrosion, particularly in the stagnant zone due to poor drainage and mud accumulation. The by-products released by the growing sulphate reducing bacteria can be acidic, which may penetrate and destroy coating, leading to accelerated corrosion in the infected areas.

The anodes in the uncoated water ballast tank only provide cathodic protection during the ballast voyage, i.e. when immersed for periods in excess of about five days.

(b) Cargo/Arrival Ballast Tank Spaces

Structural elements within the tank are protected by the adhering cargo oil except where removed by water washing. However, residual ballast water causes pits, grooves and laketype patches on the top surfaces of horizontal structural components (see Figure 1.11).

Pits are found in the vertical surface of directly water impinged areas. These are gradually formed into grooves by the running water.

The increased drainage velocity at the free edge of structural members causes the 'knife edge' type corrosion, i.e. at the free edge of the access holes, stiffener cutouts, flat bar stiffeners and brackets (see Figure 1.12).

Sacrificial anodes can provide a very effective cathodic protection system in the cargo/arrival ballast tanks and decelerate the corrosion rate substantially provided that the system is installed and maintained at an adequate current density (see Figure 1.13).

Accelerated corrosion in uncoated tanks and accelerated coating breakdown are found in the splash zone of tanks normally partially filled with ballast water.

(c) Cargo/Departure Ballast Tank Spaces

As these tanks are not generally water washed, cargo oil protects much of the steel. Residual ballast water causes pitting and grooving corrosion on horizontal and vertical surfaces of structural components, particularly in areas of poor drainage, and direct impingement by washing machines (see Figure 1.14).

(d) Cargo Only Tank Spaces

Residual water settling out from cargo oil can cause the pitting and grooving corrosion in the upper surface of horizontal structural components particularly on the bottom shell plating at the aft end of tanks where water accumulates due to the ship's normal trimming by the stern. In cases where the bottom shell plating has been protected with a hard coating, local breakdown of this barrier coating can lead to accelerated pitting corrosion where residual water has been lying. The corrosion rate is almost negligible in most other structural components.

1.4.8 In-Service Corrosion Rates

Since each tanker has a different corrosion control system, and is engaged in different trades, it usually has its own unique corrosion characteristics and its own corrosion rates.

The corrosion rates for structural components as presented in Appendix V, Tables 1 to 4 are collected from forum members. The data presented are representative 'ranges' of the empirical corrosion rates collected from experience with a limited number of tankers in real environments during the past three decades. It should be used for reference purposes only.

1.4.9 Corrosion Control Systems

An understanding of the various options that are available to control corrosion, and the limitations of each different system, will assist the surveyor in anticipating possible areas where corrosion problems may occur and help to determine what remedial action may be taken to reduce the effects on structural deterioration.

If serious corrosion has already occurred, steel renewals may not be the only option available to maintain structural integrity. Installation or upgrading of a corrosion control system may be more attractive if the steel is within allowable loss limits.

For all types of tanker structures, the main areas that are usually prone to severe corrosion will be those in direct contact with sea water, such as water ballast spaces, cargo/ballast spaces, external hull and main deck areas. In the case of cargo only spaces, the corrosion protection requirements are different for crude oil or white oil products, where the latter usually requires full protection of the internal surfaces with a coating system that will be compatible with the cargo being carried and whose main function is to prevent contamination between different grades.

In general, the most common form of corrosion protection used in tanker structures will be the application of paint (hard) coatings to either internal or external steel works in various forms to suit the type and extent of protection required. The basic function of a hard coating, such as paint, is to block access of water and oxygen to the steel structure itself. It follows, therefore, that its contact with the steel should be as good as is practically achievable, i.e. it must be firmly adherent, otherwise there will always be a possibility that rust – hydrated iron oxide – will form beneath the paint and eventually rupture the paint film.

Maintaining this protection throughout the lifespan of the vessel is an important feature in the initial choice of materials and will also be a measure of the continuing structural integrity of the vessel itself.

Potential corrosion of the internal structure in water ballast tanks is by far the most serious aspect of tanker maintenance and the protective systems normally associated with these spaces can generally be grouped under three categories:

- Hard coatings, (epoxy, vinyl, zinc silicate, bitumastic, etc.)
- soft coatings, (wool-grease, lanolin, oil-based, chemical-reaction, etc.)
- cathodic protection (zinc/aluminium anodes).

The following text gives a brief description of each type of system but is not intended as an exhaustive evaluation.

(a) Hard Coatings

The very nature of this form of corrosion protection system is to form a protective barrier on the steel surface which will provide a semi-permeable membrane to protect against the elements of corrosion. Any subsequent breakdown of this 'barrier' will, however, allow the normal corrosion process to take place, and usually at a much more accelerated rate due to the limited surface area being exposed.

This problem is, therefore, very similar to that of local pitting corrosion where, if early action is not taken, the overall integrity of the structure will be put at risk.

Further increases in the extent of breakdown of this 'barrier' will, however, reach a stage where the system is no longer considered effective and general corrosion of the structure is taking place.

If properly applied on blast cleaned surfaces, recognised coating types, such as those on an epoxy basis, should obtain a durability of at least 10 years' service life.

Sacrificial type coatings such as inorganic zinc provide 'metal' that is anodic to the steel surface and will protect the steel cathodically.

Appendix VII offers a form of rating system by which the existing condition of any 'barrier' coating can be judged. From this assessment it should be possible to either:

Reduce the extent of thickness gaugings and Close-up Survey requirements for say conditions 1 and 2, where severe corrosion of the structure is unlikely,

or

increase the extent of inspections with Close-up Surveys and thickness gaugings in way of local breakdown for say condition 3, where accelerated corrosion is likely to occur.

From this survey information (both visual and gaugings), decisions can be taken with regard to 'life continuance' and the extent of maintenance necessary to reinstate the corrosion protection system. In the case of long term (8 to 10 years) operations, recoating of the breakdown areas (or more usually the entire tank) would be regarded as a cost effective solution in lieu of any potential steel renewals that may be forecast. For short term (4 to 5 years operations), 'temporary' protection systems such as 'soft' coatings or sacrificial anodes may be considered, but their effectiveness would need to be regularly and carefully monitored with due consideration given to existing corrosion levels and anticipated corrosion rates.

b) Soft Coatings

The effectiveness of the types of protective coatings is usually much more difficult to judge, especially those relying on chemical reactions with the steel surface.

The effective life of some of the protection systems is usually restricted to about one to three years only, before further maintenance and touchup is required. Visual assessment of their existing condition can also be very difficult and somewhat misleading, especially if these have been used to cover-up already severely corroded areas of the structure.

Other typical problems found with the use of soft coatings for ballast tank protection are:

- Their 'greasy' nature, which makes physical inspection very difficult and may adversely impact safety
- their 'oily' base, which can contaminate the discharge of ballast water
- potential sagging of thick coatings attached to hot surfaces
- some vegetable based coatings are incompatible with sacrificial anodes
- when exposed to mineral oil, some lanolin based coatings go into an emulsion state, requiring removal for hot-work or pollution risk
- soft coatings on horizontal surfaces will be damaged whenever any mucking out of sediment is carried out in the ballast tank
- in the event of hot-work/welding on the outside or inside of coated plates, careful removal of the soft coating is necessary to prevent the risk of fires or explosions due to the potential buildup of gas when the coating is heated.

Much of the success with these soft coatings has usually been in connection with void spaces or water ballast tanks where there is a long retention time of the ballast (as in semi-submersibles). However, regular changes of ballast water, as occurs in tanker operations, has the effect of depleting the amount of soft protection on the internal surfaces. For this reason these protection systems should be regarded as temporary and should be subject to more regular and comprehensive thickness gauging and Close-up Surveys than that considered for hard coatings.

(c) Cathodic Protection (Sacrificial Anodes)

The principle of cathodic protection is to sacrifice the anodes in preference to the surrounding steel structures and, therefore, it relies entirely on these areas being immersed in seawater before this action can take place.

Anode material is generally of zinc. Other types of materials, for example aluminium, are limited because of the danger of sparks when dropped or struck, although these materials do offer better current output for the same weight. The use of anodes of aluminium have an installation height restriction in cargo tanks equivalent to a potential energy of 275 Joules, which effectively limits their use to bottom structures and requires that falling objects do not strike them.

The consumption rates and replacement of depleted anodes will not always be a true indication of the effectiveness of the corrosion protection system. Only regular and comprehensive visual and gauging surveys of the structure will give a correct assessment of effectiveness. Sacrificial anodes used as backup protection to a hard coating system do, however, have the benefit of controlling the accelerated rates of corrosion in way of any breakdown but, again, will only be effective when immersed in seawater. Recoating of any breakdown areas may still be required, but probably at a later date than without these back-up anodes.

(d) Selection of Protection System

The choice of corrosion protection systems for water ballast spaces has, in the past, been determined by either the Shipowner or Shipbuilder. IACS UR Z8 now require coating in segregated ballast tanks on new vessels. The continued effectiveness of these corrosion protection systems must be monitored throughout the service life of the ship by regular assessment of the condition of the steel structure that is being protected.

For hard coating protection systems applied at new building, this thickness determination need only be monitored in way of any localised breakdown, where accelerated corrosion of the exposed steel structure may be anticipated.

With soft coatings or sacrificial anodes, more frequent and extensive gauging surveys will be needed to assess the overall wastage rates in these spaces, and will generally be more difficult to survey in the later stages of the ship's service life.

In view of the importance of preserving this structural integrity, effective maintenance programs should be set up from commencement of service to repair and replace of the protection system as it deteriorates.

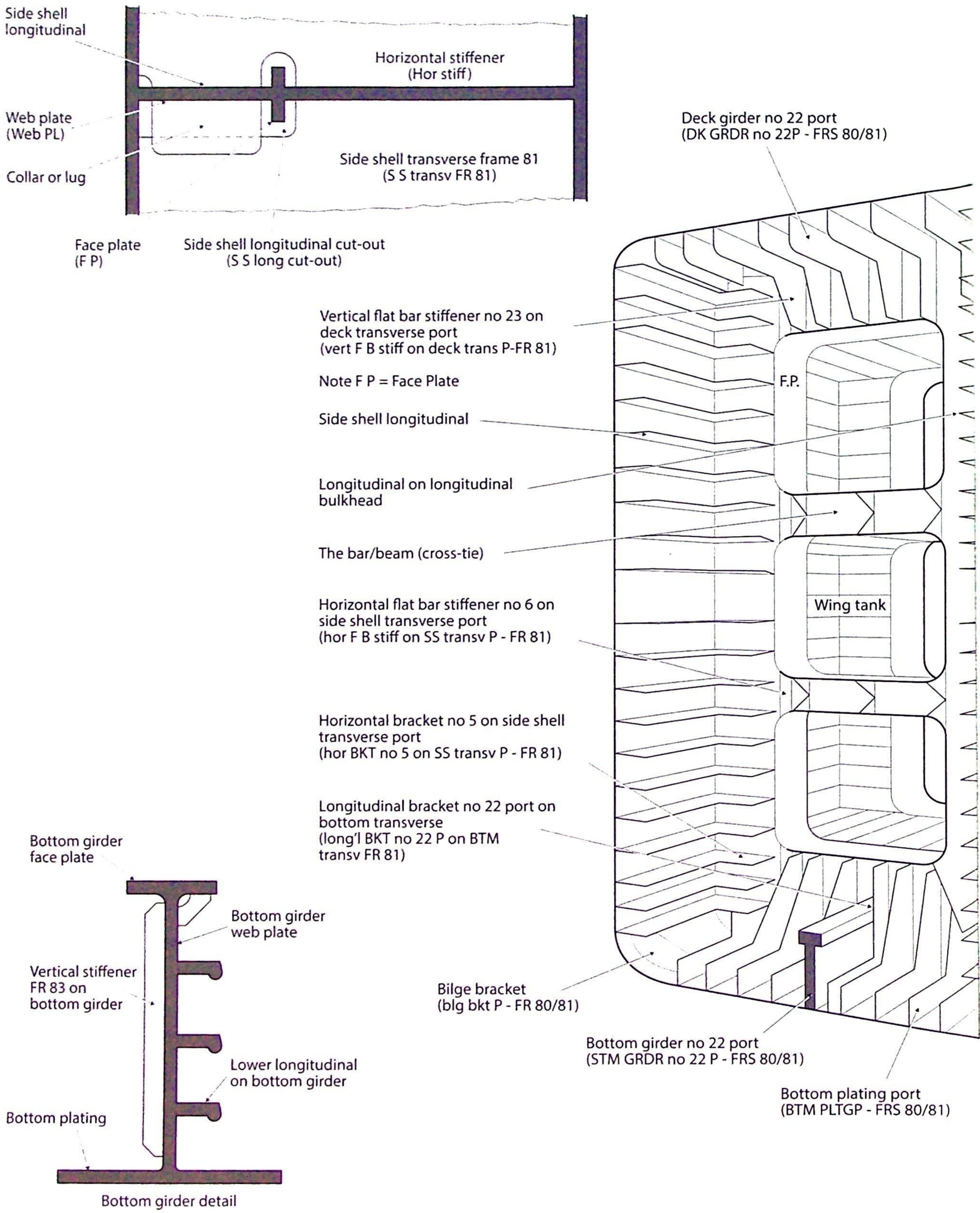
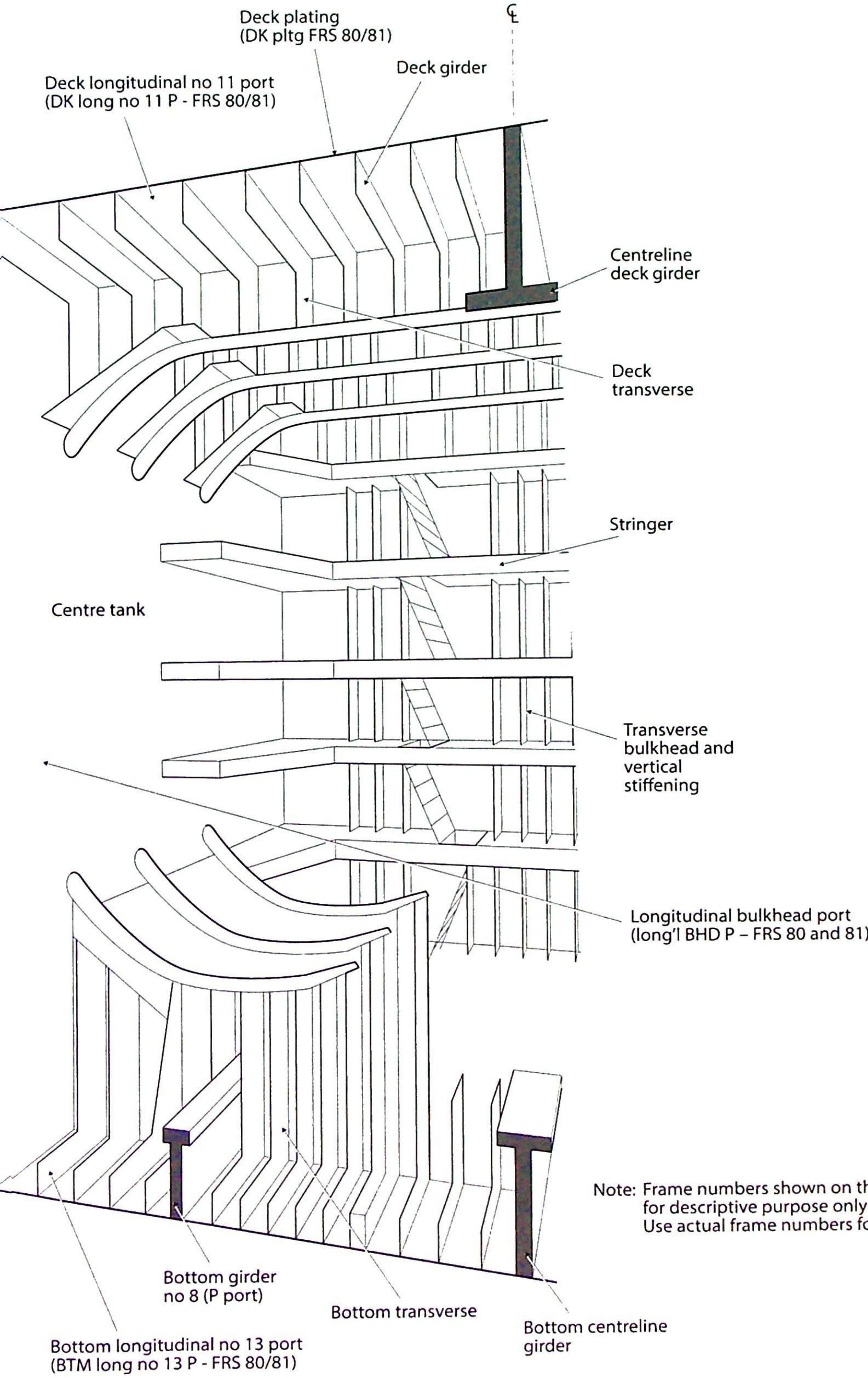


Figure 1.1: Structural Nomenclature



Note: Frame numbers shown on this drawing are typical and given for descriptive purpose only when referring to structural details. Use actual frame numbers for location description.

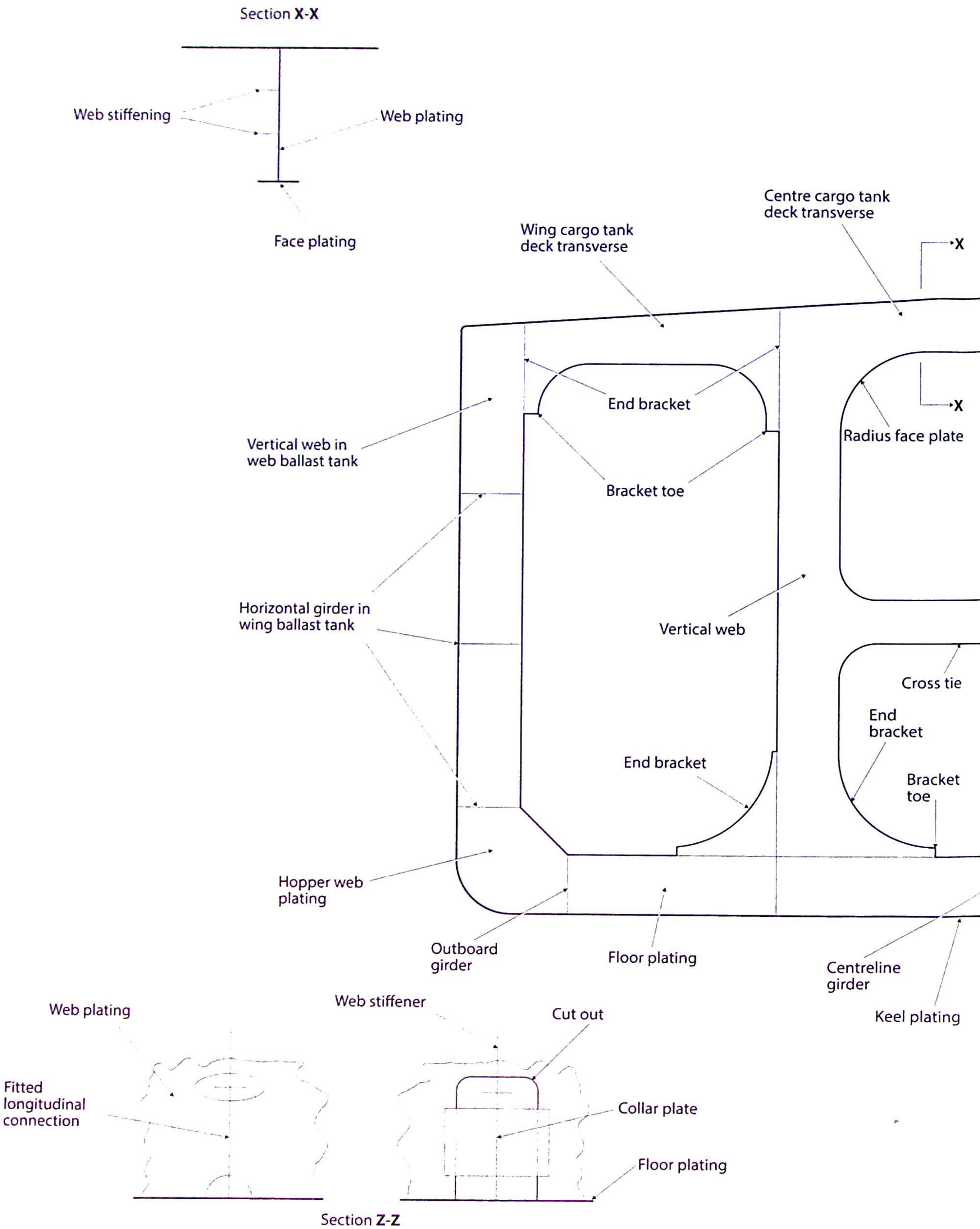
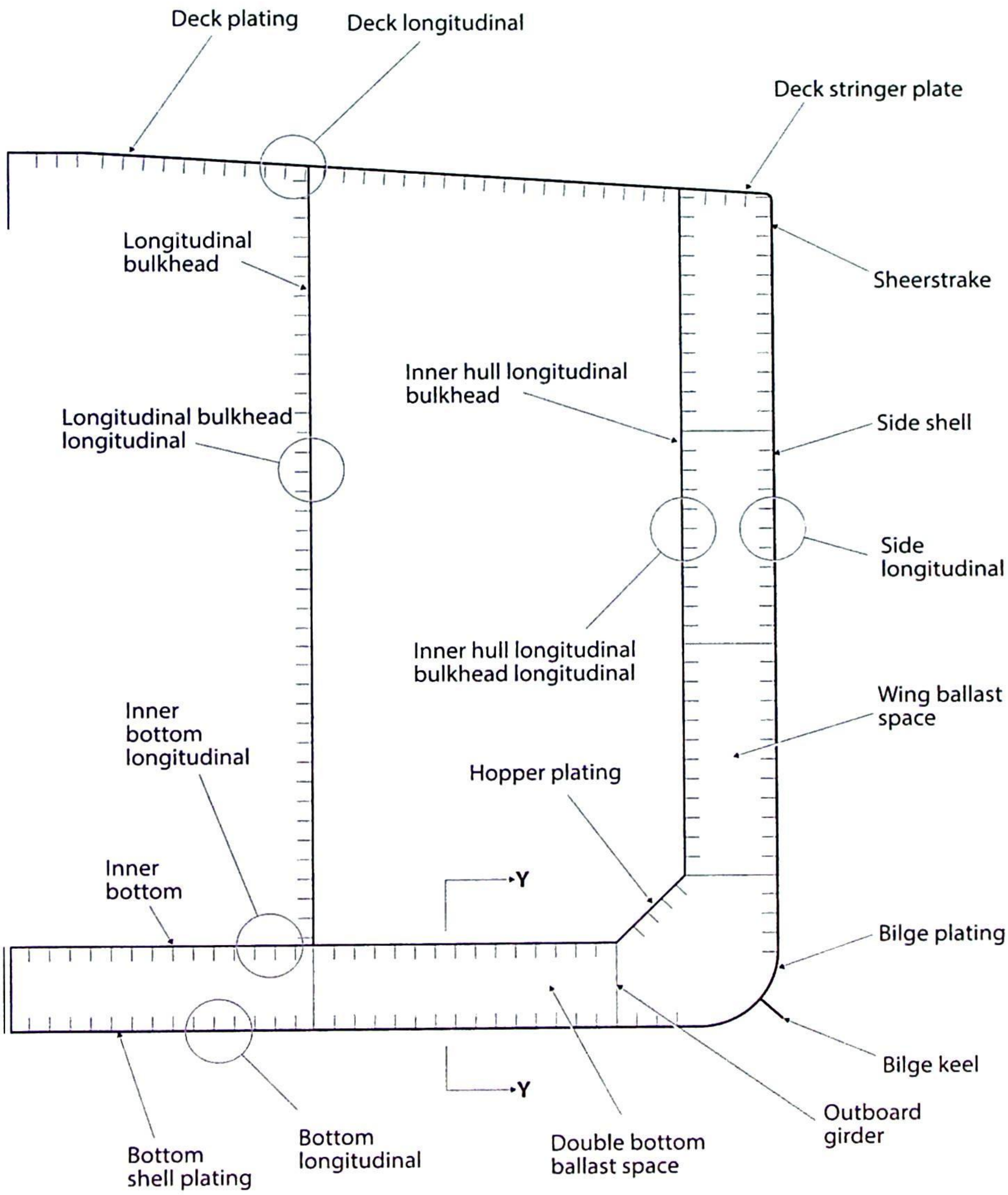
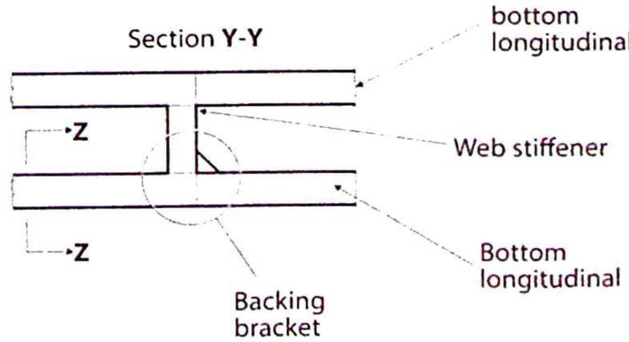
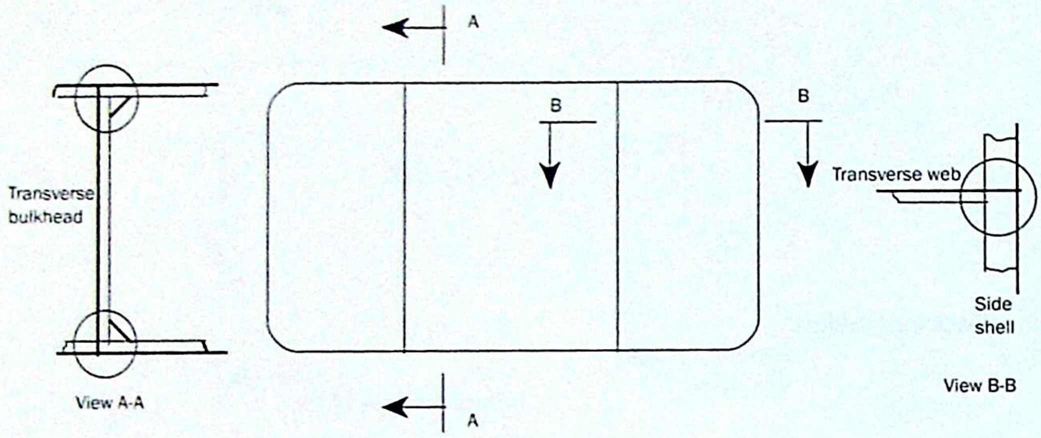


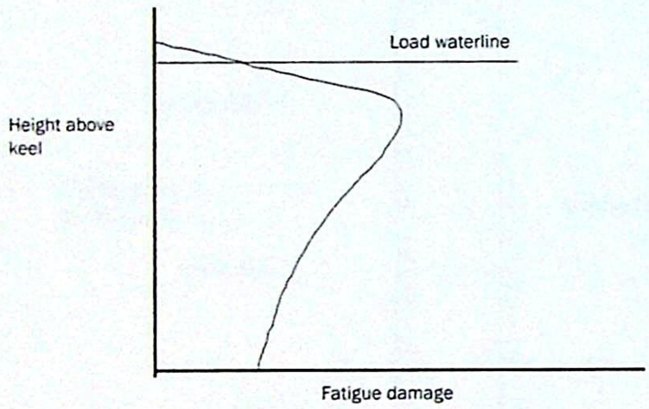
Figure 1.2: Typical Double Hull Midship Section Nomenclature


Deck plating
Deck longitudinal
Deck stringer plate
Longitudinal bulkhead
Sheerstrake
Inner hull longitudinal bulkhead
Longitudinal bulkhead longitudinal
Side shell
Side longitudinal
Inner hull longitudinal bulkhead longitudinal
Wing ballast space
Inner bottom longitudinal
Hopper plating
Y
Inner bottom
Bilge plating
Bilge keel
Y
Outboard girder
Bottom shell plating
Bottom longitudinal
Double bottom ballast space


Section Y-Y
Inner bottom longitudinal
Web stiffener
Z
Z
Bottom longitudinal
Backing bracket



Typical Connections Between Longitudinals and Transverse Web or Bulkhead



Distribution of Fatigue Damage From Wave Loading Over Depth of Vessel

Figure 1.3: Typical Fatigue Damage Locations and Distribution

B. Detail of the Necking Effect

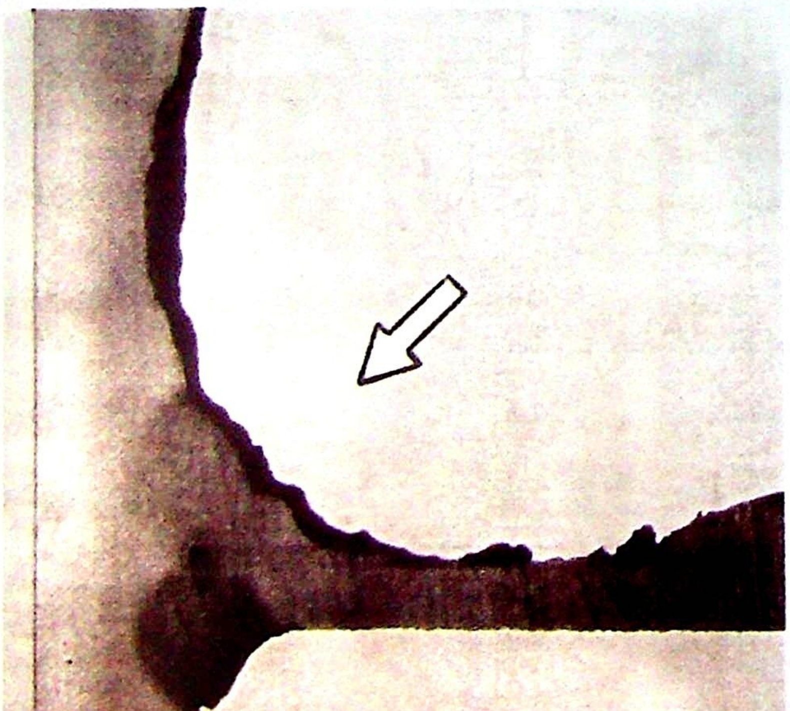


Figure 1.4: Corrosion of Longitudinal Bulkhead Stiffener, Uncoated Segregated Ballast Tank

Longitudinal Bulkhead Longitudinals (Web)

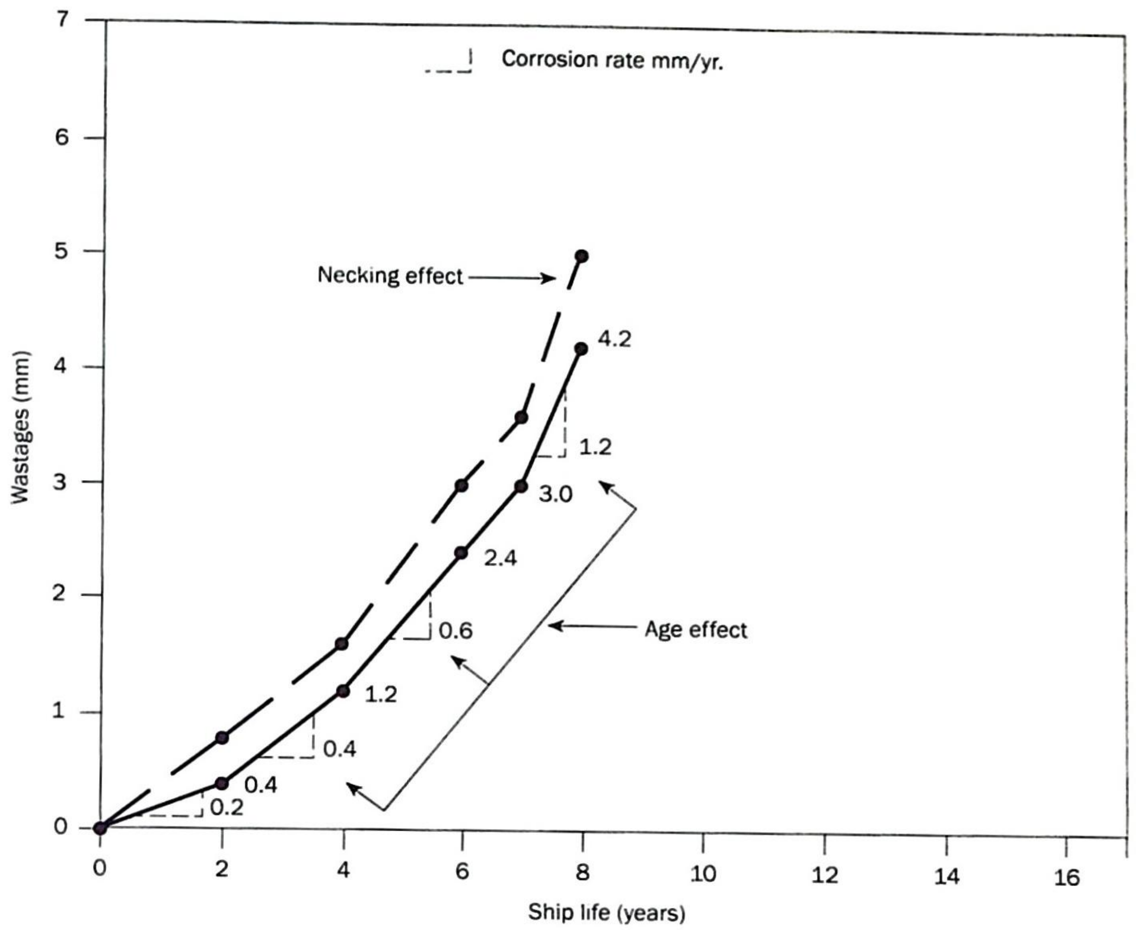


Figure 1.5: ***Accelerated Corrosion (Age and Necking Effect), Uncoated Segregated Ballast Tank***

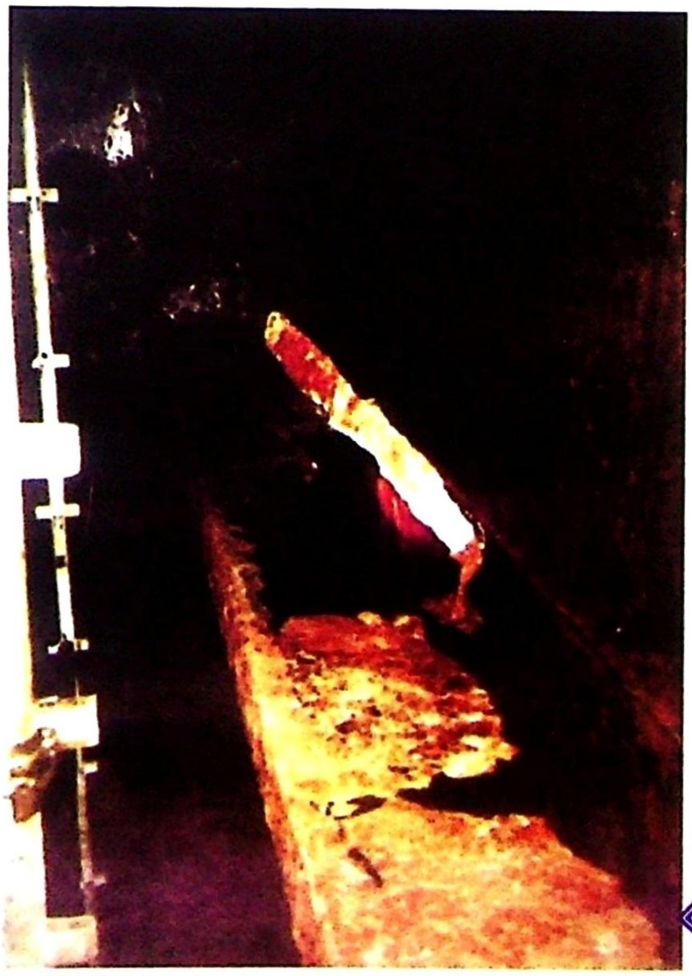


Figure 1.6: ***Corrosion of Side Shell Longitudinal, Uncoated Segregated Ballast Tank***

Figure 1.7: Corrosion of Longitudinal Bulkhead Longitudinal Stiffeners, Uncoated Segregated Ballast Tank

Figure 1.8: Local Corrosion in Way of Coating Failure, Coated Segregated Ballast Tank

Before Scale Removal *After Scale Removal*

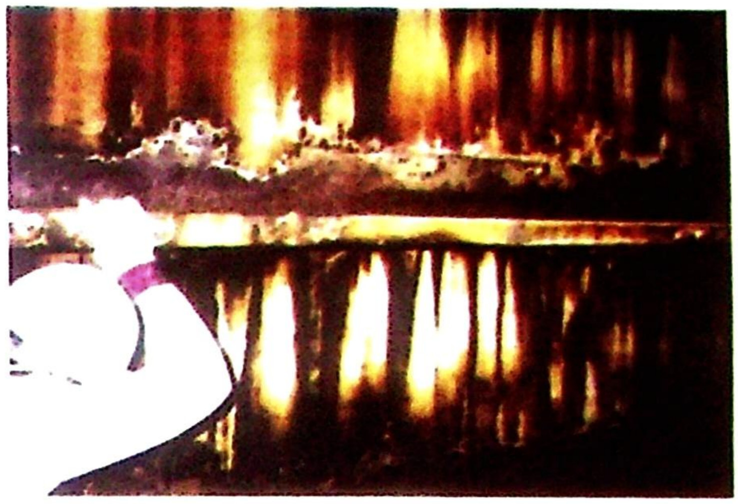


Figure 1.9: Corrosion of Longitudinal Bulkhead, Coated Segregated Ballast Tank

Longitudinal Bulkhead Longitudinals (Web)

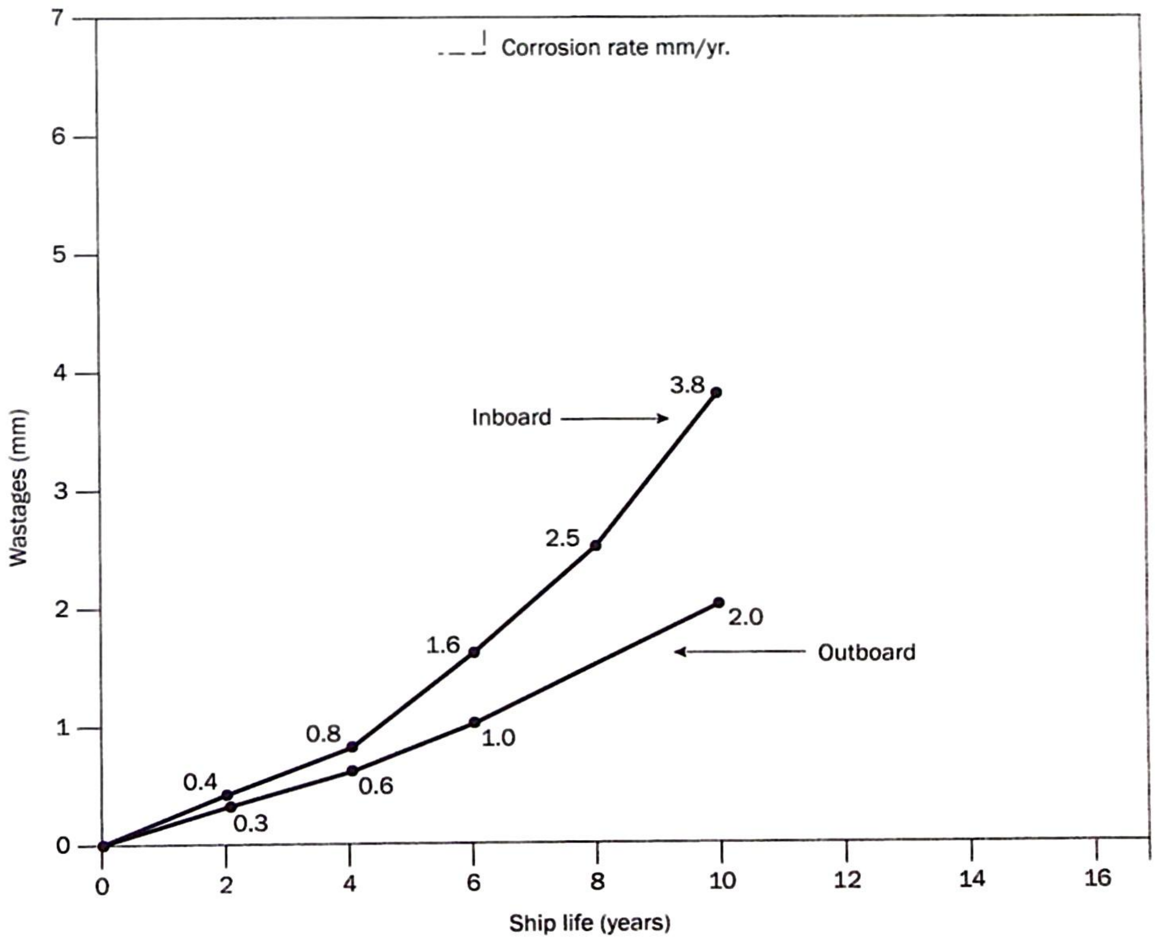


Figure 1.10: Accelerated Corrosion, Uncoated Segregated Ballast Tank

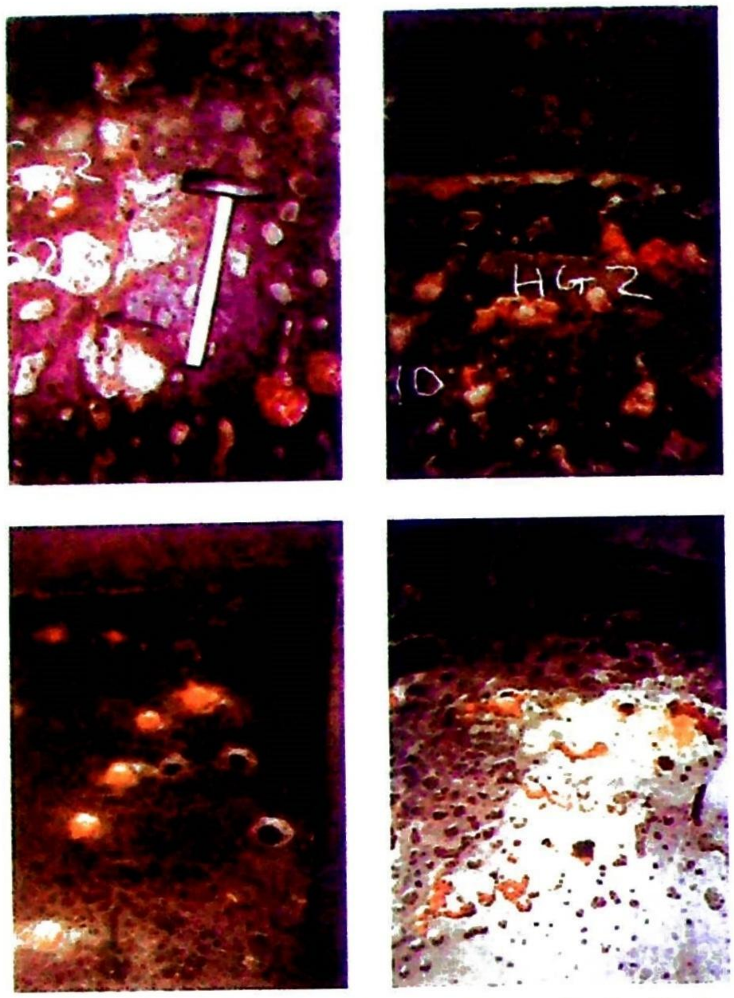


Figure 1.11: ***PIT/Groove on Top of Horizontal Surface, Uncoated Cargo/Arrival Ballast Tank***

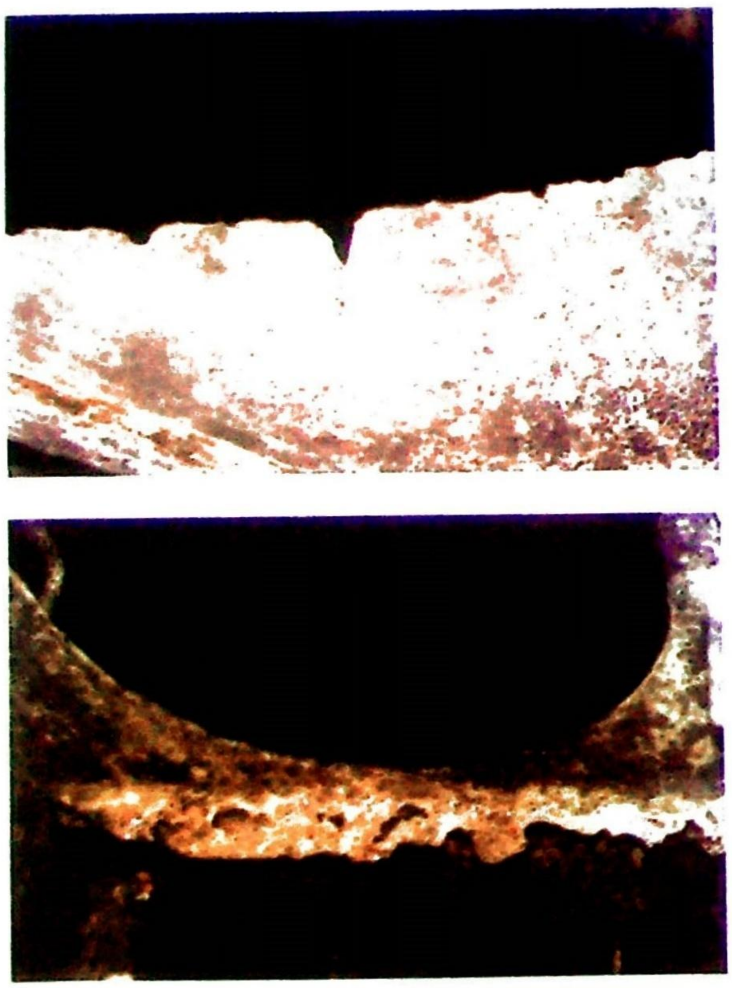


Figure 1.12: ***'Knife Edge' Corrosion, Uncoated Cargo/Arrival Ballast Tanks***

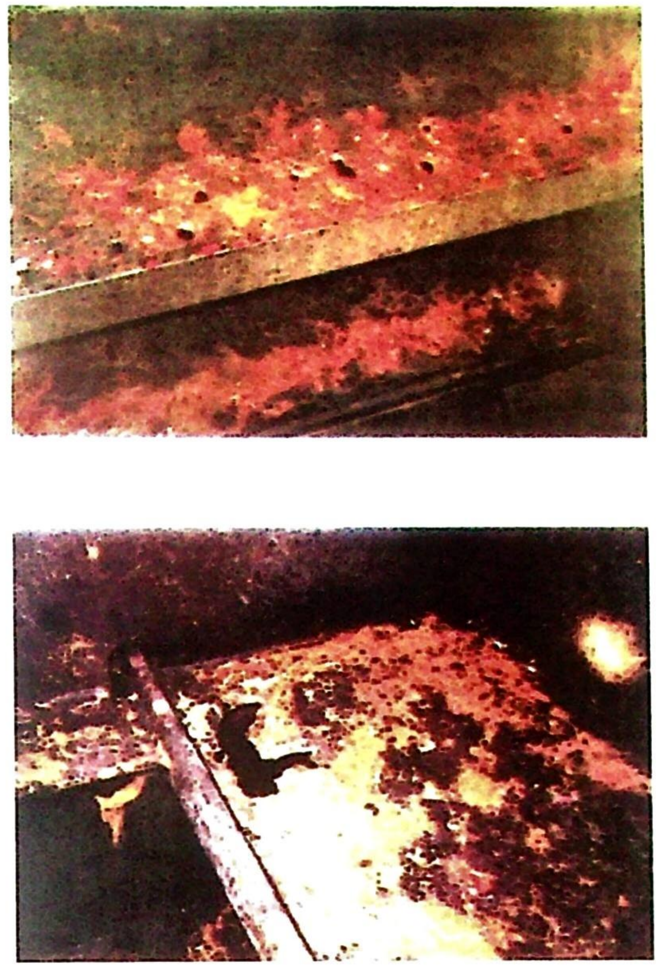
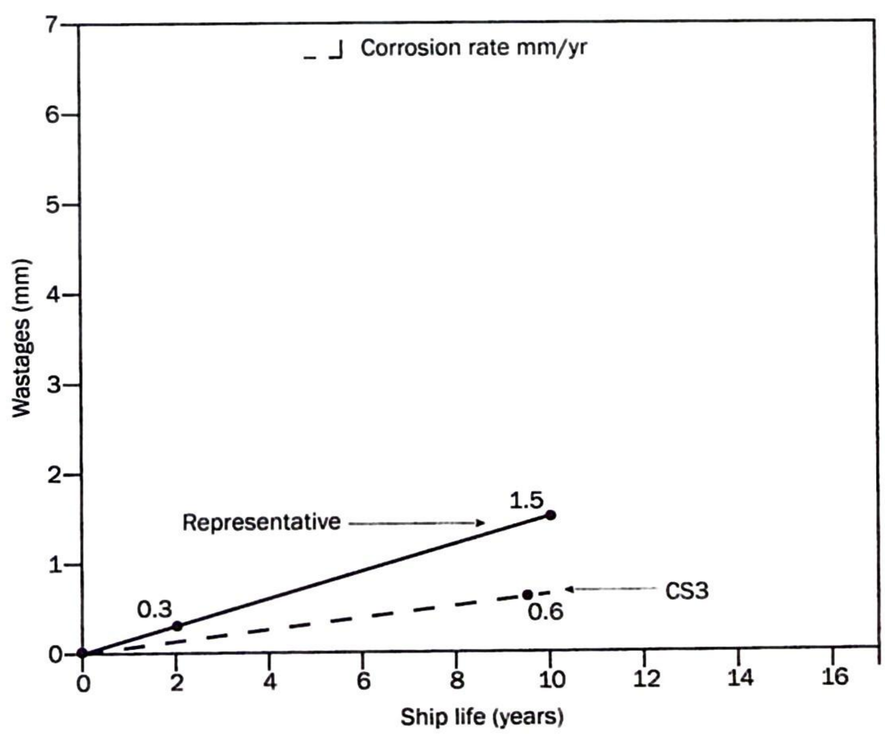


Figure 1.13: Corrosion of Side Shell Longitudinal (Uncoated Cargo/Departure Ballast Tank)

Swash Bulkhead Stringer Plating



NOTES

CS3 – 1. 150,000 dwt tanker
2. Anodes were installed and maintained since new construction

Figure 1.14: Decelerated Corrosion (Due to Anodes), Uncoated Cargo/Arrival Ballast Tank

Chapter Two

Survey Execution Guidelines

2.1 Introduction

In this section, some basic guidelines are suggested for conducting the various types of surveys highlighted in Section 1.1. These guidelines have been drawn from the wide range of experience of the Forum Members in achieving the principal objectives and intent of the various Inspections.

Apart from the main surveys associated with the Classification Society requirements, there is now a greater emphasis being placed on Owners of oil tankers to be fully aware of the structural condition of their own vessels at any stage of their service life and to take the necessary measures to maintain their integrity. For this reason, the following guidance notes address the general planning requirements applicable to all types of survey and describe the scope, detailed planning, data collection and reporting that is associated with these structural inspections.

2.2 General Planning Requirements

2.2.1 General

In preparing for any of the surveys, the Owner, the vessel operator, the shipboard personnel, the survey team and, where applicable, the Classification Society, must work together to ensure that the scope of work has been fully defined, that all equipment is ready and available and that the vessel carries out all preparations for the survey.

The first step of any survey is to define the objective and scope of the survey. For Classification Special Surveys, IACS UR Z10.1 Section 5 should be considered and a survey programme covering no less than the minimum requirements prepared. The survey programme is meant to direct the survey to the proper areas.

A major difficulty in adequately surveying tankers is the physical size of the task. For example, on a double hull vessel of 250,000 dwt, the area to inspect is around 350,000 m^2 for the total tank area and over 200,000 m^2 for the coated ballast tank area.

The structure must be adequately cleaned for visual inspection. For crude oil carriers this will require sufficient COW, often at the two discharges preceding the survey. For heavily scaled structures this may include descaling.

Due to the large areas involved and the short timeframe normally available to carry out this inspection, it is necessary to focus on suspect areas to optimise the effectiveness of the survey.

Suspect areas are those areas subject to rapid wastage, high stress or fatigue showing excessive corrosion, buckling due to corrosion, or poor structural details where cracks could initiate. Suspect areas could also include areas and details of past damage or repair on this or sister vessels. The survey team should study the vessel's structural arrangement and corrosion control systems and review the vessel's operating history and that of sister ships in accordance with 2.5, to determine any suspect areas particular to the class of ship.

Substantial corrosion is an extent of corrosion such that assessment of the corrosion pattern indicates a wastage in excess of 75% of allowable margins, but presently is still within acceptable limits.

Sketches of typical structural elements, such as web frames, stringers and bottom shell expansions, should be prepared in advance so that any defects and ultrasonic thickness measurements can be recorded rapidly and accurately.

An onboard, pre-inspection meeting with the Master should be arranged to discuss safety and scheduling and any other aspects of the survey.

2.2.2 Data Collection and Reporting – Databases

With the increasing requirement for acquisition and analysis of corrosion data for older vessels, there is a need for a means of computerised storage and retrieval. The main obstacle to this has been the problem of transfer of the data from existing paper files into the computer database. Non-destructive examination contractors are now able to provide thickness data in a computerised format should the

Owner have the appropriate facilities. It is attractive to an Owner to use a particular company that has datafiles on his particular ships to reduce the reporting costs.

A further development will be the direct input of thickness measurements directly into the database without the need for manual intervention.

The need for such a database has been heightened by the Class enhanced survey requirements and the requirement to maintain records on board.

There is a potential benefit to the industry of developing software that can be used by Owners and Class to provide a consistent technical standard and avoid duplication of documentation. In addition, feedback on design standards is improved and trends between ship designs may be more readily identified.

The database needs to have the capability to do the following tasks:

- Represent the primary structure in a simplified graphical format. This is a very complex task which will involve identifying every primary member and plate in the cargo body. The degree of definition depends on whether the owner is to use the database to provide specification details for repairs
- identify as built scantlings and any owner's/builder's margins. In addition, there should be the capability for input of re-assessed scantlings to recent Class Rules
- input corrosion data to a graphical format. It is important that the spot thickness data can be represented as well as the format required for enhanced survey, e.g. for the bottom shell the Class requirement is average values for the ends of each plate, while there may be at least 5 values from which the average is taken
- provide the capability for highlighting areas of corrosion below pre-set wastage limits for quick reference and trend identification
- pitting records need to be separately defined with the corrosion data
- provide a facility for storage of details of fractures with a graphical presentation based on a 2D or 3D simplified representation of the hull to enable trends to be identified, e.g. side shell stiffener fractures along the midbody port and starboard
- provide a storage area for narrative text regarding:
    - » repairs carried out
    - » locations/tanks inspected
    - » special comments
    - » anode wastage
    - » coating condition
- store photographs or drawings.

2.3 Structural Aspects

2.3.1 Tank Bottom Structures

The bottom is perhaps the most commonly inspected area on a tanker. The primary concern for the bottom is the determination of the type and extent of wastage.

For coated tanks, bottom wastage will take the form of localised pitting and grooving in way of coating failure. For inorganic zinc coating, the wastage will tend to be patches of scaly areas with only minimal thickness loss. For coal tar epoxy coated tanks, wastage will tend to be in deep smooth conical pits limited in area. These present a definite risk of bottom penetration if not repaired as the rate of growth of these pits can be quite rapid once coating breakdown occurs.

For uncoated tanks, bottom wastage is more general, affecting the higher velocity flow paths of the drainage patterns to a greater extent than stagnant areas. (See Figure 2.2). Therefore, wastage is highest in way of cutouts in transverse web frames and bottom longitudinals and lowest just forward and aft of web frames outside the line of the cutouts. The wastage can be rather deep in way of cutouts, particularly on tanks with no anode protection. Anodes tend to reduce the corrosion rates in these cutouts, provided these are fitted close to the bottom plating.

Particular attention should be given to the zones in the vicinity of the suction wells, which are extremely prone to wastage owing to water flow.

Bottom wastage generally increases from forward to aft, probably due to water wedges caused by the normal trim patterns by the stern, both in full load and ballast conditions. However, this can be reversed for tanks on some ships where the tendency is to trim slightly by the bow in the full load condition. The water wedges are a combination of unstrippable ballast water and water settling out from the cargo, so aft bays of cargo ballast tanks can experience corrosion almost continuously. The plating in way of the cargo suctions and inlets can also experience increased corrosion.

One other typical finding on bottom plating, and sometimes on other structures, is preferential corrosion of weld seams and butts. Often, when this occurs, the welds may have corroded 3–5 mm deeper than the surrounding plate. The most likely reason for this attack is galvanic action causing the anodic weld material to corrode rather than the surrounding plating. Attention should be paid to this problem and appropriate action, such as recoating or rewelding, should be taken.

Horizontal surfaces, such as the face flats of bottom longitudinals and transverse web frames, will also be exposed to pitting corrosion as a result of the frequent washing action in cargo/arrival ballast tanks. This pitting can be extremely severe at the edges of the face flats, to a point where concern is raised about the effect of localised stresses in way of critical connections.

Other typical problems associated with bottom structures are grooving of the welds of bilge longitudinals, thinning and cracking at the toes of longitudinal girder brackets, fracturing of web frame vertical stiffeners at the connection to bottom longitudinals and fracturing at the connection of centre tank transverse webs to the longitudinal bulkheads.

2.3.2 Side Shell, Longitudinal and Transverse Bulkheads

On the side shell and stiffened sides of longitudinal and transverse bulkheads, fractures may occur at the connections of the various structural members. These cracks occur predominantly at the side shell connections and have previously been identified as being due to cyclic loading, while those on longitudinal and transverse bulkheads do not occur to the same extent. Often cracks will be found in way of unbalanced sections, i.e. L-shaped or welded un-symmetric sections, at bracket toes and at bulkhead penetrations.

Wastage patterns on the side shell and the stiffened sides of the bulkheads are usually limited to the horizontal webs of the stiffeners. Deep pitting is often found on the lower stiffening members, usually near web frames. On ships with fabricated longitudinals, where the face flat extends above the web, wastage can be rather severe owing to the trapping of water on the upper surface of the web. Proper drainage holes for this type of stiffening are important.

On the transverse bulkhead horizontal stringer cracks may occur in the welds attaching the stringers to the longitudinal bulkheads in way of the stringer cutouts for connecting vertical stiffeners to the stringer web, and at the stringer face plate terminations where large face areas taper into the longitudinal bulkhead.

Wastage is also heavy where drainage is poor, such as along butted face flats, around the lightening and drainage holes and at steps in plating thickness. Pitting corrosion is very common and may be aided by the effects of fluids dripping from overhead structures in the tank.

In coated areas of the tank structure, accelerated wastage can occur in way of any failure of the protective coating, which generally starts at welds, cutouts and exposed edges of plating. With uncoated structures, the wastage is more general and is usually at a higher rate within the upper areas of the tanks.

2.3.3 Deckhead Structures

Inspection of deckheads of V/ULCCs can be difficult owing to the deep transverse webs. On older vessels, close-up inspection may have to be done in dry dock where proper staging can be erected. For newer vessels with deckhead walkways, inspection is improved around the periphery of the tank but staging may still be needed for the central areas.

For deckhead structures wastage may occur at the connection of the deck longitudinal to the deck plating and, as the thinning of the free edge of the longitudinal increases in severity, may lead to buckling of the deck longitudinals. Fractures in deckhead structures have not generally been a major problem.

The above gives a general guide to areas of concern within tank structures, however, before an inspection of a particular ship can be carried out, identification of the areas within the cargo and ballast tanks considered to be at greater risk requires to be defined. For this purpose, consideration of the risk category of various structural items is necessary. The following section proposes a method for identifying these risk categories.

2.4 Risk Categories

2.4.1 Corrosion

Table 2.1 sets out the level of vulnerability of various tank spaces to the risk of general and pitting corrosion associated with the choice of a particular protection system, using a simple coding system.

2.4.2 Structural Elements

Operational experience with a variety of tanker designs has shown that certain elements of structure are prone to defects from corrosion, buckling or fracture.

Table 2.2 identifies these particular structural items and indicates the areas at higher risk from defects associated with corrosion, buckling and cracks.

The principal features to be considered when assessing the structural integrity of the various structural elements listed can, therefore, be summarised as:

(a) Longitudinal Material

General

The longitudinal material that constitutes the main hull girder consists of deck, bottom, side shell and longitudinal bulkhead, and inner bottom where fitted, and normally includes plating, longitudinal profiles and longitudinal girders. These structural elements are designed with respect to nominal stress levels and buckling stability. Fatigue considerations also form the basis for their design, although this is not normally expressly calculated. The Classification Societies generally accept, in accordance with the IACS UR S7, a 10% maximum reduction in the hull section modulus in the wasted condition provided this does not involve an unacceptable risk of buckling. It should be noted that ships extensively utilising higher tensile steels, for the primary structures, are normally more susceptible to the resulting effects of corrosion in terms of buckling and cracking. This is due to the reduction in original scantlings when compared to mild steel structures and the associated higher stress levels incurred, thereby allowing smaller margins against corrosion.

Corrosion

Areas of structure that are more prone to corrosion in certain types of tanks, as shown in Table 2.1.

Buckling

The buckling of plate panels, where extensive, may lead to a total collapse of the hull girder and so must not be left unrepaired.

Oil tankers in operation today have often been built with relatively low factors of safety against buckling. This aspect, in combination with corrosion, may result in a shorter ship life than previously experienced. In this respect the hull girder compression flanges, i.e. deck and bottom, shell plating and stiffening, are considered the most susceptible. Lately the Rules of some of the Classification Societies have taken this into account and request larger margins.

Cracks

A ship is exposed to a number of different loadings that are dynamic in nature.

As the structure is an all welded construction and incorporates a large number of connections between different structural members, there are a large number of locations where cracks may occur. Steel structures are also subjected to a corrosive environment that increases the risk of cracking, both because corrosion leads to higher stresses and because the surface effects increase fatigue risks. Locations in the ship's structure subjected to higher dynamic stress levels are more susceptible to cracking and, in this respect, the ship's side longitudinals at their connection to web frames and transverse bulkheads are exposed to a higher degree than deck or bottom longitudinals. (See 1.4.4 for fatigue).

(b) Transverse Web Frames

General

Various typical web frame designs may be found. The basic types originated in European and Japanese shipyards and generally resulted in the adoption of separate primary brackets for the European design, rather than integral brackets with continuous face plates for the Japanese.

Corrosion

Areas of transverse structure can be more prone to corrosion in certain types of tanks, as is shown in Table 2.1.

Buckling

Buckling of web frames normally occurs as shear buckling of the web plate panels. These locations would be expected near the ends of the spans of the various parts of the web frame and in the region at the ends of cross ties. Tripping of face plates and buckling of brackets may also be found. See Appendix IV.

Cracks

The web frames experience dynamic loading in seaway and stress concentrations in way of the discontinuities, such as bracket toes and longitudinal connections that may lead to cracks in these regions. The dynamic loads due to the external variable wave loading are higher at the ship's side. For this reason the connections between longitudinals and web frames have been found susceptible to cracking. See Appendix IV.

(c) Transverse Bulkheads

General

Transverse bulkheads may be subjected to higher magnitudes of load. The exposure will depend on the loading conditions. Tank boundaries between ballast and cargo tanks will normally be exposed to full one side loads for the majority of the time. Tank bulkheads between cargo tanks are generally less exposed to full one side loading.

Corrosion

The scantlings of the upper parts of bulkhead plating are generally less than the remaining parts of the bulkhead due to the smaller design head. However, the environmental corrosion is greater in this area and the general wastage will result in a higher percentage corrosion of the original plate thickness than elsewhere on the bulkhead. Reference should also be made to Table 2.1.

Buckling

Buckling of the transverse bulkhead plating is not normally considered to be a problem. However, the primary horizontal and vertical girder structures may be vulnerable to shear buckling.

Cracks

Cracks in the transverse bulkhead structure, where found, are normally in the connection to the supporting structures and at the intersections with longitudinal material.

(d) Swash Bulkheads

General

The scantlings of full swash bulkheads are generally less than for boundary transverse bulkheads as they are not subjected to the same design loading normal to the plating. However, swash bulkheads may be subjected to higher inplane loadings. The wing swash bulkhead carries large shear forces between the longitudinal bulkhead and the ship's side and the centre tank swash bulkhead will provide support to a centreline girder system. Swash bulkheads are also subjected to dynamic loads from the movement of liquid through the bulkhead openings. The configuration of the openings, which may differ to a large extent, will determine the magnitude of these loads.

Aspects relating to corrosion, buckling and cracks will be similar to transverse bulkheads. For deep transverse type swash bulkheads refer to Section 2.4.2. (b).

2.5 Classification Society Surveys/ IACS Unified Requirements for Hull Surveys of Double Hull Oil Tankers

2.5.1 General

The requirements apply to all self-propelled Double Hull Oil Tankers.

The requirements apply to surveys of hull structure and piping systems in way of cargo tanks, pump rooms, cofferdams, pipe tunnels, void spaces within the cargo area and all ballast tanks. The requirements are additional to the classification requirements applicable to the remainder of the ship. Refer to Z7.

The requirements contain the minimum extent of examination, thickness measurements and tank testing. The survey is to be extended when Substantial Corrosion and/or structural defects are found and include additional Close-up Survey when necessary.

2.5.2 Special Survey

Special Surveys are to be carried out at 5 years intervals to renew the Classification Certificate.

The first Special Survey is to be completed within 5 years from the date of the initial classification survey and thereafter within 5 years from the credited date of the previous Special Survey. However, an extension of class of 3 months maximum beyond the 5th year can be granted in exceptional circumstances. In this case, the next period of class will start from the expiry date of the Special Survey before the extension was granted.

For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date.

In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date.

The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the Special Survey is commenced prior to the 4th Annual Survey, the entire survey is to be completed within 15 months if such work is to be credited to the Special Survey.

Concurrent crediting to both Intermediate Survey (IS) and Special Survey (SS) for surveys and thickness measurements of spaces are not acceptable.

2.5.3 Annual Survey

Annual Surveys are to be held within 3 months before or after anniversary date from the date of the initial classification survey or of the date credited for the last Special Survey.

2.5.4 Intermediate Survey

The Intermediate Survey is to be held at or between either the 2nd or 3rd Annual Survey. Those items, which are additional to the requirements of the Annual Surveys, may be surveyed either at or between the 2nd and 3rd Annual Survey. Concurrent crediting to both Intermediate Survey (IS) and Special Survey (SS) for surveys and thickness measurements of spaces are not acceptable. For vessels built under IACS Common Structural Rules, the identified substantial corrosion areas are required to be examined and additional thickness measurements are to be carried out.

Double Hull Oil Tankers between 5 and 10 years of age. The following is to apply:

For tanks used for salt-water ballast, an Overall Survey of Representative Tanks selected by the Surveyor is to be carried out.

If such inspections reveal no visible structural defects, the examination may be limited to a verification that the hard protective coating remains in GOOD condition.

A Ballast Tank is to be examined at subsequent annual intervals where:

(a) a hard protective coating has not been applied from the time of construction, or

(b) a soft or semi-hard coating has been applied, or

(c) substantial corrosion is found within the tank, or

(d) the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

In addition to the requirements above, suspect areas identified at previous surveys are to be examined.

Double Hull Oil Tankers between 10 and 15 years of age. The following is to apply:

The requirements of the Intermediate Survey are to be to the same extent as the previous Special Survey as required. However, pressure testing of cargo and ballast tanks *and the requirements for longitudinal strength evaluation of Hull Girder as required in 8.1.1.1.* (UR Z10.4, see Appendix II) *are not* required unless deemed necessary by the attending Surveyor.

In application of 4.2.3.1 (UR Z10.4, see Appendix II), the intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion at the third annual survey in lieu of the application of 2.1.4 (UR Z10.4, see Appendix II). In application of 4.2.3.1 (UR Z10.4, see Appendix II), an under water survey may be considered in lieu of the requirements of 2.2.2 (UR Z10.4, see Appendix II).

Double Hull Oil Tankers over 15 years of age. The following is to apply:

The requirements of the Intermediate Survey are to be to the same extent as the previous Special Survey as required. However, pressure testing of cargo and ballast tanks *and the requirements for longitudinal strength evaluation of Hull Girder as required in 8.1.1.1* (UR Z10.4, see Appendix II) *are not* required unless deemed necessary by the attending Surveyor.

In application of 4.2.4.1 (UR Z10.4, see Appendix II), the intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion at the third annual survey in lieu of the application of 2.1.4 (UR Z10.4, see Appendix II).

In application of 4.2.4.1 (UR Z10.4, see Appendix II), a survey in dry dock is to be part of the intermediate survey. The overall and close-up surveys and thickness measurements, as applicable, of the lower portions of the cargo tanks and water ballast tanks are to be carried out in accordance with the applicable requirements for intermediate surveys, if not already carried out.

Note: Lower portions of the cargo and ballast tanks are considered to be the parts below light ballast water line.

2.5.5 Preparation for Survey

The Owner in co-operation with the Classification Society is to work out a specific Survey Programme prior to the commencement of any part of:

- The Special Survey
- the Intermediate Survey for oil tanker over 10 years of age.

The Survey Programme at Intermediate Survey may consist of the Survey Programme at the previous Special Survey supplemented by the Executive Hull Summary of that Special Survey and later relevant survey reports. The Survey Programme is to be worked out taking into account any amendments to the survey requirements implemented after the last Special Survey carried out. The Survey Programme is to be in a written format based on the information in Annex IVA (see Appendix II). The survey is not to commence until the survey programme has been agreed.

Prior to the development of the survey programme, the survey planning questionnaire is to be completed by the owner based on the information set out in Annex IVB (see Appendix II), and forwarded to the Classification Society.

In developing the survey programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas, and structural elements to be examined:

.1 survey status and basic ship information;

.2 documentation on board, as described in 6.2 and 6.3 (UR Z10.4, see Appendix II);

.3 main structural plans of cargo and ballast tanks (scantlings drawings), including information regarding use of high-tensile steels (HTS);

.4 Executive Hull Summary;

.5 relevant previous damage and repair history;

.6 relevant previous survey and inspection reports from both the recognized organization and the owner;

.7 cargo and ballast history for the last 3 years, including carriage of cargo under heated conditions;

.8 details of the inert gas plant and tank cleaning procedures;

.9 information and other relevant data regarding conversion or modification of the ship's cargo and ballast tanks since the time of construction;

.10 description and history of the coating and corrosion protection system (previous class notations), if any;

.11 inspections by the Owner's personnel during the last 3 years with reference to structural deterioration in general, leakages in tank boundaries and piping and condition of the coating and corrosion protection system if any;

.12 information regarding the relevant maintenance level during operation including port state control reports of inspection containing hull related deficiencies, Safety Management System non-conformities relating to hull maintenance, including the associated corrective action(s); and

.13 any other information that will help identify suspect areas and critical structural areas.

The submitted Survey Programme is to account for and comply, as a minimum, with the requirements of Tables I, II and 2.5 (UR Z10.4, see Appendix II) for close-up survey, thickness measurement and tank testing, respectively, and is to include relevant information including at least:

.1 basic ship information and particulars;

.2 main structural plans (scantling drawings), including information regarding use of high tensile steels (HTS);

.3 plan of tanks;

.4 list of tanks with information on use, corrosion prevention and condition of coating;

.5 conditions for survey (e.g., information regarding tank cleaning, gas freeing, ventilation, lighting, etc.);

.6 provisions and methods for access to structures;

.7 equipment for surveys;

.8 nomination of tanks and areas for close-up survey (per 2.3);

.9 nominations of sections for thickness measurement (per 2.4) ((UR Z10.4, see Appendix II);

.10 nomination of tanks for tank testing (per 2.5) (UR Z10.4, see Appendix II);

.11 identification of the thickness measurement company;

.12 damage experience related to the ship in question;

.13 critical structural areas and suspect areas, where relevant.

The Classification Society will advise the Owner of the maximum acceptable structural corrosion diminution levels applicable to the vessel.

Use may also be made of the Guidelines for Technical Assessment in Conjunction with Planning for Enhanced Surveys of Double Hull Oil Tankers Special Survey – Hull, contained in Annex I (UR Z10.4, see Appendix II). These guidelines are a recommended tool which may be invoked at the discretion of the Classification Society, when considered necessary and appropriate, in conjunction with the preparation of the required Survey Programme.

Conditions for Survey

The Owner is to provide the necessary facilities for a safe execution of the survey.

In order to enable the attending surveyors to carry out the survey, provisions for proper and safe access are to be agreed between the owner and the Classification Society are to be in accordance with IACS PR 37.

Details of the means of access are to be provided in the survey planning questionnaire.

In cases where the provisions of safety and required access are judged by the attending surveyors not to be adequate, the survey of the spaces involved is to not proceed.

Tanks and spaces are to be safe for access. Tanks and spaces are to be gas free and properly ventilated. Prior to entering a tank, void or enclosed space, it is to be verified that the atmosphere in that space is free from hazardous gas and contains sufficient oxygen.

In preparation for survey and thickness measurements and to allow for a thorough examination, all spaces are to be cleaned including removal from surfaces of all loose accumulated corrosion scale. Spaces are to 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.

Sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration.

Where Soft or Semi-hard 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. When safe access cannot be provided, the soft or semi-hard coating is to be removed.

Access to Structures

For overall survey, means are to be provided to enable the surveyor to examine the hull structure in a safe and practical way. For close-up survey, one or more of the following means for access, acceptable to the Surveyor, is to be provided:

- Permanent staging and passages through structures;
- temporary staging and passages through structures;
- hydraulic arm vehicles such as conventional cherry pickers, lifts and movable platforms;
- boats or rafts;
- portable ladders;
- other equivalent means.

Equipment for Survey

Thickness measurement is normally to be carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven to the Surveyor as required. One or more of the following fracture detection procedures may be required if deemed necessary by the Surveyor:

- Radiographic equipment;
- ultrasonic equipment;
- magnetic particle equipment;
- dye penetrant.

Explosimeter, oxygen-meter, breathing apparatus, lifelines, riding belts with rope and hook and whistles together with instructions and guidance on their use are to be made available during the survey. A safety check-list is to be provided. Adequate and safe lighting is to be provided for the safe and efficient conduct of the survey.

Adequate protective clothing is to be made available and used during the survey (e.g. safety helmet, gloves, safety shoes, etc.).

Rescue and Emergency Response Equipment

If breathing apparatus and/or other equipment is used as 'Rescue and emergency response equipment' then it is recommended that the equipment should be suitable for the configuration of the space being surveyed.

Survey at Sea or at Anchorage

Survey at sea or at anchorage may be accepted provided the Surveyor is given the necessary assistance from the personnel on board. Necessary precautions and procedures for carrying out the survey are to be in accordance with 5.1, 5.2, 5.3 and 5.4 (UR Z10.4, see Appendix II).

A communication system is to be arranged between the survey party in the tank and the responsible officer on deck. This system is to include the personnel in charge of ballast pump handling if boats or rafts are used.

Surveys of tanks by means of boats or rafts may only be undertaken with the agreement of the Surveyor, who is to 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.

When rafts or boats are used for close-up surveys, the following conditions are to be observed:

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

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

.3 appropriate lifejackets are to be available for all participants;

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

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

.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;

.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).

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

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:

i. access direct from the deck via a vertical ladder and a small platform fitted approximately 2 m below the deck in each bay; or

ii. access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform shall, 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 is to 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 (see UR Z10.4 Figure 4).

If neither of the above conditions are met, then staging or an "other equivalent means" is to be provided for the survey of the under deck areas.

The use of rafts or boats alone in paragraphs 5.6.5 and 5.6.6 (UR Z10.4, see Appendix II) does not preclude the use of boats or rafts to move about within a tank during a survey.

Reference is made to IACS Recommendation 39 – Guidelines for the use of Boats or Rafts for Close-up surveys.

Survey Planning Meeting

Proper preparation and close co-operation between the attending surveyor(s) and the owner's representatives on board prior to and during the survey are an essential part in the safe and efficient conduct of the survey. During the survey on board safety meetings are to be held regularly.

Prior to the commencement of any part of the Special and Intermediate Survey a survey planning meeting is to be held between the attending Surveyor(s), the Owner's Representative in attendance, the TM company representative, where involved, and the master of the ship or an appropriately qualified representative appointed by the master or Company for the purpose of ascertaining 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. See also 7.1.2 (UR Z10.4, see Appendix II).

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

.1 schedule of the vessel (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 representative(s) concerning findings.

2.6 Owner's Surveys

2.6.1 General

For all the various types and combinations of surveys, there are many common considerations for execution.

When the survey team arrives on board the vessel, they review the plan and ensure that all parties agree on the scope of the surveys, the scheduling of surveys (and the voyage) and the safety procedures. Given good planning, all parties should be aware of and capable of their tasks.

All surveys require proper reporting. For some surveys, such as thickness measurement, the plan can be very specific and the reporting fully prescribed. For other surveys, such as repair specifications or defect surveys, the overall format can be specified beforehand but the scope entirely depends on the defects that are found.

Reports of structural inspections and previous repairs must be kept on board with the supporting documents of the survey report file, as required by IACS UR Z10.1 6.3.

2.6.2 General Condition Survey

(a) Scope of Survey

The intent of this type of survey is to obtain an overall impression of the structural integrity and corrosion condition of the vessel's tanks in a relatively short period of time, with minimum requirements for access for close-up inspection. The scope and data collection procedures will vary depending on the objective. The report of the survey is generally a narrative of the findings with, perhaps, some detailed sketches of problem areas.

As a minimum to assess the general condition of a vessel, the survey should attempt to cover one tank of each type of cargo/ballast service (i.e. segregated ballast, cargo/arrival ballast, cargo/departure ballast and cargo only). This, however, can only be considered valid where the ballast history and corrosion control system for each type of service are similar. Otherwise, erroneous conclusions may be drawn. Where the service and corrosion control systems differ within a type of tank, additional tanks should be surveyed. Ideally, all tanks should be included in the survey programme.

Within each tank, close-up inspection is generally restricted to areas readily accessible from ladders and walkways, such as stringer platforms and bottom structures. General inspection of all viewable areas is carried out.

(b) Planning

Although the general condition survey is not intended to produce detailed measurements of the tanks' condition, the survey extent, timing, safety aspects, tank cleaning and access must be considered as with any other survey. Onboard, pre-inspection meetings with the Master should be held before commencing tank entry and inspection.

(c) Data Collection and Reporting

As the inspection is a visual one, and does not allow for close-up inspection, the surveyor must ensure that he systematically looks at all important items on which the condition assessment will be based. In his report, he should specifically cover the following structural categories:

Reference is also made to 2.3 and 2.4.

- Bottom shell including under bellmouths
- side shell
- longitudinal bulkheads
- transverse bulkheads
- swash bulkheads
- stringer platforms
- deckhead
- girder systems
- web frames and crossties.

Within each category he should note the following:

- Condition of coating or anodes (if any)
- scale formation and evidence of general scaling
- global buckling in the grillage system or localised buckling of plating or stiffening
- fracturing of plating or stiffening
- structural condition (relative to allowance and substantial corrosion) and possible need for steel renewal or for more in depth inspection
- flexing of local structure (often recognised by local shedding or the lack of scale)

- pitting corrosion and, where possible, the depth, diameter and intensity
- condition of piping and fittings
- condition of handrails, ladders and walkways
- areas unseen due to sludge, sediment or water wedges or lack of access or lighting.

The report for this survey should fully describe the items listed above, possibly with illustrations of problem areas that were identified.

2.6.3 Detailed Condition Survey

(a) Scope of Survey

The intent of these surveys is to perform a close-up inspection and thickness determination of sufficient structural elements in a tank, group of tanks or the entire vessel to assess the present condition, so that appropriate present and future repair action can be taken.

When conducted under the guidance of the appropriate Classification Society, the survey can also be planned so as to satisfy the enhanced survey requirements including the IACS UR Z10.1. In this case, the Classification Society surveyor has the responsibility to ensure that the Classification Society requirements are fulfilled.

The timing and degree of intensity of these surveys can vary considerably. Generally, such a survey would not be performed on a new vessel, i.e. prior to first Special Survey, but should be considered as the vessel approaches second Special Survey. In this time range of about 9–10 years' service, corrosion control systems may start to lose their effectiveness and structural and corrosion problems may have developed to a point where identification and repair action is important.

The intensity of survey needed may vary between tank service types. For example, segregated ballast tanks with coating systems in GOOD condition would not normally need extensive gauging. However, if coating systems have failed, close-up inspections are required annually and gauging would be in order. In cargo/ballast tanks, the age, the amount of ballast service and the condition of any corrosion control will help govern the intensity of survey required. Tanks seldom used for ballast would not normally need an intensive gauging survey until later in the vessel's life, although close-up visual survey for structural defects may be warranted.

This type of survey can be carried out while in dock or at sea. The at sea version has been found to be a viable option for most cases as access can be achieved by using rafts in ballasted tanks. If carried out in dock, staging may be required to reach upper areas of tanks, particularly on large vessels, thereby increasing the cost of survey.

For V/ULCCs, surveys of this nature could last anywhere from 10–25 days. The length required should depend on the scope and the condition of the tanks. For smaller vessels, the surveys are shorter due to less difficulties with access to structures. Five to seven days would normally be sufficient for a complete detailed condition survey of a handy sized vessel.

By performing periodic general condition surveys, sufficient information can be gained to plan the detailed condition surveys.

(b) Planning

Before a detailed condition survey is undertaken, plans must be developed to ensure that all parties understand what is involved. The general planning requirements should be followed and an outline prepared of what is to be accomplished.

The survey report file and supporting documents as required by IACS UR Z10.1 Sections 6.2 and 6.3 should be used in planning a survey.

One result of this planning should be a diagrammatic layout of the vessel showing the tanks to be surveyed, the extent or access for these surveys and a listing for each tank indicating the locations to be gauged.

Any other supplemental information required should be specified in separate instructions to the survey team.

(c) Data Collection and Reporting

The data is generally collected by a survey team composed of a surveyor and one or more ultrasonic engineers, depending on the size of the vessel and the time available for survey.

The surveyor has the responsibility of ensuring that all ultrasonic measurements are taken as planned. He is also responsible for checking the overall condition of each tank and performing Close-up Surveys as planned.

In addition to identifying areas with a thickness below the allowable wastage limits, areas with a thickness below the substantial corrosion limit should also be highlighted. Individual readings that indicate substantial corrosion require additional readings to verify it as shown in IACS UR Z10.1 Table IV.

To obtain meaningful data from ultrasonic gaugings, care must be taken in adopting a systematic approach to data collection. The number and extent of readings may have to be substantially increased if the effects of general rather than local corrosion rates are desired. The readings must be representative as well as accurate to correctly record the condition.

2.6.4 Corrosion Rate Survey

(a) Scope of Survey

These are intended to collect information on corrosion rates being experienced by vessel structure and may cover specific structural components of specific tanks, or may seek more general information on corrosion rates of the entire vessel.

The scope is determined by the needs of the user and may come about to plan specific maintenance, as a result of a desire for general information on corrosion rates of a particular vessel, or because of findings of a general condition survey.

(b) Planning

The primary objective of planning for this survey involves the identification of specific structural components to be measured. For the case of a general corrosion rate assessment of the entire vessel, the tanks selected for survey must be sufficiently representative of the various cargo/ballast services to guard against erroneous conclusions. The thickness measurements taken in way of specified key panels can be used to determine overall corrosion rates for structural areas. Care must be taken to account for the various factors that affect the corrosion rate, such as location relative to cargo and washing, orientation (vertical/horizontal), exposed surfaces (one or two-sided corrosion) and general tank service. See Sections 1.4.5–1.4.7.

A set of key plans should be prepared showing schematically all of the pre-determined locations of the structure that are to be measured during the survey.

(c) Data Collection and Reporting

Each data panel indicated on the key plan should undergo ultrasonic thickness measurements and pitting assessment.

Each spot selected for measurement should be accurately located and recorded. Where possible, sufficient reference markings of point or centrepunches should be placed on the structure without interfering with the measuring points, so that the same locations can be found at the next survey. Each location should have a pre-assigned reference identification number.

The thickness measurements should be taken as accurately as possible as even slight errors can seriously affect the results. The type of instrument used for measuring should be noted and the same instrument type should be used in subsequent surveys. Where possible, the same personnel should be used to minimise factors contributing to measurement errors.

Some work has been done by Owners and research organisations in the past on the use of corrosion coupons or resistance probes to determine corrosion rate data. These may produce usable results, but care must be taken in the numbers and locations used or un-representative data may result.

Results of corrosion rate surveys should be maintained on board with the supporting documents, as is the case with other owner surveys.

Measurements for Classification purpose must be carried out by a certified company.

2.6.5 Repair Specification Survey

(a) Scope of Survey

The intention of this type of survey is to obtain sufficient detailed information to specify precise steel renewal requirements, structural repairs and reinforcements and corrosion control measures, in order to prepare a detailed shipyard repair specification. This type of survey may be conducted as part of a detailed condition survey or may come about as a result of findings of other structural surveys.

Generally, this survey is more limited in scope than a detailed condition survey, focusing on a particular tank or area requiring repair action. The object is to collect detailed information so that an accurate repair specification can be written. Often a more general survey will require that repair specification items be developed for any items requiring it as found during the general survey.

(b) Planning

The planning of a repair specification survey will be dependent on the extent and immediacy of repair work. In cases of localised failures, inspection of adjacent spaces may also be necessary.

(c) Data Collection and Reporting

The data collection guidelines are similar to the detailed condition survey, but in general the data collected will be for specific areas of the tank and include precise data collection on steel thickness loss, coating failure or anode wastage. The repair item should specify sizes and thicknesses, material grades, access requirements, and foreseeable cleaning requirements.

For steel renewal determination it is important that sufficient thickness measurements are taken to determine the true residual strength of the structure. The readings should be well documented and taken in accordance with accepted procedures.

The survey report should be produced in a form of sufficient detail to enable a repair specification to be compiled. This must incorporate an accurate assessment of material quantities and repair methods leading to cost estimates. In cases where detailed modifications are required, due cognisance should be given to the Catalogue of Structural Detail Failures of Appendix IV.

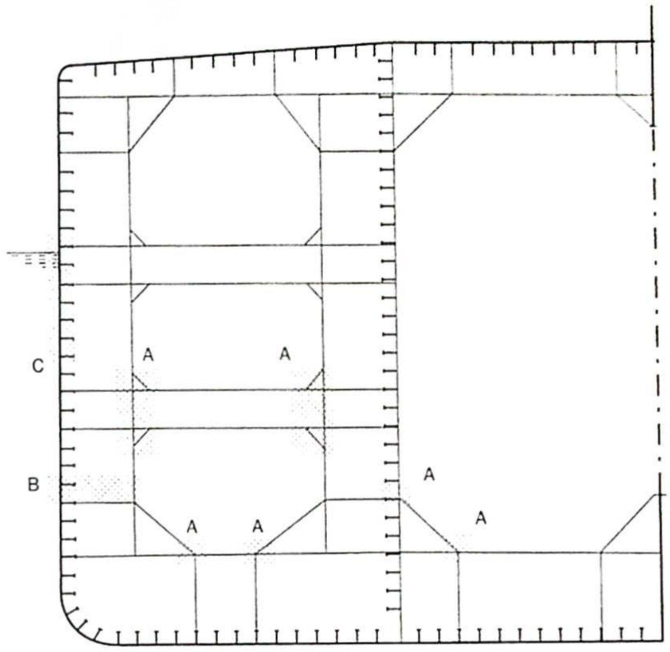
Risk of Corrosion and Pitting					
Type of Tank	**Fully Coated**	**Upper Part Coated**	**Upper + Lower Part**	**Anodes**	**None**
Segregated Ballast	L	H+	H+	M–H	1) H++
Cargo/Clean Ballast (Arrival Ballast)	Lp	H	Hp	M	2) H+
Cargo/Dirty Ballast (Departure Ballast)	Lp	M	Mp	M–L	M–H
Cargo/Heavy Ballast	(L)	L	L	X	L–M
Cargo Only	X	L-	L-	X	L
H = High Risk M = Medium Risk	H+ = Higher Risk	X = Not Considered	T = Low Risk p = Risk of Pittings	L– = Lower Risk () = Negligible	

NOTES		
1) Especially exposed items: – Horizontal stringers. – Longitudinals on longitudinal bulkhead. – Longitudinal bulkhead plating. – Web frames upper part and close to longitudinal bulkheads. – Cross ties. – Transverse bulkhead plating, upper part.	2) Exposed to pitting: – Horizontal surface of stringers. – Bottom plating. – Bottom longitudinal face plates/flanges.	3) Other factors contributing to the risk of corrosion: – Neighbouring tanks heated. – Local coating faults due to poor workmanship. – Unfavourable structural details from coating point of view. – High local stress areas (see Figure 3.1). – Areas with high flow rate, i.e. around openings, notches etc. (see Figure 2.2). – Drip locations of cleaning guns.

Table 2.1: Risk of Corrosion and Pitting

Typical Defect Types			
Item	**Corrosion**	**Buckling**	**Cracks**
Longitudinal Material	– Upper deck plating. – Upper deck longitudinals. – Weldment between structural elements, deck longitudinals to deck plating in particular. – Scallops and openings for drainage. – Webs of longitudinals on longitudinal bulkheads, longitudinals, high rates and localized corrosion (grooving). – Flanges of bottom longs, pitting. – Bottom plating, pitting, erosion near suctions. – Longitudinal bulkhead plating (Rel. thin).	– Upper deck plating. – Upper deck longitudinals. – Bottom plating. – Bottom longitudinals. – Longitudinal bulkhead plating middle and upper part. – Deck and bottom girders.	– At discontinuities. – At openings, notches. – At connections with transverse elements.
Transverse Web Frames	– Upper part, connection to deck. – Just below top coating. – Flanges of bottom transverses.	– Web plate (Shear). – Brackets. – Flanges. – Cross ties.	– Connections with longitudinal elements. – Scallops in connection with longitudinals. – Bracket toes. – Holes and openings. – Crossing face flats.
Transverse Bulkheads	– Upper part, connection to deck. – Stringer webs. – Close to openings in stringers. – High stress locations, i.e. around bracket toes etc.	– Horizontal stringers, web plate (Shear). – Girder/stringer brackets. – Vertical girders, web plate (Shear). – Corrugated bulkhead plate.	– Connections with longitudinal elements. – Connection between girder systems. – Bracket toes.
Swash Bulkheads	– Upper part, connection to deck. – Stringer webs. – Close to openings in bulkhead plating. – High stress locations, i.e. around bracket toes.	– Horizontal stringers, web plate (Shear). – Vertical girders, web plate (Shear). – Girder/stringer brackets. – Bulkhead plating around openings.	– Connections with longitudinal elements. – Connections between girder systems. – Bracket toes. – At openings in bulkhead plating.

Table 2.2: Typical Defect Types



A – At end of brackets, toes and similar

B – High shear stress at ends of span

C – Local high stresses at connections between longitudinals and web frame, particularly within area of wind and water levels where both web and longitudinal exposed.

Figure 2.1: Local Areas of High Stress in Transverse Web Frames

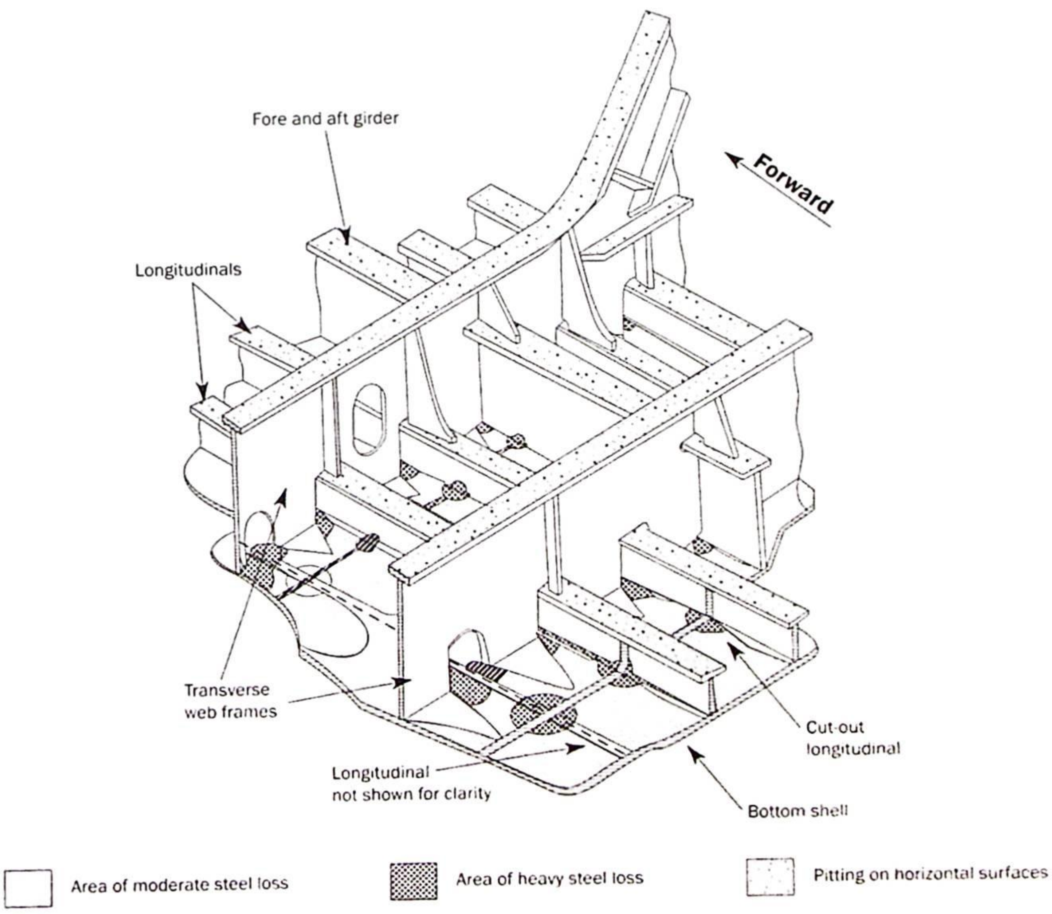


Figure 2.2: Typical Wastage of Bottom Structure

Chapter Three

Survey Data Analysis Guidelines

3.1 Method of Assessment

When all the necessary survey data and findings with respect to overall and local corrosion, fractures and deformations, including conditions of coating and corrosion protection systems, have been collected the residual strength of the ship should be evaluated and maintenance need considered for a further period of operation. In doing this evaluation, corrosion trends and present and potential critical and high risk areas of corrosion cracking, buckling and leakage must be taken into account. If the survey coincides with the special periodical survey for class, the further period of operation will, in general, be considered to be 5 years.

This assessment should be carried out using guidance from this chapter and any additional information from the Classification Society. For general guidance in carrying out this evaluation process, reference should be made to the typical flow chart of activities shown in Figure 3.1.

The objective should be to determine the following:

- Corrosion trends
- potential risk areas for corrosion, cracking, buckling and leakage. These two objectives can be assessed using the following guidelines.

3.1.1 Steel Condition

- For uncoated steel, identify corrosion levels in structural components that may not comply with the Classification Society's definitions of minimum acceptable corrosion wastage or substantial corrosion
- for coated steel, identify the extent of coating breakdown areas and corrosion levels and identify structural items that do not comply with rule requirements
- determine corrosion rates for general corrosion and pitting/grooving corrosion
- identify the causes or influence factors contributing to corrosion.

This assessment should assure a continuing efficient structure with acceptable overall and local stress levels, margins against buckling and further corrosion losses, and should also safeguard against the consequence of new or repeated fractures. The rate of corrosion prior to the survey should be taken into account when making an assessment of the structure.

Such an assessment should conclude with any necessary recommendations concerning repairs, renewals and/or corrosion control provisions.

- Develop steel repair and maintenance plan
- identify areas requiring coating.

3.1.2 Coating Condition Assessment

To assist in consistent assessment of the condition of existing surface coating systems, reference should be made to Appendix VII and the following items considered:

- Identify type of existing coatings
- record when the existing coatings were applied
- confirm extent of existing coatings
- determine percentage of breakdown
- identify type of coating failures: peeling, flaking, blistering, pitting/grooving, free edge breakdown and discoloration
- review adhesion test results
- evaluate the continuing effectiveness and assess the remaining coating life
- develop coating repair and maintenance plans in conjunction with steel repair and maintenance plans.

3.1.3 Cathodic Protection System Assessment

- Evaluate the continuing effectiveness of the existing anodes. Anode efficiency can be judged by the calcareous deposits on the adjacent steel and consumption of anode material
- develop anodes replacement plan, and/or plan for new anode installations
- evaluate the effectiveness of impressed current cathodic protection systems, by evaluating operating records, for external hulls.

3.2 Structural Integrity

In addition to the application of specific allowable corrosion diminution values and buckling criteria, consideration has to be given to the possible consequences of failure and its effect, not only on the safety of the ship and personnel, but also on the environment.

The structural integrity of the corroded hull should be considered, taking into account guidance from the Classification Society on the basis for the initial scantlings since this will affect the allowable reductions based on stress levels and buckling. The assessment should address the integrity of localised areas of structure and also the overall strength of the hull girder.

The overall hull girder strength should be confirmed on the basis of the actual hull girder section modulus, which may be assessed initially using an allowable area diminution at deck and bottom.

The integrity of corroded local structure may normally be considered by applying a percentage allowance of the thickness, supplemented where necessary by the application of buckling criteria (see Table 3.11).

Any buckling found during the survey is important and should be taken as an indication of areas that require stiffening or renewal of material.

Any fractures found are normally to be repaired by part renewal of material or by welding. Structural modifications may also be advisable to avoid repetition of fractures (see Section 1.4 and Appendix IV relating to structural defects and proposed repairs).

Moderate plating indents between stiffeners may be acceptable provided they are outside the areas where buckling requirements are relevant, but deformations affecting stiffeners or the primary structure are normally to be repaired.

Isolated local corrosion or pitting of the shell can lead to possible hull penetration. Isolated pits are not believed to influence the strength of plates or other structural members. When large areas of structure are affected, however, this will influence the strength and must be considered when assessing the residual mean thickness of material.

Extensive pitting corrosion will reduce the bending capacity of unstiffened plates significantly (the influence of pitting corrosion on buckling and tension capacity has not yet been investigated). The bending capacity reduction obtained from testing of plates with uniform machined pits suggests that the capacity reduction is roughly proportional to the loss of material. See Table 3.2.

3.3 Acceptance Criteria

All ships are individually designed. The scantlings may be based on different rule requirements applicable at the time of building, different construction requirements and practices of the builder and any special requirements requested by the initial Owner. These factors must be taken into account when considering a corroded structure for acceptance and, as a result, specific values for allowable wastage will not always be applicable. The following criteria, therefore, are of a general nature and are only given for guidance and are based on current practices of participating Classification Societies.

Table 3.1 indicates in column A the level of corrosion for individual structural members above which further assessment is required. It also indicates the percentage corrosion loss above which steel renewals may be required in column B. The thickness to be used is the mean thickness of the panel between stiffeners or edges to take adequate account of local corrosion and pitting (see Section 1.3 on measurement procedures).

Where the measured mean thickness is equal to or below that corresponding to the allowance in column A of Table I, the buckling requirements do not apply and the diminution is normally acceptable. Between columns A and B, buckling guidelines apply as indicated in the last column, together with other considerations that may be applicable.

In some areas it is not possible to give general buckling guidance due to the variation in stress levels experienced and arrangements of stiffening fitted. In other cases, buckling is not considered to be a problem and here only one value of percentage diminution is given and included in column B.

Buckling criteria will vary significantly with differences in longitudinal strength stress levels associated with the original structure. Therefore, in general, only a range of applicable buckling guidelines has been included.

The range of values given in Table I for buckling requirements of longitudinal elements are based on normally applied stress levels. These requirements may be reassessed by the Classification Society concerned after special consideration of the particular ship or structure this reassessment could be according to the current rules of the Classification Society.

The basis for such consideration could, for instance, be that the relevant load and ballast conditions do not utilise the initially designed bending moments or the shear carrying capacity of the vessel, or that the initial reserve strength is above normal. It should be noted that the guidance figures given in the table may be conservative if applied to small ships.

Table 3.2 indicates the normally acceptable pitting corrosion depths for scattered pitting, usually considered to be a pitting intensity up to 20% of the area in question. Scattered pitting can normally be considered a potential pollution or leakage problem, not a structural strength problem. If more extensive pitting is found, the corrosion loss should also be considered according to Table 3.1.

The allowable reduction in hull girder section modulus is determined for each ship by the Classification Society concerned, whose advice should be sought in each case. The International Association of Classification Societies' (IACS) UR S7 (Rev.4 May 2010), shown as Figure 3.2, provides for a minimum section modulus of ships in service of 90% of the specified new ship minimum. In certain cases, however, a higher minimum modulus may be applicable because of the assigned value of the still water bending moment. For general guidance in these cases, the average maximum diminution of area at both the deck and bottom will normally be between 10% and 17%.

Table 3.1 provides guidance for the assessment of wastage data for local strength of structural components. The section modulus for overall strength must also be checked.

Structural Component	% Corrosion (1) Loss Indicator		Buckling Guidelines (Longitudinal Framing)	
	A(2)	B(3)	Mild Steel	HTS 36
Deck and bottom plating and longitudinal girders	10	25	s/t = 55 to 60	s/t = 49 to 52
Webs of deck and bottom longitudinals	15	30	h/t = 50 to 65	h/t = 45 to 55
Flat bar longitudinal at deck and bottom (4)	10	25	h/t = 15 to 20	h/l = 15 to 17
Face plates and flanges of longitudinals and longitudinal girders	15	25	b/t = 10	b/t = 10
Side shell	—	20	(5)	
Longitudinal bulkhead plating	15	25	s/t = 70 to 75	s/t = 60 to 79
Webs of side shell and longitudinal bulkhead longitudinals	—	25	(5)	(5)
Transverse bulkhead structure, transverses and side stringers	15	25	(6)	(6)
Remaining secondary structure	—	30	—	

NOTES

(1) Percentages are to be applied to original Rule thicknesses without corrosion allowance reductions for corrosion control notation.
(2) Column A refers to percent reductions above which further assessment is required.
(3) Column B refers to percentage reductions where steel renewals may be required.
(4) The deck and bottom plating and associated longitudinals are to include side and longitudinal bulkhead plating and associated longitudinals within 10% of the depth of ship from the deck and bottom respectively.
(5) No buckling guidelines are given as the components are not usually limited by this.
(6) Due to the variation in stress levels and stiffening arrangements, no general guidance figure can be given. Individual guidance should be sought from the Classification Society concerned.

DEFINITIONS

t = Thickness of structure after corrosion.
s = Spacing between longitudinal stiffeners.
h = Web depth of longitudinal stiffeners.
b = Half-breadth of flange for symmetrical sections, and the flange breadth for asymmetrical sections.

Table 3.1: Guidelines for Corrosion Wastage

Table 3.2 provides guidance for the assessment of wastage data for local strength and leakage potential for structural components.

Guidance on Min. Remaining Plate Thickness in Pits for Pitting Intensity < 20% (1)	
Structural component	**Normally no action is required when the following conditions are fulfilled:**
Bottom plating	t_{min} = ~ 2/3 * t_0 (2) (3)
Webs of horizontal members (stringers, longitudinals etc.)	t_{min} = ~1/2 *t_0 (4)

NOTES

(1) For higher intensities the average corrosion loss should also be considered.

(2) The limit differs between the Classification Societies, guidance should be obtained in each case.

(3) Min. remaining thickness t_{min} = 6.0 mm in bottom plating pits when welding afloat.

(4) In highly stressed areas, e.g. at supports, the remaining cross-sectional area should be checked in separate cross-sections and related to actual stress condition, (shear and/or axial stress) and acceptable general corrosion, see Table 3.1.

GENERAL GUIDANCE ON PIT REPAIR

The advice and approval of the procedures and materials must be obtained from the Classification Society before pit filling/welding repairs are carried out.

Welding material and procedures must correspond to the base material.

Pitting corrosion can develop very rapidly, especially in coated areas, and early corrective action is essential to control it.

Proper drying of pits, by torch heating or equivalent, and cleaning before welding is essential and required for a satisfactory result and avoidance of hydrogen cracking.

Isolated pits in bottom plating down to 3.0 mm remaining plate should only be welded upon advice from the Classified Society and only when the vessel is in dry dock.

Pits with remaining thickness min. 6.0 mm may normally be filled with a suitable filler material.

Spot NDT checking of welded pits should be carried out, both surface and sub-surface cracks to be checked for.

Proper drying and surface preparation prior to pit filling is to be carried out in accordance with the filler manufacturer's recommendations.

For bottom plating pitting maintenance and repair, refer to 4.3.3 for guidance.

DEFINITIONS

t_{min} = Minimum acceptable remaining thickness.

t_0 = Original thickness or Rule thickness.

Table 3.2: Guidelines for Pitting Repair

Analysis Chart for 'Life Continuance'

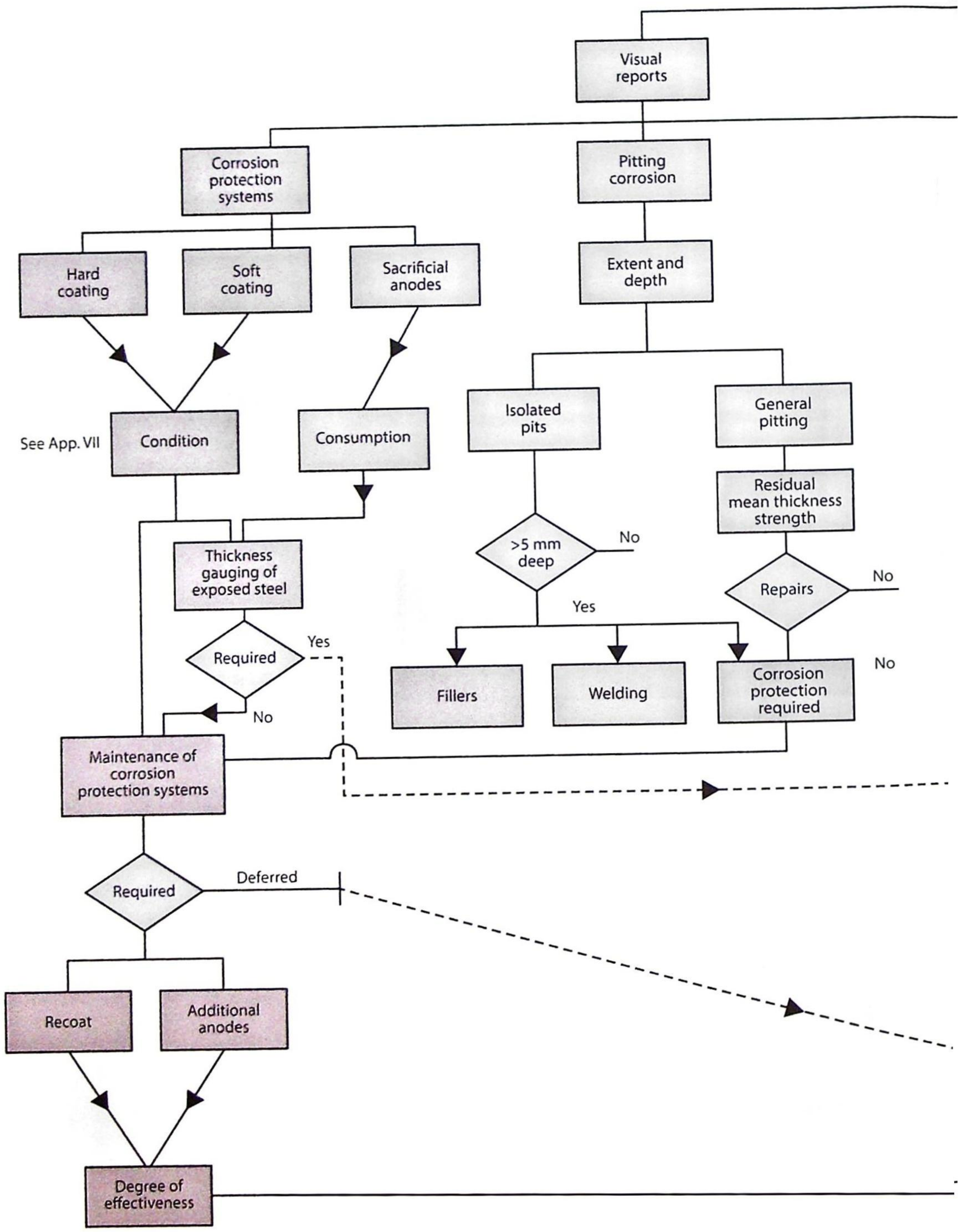
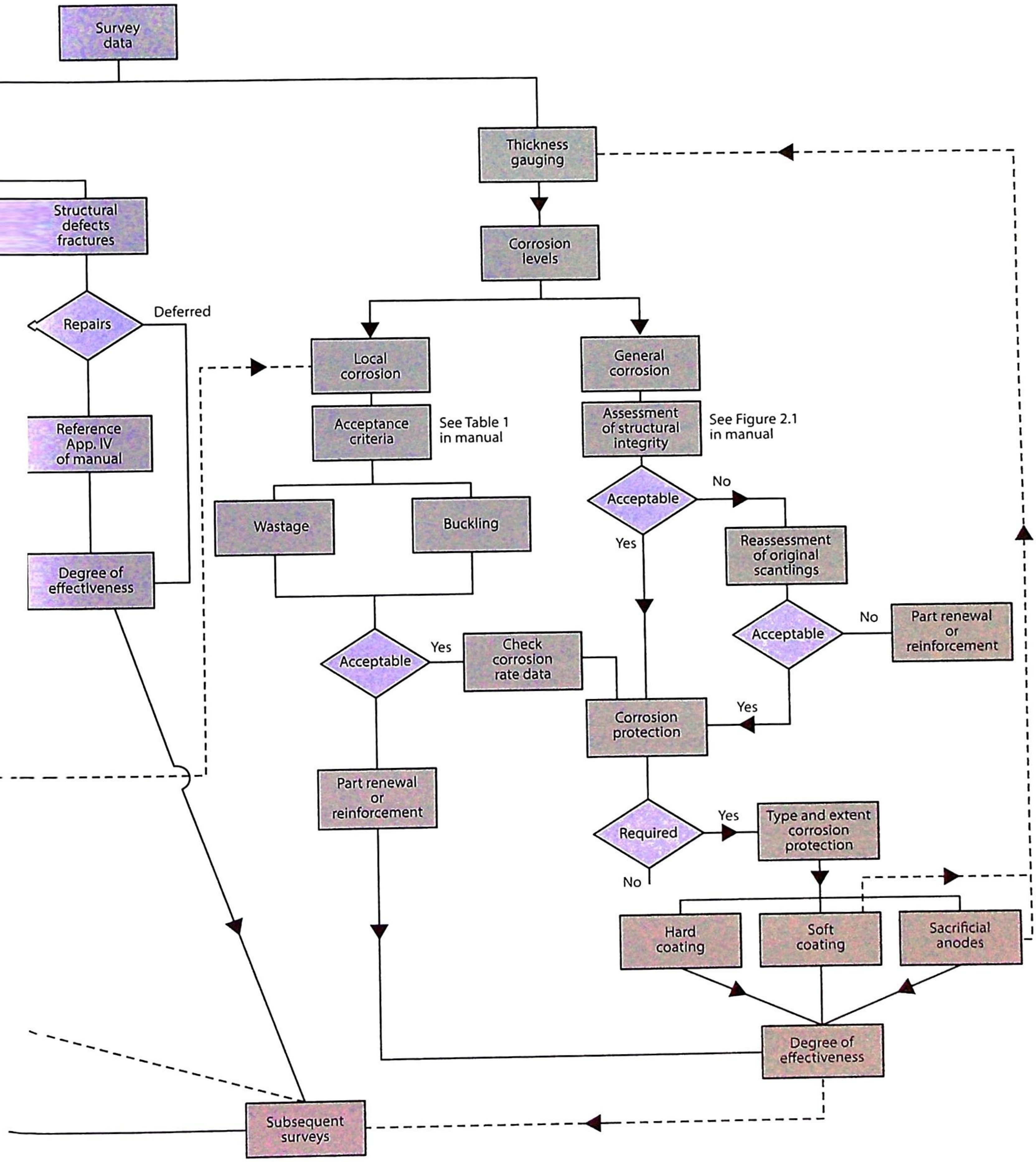


Figure 3.1: Flow Chart of 'Structural Condition Analysis'


Survey data
Thickness gauging
Structural defects fractures
Corrosion levels
Repairs
Deferred
Local corrosion
General corrosion
Reference App. IV of manual
Acceptance criteria
See Table 1 in manual
Assessment of structural integrity
See Figure 2.1 in manual
Acceptable
No
Yes
Wastage
Buckling
Reassessment of original scantlings
Degree of effectiveness
Acceptable
No
Part renewal or reinforcement
Acceptable
Yes
Check corrosion rate data
Yes
Corrosion protection
Part renewal or reinforcement
Required
Yes
Type and extent corrosion protection
No
Hard coating
Soft coating
Sacrificial anodes
Degree of effectiveness
Subsequent surveys

S7 Minimum Longitudinal Strength Standards†

(1973)
(Rev.1 1976)
(Rev.2 1978)
(Rev.3 1989)
(Rev.4 May 2010)

S7.0 Application

This UR does not apply to CSR Bulk Carriers and Oil Tankers.

S7.1 The minimum midship section modulus at deck and keel for ships 90 m ≤ L ≤ 500 m and made of hull structural steel is

$$W_{min} = cL^2B\,(C_b + 0.7)\,k \quad (cm^3)$$

where L = Rule length (m)

B = Rule breadth (m)

C_b = Rule block coefficient; C_b is not to be taken less than 0.60

c = c_n for new ships
c = c_s for ships in service = 0.9 c_n

$$c_n = 10.75 - \left(\frac{300 - L}{100}\right)^{3/2} \quad \text{for } 90\text{ m} \le L \le 300\text{ m}$$

$$= 10.75 \quad \text{for } 300\text{ m} < L < 350\text{ m}$$

$$= 10.75 - \left(\frac{L - 350}{150}\right)^{3/2} \quad \text{for } 350\text{ m} \le L \le 500\text{ m}$$

k = material factor
k = 1.0 for ordinary hull structural steel,
k < 1.0 for higher tensile steel according to S4.

S7.2 Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in S7.1 are to be maintained within 0.4 L amidships.

However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the end of the 0.4 L part, bearing in mind the desire not to inhibit the vessel's loading flexibility.

S7.3 In ships where part of the longitudinal strength material in the deck or bottom area are forming boundaries of tanks for oil cargoes or ballast water and such tanks are provided with an effective corrosion protection system, certain reductions in the scantlings of these boundaries are allowed. These reductions, however, should in no case reduce the minimum hull girder section modulus for a new ship by more than 5%.

NOTE

The above standard refers in unrestricted service with minimum midship section modulus only. However, it may not be applicable to ships of unusual type or design, e.g. for ships of unusual main proportions and/or weight distributions.

'New Ships' are ships in the stage directly after completion.

† This Requirement is subject to periodical updating.

End of Document

Figure 3.2: IACS Requirements S7 (Rev. 4 2010)

Chapter Four

Maintenance and Repair Guidelines

4.1 General

The basic objective of maintenance and repair of ship structures is to maintain the structural integrity and prevent unwarranted degradation in the strength and serviceability during the ship's service life.

It is the Owner's responsibility to maintain the ship structures throughout the ship's service life. The Owner should have a proper maintenance and repair program to be implemented for each ship which complies with the mandatory requirements of the Flag Administration and Classification Society, and which maintains the structural soundness and appropriate environmental protection.

4.2 Type of Repair

To maintain the structural soundness, there are two types of repair:

Mandatory Repair

Repairs are carried out only to comply with the mandatory requirements imposed by the Flag Administration and/or by the Classification Society.

Voluntary Repair and Maintenance

Repairs are carried out to minimise the total maintenance cost for the intended service life. Voluntary repairs and maintenance are focused on the following activities:

- Maintain or improve corrosion control system effectiveness, including coatings and anodes
- maintain the steel thickness above the Classification Society Rules for corrosion wastage allowance
- improve and modify the design of structural details.

4.3 Maintenance and Repair Methods

Many different methods of structural maintenance and repair are available. The methods listed below cover the various scenarios experienced during the ship's service life:

4.3.1 Repairs of Existing Coated Areas in Segregated Ballast Tanks

No Coating Repair

Coating repairs are not necessary if the coating condition is GOOD or FAIR and the corrosion wastage does not exceed acceptable allowances within the intended service life. Further inspections might be advisable to verify the effectiveness of this coating.

If the coating condition is POOR then an annual survey will be required by the Classification Society. The extent of thickness measurements may be increased at the current and subsequent surveys.

If the local corrosion wastage has exceeded the 'substantial corrosion' level, defined as 75% of the allowable corrosion margin, regardless of coating condition, the extent of thickness measurements must be increased at the current and subsequent surveys.

Soft Coating Repair

Soft coating repair should only be considered as a temporary maintenance method and is not considered equivalent to the renewal of hard coating. Soft coatings may have to be removed for Survey. Annual inspection would be required to verify the soft coating effectiveness and continued structural soundness, reference is also made to Section 1.4.9.

If the hard coating condition is POOR then annual inspections will be required by the Classification Society.

Hard Coating Repair

Hard coating in POOR condition should be renewed prior to corrosion wastage exceeding acceptable corrosion allowances.

Anode Replacement or New Installation

Existing wasted anodes should be replaced or new anodes can be installed to reduce future corrosion. Anodes only become effective while immersed in water and should only be used as a secondary corrosion protection method. Anodes should be renewed on the basis of the consumption rate and the remaining anode material.

4.3.2 Repairs of Uncoated Areas in Cargo Tanks

No New Coating

If the corrosion rate is expected to be low and the corrosion wastage will not result in exceeding the corrosion wastage allowance through the intended remaining life, then new coating is not required.

New Hard Coating

New hard coating can be applied prior to the corrosion wastage exceeding the substantial corrosion wastage allowance.

Anode Replacement or New Installation

Existing wasted anodes should be replaced or new anodes can be installed to reduce future corrosion.

Anodes should be renewed on basis of the consumption rate and the remaining anode material.

4.3.3 Pitting and Grooving Repair

The following guidelines apply mainly to the bottom plating. Pitting on other structures have to be considered on basis of actual stress patterns, refer to Table 3.2.

- Coat shallow pits by applying coating or pit filler. Shallow pits can be defined to be less than about 1/3 of the original thickness
- deep pits and grooves greater than about 1/3 of the original thickness can be welded flush with the original surface. For HTS special welding procedures are required.

  If deep pits/grooves are clustered together the plate should be renewed by plate inserting instead of repairing by welding repairs
- weld the deep pits plus apply coating or pit filler.

4.3.4 Steel Renewal

- All material renewed should be replaced by steel of the same or higher grade and to the original or greater scantling. A re-assessment of the rule requirements may, however, in some cases lead to smaller scantlings
- replace wasted steel with new steel to the original design
- replace buckled steel with new steel to original or enhanced design together with consideration of 4.3.5 and 4.3.6 below.

4.3.5 Steel Reinforcement

- Install intermediate stiffeners to restore original strength in bending, shear and buckling. Additional coating could be required to arrest the corrosion in the wasted plating and stiffeners if the reinforcement is needed due to the corrosion wastage
- install reinforcing stiffeners to the indented plate
- install reinforcing doubler ring around the edge of the opening.

4.3.6 Steel Design Modification

- Enhance scantlings in size and/or thickness and/or steel grade to improve the local strength
- add brackets to relieve the stress concentrations, hot spots and to improve load transmission
- add stiffeners to improve buckling or bending strength
- add lugs, collar plates or closing plates to cut-outs to improve the shear force carrying capacity and improve the fatigue strength
- change structural configuration by applying soft toe, new face plate, radius change, etc., to improve the local strength and fatigue strength.

4.3.7 Repairs of Structural Defects

- Gouge and reweld the fracture to the original condition
- replace the fractured plating or stiffeners with new steel to the original design
- modify the structural details to avoid re-occurrence (see 4.3.6 above). Appendix IV provides a catalogue of structural defects and proposed repairs and modifications.

4.4 Optimum Maintenance and Repair Strategy

4.4.1 General

The optimum maintenance and repair strategy will combine any of the above repair methods, together with structural survey programs, while aiming to achieve the following objectives:

- Maintain structural soundness and reduce risk of pollution and other losses from corrosion and structural failure
- meet the Flag Administration regulations and Classification Society Rules
- provide the lowest overall life-cycle cost of maintenance and repairs and out of service time
- provide the most cost effective and least out of service time for repairs
- effectively reduce future ship out of service time due to elimination of unwanted repairs between scheduled periodic overhauls.

The maintenance and repair strategy could either be a short-term program or a long-term program, depending on the intended remaining service life of the ship.

4.4.2 Short-Term Maintenance and Repair Program

A short-term repair program would only apply if the intended remaining service life is less than 5 years and would include:

- Steel and coating repairs to comply with the mandatory repair requirements imposed by the Flag Administration and Classification Society
- additional steel and coating repairs to ensure structural integrity and environmental protection
- future inspection and closer surveillance if necessary.

4.4.3 Long-Term Maintenance and Repair Program

A long term maintenance and repair program for a remaining service life of more than 5 years should emphasise preventive maintenance measures such as:

- Maintenance of coating and corrosion control systems by:
  - » implementing a coating program for the uncoated areas prior to the steel reaching the substantial corrosion level
  - » implementing a recoating program for the coated areas
  - » implementing an effective sacrificial anodes installation and replacement program
- implementing a timely structural design modification program if required.

Bibliography

General Corrosion

1 Herring, L.C. Jr., Titcomb, A.N., 'Investigation of Internal Corrosion and Corrosion Control Alternatives in Commercial Tankships', Newport News Shipbuilding Report to the U.S. Coast Guard Ship Structure Committee, Report No. SSC-312, July 1981.

2 Hunt, P.J., 'The Identification of Ship's Internal Structural Corrosion Problems', General Council of British Shipping Technical Research Report TR/108, February 1984.

3 Weber, P.F., 'Structural Surveys of Oil Tankers', Exxon paper presented at a joint meeting of the Institute of Marine Engineers and Royal Institution of Naval Architects. Trans I Mar E Vol. 96, 1984, Paper 65.

4 Exxon Corporation Position Paper, 'Large Oil Tanker Structural Survey Experience', June 1, 1982.

5 De Wazard, C, and Posch, W., 'Cathodic Protection of Cargo/Ballast Tanks of Crude Oil Tanks', Werkstoffe und Korrosion, November 1972.

6 Avondale Shipyards Inc., 'Cathodic Protection/ Partial Coatings Versus Complete Coatings in Tanks', prepared for U.S. D.O.T Maritime Administration, May 1982, updated February 1985.

7 Munger, C.G., 'Deep Pitting Corrosion in Sour Crude Oil Tankers', Materials Performance, March 1976.

8 Kurr, G.W., 'Sacrificial Anode Applications in Ships', Materials Protection, November 1969.

9 Nelson, E.E., 'Galvanic Anodes and Fresh Water Rinse Reduce Tanker Corrosion', Corrosion, Vol. 17, 1969, pp. 463–468.

10 Hasson, N., 'Cathodic Protection in Cargo Tanks – Does it Work?', paper presented at the Third International Ship Painting and Corrosion Conference, April 1978.

Structural Failure, Fatigue and Repair Methods

1 'Structural Details of Ships in Service', by C.R. Jordan and W.C. Ward, Jr. SNAME March 1978.

2 'In-Service Performance of Structural Details', by C.R. Jordan and C.S. Cohran. Ship Structure Committee (SSC-272) 1978.

3 'Further Survey of In-Service Performance of Structural Details', by C.R. Jordan and L.T. Knight. Ship Structures Committee (SSC-294) 1980.

4 'Lessons Learned from Failure and Damage of Ships', by Y. Akita. 8th International Ship Structures Congress, Gdansk 1982.

5 'Large Oil Tanker Structural Survey Experience', by Exxon Corporation, June 1981.

6 'Structural Surveys of Oil Tankers', by RE Weber. Joint Meeting, the Institute of Marine Engineers and RINA, April 1984.

7 'Structural Detail Design In-Service Performance of Structural Details'. Proceedings of the Seventh International Ship Structures Congress, Paris, August 1979.

8 'A Survey on Cracks in Tankers Under Repairs', by A.C. Antoniou. International Symposium on Practical Design in Shipbuilding, Tokyo, October 1977.

9 'Fatigue Characterization of Fabricated Ship Details for Design', by W.H. Munse, T.W. Wilbur, M.L. Tellalian, K. Nicoll and K. Wilson. Ship Structures Committee (SSC-318) 1983.

10 'Design Guide for Ship Structural Details'. Ship Structures Committee Report for publication in 1985.

11 'Ship Structural Maintenance: Results and Experience' by R.G. Bea. Institute of Marine Engineers, June 1993.

12 'Structural Performance Management of VLCCs – an owner's approach'. D.T. Melitz, E.J. Robertson and N.J. Davison. Marine Technology, Vol 29, No.4, October 1992.

13 'The Use of Finite Element Modelling Techniques in the Investigation of Structural Failure in Ships'. D.J. Witmer and M.C. Cheung. Proceedings of SNAME West Coast Tanker Operation Symposium, October 1991.

14 'Effective Fatigue Damage Control for Critical Details in Oil Tankers'. R. Schulte-Strathaus. Paper presented to the North California Section of SNAME, May 1993.

15 'ARCO Tanker Slamming Study'. P. Lacey and R. Edwards. Proceedings of the SNAME West Coast Tanker Operation Symposium, October 1991.

16 'Structural Maintenance for New and Existing Ships'. R.G. Bea, R. Pollard, R. Schulte-Strathaus and R. Baker. Proceedings of the Marine Structural Inspection, Maintenance and Monitoring Symposium, Arlington, 1991.

17 'Fracture Toughness of Ship Steels'. J.D.G. Sumpter. Paper read to RINA, 1988.

18 'Fatigue Strength of Ship Structure'. Y. Nakajima et al. IHI Engineer Review, Vol 26, No.3, 1993.

19 'Deterioration Measurement of Ship's Hull and Application to Design'. K. Okamoto and E. Sugita. IHI Engineer Review, Vol 26, No.1, 1993.

20 'Closing the Gap on Tanker Structural Approval'. J.A. Lee. RINA Naval Architect, November 1994.

Strength of Pitted Plates

1 Chapkis, D.T., 'Simulation of Pitting Corrosion of Hull Plating Under Static Loading', Trudy TSNIIMF, No. 82, pp. 34–50, 1967. English translation.

2 Flaks, V.Ya. 'Correlation of Pitting Corrosion of Aluminium Plates and Reduction of Load-bearing Capacity Under Tension', Fizico-Khimieheskaya Mekhanika Materialov, Vol.14, No. 1, pp. 89–93, 1978.

Appendix I

Background to Forum Activities

For some time the marine industry lacked a suitable international forum for technical dialogue on the structural aspects of tankers. Shipowners have their own organisations, such as OCIMF, INTERTANKO and ICS, while the Classification Societies have IACS. Shipowners and Classification Societies have always had a close relationship with regard to individual vessels and fleets, but a wider forum in which to discuss structural problems and share experience did not exist. Early in 1983, Shell International Marine took the initiative of inviting a group of Shipowners and Classification Societies to a meeting to discuss the formation of such a group. As a result of that meeting, the Tanker Structure Co-operative Forum was established, with major Oil Companies, Independent Tanker Operators and Classification Societies having representation.

The principal objective of the Forum is the sharing of knowledge and experience to gain a better technical understanding of the performance of tanker structures in service. The Forum also aims to improve the technical basis for acceptance criteria used for determining when damage or corroded structure should be renewed. The general fields of interest covered by the Forum include corrosion, structural defects, inspection procedures and acceptance criteria. Since the emphasis of the Forum is on the service performance of the hull structure, its work has relevance to new designs through the feedback of broadbased service experience as well as being directly applicable to current vessels.

The Forum consists of members from Classification Societies, Oil Companies and Independent Ship Operators. From the outset it was intended to keep to a small organisation while maintaining a balance in the total composition of members.

The Tanker Structure Co-operative Forum is managed by a Steering Committee, currently meeting annually. The Forum tasks have been controlled through a work group divided into project groups of four or five member organisations.

The Forum work group initially considered the topics that would advance the state of the art, including improved assessment of residual strength, hull integrity and sounder acceptance criteria and the constituent elements associated with these subjects, such as hull condition assessment and inspection procedures, experimental and theoretical analyses on the strength of pitted plates and corroded plates, crack propagation and hull girder loading. The Group then identified projects appropriate to the Forum and achievable in the short-term.

The project work undertaken to date, and incorporated where appropriate in this guidance manual, has fallen into six elements covering inspection techniques, corrosion aspects and structural defects. A separate report of each of the projects (100 to 300) has been produced and is now freely available to non-members (deposited with U.S. Merchant Marine Academy, Kings Point, NY 11024).

Project 100 – Determination of Optimum Data Collection Procedures

As an extension of work undertaken by a Forum ad hoc group in 1983, this project group developed guidelines for the extent of data collection necessary for various types of survey. Five survey types were identified i.e. mandatory Classification surveys (IACS Surveys) and four distinct surveys that may be carried out at the Owner's option – i.e. General Condition Survey, Corrosion Rate Survey, Detailed Condition Survey and Repair Specification Survey. Planning, execution and reporting aspects of these have been addressed. A standard format for reporting corrosion data has been proposed.

Project 101 – Gauging Accuracy and Gauging Guidelines

To complement the work on corrosion data collection procedures, a series of tests were undertaken to assess the accuracy from ultrasonic thickness gaugings, and a guideline procedure for ultrasonic thickness gauging techniques was developed. This involved readings being taken at specified locations, at sea and in the shipyard and again in the laboratory after selected pieces of plate had been cropped out for renewal. The readings were repeated with a number of gauging teams and all readings compared against calliper readings, and residual thickness determined from weighing the test panels.

Project 102 – Factors Contributing to Corrosion

The significant corrosion problems of concern to Forum members and possible contributing factors to these problems were identified on the basis of a questionnaire to members and a review of available literature. Areas that might warrant further investigation to gain an understanding of the corrosion mechanism have been suggested.

Project 200 – Catalogue of Structural Detail Failures

Several generations of large tankers have suffered varying degrees of fatigue fractures at structural details. A catalogue of such typical details has been compiled from the experience of Forum members. This catalogue lists some 50 examples of defects grouped according to location. Suggested repair methods for these defects have been incorporated in the catalogue together with a list of possible contributing factors for each defect.

Project 300 – Pilot Study on the Effects of Pitting Upon the Strength of Plates

Although any assessment of hull integrity must be heavily dependent upon adequate and thorough inspection procedures, there is a recognised need for improved techniques to evaluate residual strength of damaged or corroded structure once the inspection data is available. As a first step in this direction, a pilot programme of tests on pitted plates was undertaken to assess the influence of pitting intensity on the residual strength of individual plates. The project work also included complementary analytical work undertaken to check correlation of test results with theoretical predictions.

Project 400 – Guidance Manual for the Inspection and Condition Assessment of Tanker Structures

This activity incorporated the principal results of all the above project work together with general guidance based upon Forum members' experience. The intention of this manual was to provide guidance for both inspectors and designers on various aspects of monitoring and assessment of tanker structures in service.

Further work/publications since the publishing of the Guidance Manual for the Inspection and Condition Assessment of Tanker Structures in 1986:

Shipbuilders' Meetings

The objective of these meetings is to provide a venue for three-way sharing of information among shipyards, tanker operators and Classification Societies as a means to ensure that lessons learned in service from existing designs are available to shipbuilders and ship repairers.

November 1987:

The meeting was held at the former ABS Headquarters, Paramus, New Jersey, USA. The following topics were presented and discussed:

- Inspection Procedures and Their Influence on Tanker Design, Presented by Bureau Veritas/ Exxon.
- Corrosion in Cargo and Ballast Tanks - Causes and Prevention, Presented by Chevron Shipping Company.
- Structural Details, Previous Failures and Their Implications for New Designs, Presented by Lloyd's Register/Germanischer Lloyd.
- Use of High Tensile Steel in Ship Structures, Presented by Det Norske Veritas.
- Structural Design Concerns with Respect to the New Generation of Tankers, Presented by Mobil Oil Corp.

October 2000:

The meeting was held in Tokyo, Japan. The following topics were presented and discussed:

- Ballast Tanks – An Overview of the TSCF Guidelines for Ballast Tank Coating Systems and Surface Preparation
Presented by: Shell International Trading and Shipping Company.
- Corrosion Protection of Cargo Tanks
Presented by: Chevron Shipping Company.
- Follow Up Inspection – In Service
Presented by: Stena Bulk.
- Present Status and Future Development for the Design and Construction of Double Hull Tankers
Presented by: Mitsubishi Heavy Industries Ltd.
- New Design of Suezmax Class Tanker
Presented by: Hyundai Heavy Industries Co Ltd.
- Shipyard Design and Construction for Envisaged Lifetime
Presented by: Odense Steel Shipyard Ltd.
- Classification Societies' Viewpoint
Presented by: American Bureau of Shipping.

- Experience with Double Hull Tankers – An Owners Viewpoint
  Presented by: Bergesen D.Y. ASA.

- Presentation of the 1997 TSCF 'Guidance Manual for Tanker Structures'
  Presented by: Germanischer Lloyd.

October 2007:

The meeting was held in Busan, South Korea. The following topics were presented and discussed:

- Examples of the application of Permanent Means of Access to Tankers
  Presented by: Korean Register of Shipping, Daewoo Shipbuilding & Marine Engineering Co., Ltd., Hyundai Mipo Dockyard Co., Ltd. and Samsung Heavy Industries Co., Ltd.

- Evaluation of Necessity and Usefulness of IMO PSPC – Performance Standard of Protective Coating
  Presented by: Samsung Heavy Industries Co., Ltd.

- IACS CSR on Tankers
  Presented by: Hyundai Heavy Industries Co., Ltd.

- Development of Anti-Corrosion Steel for Cargo Oil Tanks
  Presented by: The Japan Iron and Steel Federation, Technical Committee of Steel Plates for Shipbuilding, Nippon Steel Corporation, Sumitomo Metal Industries LTD., Kobe Steel LTD. and JFE Steel Corporation.

- Ultimate Limit State Assessment of Tankers considering Common Structural Rules
  Presented by: Samsung Heavy Industries and Dept. of Naval Architecture and Ocean Engineering.

- Development of Arctic double acting shuttle tankers for the Prirazlomnoye project
  Presented by: Aker Arctic Technology Inc., Russian Maritime Register of Shipping and Lloyd's Register Asia.

- Fatigue Analysis and Condition Assessment of FPSO Structures
  Presented by: Germanischer Lloyd.

- The outlook for oil tanker new construction
  Presented by: American Bureau of Shipping.

- Shipbuilding Experience Outside Of Asia – A Cooperative Global Approach to U.S. Shipbuilding
  Presented by: Aker Philadelphia Shipyard, Inc and OSG Ship Management, Inc.

- Chinese Tanker Shipbuilding Capability – Today and in the Future
  Presented by: China Shipbuilding Economy Research Center.

October 2010:

The meeting was held in Tokyo, Japan. The following topics were presented and discussed:

- An Overview of the Tanker Structure Cooperative Forum
  Presented by: SeaRiver Maritime.

- Oil Majors' Structural Requirements for Newbuild Tankers and Trading Vessels
  Presented by: BP Shipping.

- The Common Structural Rules: Initial Designs and Future Developments
  Presented by: American Bureau of Shipping.

- Design Experience on CSR VLCC
  Presented by: Marine Design & Research Institute of China.

- The State of Oil Tanker Construction for CSR in Shipbuilding Industry
  Presented by: Dalian Shipbuilding Industry.

- Cargo Tank Corrugated Bulkhead Damages of Double Hull Tankers
  Presented by: Lloyds Register.

- Design Development of Corrugated Bulkheads
  Presented by: ClassNK.

- Outfitting Related Structural Defects
  Presented by: TOTAL.

- Simplified Fatigue Guideline for Deck Opening and Outfitting Supports
  Presented by: Daewoo Shipbuilding & Marine Engineering.

- The Way to ECO-vessel ~ Reducing VOC from Hull Structural Aspects
  Presented by: Samsung Heavy Industry.

- Application of the Latest Technologies to Fatigue Strength Improvement
  Presented by: IHI Marine United.

- Double Hull Tanker Structures – Some Practical Considerations about CSR Application
  Presented by: IHI Marine United.

- 'MHI DILAM', the most Sophisticated Fatigue Design Methodology Developed by MHI
  Presented by: Mitsubishi Heavy Industries.

- PSPC – Preparation and Application in Korean Shipyard
  Presented by: Hyundai Heavy Industries.

- Implementation of PSPC in China Shipbuilding
  Presented by: Shipbuilding Technology Research Institute, CSSC, China.

- Development of Eco-friendly High Pressure Water Blasting Technique 'Konki-Jet' to meet the PSPC Requirements
  Presented by: IHI AMTEC.

- Service Experiences Gas Carriers – Hull Structures
  Presented by: DNV.

- A Study of the Effect of Whipping on the Fatigue Life
  Presented by: Mitsubishi Heavy I Engineering.

- Fatigue Design of a Shuttle Tanker for the North Atlantic Operation
  Presented by: Hyundai Heavy Industries.

- Not Repeating the Past - A Case Study of Fatigue Fracture in Midship Cargo Tanks
  Presented by: American Bureau of Shipping and Hellespont Ship Management GmbH & Co.

- Comparison of TSCF and PSPC Ballast Tank Coating Guidance – Owners Experiences and Best Practice.

- The Implementation Process Analysis and Improvement on PSPC in China Shipyards
  Presented by: Shanghai Waigaoqiao Marine & Offshore Design Co., Ltd and Shanghai Shipbuilding Technology Research Institute.

October 2013:

The meeting was held in Shanghai, China. The following topics were presented and discussed:

- An Overview of the Tanker Structure Cooperative Forum
  Presented by: SeaRiver Maritime, Inc.

- Guidance Note on Fatigue for Double Hull Oil Tankers Complying with the Common Structural Rules
  Presented by: TSCF.

- Guidance Notes on High Tensile Steel
  Presented by: American Bureau of Shipping.

- IMO GBS and IACS CSR-H
  Presented by: American Bureau of Shipping, Nippon Kaiji Kyokai (ClassNK), Bureau Veritas, Det Norske Veritas and Lloyd's Register.

- Impact of IACS Harmonised CSR on Tankers
  Presented by: Marine Design & Research Institute of China Marine Design & Research.

- Comparison Analysis between CSR-OT and CSR-H for Corrugated Bulkhead of Large Product Tanker
  Presented by: Marine Design & Research Institute of China.

- Japanese Joint Research Project on the Thickness Effect to Fatigue Strength
  Presented by: Japan Marine United Corporation, Nippon Kaiji Kyokai, IHI Corporation and Hosei University.

- Development of Corrosion-resistant Steels and their Application
  Presented by: NYK Line, Minoru Ito, Seiji Nishimura, Nippon Steel & Sumitomo Metal Corporation, Kazuyuki Kashima and Nippon Steel & Sumitomo Metal Corporation.

- Introduction of Korean Shipbuilders' Painting and Inspection Practice
  Presented by: The Korean Shipbuilders' Association.

- Development of VLCC without the Cross-tie between Longitudinal ('Cross-tieless Cargo Tank of VLCC')
  Presented by: Daewoo Shipbuilding & Marine Engineering Co., LTD.

- Arctic Tankers – structural dimensioning considerations
  Presented by: Lloyd's Register.

- Cabins Noise Control on the Large Oil Tanker
  Presented by: China Ship Scientific Research Center.

- A Study on Thermal Loading Effects in Tankers
  Presented by: Samsung Heavy Industries.

All of the papers presented to the TSCF Shipbuilders Meetings may be downloaded from: www.tscforum.org

October 2016:

The meeting was held in Korea on 26–27 October 2016 with around 150 participants. The conference provided an ideal environment for the sharing of information between shipyards, tanker operators, oil majors and classification societies on a range of technical topics such as CSR BC & OT and CSR in-service experience, polar design and operational experience, material and welding, innovative design, and coating and corrosion control.

At the conference, 16 papers were presented by the major shipyards from China, Japan and Korea and classification societies.

1. Shipbuilding industry's perspective on the new IACS Common Structural Rules.
2. Impact of Harmonized CSR for oil tanker.
3. Application of New Common Structural Rules on Aframax Tankers.
4. MR Tanker with Harmonized CSR.
5. Thickness effect of fatigue on butt weld joints.
6. A developing of Arctic Shuttle Tanker with ARC7 ICE Class.
7. Special Consideration for Structural design and fabrication.
8. Sharing operational CSR in service experience.
9. Innovative Ship Design with less ballast water and less GHG.
10. Research on Topology Optimization Method for Tanker Structures in Cargo Tank Region.
11. Vibration control of ship.
12. Hull Structures with Newly Developed Highly Ductile Steel to Mitigate Impact Damage and Cargo Loss in Ship to Ship Collision.
13. Enhanced safety of a VLCC by employing Fatigue Crack Arrester steel.
14. New Common Structural Rules for Bulk Carriers and Oil Tankers Compliance with IMO GBS.
15. Corrosion-resistance steels, NSGPTM-1,-2 for Crude Oil Tankers and their performance.
16. Study on Fatigue Strength for Tank Structures subject to Harmonized CSR.

All of the papers presented are now available on the TSCF website (http://www.tscforum.org/news/ShipbuildersMeetings.aspx).

Appendix II

IACS Unified Requirements UR Z10.4

Z10.4 Hull Surveys of Double Hull Oil Tankers

(Dec. 2001) (Rev. 1 Oct. 2002) (Rev.2 June 2005) (Rev.3 Jan 2006) (Rev.4 June 2006) (Corr.1 Sept 2006) (Rev.5 Feb 2007) (Rev.6 Nov 2007) (Rev.7 Mar 2009) (Rev.8 Feb 2010) (Rev.9 Mar 2011) (Rev.10 July 2011) (Rev.11 June 2013) (Rev.12 Jan 2014) (Rev.13 Feb 2015) (Rev.14 Nov 2016) (Rev.15 Jan 2018) (Rev.16 May 2019)

6. Documentation On Board

6.1 General

6.2 Survey Report File

6.3 Supporting Documents

6.4 Review of Documentation on Board

7. Procedures for Thickness Measurement

7.1 General

7.2 Certification of Thickness Measurement Firm

7.3 Number and Locations of Measurements

7.4 Reporting

8. Acceptance Criteria

8.1 General

8.2 Acceptance Criteria for Pitting Corrosion of CSR Ships

8.3 Acceptance Criteria for Edge Corrosion of CSR Ships

8.4 Acceptance Criteria for Grooving Corrosion of CSR Ships

9. Reporting and Evaluation of Survey

9.1 Evaluation of Survey Report

9.2 Reporting

ENCLOSURES

Notes:

1. Changes introduced in Rev. 2 are to be uniformly implemented from 1 July 2006. The amendments to paragraphs 2.2.3.1 and 4.2.2.2 related to the protective coating condition are to apply to the ballast tanks of which the coating condition will be assessed at the forthcoming Special Survey and Intermediate Survey on or after 1 July 2006.
2. Changes introduced in Rev.3 (para. 1.4, 5.5.4, 5.5.6 and 7.1.3) are to be uniformly applied by IACS Societies on surveys commenced on or after 1 January 2007.
3. Changes introduced in Rev.4 are to be uniformly applied by IACS Societies on surveys commenced on or after 1 July 2007.
4. Changes introduced in Rev.5 are to be uniformly implemented for surveys commenced on or after 1 January 2008, whereas statutory requirements of IMO Res. MSC 197(80) apply on 1 January 2007.
5. Changes introduced in Rev.6 are to be uniformly applied by IACS Societies for surveys commenced on or after the 1 January 2009.
6. Changes introduced in Rev.7 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2010.

   As for the requirements regarding semi-hard coatings, these coatings, if already applied, will not be accepted from the next special or intermediate survey commenced on or after 1 July 2010, whichever comes first, with respect to waiving the annual internal examination of the ballast tanks.
7. Changes introduced in Rev.9 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2012.
8. Changes introduced in Rev.10 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2012.
9. The changes to section 6 introduced in Rev.11 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2016.

   The other changes introduced in Rev.11 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2014.

10. Changes introduced in Rev.12 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 January 2015.
11. Changes introduced in Rev.13 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2016.
12. Changes introduced in Rev.14 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 January 2018.
13. Changes introduced in Rev.15 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 January 2019.
14. Changes introduced in Rev.16 are to be uniformly applied by IACS Societies for surveys commenced on or after 1 July 2020.

1. GENERAL

1.1 Application

1.1.1 The requirements apply to all self propelled double hull oil tankers.

1.1.2 The requirements apply to surveys of hull structure and piping systems in way of cargo tanks, pump rooms, cofferdams, pipe tunnels, void spaces within the cargo area and all ballast tanks. The requirements are additional to the Classification requirements that are applicable to the remainder of the ship. (Refer to Z7).

1.1.3 The requirements contain the minimum extent of examination, thickness measurements and tank testing. The survey is to be extended when substantial corrosion and/or structural defects are found and include an additional close-up survey when necessary.

1.2 Definitions

1.2.1 Double Hull Oil Tanker

A double hull oil tanker is a ship that is constructed primarily for the carriage of oil[1] in bulk, where the cargo tanks are protected by a double hull that extends for the entire length of the cargo area and consists of double sides and double bottom spaces for the carriage of water ballast or void spaces.

1.2.2 Ballast Tank

A ballast tank is a tank that is used solely for the carriage of salt water ballast.

1.2.3 Combined Cargo/Ballast Tank. This is a tank that is used for the carriage of cargo or ballast water as a routine part of the ship'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.

1.2.4 Overall Survey

An 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.

1.2.5 Close-up Survey

A 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.

1.2.6 Transverse Section

A transverse section includes all longitudinal member, such as plating, longitudinals and girders at the deck, sides, bottom, inner bottom and longitudinal bulkheads. For transversely framed ships, a transverse section includes adjacent frames and their end connections in way of transverse sections.

1.2.7 Representative Tank

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.

1.2.8 Suspect Area

Suspect areas are locations showing substantial corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

1.2.9 Critical Structural Area

Critical structural areas are locations that have been identified, either by calculation to require monitoring or from the service history of the subject ship or similar or sister ships (if available), to be sensitive to cracking, buckling or corrosion that would impair the structural integrity of the ship.

1.2.10 Renewal Thickness

Renewal thickness (t_{ren}) is the minimum allowable thickness, in mm, below which renewal of structural members is to be carried out.

[1] MARPOL Annex I cargoes
The requirements in this UR are also applicable to existing double hull tankers not complying with MARPOL Regulation 13F, but having a U-shaped midship section.

1.2.11 Substantial Corrosion

Substantial corrosion is an extent of corrosion such that assessment of corrosion pattern indicates a wastage in excess of 75% of allowable margins, but remains 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 measured thickness between t_{ren} + 0.5 mm and t_{ren}.

1.2.12 Corrosion Prevention System

A corrosion prevention system is normally considered to be a full hard protective coating.

Hard protective coating is usually epoxy coating or equivalent. Other coating systems, which are neither soft nor semi-hard coatings, may be considered acceptable as alternatives provided they are applied and maintained in compliance with the manufacturer's specifications.

1.2.13 Coating Condition

Coating condition is defined as follows:

GOOD condition with only minor spot rusting

FAIR condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% 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'

1.2.14 Cargo Area

Cargo area is the part of the ship that contains cargo tanks, slop tanks and cargo/ballast pump-rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks and the deck areas throughout the entire length and breadth of the part of the ship over those spaces.

1.2.15 Special consideration

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

1.2.16 Prompt and Thorough Repair

A prompt and thorough repair is a permanent repair completed at the time of survey to the satisfaction of the Surveyor, which removes the need for the imposition of any associated condition of Class.

1.2.17 Pitting Corrosion

Pitting corrosion is defined as scattered corrosion spots/areas with local material reductions that are greater than the general corrosion in the surrounding area. Pitting intensity is defined in Figure 1.

1.2.18 Edge Corrosion

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 Figure 2.

1.2.19 Grooving Corrosion

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 Figure 3.

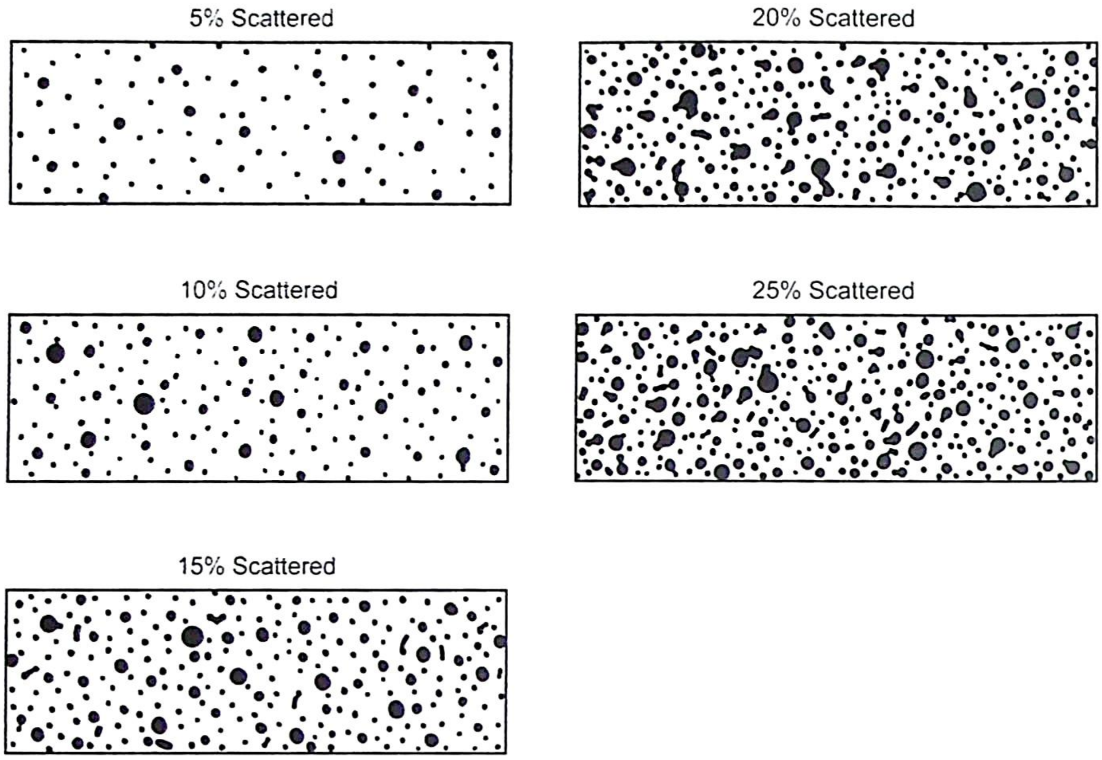


Figure 1: Pitting intensity diagrams

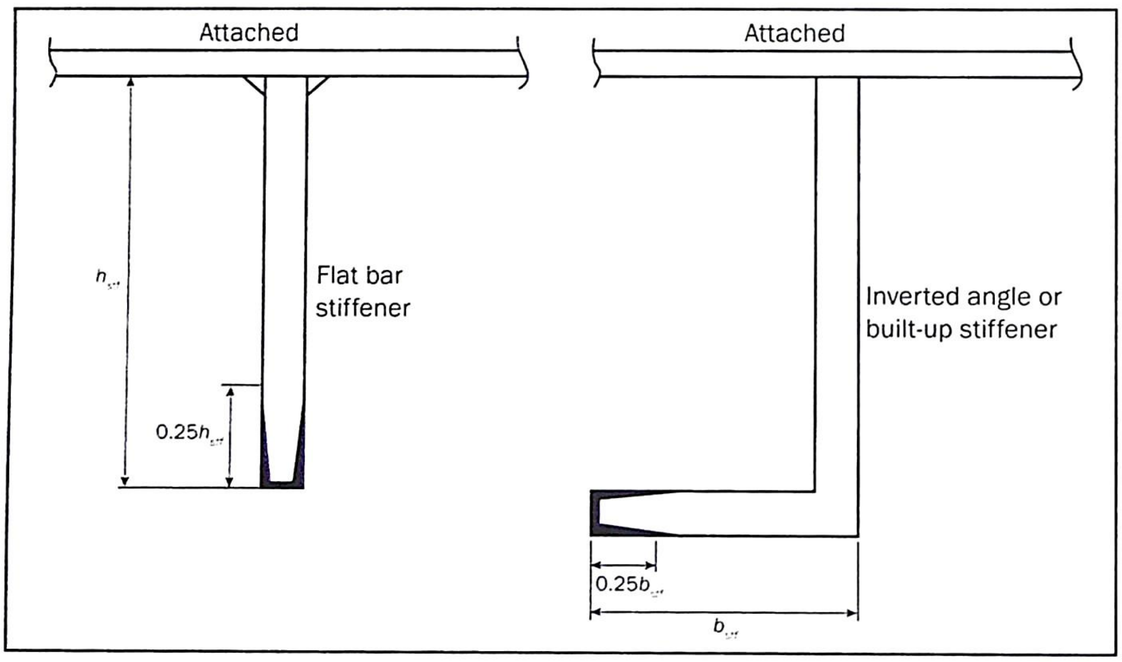


Figure 2: Edge corrosion

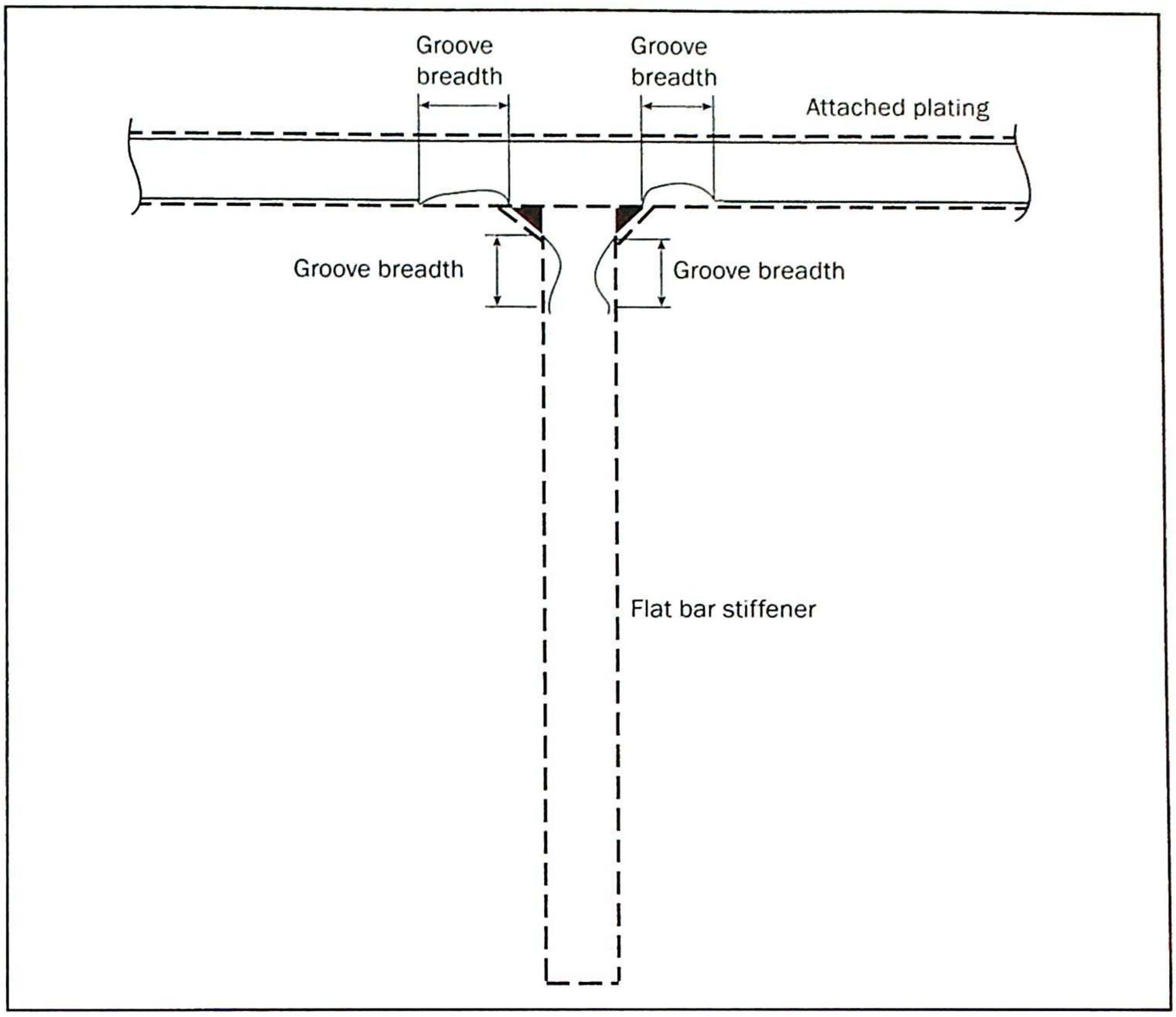


Figure 3: Grooving corrosion

1.3 Repairs

1.3.1 Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the ship's structural, watertight or weathertight integrity, is to be promptly and thoroughly (see 1.2.14) repaired. Areas to be considered include:

- bottom structure and bottom plating
- side structure and side plating
- deck structure and deck plating
- watertight or oiltight bulkheads
- hatch covers or hatch coamings, where fitted (combination carriers).

For locations where adequate repair facilities are not available, consideration may be given to allowing the ship to proceed directly to a repair facility. This may require discharge of the cargo and/or temporary repairs for the intended voyage.

1.3.2 When a survey results in the identification of structural defects or corrosion, either of which, in the opinion of the Surveyor, will impair the ship's fitness for continued service, remedial measures are to be implemented before the ship continues in service.

1.3.3 Where the damage of the type noted in 1.3.1 is isolated and of a localised nature, which does not affect the ship's structural integrity, consideration may be given by the surveyor to allowing an appropriate temporary repair to restore watertight or weather tight integrity. A condition of class in accordance with IACS PR 35, with a specific time limit, will be imposed.

1.4 Thickness Measurements and Close-up Surveys

For any kind of survey, i.e. special, intermediate, annual (or any other survey with the same scope), thickness measurements required by Table II, of structures in areas where close-up surveys are also required, shall be carried out at the same time as the close-up survey.

2. SPECIAL SURVEY[2]

2.1 Schedule

2.1.1 Special Surveys are to be carried out at 5 year intervals to renew the Classification Certificate.

2.1.2 The first Special Survey is to be completed within 5 year of the date of the initial Classification survey and thereafter within 5 years from the credited date of the previous Special Survey. However, an extension of Class of 3 months maximum, beyond the 5th year, can be granted in exceptional circumstances.

In this case, the next period of Class will start from the expiry date of the Special Survey before the extension was granted.

2.1.3 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of Class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of Class will start from the survey completion date.

In cases where the ship has been laid up or has been out of service for a considerable period because of a major repair or modification, and the owner elects to only carry out the overdue surveys, the next period of Class will start from the expiry date of the Special Survey. If the owner elects to carry out the next due Special Survey, the period of class will start from the survey completion date.

2.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the Special Survey is commenced prior to the 4th Annual Survey, the entire survey is to be completed within 15 months if the work is to be credited to the Special Survey.

2.1.5 Concurrent crediting of both the Intermediate Survey (IS) and the Special Survey (SS), for surveys and thickness measurements of spaces, is not acceptable.

2.2 Scope

2.2.1 General

2.2.1.1 The Special Survey is to include, in addition to the requirements of the Annual Survey, examination, tests and checks of sufficient extent to ensure that the hull and related piping, as required in 2.2.1.3, are in a satisfactory condition and fit for intended purpose for the new period of Class of 5 years, subject to proper maintenance and operation and to periodic surveys being carried out at the due dates.

2.2.1.2 All cargo tanks, ballast tanks, including double bottom tanks, pump rooms, pipe tunnels, cofferdams and void spaces bounding cargo tanks, decks and outer hull are to be examined. This examination is to be supplemented by thickness measurement and testing as required in 2.4 and 2.5, to ensure that the structural integrity remains effective. The aim of the examination is to discover any substantial corrosion, significant deformation, fractures, damages or other structural deterioration that may be present.

2.2.1.3 Cargo piping on deck, including crude oil washing (COW) piping, cargo and ballast piping within the above tanks and spaces are to be examined and operationally tested to working pressure, to the attending Surveyor's satisfaction, to ensure that tightness and condition remain satisfactory. Special attention is to be given to ballast piping in cargo tanks and cargo piping in ballast tanks and void spaces and Surveyors are to be advised on all occasions when this piping, including valves and fittings, is open during repair periods and can be examined internally.

2.2.2 Dry Dock Survey

2.2.2.1 A survey in dry dock is to be a part of the Special Survey. The overall and closeup surveys and thickness measurements, as applicable, of the lower portions of the cargo tanks and ballast tanks are to be carried out in accordance with the applicable requirements for special surveys if not already performed.

Note: Lower portions of the cargo and ballast tanks are considered to be the parts below light ballast water line.

2.2.3 Tank Protection

2.2.3.1 Where provided, the condition of the corrosion prevention system of cargo tanks is to be examined.

A ballast tank is to be examined at subsequent annual intervals where:

a. a hard protective coating has not been applied from the time of construction, or

b. a soft or semi-hard coating has been applied, or

c. substantial corrosion is found within the tank, or

d. the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

[2] Some member Societies use the term 'Special Periodical Survey' others use the term 'Class Renewal Survey' instead of the term 'Special Survey'.

Thickness measurements are to be carried out as deemed necessary by the surveyor.

2.3 Extent of Overall and Close-up Surveys

2.3.1 An Overall Survey of all tanks and spaces is to be carried out at each Special Survey.

2.3.2 The minimum requirements for Close-up Surveys at Special Survey are given in Table I.

2.3.3 The Surveyor may extend the Close-up Survey, as deemed necessary when taking into account the maintenance of the tanks under survey, and the condition of the corrosion prevention system and also in the following cases:

a. in particular, tanks having structural arrangements or details that have suffered defects in similar tanks or on similar ships according to available information

b. in tanks that have structures approved with reduced scantlings due to an approved corrosion control system.

2.3.4 For areas in tanks where hard protective coatings are found to be in a GOOD condition, as defined in 1.2.11, the extent of Close-up Surveys according to Table I may be specially considered.

2.4 Extent of Thickness Measurements

2.4.1 The minimum requirements for thickness measurements at Special Survey are given in Table II.

2.4.2 Provisions for extended measurements for areas with substantial corrosion are given in Table IV and as may be additionally specified in the Survey Programme required in 5.1. The extended thickness measurements are to be carried out before the survey is credited as completed. Suspect areas identified at previous surveys are to be examined. Areas of substantial corrosion identified at previous surveys are to have thickness measurements taken.

For vessels built under 'IACS Common Structural Rules', the identified substantial corrosion areas are required to be examined and additional thickness measurements carried out at annual and intermediate surveys.

2.4.3 The Surveyor may further extend the thickness measurements, as deemed necessary.

2.4.4 For areas in tanks where hard protective coating is found to be in a GOOD condition as defined in 1.2.11, the extent of thickness measurements according to Table II may be specially considered.

2.4.5 Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements.

2.4.6 In cases where two or three sections are to be measured, at least one is to include a ballast tank within 0.5L amidships.

For oil tankers of 130m in length and upwards (as defined in the International Convention on Load Lines in force) and more than 10 years of age, for the evaluation of the ship's longitudinal strength as required in 9.1.1.1, the sampling method of thickness measurements is given in Annex III Appendix 3.

2.5 Extent of Tank Testing

2.5.1 The minimum requirements for ballast tank testing at Special Survey are given in 2.5.3 and Table III.

The minimum requirements for cargo tank testing at Special Survey are given in 2.5.4 and Table III.

Cargo tank testing carried out by the ship's crew, under the direction of the Master, may be accepted by the surveyor provided the following conditions are complied with:

a. a tank testing procedure, specifying fill heights, tanks being filled and bulkheads being tested, has been submitted by the owner and reviewed by the Society prior to the testing being carried out

b. there is no record of leakage, distortion or substantial corrosion that would affect the structural integrity of the tank

c. the tank testing has been satisfactorily carried out within special survey window not more than 3 months prior to the date of the survey on which the overall or close up survey is completed

d. the satisfactory results of the testing are recorded in the vessel's logbook

e. the internal and external condition of the tanks and associated structure are found satisfactory by the surveyor at the time of the overall and close up survey.

2.5.2 The Surveyor may extend the tank testing where deemed necessary.

2.5.3 Boundaries of ballast tanks are to be tested with a head of liquid to the top of air pipes.

2.5.4 Boundaries of cargo tanks are to be tested to the highest point that liquid will rise under service conditions.

2.5.5 Testing of double bottom tanks and other spaces not designed for the carriage of liquid may be omitted, provided a satisfactory internal examination, together with an examination of the tanktop, is carried out.

3. ANNUAL SURVEY

3.1 Schedule

3.1.1 Annual Surveys are to be held within 3 months before or after anniversary date of the initial Classification survey or of the date credited for the last Special Survey.

3.2 Scope

3.2.1 General

3.2.1.1 The survey is to consist of an examination for the purpose of ensuring, as far as practicable, that the hull and piping are maintained in a satisfactory condition. It should take into account the service history, condition and extent of the corrosion prevention system of ballast tanks and areas identified in the survey report file.

3.2.2 Examination of the hull

3.2.2.1 Examination of the hull plating and its closing appliances as far as they can be seen.

3.2.2.2 Examination of watertight penetrations as far as practicable.

3.2.3 Examination of the weather deck

3.2.3.1 Examination of cargo tank openings, including gaskets, covers, coamings and flame screens.

3.2.3.2 Examination of cargo tank pressure/vacuum valves and flame screens.

3.2.3.3 Examination of flame screens on vents to all bunker tanks.

3.2.3.4 Examination of cargo, crude oil washing, bunker and vent piping systems, including vent masts and headers.

3.2.4 Examination of cargo pump rooms and pipe tunnels if fitted.

3.2.4.1 Examination of all pump room bulkheads for signs of oil leakage or fractures and, in particular, the sealing arrangements of all penetrations of pump room bulkheads.

3.2.4.2 Examination of the condition of all piping systems.

3.2.5 Examination of ballast tanks

3.2.5.1 Examination of ballast tanks, where required as a consequence of the results of the Special Survey (see 2.2.3) or Intermediate Survey (see 4.2.2.1 and 4.2.2.2), is to be carried out. When considered necessary by the Surveyor, or when extensive corrosion exists, thickness measurements are to be carried out and if the results of these thickness measurements indicate that substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with Table IV. These extended thickness measurements are to be carried out before the survey is credited as completed. Suspect areas identified at previous surveys are to be examined. Areas of substantial corrosion identified at previous surveys are to have thickness measurements taken.

For vessels built under 'IACS Common Structural Rules', the identified substantial corrosion areas are required to be examined and additional thickness measurements be carried out.

4. INTERMEDIATE SURVEY

4.1 Schedule

4.1.1 The Intermediate Survey is to be held at or between either the 2nd or 3rd Annual Survey.

4.1.2 Items additional to the requirements of the Annual Surveys may be surveyed either at or between the 2nd and 3rd Annual Survey.

4.1.3 Concurrent crediting to both Intermediate Survey (IS) and Special Survey (SS) for surveys and thickness measurements of spaces is not acceptable.

4.2 Scope

4.2.1 General

4.2.1.1 The survey extent depends on the age of the ship, as specified in 4.2.2 to 4.2.4 and as shown in Table V.

4.2.1.2 For weather decks, an examination, as far as applicable, of cargo, crude oil washing, bunker, ballast, steam and vent piping systems, as well as vent masts and headers, is to be carried out. If upon examination there is any doubt as to the condition of the piping, the piping may be required to be pressure tested, thickness measured or both.

4.2.1.3 For vessels built under 'IACS Common Structural Rules', the identified substantial corrosion areas are required to be examined and additional thickness measurements are to be carried out.

4.2.2 Double hull oil tankers of between 5 and 10 years of age.

4.2.2.1 For tanks used for salt water ballast, an Overall Survey of representative tanks, selected by the Surveyor, is to be carried out.

If such inspections reveal no visible structural defects, the examination may be limited to a verification that the hard protective coating remains in GOOD condition.

4.2.2.2 A ballast tank is to be examined at subsequent annual intervals where:

a. a hard protective coating has not been applied from the time of construction, or

b. a soft or semi-hard coating has been applied, or

c. substantial corrosion is found within the tank, or

d. the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

4.2.2.3 In addition to the requirements above, suspect areas identified at previous surveys are to be examined.

4.2.3 Double hull oil tankers between 10 and 15 years of age.

4.2.3.1 The requirements of the Intermediate Survey are to be to the same extent as the previous Special Survey, as required in 2 and 5.1. However, pressure testing of cargo and ballast tanks *and the requirements for longitudinal strength evaluation of Hull Girder as required in 8.1.1.1. are not* required unless deemed necessary by the attending Surveyor.

4.2.3.2 In application of 4.2.3.1, the intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion at the third annual survey in lieu of the application of 2.1.4.

4.2.3.3 In application of 4.2.3.1, an under water survey may be considered in lieu of the requirements of 2.2.2.

4.2.4 Double Hull Oil Tankers over 15 years of age. The following is to apply:

4.2.4.1 The requirements of the Intermediate Survey are to be to the same extent as the previous Special Survey as required in 2 and 5.1. However, pressure testing of cargo and ballast tanks *and the requirements for longitudinal strength evaluation of Hull Girder as required in 8.1.1.1 are not* required unless deemed necessary by the attending Surveyor.

4.2.4.2 In application of 4.2.4.1, the Intermediate Survey may be commenced at the second Annual Survey and be progressed during the succeeding year with a view to completion at the third Annual Survey in lieu of the application of 2.1.4.

4.2.4.3 In application of 4.2.4.1, a survey in dry dock is to be part of the Intermediate Survey. The overall and close-up surveys and thickness measurements, as applicable, of the lower portions of the cargo tanks and water ballast tanks are to be carried out in accordance with the applicable requirements for intermediate surveys, if not already carried out.

Note: Lower portions of the cargo and ballast tanks are considered to be the parts below light ballast water line.

5. PREPARATION FOR SURVEY

5.1 Survey Programme

5.1.1 The owner in cooperation with the Classification Society is to work out a specific Survey Programme prior to the commencement of any part of:

- the Special Survey
- the Intermediate Survey for an oil tanker over 10 years of age

The Survey Programme at Intermediate Survey may consist of the Survey Programme at the previous Special Survey supplemented by the Executive Hull Summary of that Special Survey and later relevant survey reports.

The Survey Programme is to take into account any amendments to the survey requirements implemented after the last Special Survey carried out.

The Survey Programme is to be in a written format based on the information in Annex IVA. The survey is not to commence until the Survey Programme has been agreed.

5.1.1.1 Prior to the development of the Survey Programme the survey planning questionnaire is to be completed by the owner, based on the information set out in Annex IVB, and forwarded to the Classification Society.

5.1.2 In developing the Survey Programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas and structural elements to be examined:

.1 survey status and basic ship information;

.2 documentation on board, as described in 6.2 and 6.3;

.3 main structural plans of cargo and ballast tanks (scantlings drawings), including information regarding use of high-tensile steels (HTS);

.4 Executive Hull Summary;

.5 relevant previous damage and repair history;

.6 relevant previous survey and inspection reports from both the recognized organization and the owner;

.7 cargo and ballast history for the last 3 years, including carriage of cargo under heated conditions;

.8 details of the inert gas plant and tank cleaning procedures;

.9 information and other relevant data regarding conversion or modification of the ship's cargo and ballast tanks since the time of construction;

.10 description and history of the coating and corrosion protection system (previous Class notations), if any;

.11 inspections by the owner's personnel during the last 3 years, with reference to structural deterioration in general, leakages in tank boundaries and piping and condition of the coating and corrosion protection system if any. Guidance for reporting is shown in Annex IVC;

.12 information regarding the relevant maintenance level during operation, including port State control reports of inspection containing hull related deficiencies and Safety Management System non-conformities relating to hull maintenance, including the associated corrective action(s); and

.13 any other information that will help identify suspect areas and critical structural areas.

5.1.3 The submitted Survey Programme is to account for and comply with, as a minimum, the requirements of Tables I, II and 2.5 for close-up survey, thickness measurement and tank testing and is also to include relevant information including at least:

.1 basic ship information and particulars;

.2 main structural plans (scantling drawings), including information regarding use of high tensile steels (HTS);

.3 plan of tanks;

.4 list of tanks with information on use, corrosion prevention and condition of coating;

.5 conditions for survey (e.g., information regarding tank cleaning, gas freeing, ventilation, lighting, etc.);

.6 provisions and methods for access to structures;

.7 equipment for surveys;

.8 nomination of tanks and areas for close-up survey (per 2.3);

.9 nominations of sections for thickness measurement (per 2.4);

.10 nomination of tanks for tank testing (per 2.5);

.11 identification of the thickness measurement firm;

.12 damage experience related to the ship in question;

.13 critical structural areas and suspect areas, where relevant.

5.1.4 The Classification Society will advise the owner of the maximum acceptable structural corrosion diminution levels applicable to the ship.

5.1.5 Use may also be made of the 'Guidelines for Technical Assessment in Conjunction with Planning for Enhanced Surveys of Double Hull Oil Tankers Special Survey - Hull', contained in Annex I. These Guidelines are a recommended tool that may be invoked at the discretion of the Classification Society, when considered necessary and appropriate, in conjunction with the preparation of the required Survey Programme.

5.2 Conditions for Survey

5.2.1 The owner is to provide the necessary facilities for a safe execution of the survey.

5.2.1.1 To enable the attending surveyors to carry out the survey, provisions for proper and safe access are to be agreed between the owner and the Classification Society and are to be in accordance with IACS PR 37.

5.2.1.2 Details of the means of access are to be provided in the survey planning questionnaire.

5.2.1.3 In cases where the provisions of safety and required access are judged not to be adequate by the attending surveyors, the survey of the spaces involved is not to proceed.

5.2.2 Tanks and spaces are to be safe for access. Tanks and spaces are to be gas free and properly ventilated. Prior to entering a tank, void or enclosed space, it must be verified that the atmosphere in that space is free from hazardous gas and contains sufficient oxygen.

5.2.3 In preparation for survey and thickness measurements, and to allow for a thorough examination, all spaces are to be cleaned, including removal from surfaces of all loose accumulated corrosion scale. Spaces are to 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.

5.2.4 Sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration.

5.2.5 Where soft or semi-hard 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. When safe access cannot be provided, the soft or semi-hard coating is to be removed.

5.3 Access to Structures

5.3.1 For an overall survey, means are to be provided to enable the surveyor to examine the hull structure in a safe and practical way.

5.3.2 For a close-up survey, one or more of the following means for access, acceptable to the Surveyor, is to be provided:

- Permanent staging and passages through structures;
- temporary staging and passages through structures;
- hydraulic arm vehicles such as conventional cherry pickers, lifts and movable platforms;
- boats or rafts;
- portable ladders;
- other equivalent means.

5.4 Equipment for Survey

5.4.1 Thickness measurement is normally to be carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven to the Surveyor as required.

5.4.2 One or more of the following fracture detection procedures may be required if deemed necessary by the Surveyor:

- Radiographic equipment;
- ultrasonic equipment;
- magnetic particle equipment;
- dye penetrant.

5.4.3 Explosimeter, oxygen meter, breathing apparatus, lifelines, riding belts with rope and hook and whistles, together with instructions and guidance on their use, are to be made available during the survey. A safety checklist is to be provided.

5.4.4 Adequate and safe lighting is to be provided for the safe and efficient conduct of the survey.

5.4.5 Adequate protective clothing is to be made available and used during the survey (e.g. safety helmet, gloves, safety shoes, etc.).

5.5 Rescue and Emergency Response Equipment

If breathing apparatus and/or other equipment is used as 'rescue and emergency response equipment' then it is recommended that the equipment should be suitable for the configuration of the space being surveyed.

5.6 Survey at Sea or at Anchorage

5.6.1 Survey at sea or at anchorage may be accepted provided the Surveyor is given the necessary assistance from the personnel onboard. Precautions and procedures for carrying out the survey are to be in accordance with 5.1, 5.2, 5.3 and 5.4.

5.6.2 A communication system is to be arranged between the survey party in the tank and the responsible officer on deck. This system is to include the personnel in charge of ballast pump handling if boats or rafts are used.

5.6.3 Surveys of tanks by means of boats or rafts may only be undertaken with the agreement of the Surveyor, who is to 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.

5.6.4 When rafts or boats are used for close-up surveys, the following conditions are to be observed:

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

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

.3 appropriate lifejackets are to be available for all participants;

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

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

.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;

.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).

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

5.6.6 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:

i. access direct from the deck via a vertical ladder and a small platform fitted approximately 2 m below the deck in each bay; or

ii. access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform shall, 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 is to 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 (see Figure 4).

If neither of the above conditions are met, then staging or an "other equivalent means" is to be provided for the survey of the under deck areas.

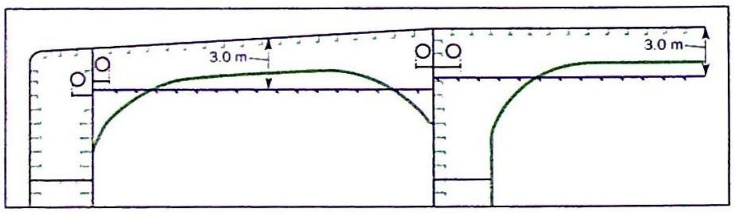


Figure 4: Maximum water level in a tank

5.6.7 The use of rafts or boats alone in paragraphs 5.6.5 and 5.6.6 does not preclude the use of boats or rafts to move about within a tank during a survey.

Refer to IACS Recommendation 39 - Guidelines for the use of Boats or Rafts for Close-up surveys.

5.7 Survey Planning Meeting

5.7.1 Proper preparation and close cooperation between the attending surveyor(s) and the owner's representatives onboard, prior to and during the survey, are an essential part of the safe and efficient conduct of the survey. During the survey on board safety meetings are to be held regularly.

5.7.2 Prior to the commencement of any part of the Special and Intermediate Survey a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance, the TM firm representative, where involved, and the Master of the ship or an appropriately qualified representative appointed by the Master or Company for the purpose of ascertaining that all the arrangements envisaged in the survey programme are in place. This is to ensure the safe and efficient conduct of the survey work to be carried out. See also 7.1.2.

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

.1 schedule of the vessel (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 firm operator(s) and owner representative(s) concerning findings.

6. DOCUMENTATION ON BOARD

6.1 General

6.1.1 The owner is to obtain, supply and maintain on board documentation as specified in 6.2 and 6.3, which is to be readily available for the Surveyor.

6.1.2 The documentation is to be kept on board for the lifetime of the ship.

6.1.3 For tankers and bulk carriers subject to SOLAS Chapter II-1 Part A-1 Regulation 3-10, the owner is to arrange the updating of the ship construction file (SCF) throughout the ship's life and whenever a modification of the documentation included in the SCF has taken place. Documented procedures for updating the SCF are to be included within the Safety Management System.

6.2 Survey Report File

6.2.1 A survey report file is to be a part of the documentation on board consisting of:

- Reports of structural surveys;
- Executive Hull Summary;
- thickness measurement reports.

6.2.2 The survey report file is to be available in the owner's and the Classification Society's management offices.

6.3 Supporting Documents

6.3.1 The following additional documentation is to be available onboard:

- Survey Programme as required by 5.1 until such time as the Special Survey or Intermediate Survey, as applicable, has been completed;
- main structural plans of cargo and ballast tanks (for CSR ships these plans are to include, for each structural element, both the as-built and the renewal thickness. Any thickness for voluntary addition is also to be clearly indicated on the plans. The midship section plan, to be supplied on board the ship, is to include the minimum allowable hull girder sectional properties for the tank transverse section in all cargo tanks);
- previous repair history;
- cargo and ballast history;
- extent of use of inert gas plant and tank cleaning procedures;
- inspections by ship's personnel with reference to
  - » structural deterioration in general;
  - » leakage in bulkheads and piping;
  - » condition of coating or corrosion prevention system, if any.
- any other information that will help identify Critical Structural Areas and/or Suspect Areas requiring inspection;

6.3.2 For tankers and bulk carriers subject to SOLAS Chapter II-1 Part A-1 Regulation 3-10, the SCF, limited to the items to be retained on board, is to be available on board.

6.4 Review of Documentation on Board

6.4.1 Prior to survey, the Surveyor is to examine the completeness of the documentation onboard, and its contents, as a basis for the survey.

6.4.2 For tankers and bulk carriers subject to SOLAS Chapter II-1 Part A-1 Regulation 3-10, on completion of the survey, the surveyor is to verify that the update of the SCF has been made whenever a modification of the documentation included in the SCF has taken place.

6.4.2.1 For the SCF stored on board ship, the surveyor is to examine the information on board ship.

In cases where any major event including, but not limited to, substantial repair and conversion, or any modification to the ship structures, the surveyor is to also verify that the updated information is kept on board the ship.

If the SCF onboard update is not completed at the time of survey, the Surveyor records this and requires confirmation at the next periodic survey.

6.4.2.2 For the SCF stored on shore archive, the surveyor is to examine the list of information included.

In cases where any major event, including, but not limited to, substantial repair and conversion, or any modification to the ship structures, the surveyor is to also verify that the updated information is stored on shore archive by examining the list of information included on shore archive or kept on board the ship.

In addition, the surveyor is to confirm that the service contract with the archive centre is valid.

If the updating of the SCF Supplement ashore is not updated at the time of survey, the Surveyor records this and will require confirmation at the next periodic survey.

6.4.3 For tankers and bulk carriers subject to SOLAS Chapter II-1 Part A-1 Regulation 3-10, on completion of the survey, the surveyor is to verify that any addition and/or renewal of materials used for the construction of the hull structure are documented within the SCF inventory list.

7. PROCEDURES FOR THICKNESS MEASUREMENT

7.1 General

7.1.1 The required thickness measurements, if not carried out by the Society itself, are to be witnessed by a Surveyor of the Society. The Surveyor is to be on board to the extent necessary to control the process.

7.1.2 The thickness measurement firm is to be part of the survey planning meeting that is to be held prior to commencing the survey.

7.1.3 Thickness measurements of structures in areas where close-up surveys are required shall be carried out simultaneously with close-up surveys.

7.1.4 In all cases, the extent of the thickness measurements are to be sufficient as to represent the actual average condition.

7.2 Certification of Thickness Measurement Firm

7.2.1 The thickness measurement is to be carried out by a qualified firm certified, by the Classification Society, according to principles stated in Table VII.

7.3 Number and Locations of Measurements

7.3.1 Application

The item 7.3 only applies to ships built under the IACS Common Structural Rules[1]. For ships not built under IACS Common Structural Rules, the requirements for number and locations of measurements are according to the Rules of the individual Classification Society and/or specific IACS UR, depending on ship's age and structural elements concerned.

7.3.2 Number of measurements

Considering the extent of thickness measurements according to the different structural elements of the ship and surveys (special, intermediate and annual), the locations of the points to be measured are given for the most important items of the structure.

7.3.3 Locations of measurements

Table 1 provides explanations and/or interpretations for the application of the requirements indicated in the Rules that refer to both systematic thickness measurements related to the calculation of global hull girder strength and specific measurements connected to close-up surveys.

Figure 5 to Figure 8 are provided to facilitate the explanations and/or interpretations given in Table 1 and to show typical arrangements of double hull oil tankers.

[1] IACS Common Structural Rules mean IACS Common Structural Rules for Double Hull Oil Tankers (IACS CSR for Oil Tankers) or IACS Common Structural Rules for Bulk Carriers and Oil Tankers (IACS CSR BC&OT).

Interpretations of rule requirements for the locations and number of points to be measured

Item	Interpretation	Figure Reference
Selected plates	'Selected' means at least a single point on one out of three plates, to be chosen on representative areas of average corrosion.	
Deck, bottom plates and wind-and-water strakes	At least two points on each plate to be taken, either at each 1/4 extremity of plate or at representative areas of average corrosion.	
Transverse section	Measurements to be taken on all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom, longitudinal bulkheads, inner bottom and hopper. One point to be taken on each plate. Both web and flange to be measured on longitudinals, if applicable. For tankers older than 10 years of age: within 0.1D (where D is the ship's moulded depth) of the deck and bottom at each transverse section to be measured, every longitudinal and girder is to be measured on the web and face plate and every plate is to be measured at one point between longitudinals.	Figure 5
Transverse rings (#) in cargo and ballast tanks	At least two points on each plate in a staggered pattern and two points on the corresponding flange where applicable. Minimum four points on the first plate below deck. Additional points in way of curved parts. At least one point on each of two stiffeners between stringers/ longitudinal girders.	Figure 6
Transverse bulkheads in cargo tanks	At least two points on each plate. Minimum 4 points on the first plate below main deck. At least one point on every third stiffener to be taken between each stringer. At least two points on each plate of stringers and girders, and two points on the corresponding flange. Additional points in way of curved part. Two points of each diaphragm plate of stools if fitted.	Figure 7
Transverse bulkheads in ballast tanks	At least 4 points on plates between stringers/ longitudinal girders, or per plate if stringers/girders not fitted. At least two points on each plate of stringers and girders and two points on the corresponding flange. Additional points in way of curved part. At least one point on two stiffeners between each stringer/longitudinal girder.	Figure 8
Adjacent structural members	On adjacent structural members one point per plate and one point on every third stiffener/longitudinal.	

(#°) 'Transverse rings' means all transverse material appearing in a cross-section of the ship's hull, in way of a double bottom floor, vertical web and deck transverse (definition from CSR)

Table 1: Z10.4

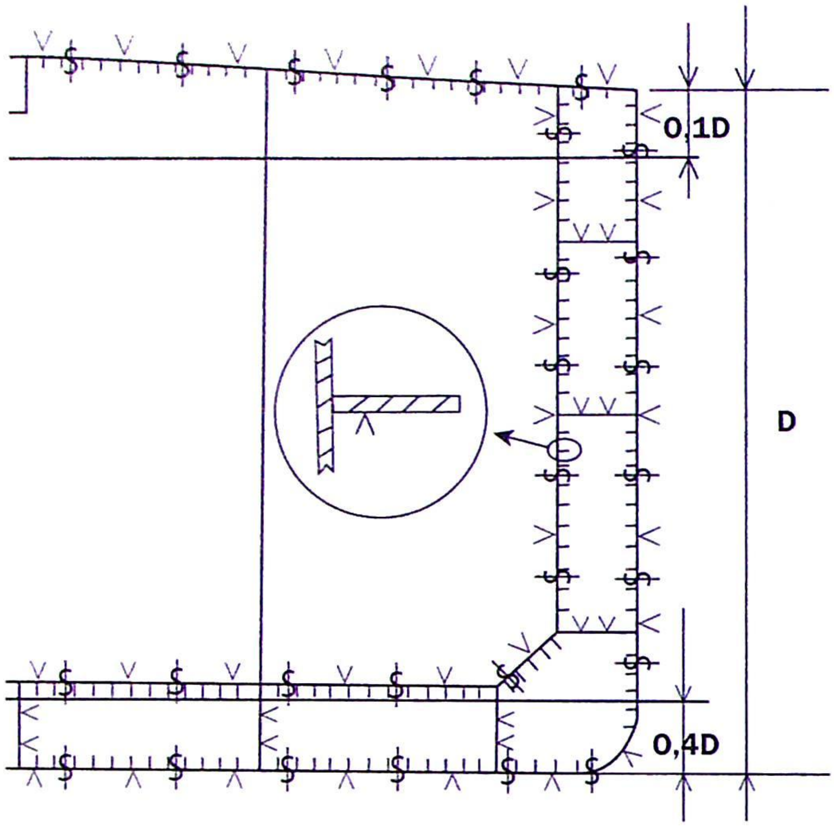


Figure 5: Transverse section

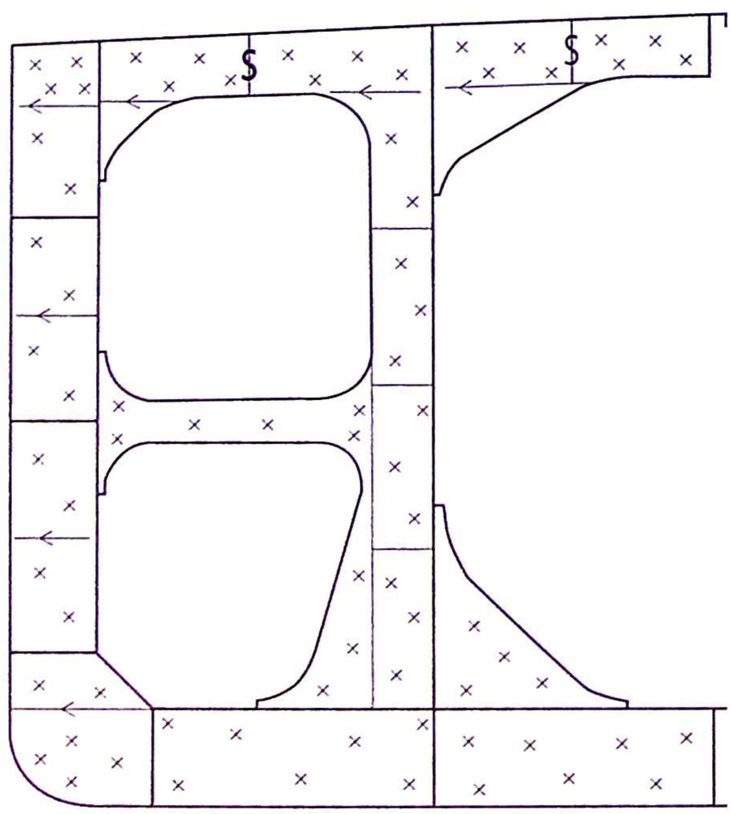


Figure 6: Transverse rings in cargo and ballast tanks

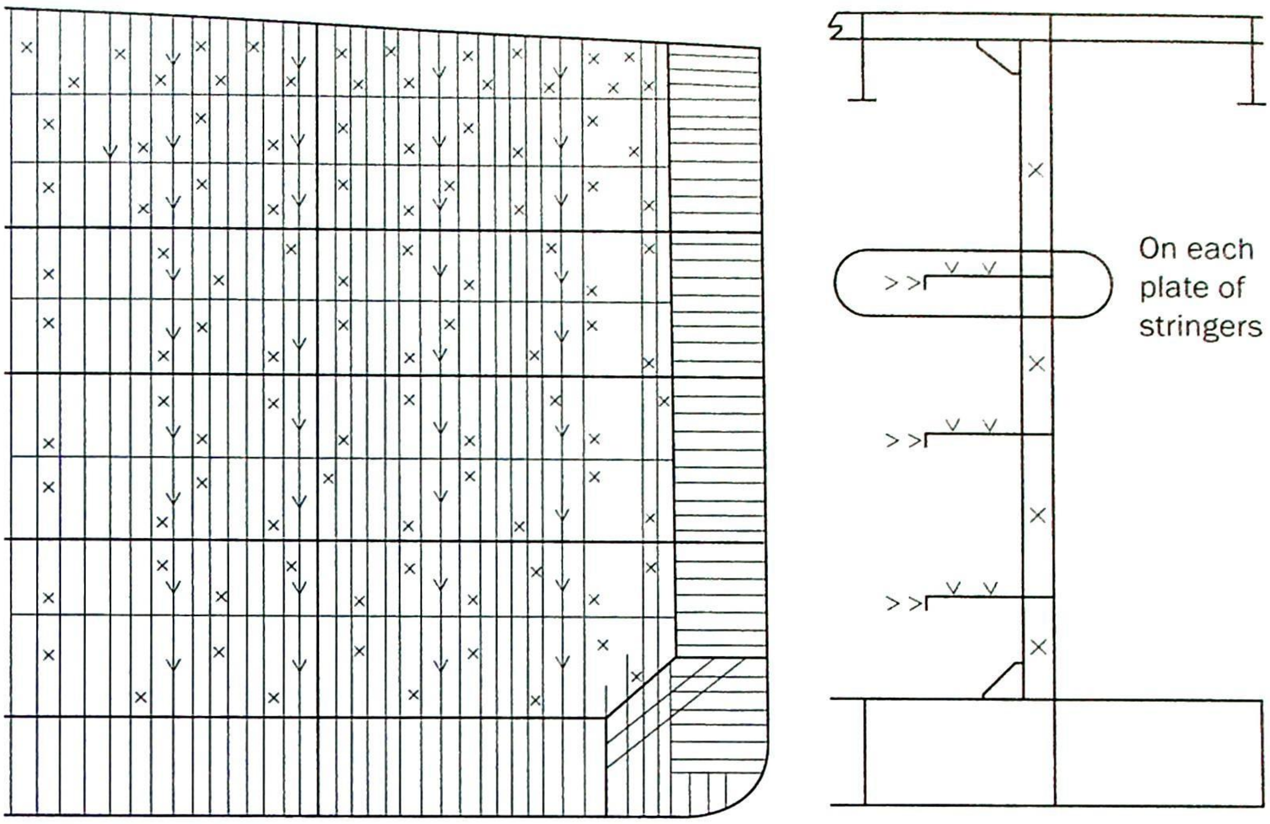


Figure 7: Transverse bulkheads in cargo tanks

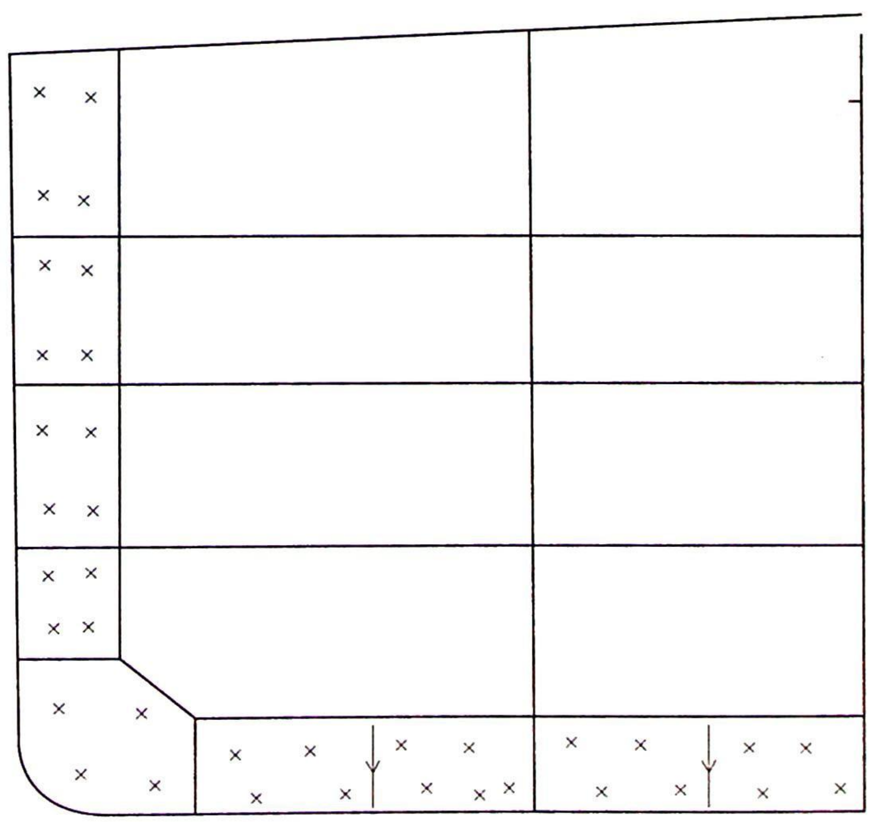


Figure 8: Transverse bulkheads in ballast tanks

7.4 Reporting

7.4.1 A thickness measurement report is to be prepared. The report is to give the location of measurement, the thickness measured and the corresponding original thickness. The report is to also give the date when the measurement was carried out, type of measuring equipment, names of personnel and their qualifications and has to be signed by the operator.

The thickness measurement report is to follow the principles specified in the 'Recommended Procedures for Thickness Measurement of Double Hull Oil Tankers', contained in Annex II.

7.4.2 The Surveyor is to review the final thickness measurement report and countersign the cover page.

8. ACCEPTANCE CRITERIA

8.1 General

8.1.1 For ships built under IACS Common Structural Rules, the Acceptance Criteria is according to IACS Common Structural Rules[1] and as specified in 8.2, 8.3 and 8.4.

8.1.2 For ships not built under IACS Common Structural Rules, the Acceptance Criteria are according to the Rules of the individual Classification Society and/or specific IACS URs, depending on ship's age and structural elements concerned.

8.2 Acceptance Criteria for Pitting Corrosion of CSR Ships

8.2.1 For plates with pitting intensity of less than 20%, see Figure 1, the measured thickness, t_m, of any individual measurement is to meet the lesser of the following criteria:

$$t_m \geq 0.7\,(t_{as\text{-}built} - t_{vol\ add})\ \text{mm}$$

$$t_m \geq t_{ren} - 1\ \text{mm}$$

Where:

$t_{as\text{-}built}$ as-built thickness of the member, in mm

$t_{vol\ add}$ voluntary thickness addition; thickness, in mm, voluntarily added as the owner's extra margin for corrosion wastage in addition to t_c

t_{ren} renewal criteria for general corrosion as defined in IACS Common Structural Rules[2].

8.2.2 The average thickness across any cross section in the plating is not to be less than the renewal criteria for general corrosion given in IACS Common Structural Rules[2].

8.3 Acceptance Criteria for Edge Corrosion of CSR Ships

8.3.1 Provided that the overall corroded height of the edge corrosion of the flange, or web in the case of flat bar stiffeners, is less than 25%, see Figure 2, of the stiffener flange breadth or web height, as applicable, the measured thickness, t_m, is to meet the lesser of the following criteria:

$$t_m \geq 0.7\,(t_{as\text{-}built} - t_{vol\ add})\ \text{mm}$$

$$t_m \geq t_{ren} - 1\ \text{mm}$$

Where:

$t_{as\text{-}built}$ as-built thickness of the member, in mm

$t_{vol\ add}$ voluntary thickness addition; thickness, in mm, voluntarily added as the owner's extra margin for corrosion wastage in addition to t_c

t_{ren} renewal criteria for general corrosion as defined in IACS Common Structural Rules[1].

8.3.2 The average measured thickness across the breadth or height of the stiffener is not to be less than that defined in IACS CSR[2].

8.3.3 Plate edges at openings for manholes, lightening holes etc. may be below the minimum thickness given in IACS CSR[2] provided that:

a. the maximum extent of the reduced plate thickness, below the minimum given in IACS CSR[2] from the opening edge is not more than 20% of the smallest dimension of the opening and does not exceed 100 mm.

b. rough or uneven edges may be cropped-back provided that the maximum dimension of the opening is not increased by more than 10% and the remaining thickness of the new edge is not less than t_{ren} - 1 mm.

8.4 Acceptance Criteria for Grooving Corrosion of CSR Ships

8.4.1 Where the groove breadth is a maximum of 15% of the web height, but not more than 30 mm (see Figure 3), the measured thickness, t_m, in the grooved area is to meet the lesser of the following criteria:

$$t_m \geq 0.75\,(t_{as\text{-}built} - t_{vol\ add})\ \text{mm}$$

$$t_m \geq t_{ren} - 0.5\ \text{mm}$$

but is not to be less than

$$t_m = 6\ \text{mm}$$

[1] Section 12 of IACS CSR for Oil Tankers, or Ch. 13, Part 1 of IACS CSR BC&OT

[2] 1.4.2.1 of Section 12 of IACS CSR for Oil Tankers, or 2.1.1 of Sec. 2, Ch. 13, Part 1 of IACS CSR BC&OT

Where:

$t_{as\text{-}built}$ as-built thickness of the member, in mm

$t_{vol\ add}$ voluntary thickness addition; thickness, in mm, voluntarily added as the Owner's extra margin for corrosion wastage in addition to t_c

t_{ren} renewal criteria for general corrosion as defined in IACS CSR[1].

8.4.2 Structural members with areas of grooving greater than those in 8.4.1 are to be assessed based on the criteria for general corrosion as defined in IACS CSR[2] using the average measured thickness across the plating/stiffener.

9. REPORTING AND EVALUATION OF SURVEY

9.1 Evaluation of Survey Report

9.1.1 The data and information on the structural condition of the vessel collected during the survey is to be evaluated for acceptability and continued structural integrity of the vessel.

9.1.1.1 For oil tankers of 130 m in length and upwards (as defined in the International Convention on Load Lines in force), the ship's longitudinal strength is to be evaluated by using the thickness of structural members measured, renewed and reinforced, as appropriate, during the special survey carried out after the ship reached 10 years of age and in accordance with the criteria for longitudinal strength of the ship's hull girder for oil tankers specified in Annex III.

9.1.1.2 The final result of evaluation of the ship's longitudinal strength required in 9.1.1.1, after renewal or reinforcement work of structural members, if carried out as a result of initial evaluation, is to be reported as a part of the Executive Hull Summary.

9.2 Reporting

9.2.1 Principles for survey reporting are shown in Table VIII.

9.2.2 When a survey is split between different survey stations, a report is to be made for each portion of the survey. A list of items examined and/or tested, (pressure testing, thickness measurements etc.) and an indication of whether the item has been credited, are to be made available to the next attending Surveyor(s) prior to them continuing or completing the survey.

9.2.3 An Executive Hull Summary of the survey and results is to be issued to the owner, as shown in Table IX, and placed on board the ship for reference at future surveys. The Executive Hull Summary is to be endorsed by the Classification Society's head office or regional managerial office.

[1] 1.4.2.1 of Section 12 of IACS CSR for Oil Tankers, or 2.1.1 of Sec. 2, Ch. 13, Part 1 of IACS CSR BC&OT

[2] 1.4.2 of Section 12 of IACS CSR for Oil Tankers, or 2.1 of Sec. 2, Ch. 13, Part 1 of IACS CSR BC&OT

Minimum Requirements for Close-Up Survey at Special Survey of Double Hull Oil Tankers

Special Survey No.1 age ≤ 5	Special Survey No.2 5 < age ≤ 10	Special Survey No.3 10 < age ≤ 15	Special Survey No.4 and Subsequent age > 15
One web frame **(1)**, in a ballast tank (see **Note 1**)	All web frames **(1)**, in a ballast tank (see **Note 1**) The *knuckle area* and the upper part (5 metres approximately) of one web frame in each remaining ballast tank **(6)**	All web frames **(1)**, in all ballast tanks	As for Special Survey for age from 10 to 15 years Additional transverse areas as deemed necessary by the Society
One deck transverse, in a cargo oil tank **(2)**	One deck transverse, in two cargo oil tanks **(2)**	All web frames **(7)**, including deck transverse and cross ties, if fitted, in a cargo oil tank One web frame **(7)**, including deck transverse and cross ties, if fitted, in each remaining cargo oil tank	
One transverse bulkhead **(4)**, in a ballast tank (see **Note 1**)	One transverse bulkhead **(4)**, in each ballast tank (see **Note 1**)	All transverse bulkheads, in all cargo oil **(3)** and ballast **(4)** tanks	
One transverse bulkhead **(5)**, in a cargo oil centre tank One transverse bulkhead **(5)**, in a cargo oil wing tank (see **Note 2**)	One transverse bulkhead **(5)**, in two cargo oil centre tanks One transverse bulkhead **(5)**, in a cargo oil wing tank (see **Note 2**)		

(1), (2), (3), (4), (5), (6) and **(7)** are areas to be subjected to close-up surveys and thickness measurements (see Figure 9 and Figure 10)

(1): Web frame in a ballast tank means vertical web in side tank, hopper web in hooper tank, floor in double bottom tank and deck transverse in double deck tank (where fitted), including adjacent structural members. In fore and aft peak tanks web frame means a complete transverse web frame ring including adjacent structural members

(2): Deck transverse, including adjacent deck structural members (or external structure on deck in way of the tank, where applicable)

(3): Transverse bulkhead complete in cargo tanks, including girder system, adjacent structural members (such as longitudinal bulkheads) and internal structure of lower and upper stools, where fitted

(4): Transverse bulkhead complete in ballast tanks, including girder system and adjacent structural members, such as longitudinal bulkheads, girders in double bottom tanks, inner bottom plating, hopper side, connecting brackets

(5): Transverse bulkhead lower part in cargo tank, including girder system, adjacent structural members (such as longitudinal bulkheads) and internal structure of lower stool, where fitted

(6): The *knuckle area* and the upper part (5 metres approximately), including adjacent structural members. *Knuckle area* is the area of the web frame around the connections of the slope hopper plating to the inner hull bulkhead and the inner bottom plating, up to 2 metres from the corners both on the bulkhead and the double bottom

(7): Web frame in a cargo oil tank means deck transverse, longitudinal bulkhead structural elements and cross ties, where fitted, including adjacent structural members

Note 1: Ballast tank: Apart from the fore and aft peak tanks, the term 'ballast tank' has the following meaning:

.1 all ballast compartments (hopper tank, side tank and double-deck tank, if separate from double-bottom tank) located on one side, i.e. portside or starboard side, and additionally double-bottom tank on portside plus starboard side, when the longitudinal central girder is not watertight and, therefore, the double-bottom tank is a unique compartment from portside to starboard side; or

.2 all ballast compartments (double-bottom tank, hopper tank, side tank and double-deck tank) located on one side, i.e. portside or starboard side, when the longitudinal central girder is watertight and, therefore, the portside double-bottom tank separate from the starboard-side double-bottom tank.

Note 2: Where no centre cargo tanks are fitted (as in case of centre longitudinal bulkhead), transverse bulkheads in wing tanks are to be surveyed

Table I: Z10.4 cont'd

Minimum Requirements for Thickness Measurements at Special Survey of Double Hull Oil Tankers

Special Survey No.1 age ≤ 5	Special Survey No.2 5 < age ≤ 10	Special Survey No.3 10 < age ≤ 15	Special Survey No.4 and Subsequent age > 15
1. Suspect areas	1. Suspect areas	1. Suspect areas	1. Suspect areas
2. One section of deck plating for the full beam of the ship within the cargo area	2. Within the cargo area: .1 Each deck plate .2 One transverse section	2. Within the cargo area: .1 Each deck plate .2 Two transverse sections **(1)** .3 All wind and water strakes	2. Within the cargo area: .1 Each deck plate .2 Three transverse sections **(1)** .3 Each bottom plate
	3. Selected wind and water strakes outside the cargo area	3. Selected wind and water strakes outside the cargo area	3. All wind and water strakes, full length
4. Measurements, for general assessment and recording of corrosion pattern, of those structural members subject to close-up survey according to Table I	4. Measurements, for general assessment and recording of corrosion pattern, of those structural members subject to close-up survey according to Table I	4. Measurements, for general assessment and recording of corrosion pattern, of those structural members subject to close-up survey according to Table I	4. Measurements, for general assessment and recording of corrosion pattern, of those structural members subject to close-up survey according to Table I
(1): at least one section is to include a ballast tank within 0.5L amidships.			

Table II: Z10.4 cont'd

Minimum Requirements for Tank Testing at Special Survey of Double Hull Oil Tankers
Age of ship (in years at time of special survey due date)

Special Survey No.1 age ≤ 5	Special Survey No.2 and Subsequent age > 5
All ballast tank boundaries	All ballast tank boundaries
Cargo tank boundaries facing ballast tanks, void spaces, pipe tunnels, pump rooms or cofferdams	All cargo tank bulkheads

Table III: Z10.4 cont'd

Requirements for Extent of Thickness Measurements at Those Areas of Substantial Corrosion – Special Survey of Double Hull Oil Tankers within the Cargo Area Length
Bottom, Inner Bottom and Hopper Structure

Structural Member	Extent of Measurement	Pattern of Measurement
Bottom, inner bottom and hopper structure plating	Minimum of three bays across double bottom tank, including aft bay Measurements around and under all suction bell mouths	5-point pattern for each panel between longitudinals and floors
Bottom, inner bottom and hopper structure longitudinals	Minimum of three longitudinals in each bay where bottom plating measured	Three measurements in line across the flange and three measurements on vertical web
Bottom girders, including the watertight ones	At fore and aft watertight floors and in centre of tanks	Vertical line of single measurements on girder plating with one measurement between each panel stiffener, or a minimum of three measurements
Bottom floors, including the watertight ones	Three floors in the bays where bottom plating measured, with measurements at both ends and middle	5-point pattern over 2 m^2 area
Hopper structure web frame ring	Three floors in bays where bottom plating measured	5-point pattern over 1 m^2 of plating. Single measurements on flange
Hopper structure transverse watertight bulkhead or swash bulkhead	– lower 1/3 of bulkhead	– 5-point pattern over 1 m^2 of plating
	– upper 2/3 of bulkhead	– 5-point pattern over 2 m^2 of plating
	– stiffeners (minimum of three)	– For web, 5-point pattern over span (two measurements across web at each end and one at centre of span). For flange, single measurements at each end and centre of span
Panel stiffening	Where applicable	Single measurements

Table IV: Sheet 1 Z10.4 cont'd

Requirements for Extent of Thickness Measurements at Those Areas of Substantial Corrosion – Special Survey of Double Hull Oil Tankers within the Cargo Area Length
Deck Structure

Structural Member	Extent of Measurement	Pattern of Measurement
Deck plating	Two transverse bands across tank	Minimum of three measurements per plate per band
Deck longitudinals	Every third longitudinal in each of two bands with a minimum of one longitudinal	Three measurements in line vertically on webs and two measurements on flange (if fitted)
Deck girders and brackets (usually in cargo tanks only)	At fore and aft transverse bulkhead, bracket toes and in centre of tanks	Vertical line of single measurements on web plating with one measurement between each panel stiffener, or a minimum of three measurements Two measurements across flange. 5-point pattern on girder/bulkhead brackets
Deck transverse webs	Minimum of two webs, with measurements at both ends and middle of span	5-point pattern over one square metre area Single measurements on flange
Vertical web and transverse bulkhead in wing ballast tank (two metres from deck)	Minimum of two webs, and both transverse bulkheads	5-point pattern over 1 m^2 area
Panel stiffening	Where applicable	Single measurements

Table IV: Sheet 2 Z10.4 cont'd

Requirements for Extent of Thickness Measurements at Those Areas of Substantial Corrosion – Special Survey of Double Hull Oil Tankers within the Cargo Area Length
Structure in Wing Ballast Tanks

Structural Member	Extent of Measurement	Pattern of Measurement
Side shell and longitudinal bulkhead plating: – Upper strake and strakes in way of horizontal girders – All other strakes	 – Plating between each pair of longitidinals in a minimum of three bays (along the tank) – Plating between every third pair of longitudinals in same three bays	 – Single measurement – Single measurement
Side shell and longitudinal bulkhead longitudinals on: – Upper strake – All other strakes	 – Each longitudinal in same three bays – Every third longitudinal in same three bays	 – 3 measurements across web and 1 measurement on flange – 3 measurements across web and 1 measurement on flange
Longitudinals – brackets	Minimum of three at top, middle and bottom of tank in same three bays	5-point pattern over area of bracket
Vertical web and transverse bulkheads (excluding deckhead area): – Strakes in way of horizontal girders – Other strakes	 – Minimum of two webs and both transverse bulkheads – Minimum of two webs and both transverse bulkheads	 – 5-point pattern over approx. two square metre area – Two measurements between each pair of vertical stiffeners
Horizontal girders	Plating on each girder in a minimum of three bays	Two measurements between each pair of longitudinal girder stiffeners
Panel stiffening	Where applicable	Single measurements

Table IV: Sheet 3 Z10.4 cont'd

Requirements for Extent of Thickness Measurements at Those Areas of Substantial Corrosion – Special Survey of Double Hull Oil Tankers within the Cargo Area Length
Longitudinal Bulkheads in Cargo Tanks

Structural Member	Extent of Measurement	Pattern of Measurement
Deckhead and bottom strakes, and strakes in way of the horizontal stringers of transverse bulkheads	Plating between each pair of longitudinals in a minimum of three bays	Single measurement
All other strakes	Plating between every third pair of longitudinals in same three bays	Single measurement
Longitudinals on deckhead and bottom strakes	Each longitudinal in same three bays	Three measurements across web and one measurement on flange
All other longitudinals	Every third longitudinal in same three bays	Three measurements across web and one measurement on flange
Longitudinals – brackets	Minimum of three at top, middle and bottom of tank in same three bays	5-point pattern over area of bracket
Web frames and cross ties	Three webs with minimum of three locations on each web, including in way of cross tie connections	5-point pattern over approximately 2 m^2 area of webs, plus single measurements on flanges of web frame and cross ties
Lower end brackets (opposite side of web frame)	Minimum of three brackets	5-point pattern over approximately 2 m^2 area of brackets, plus single measurements on bracket flanges

Table IV: Sheet 4 Z10.4 cont'd

Requirements for Extent of Thickness Measurements at Those Areas of Substantial Corrosion – Special Survey of Double Hull Oil Tankers within the Cargo Area Length
Transverse Watertight and Swash Bulkheads in Cargo Tanks

Structural Member	Extent of Measurement	Pattern of Measurement
Upper and lower stool, where fitted	– Transverse band within 25 mm of welded connection to inner bottom/deck plating – Transverse band within 25 mm of welded connection to shelf plate	5-point pattern between stiffeners over one metre length
Deckhead and bottom strakes, and strakes in way of horizontal stringers	Plating between pair of stiffeners at three locations: approximately 1/4, 1/2 and 3/4 width of tank	5-point pattern between stiffeners over one metre length
All other strakes	Plating between pair of stiffeners at middle location	Single measurement
Strakes in corrugated bulkheads	Plating of each change of scantling at centre of panel and at flange of fabricated connection	5-point pattern over about 1 m^2 of plating
Stiffeners	Minimum of three typical stiffeners	For web, 5-point pattern over span between bracket connections (two measurements across web at each bracket connection and one at centre of span) For flange, single measurements at each bracket toe and at centre of span
Brackets	Minimum of three at top, middle and bottom of tank	5-point pattern over area of bracket
Horizontal stringers	All stringers with measurements at both ends and middle	5-point pattern over 1 m^2 area, plus single measurements near bracket toes and on flanges

Table IV: Sheet 5 Z10.4 cont'd

Minimum Requirements for Overall and Close-Up Survey and Thickness Measurements at Intermediate Survey of Double Hull Oil Tankers
Age of Ship at Time of Intermediate Survey Due Date

5 < age ≤ 10	10 < age ≤ 15	age > 15
Overall survey of representative ballast tanks selected by the attending surveyor (see 4.2.2)	The requirements of the previous Special Survey (see 4.2.3)	The requirements of the previous Special Survey (see 4.2.4)
Suspect areas identified at previous surveys are to be examined (see 4.2.2)		

Table V: Z10.4 cont'd

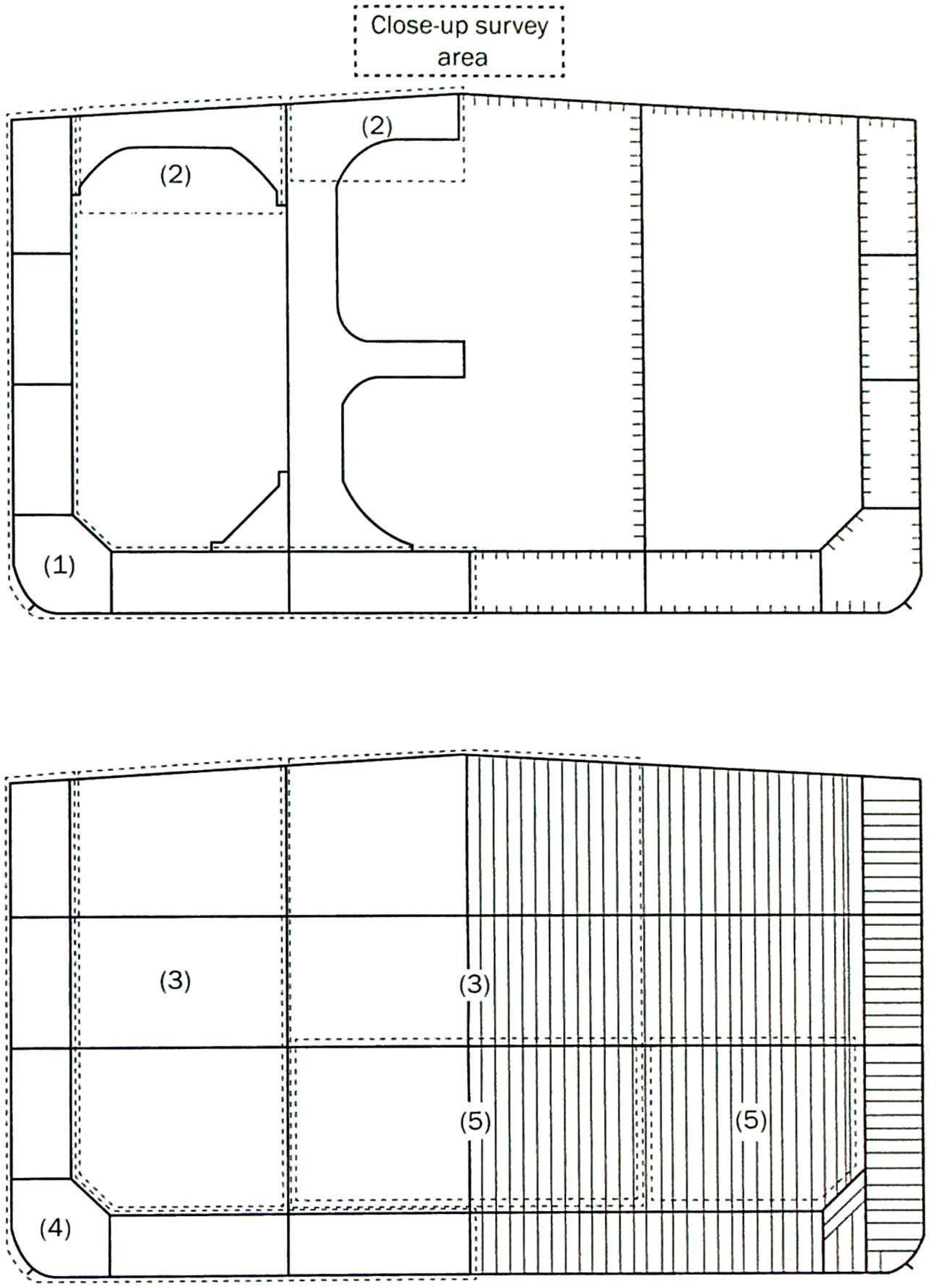


Figure 9: Close-up Survey Requirements for Double Hull Oil Tankers Areas (1) to (5)

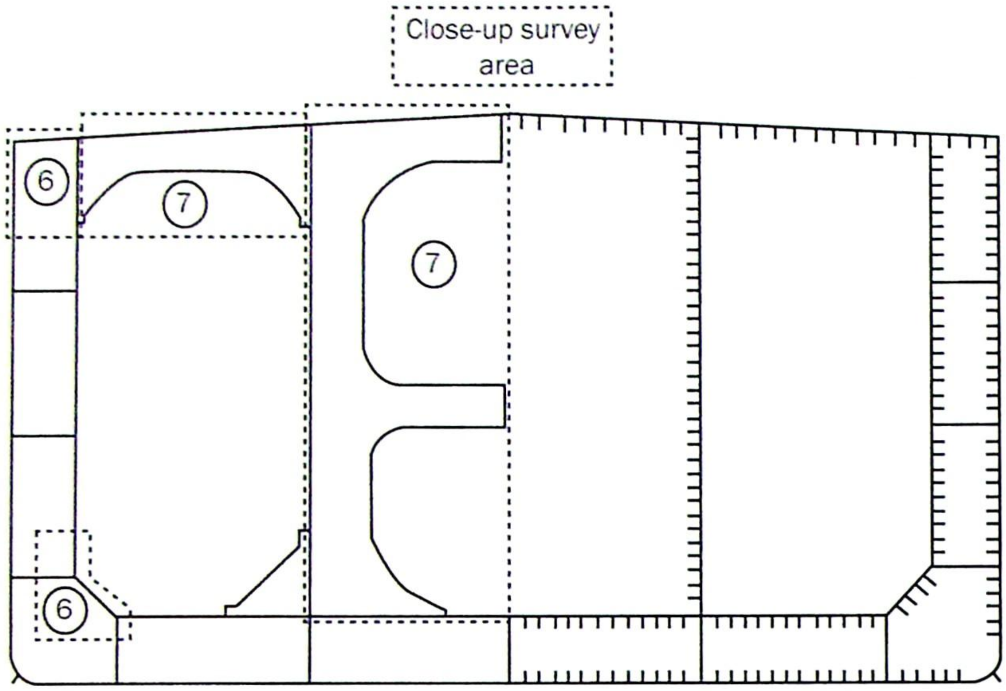


Figure 10: Close-up Survey Requirements for Double Hull Oil Tankers Areas (6) and (7)

Note: Table VI is retitled Annex IVC.

Table VI: Z10.4 cont'd

Procedures for Certification of Firms Engaged in Thickness Measurement of Hull Structures

1. Application

This guidance applies for certification of the firms that intend to engage in the thickness measurement of hull structures of the ships.

2. Procedures for Certification

(1) Submission of Documents:
Following documents are to be submitted to the society for approval;

a) Outline of firms, e.g. organization and management structure.

b) Experience of the firms on thickness measurement inter alia of hull structures of the ships.

c) Technicians' careers, i.e. experience of technicians as thickness measurement operators, technical knowledge of hull structure etc. Operators, are to be qualified according to a recognized industrial NDT Standard.

d) Equipment used for thickness measurement such as ultrasonic testing machines and its maintenance/calibration procedures.

e) A guide for thickness measurement operators.

f) Training programmes of technicians for thickness measurement.

g) Measurement record format in accordance with the Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers contained in Annex II.

(2) Auditing of the firms:
Upon reviewing the documents submitted with satisfactory results, the firm is audited to ascertain that it is organized and managed in accordance with the documents submitted and eventually is capable of conducting thickness measurement of the hull construction of the ships.

(3) Certification is conditional on an onboard demonstration of thickness measurements as well as satisfactory reporting.

3. Certification

(1) Upon satisfactory results of both the audit of the firm in 2(2) and the demonstration tests in 2(3) above, the Society will issue a Certificate of Approval as well as a notice to the effect that the thickness measurement operation system of the firm has been certified by the Society.

(2) Renewal/endorsement of the Certificate is to be made at intervals not exceeding 3 years by verification that original conditions are maintained.

4. Information of any alteration to the Certified Thickness Measurement Operation System

Where any alteration to the certified thickness measurement operation system of the firm is made, such an alteration is to be immediately informed to the Society. Re-audit will be made if deemed necessary by the Society.

5. Cancellation of Approval

Approval may be cancelled in the following cases:

(1) Where the measurements were improperly carried out or the results were improperly reported.

(2) Where the Society's surveyor found any deficiencies in the approved thickness measurement operation systems of the firm.

(3) Where the firm failed to inform of any alteration in 4 above to the Society.

Table VII: Z10.4 cont'd

Survey Reporting Principles

As a principle, for oil tankers subject to ESP, the Surveyor is to include the following content in their report for survey of hull structure and piping systems, as relevant for the survey.

The structure of the reporting content may be different, depending on the report system for the respective Societies.

1. General

1.1 A survey report is to be generated in the following cases:

- In connection with commencement, continuation and/or completion of periodical hull surveys, i.e. annual, intermediate and special surveys, as relevant
- When structural damages/defects have been found
- When repairs, renewals or modifications have been carried out
- When condition of Class has been imposed or deleted

1.2 The purpose of reporting is to provide:

- Evidence that prescribed surveys have been carried out in accordance with applicable Classification rules
- Documentation of surveys carried out with findings, repairs carried out and condition of Class imposed or deleted
- Survey records, including actions taken, which shall form an auditable documentary trail. Survey reports are to be kept in the survey report file required to be on board
- Information for planning of future surveys
- Information that may be used as input for maintenance of Classification rules and instructions

1.3 When a survey is split between different survey stations, a report is to be made for each portion of the survey. A list of items surveyed, relevant findings and an indication of whether the item has been credited, is to be made available to the next attending surveyor, prior to continuing or completing the survey. Thickness measurement and tank testing carried out is also to be listed for the next surveyor.

2. Extent of the survey

2.1 Identification of compartments where an overall survey has been carried out.

2.2 Identification of locations, in each tank, where a close-up survey has been carried out, together with information of the means of access used.

2.3 Identification of locations, in each tank, where thickness measurement has been carried out.

Note: As a minimum, the identification of location of close-up survey and thickness measurement is to include a confirmation with description of individual structural members corresponding to the extent of requirements stipulated in Z10.4 based on type of periodical survey and the ship's age.

Where only partial survey is required, i.e. one web frame ring / one deck transverse, the identification is to include location within each tank by reference to frame numbers.

2.4 For areas in tanks where protective coating is found to be in GOOD condition and the extent of close-up survey and / or thickness measurement has been specially considered, structures subject to special consideration are to be identified.

2.5 Identification of tanks subject to tank testing.

2.6 Identification of cargo piping on deck, including crude oil washing (COW) piping, and cargo and ballast piping within cargo and ballast tanks, pump rooms, pipe tunnels and void spaces, where:

- Examination including internal examination of piping with valves and fittings and thickness measurement, as relevant, has been carried out
- Operational test to working pressure has been carried out.

Table VIII: Z10.4 cont'd

Survey Reporting Principles

3. Result of the survey

3.1 Type, extent and condition of protective coating in each tank, as relevant (rated GOOD, FAIR or POOR).

3.2 Structural condition of each compartment with information on the following, as relevant:

– Identification of findings, such as:
  - Corrosion with description of location, type and extent
  - Areas with substantial corrosion
  - Cracks/fractures with description of location and extent
  - Buckling with description of location and extent
  - Indents with description of location and extent

– Identification of compartments where no structural damages/defects are found

The report may be supplemented by sketches/photos.

3.3 Thickness measurement report is to be verified and signed by the surveyor controlling the measurements on board.

3.4 Evaluation result of longitudinal strength of the hull girder of oil tankers of 130 m in length and upwards and over 10 years of age. The following data is to be included, as relevant:

– Measured and as-built transverse sectional areas of deck and bottom flanges

– Diminution of transverse sectional areas of deck and bottom flanges

– Details of renewals or reinforcements carried out, as relevant (as per 4.2)

4. Actions taken with respect to findings

4.1 Whenever the attending Surveyor is of the opinion that repairs are required, each item to be repaired is to be identified in the survey report. Whenever repairs are carried out, details of the repairs effected are to be reported by making specific reference to relevant items in the survey report.

4.2 Repairs carried out are to be reported with identification of:

– Compartment

– Structural member

– Repair method (i.e. renewal or modification) including:
  - Steel grades and scantlings (if different from the original)
  - Sketches/photos, as appropriate

– Repair extent

– NDT/tests

4.3 For repairs not completed at the time of survey, condition of Class is to be imposed with a specific time limit for the repairs. To provide correct and proper information to the Surveyor attending for survey of the repairs, condition of Class is to be sufficiently detailed with identification of each item to be repaired. For identification of extensive repairs, reference may be given to the survey report.

Table VIII: Z10.4 cont'd

IACS Unified Requirements for Enhanced Surveys Executive Hull Summary Issued upon Completion of Special Survey

GENERAL PARTICULARS

SHIP'S NAME:

CLASS IDENTIFY NUMBER:

IMO IDENTIFY NUMBER:

PORT OF REGISTRY:

NATIONAL FLAG:

DEADWEIGHT (M. TONNES):

GROSS TONNAGE:
NATIONAL:
ITC (69):

DATE OF BUILD:

CLASSIFICATION NOTATION:

DATE OF MAJOR CONVERSION:

TYPE OF CONVERSION:

a) The survey reports and documents listed below have been reviewed by the undersigned and found to be satisfactory

b) A summary of the survey is attached on sheet 2

c) The Hull Special Survey has been completed, in accordance with the Regulations, on [date]

Executive Summary Report completed by:	Name Signature	Title
OFFICE	DATE	
Executive Summary Report verified by:	Name Signature	Title
OFFICE	DATE	

Attached reports and documents:

1)
2)
3)
4)
5)
6)

Table IX (i): Z10.4 cont'd

Executive Hull Summary

A)	General Particulars:	-	Ref. Table IX (i)
B)	Report Review:	-	Where and how survey was done
C)	Close-up Survey:	-	Extent (Which tanks)
D)	Cargo & Ballast Piping System:	-	Examined
		-	Operationally tested
E)	Thickness measurements:	-	Reference to Thickness Measurement report
		-	Summary of where measured
		-	Separate form indicating the tanks/areas with Substantial Corrosion, and corresponding
			* Thickness diminution
			* Corrosion pattern
F)	Tank Protection:		Separate form indicating:
		-	Location of coating
		-	Condition of coating (if applicable)
G)	Repairs:	-	Identification of tanks/areas
H)	Conditions of Class:		
I)	Memoranda:	-	Acceptable defects
		-	Any points of attention for future surveys, e.g. for Suspect Areas.
		-	Extended Annual/Intermediate survey due to coating breakdown
J)	Evaluation results of the ship's longitudinal strength (for oil tankers of 130 m in length and upwards and of over 10 years of age)		
K)	Conclusion:	-	Statement on evaluation/verification of survey report

Table IX (ii): Z10.4 cont'd

Extract of Thickness Measurements
Non CSR ships

Reference is made to the thickness measurements report:

1) Position of substantially corroded Tanks/Areas or Areas with deep pitting	Thickness diminution[%]	2) Corrosion pattern	Remarks: e.g. Ref. attached sketches

Remarks

1) Substantial corrosion, i.e. 75 – 100% of acceptable margins wasted.

2) P = Pitting
C = Corrosion in general
Any bottom plating with a pitting intensity of 20% or more, with wastage in the substantial corrosion range or having an average depth of pitting of 1/3 or more of actual plate thickness, is to be noted.

Table IX (iii) A: Z10.4 cont'd

Extract of Thickness Measurements
CSR ships

Reference is made to the thickness measurements report:

1) Position of substantially corroded Tanks/Areas or Areas with deep pitting	$t_m - t_{ren}$ (mm)	2) Corrosion pattern	Remarks: e.g. Ref. Attached sketches

Remarks

1) Substantial corrosion, an extent of corrosion such that the assessment of the corrosion pattern indicates a measured thickness between t_{ren} + 0.5 mm and t_{ren}.

2) P = Pitting
C = Corrosion in general
Areas with deep pitting assessed according to 8.2 are to be recorded in this column.

Table IX (iii) B: Z10.4 cont'd

Tank Protection

1) Tank Nos.	2) Tank protection	3) Coating condition	Remarks

Remarks

1) All segregated ballast tanks and combined cargo/ballast tanks to be listed.

2) C = Coating NP = No Protection

3) Coating condition according to the following standard

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 of areas or hard scale at 10% or more of areas under consideration.

If coating condition **less than 'GOOD'** is given, extended annual surveys are to be introduced. This is to be noted in part I) of the Executive Hull Summary.

Table IX (iv): Z10.4 cont'd

Evaluation result of longitudinal strength of the hull girder of oil tankers of 130 m in length and upwards and of over 10 years of age (of sections 1, 2 and 3 below, only one applicable section is to be completed)

1 This section applies to ships regardless of the date of construction: Transverse sectional areas of the deck flange (deck plating and deck longitudinals) and bottom flange (bottom shell plating and bottom longitudinals) of the ship's hull girder have been calculated by using the thickness measured, renewed or reinforced, as appropriate, during the Special Survey most recently conducted after the ship reached 10 years of age, and found that the diminution of the transverse sectional area does not exceed 10% of the as-built area, as shown in the following table:

Table 1 Transverse sectional area of hull girder flange

		Measured	As-built	Diminution
Transverse Section 1	**Deck flange**	cm^2	cm^2	cm^2 (%)
	Bottom flange	cm^2	cm^2	cm^2 (%)
Transverse Section 2	**Deck flange**	cm^2	cm^2	cm^2 (%)
	Bottom flange	cm^2	cm^2	cm^2 (%)
Transverse Section 3	**Deck flange**	cm^2	cm^2	cm^2 (%)
	Bottom flange	cm^2	cm^2	cm^2 (%)

2 This section applies to ships constructed on or after 1 July 2002: Section moduli of transverse section of the ship's hull girder have been calculated by using the thickness of structural members measured, renewed or reinforced, as appropriate, during the Special Survey most recently conducted after the ship reached 10 years of age, in accordance with the provisions of paragraph 2.2.1.1 of Annex III, and are found to be within their diminution limits determined by the Classification Society*, as shown in the following table:

Table 2 Transverse section modulus of hull girder

		Z_{act} (cm^3) *1	Z_{req} (cm^3) *2	Remarks
Transverse Section 1	**Upper deck**			
	Bottom			
Transverse Section 2	**Upper deck**			
	Bottom			
Transverse Section 3	**Upper deck**			
	Bottom			

* The actual transverse section modulus of the hull girder of oil tankers calculated under paragraph 2.2.1.1 of Annex III to UR Z10.4 is not to be less than 90% of the required section modulus for new buildings specified in IACS Unified Requirements S7* or S11, whichever is the greater.

* $C = 1.0\ c_n$ is to be used for the purpose of this calculation.

Table IX (v): Z10.4 cont'd

Evaluation result of longitudinal strength of the hull girder of oil tankers of 130 m in length and upwards and of over 10 years of age (of sections 1, 2 and 3 below, only one applicable section is to be completed)

NOTES

*1 Z_{act} means the actual section moduli of the transverse section of the ship's hull girder calculated by using the thickness of structural members measured, renewed or reinforced, as appropriate, during the Special Survey, in accordance with the provisions of paragraph 2.2.1.1 of Annex III.

*2 Z_{req} means diminution limit of the longitudinal bending strength of ships, as calculated in accordance with the provisions of paragraph 2.2.1.1 of Annex III.

The calculation sheets for Z_{act} are to be attached to this report.

3 This section applies to ships constructed before 1 July 2002: Section moduli of the transverse section of the ship's hull girder have been calculated by using the thickness of structural members measured, renewed or reinforced, as appropriate, during the Special Survey most recently conducted after the ship reached 10 years of age, in accordance with the provisions of paragraph 2.2.1.2 of Annex III, and found to meet the criteria required by the Classification Society and that Z_{act} is not less than Z_{mc} (defined in *2 below) as specified in appendix 2 to Annex III, as shown in the following table:

Describe the criteria for acceptance of the minimum section moduli of the ship's hull girder for ships in service required by the Classification Society.

Table 3 Transverse section modulus of hull girder

		Z_{act} (cm^3) *1	Z_{req} (cm^3) *2	Remarks
Transverse Section 1	**Upper deck**			
	Bottom			
Transverse Section 2	**Upper deck**			
	Bottom			
Transverse Section 3	**Upper deck**			
	Bottom			

Notes

*1 As defined in note *1 of Table 2.

*2 Z_{mc} means the diminution limit of minimum section modulus calculated in accordance with provisions of paragraph 2.2.1.2 of Annex III.

End of
Main Section

Table IX (v): Z10.4 cont'd

Guidelines for Technical Assessment in Conjunction with Planning for Enhanced Surveys of Double Hull Oil Tankers Special Survey – Hull

Contents:

REFERENCES

1. IACS Unified Requirement Z10.4, 'Hull Surveys of Double Hull Oil Tankers'.
2. TSCF, 'Guidelines for the Inspection and Maintenance of Double Hull Tanker Structures, 1995'.
3. TSCF, 'Guidance Manual for Tanker Structures, 1997'.

1. INTRODUCTION

These guidelines contain information and suggestions concerning technical assessments which may be of use in conjunction with the planning of enhanced special surveys of double hull oil tankers. As indicated in 5.1.5 of IACS Unified Requirement Z10.4, 'Hull Surveys of Double Hull Oil Tankers', (Ref. 1), the guidelines are a recommended tool that may be invoked at the discretion of an IACS Member Society, when considered necessary and appropriate, in conjunction with the preparation of the required Survey Programme.

2. PURPOSE AND PRINCIPLES

2.1 Purpose

The purpose of the technical assessments described in these guidelines is to assist in identifying critical structural areas, nominating suspect areas and to focus attention on structural elements or areas of structural elements that may be particularly susceptible to, or evidence a history of, wastage or damage. This information may be useful in nominating locations, areas and tanks for thickness measurement, close-up survey and tank testing.

Critical Structural Areas are locations that have been identified, from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships (if available), to be sensitive to cracking, buckling or corrosion that would impair the structural integrity of the ship.

2.2 Minimum Requirements

However, these guidelines may not be used to reduce the requirements pertaining to thickness measurement, close-up survey and tank testing contained in Tables I, II and III of Z10.4, which are, in all cases, to be complied with as a minimum.

2.3 Timing

As with other aspects of survey planning, the technical assessments described in these guidelines are to be worked out by the Owner or operator in cooperation with the Classification Society well in advance of the commencement of the Special Survey, i.e., prior to commencing the survey and normally at least 12 to 15 months before the survey's completion due date.

2.4 Aspects to be Considered

Technical assessments, which may include quantitative or qualitative evaluation of relative risks of possible deterioration, of the following aspects of a particular ship, may be used as a basis for the nomination of tanks and areas for survey:

* Design features such as stress levels on various structural elements, design details and extent of use of high tensile steel.
* Former history with respect to corrosion, cracking, buckling, indents and repairs for the particular ship and similar ships where available.
* Information with respect to types of cargo carried, use of different tanks for cargo/ballast, protection of tanks and condition of coating, if any.

Annex I: Z10.4 cont'd

Guidelines for Technical Assessment in Conjunction with Planning for Enhanced Surveys of Double Hull Oil Tankers Special Survey – Hull

Technical assessments of the relative risks of susceptibility to damage or deterioration of various structural elements and areas are to be judged and decided on the basis of recognised principles and practices, such as may be found in publications of the Tanker Structure Cooperative Forum (TSCF), (Refs. 2 and 3).

3. TECHNICAL ASSESSMENT

3.1 General

There are three basic types of possible failure which may be the subject of technical assessment in connection with planning of surveys; corrosion, cracks and buckling. Contact damages are not normally covered by the survey plan since indents are usually noted in memoranda and assumed to be dealt with as a normal routine by Surveyors.

Technical assessments performed in conjunction with the survey planning process are, in principle to be as shown schematically in Figure 1, which depicts how technical assessments can be carried out in conjunction with the survey planning process. The approach is basically an evaluation of the risk based on the knowledge and experience related to design and corrosion.

The design is to be considered with respect to structural details that may be susceptible to buckling or cracking as a result of vibration, high stress levels or fatigue.

Corrosion is related to the ageing process and is closely connected with the quality of corrosion protection at newbuilding and subsequent maintenance during the service life. Corrosion may also lead to cracking and/or buckling.

3.2 Methods

3.2.1 Design Details

Damage experience related to the ship in question, and similar ships, where available, is the main source of information to be used in the process of planning. In addition, a selection of structural details from the design drawings is to be included.

Typical damage experience to be considered will consist of:

- Number, extent, location and frequency of cracks;
- Location of buckles.

This information may be found in the survey reports and/or the owner's files, including the results of the owner's own inspections. The defects should be analyzed, noted and marked on sketches.

In addition, general experience is to be utilized. For example, reference is to be made to the two TSCF publications mentioned in Ref.2 and Ref.3, which contain a catalogue of typical damages and proposed repair methods for various tanker structural details.

Such figures are to be used, together with a review of the main drawings, to compare with the actual structure and search for similar details that may be susceptible to damage. An example is shown in Figure 2. In particular, Chapter 3 of Ref.2 deals with aspects specific to double hull tankers, such as stress concentration locations, misalignment during construction, corrosion trends, fatigue considerations and areas requiring special attention, which are to be considered in working out the survey plan.

The review of the main structural drawings, in addition to using the above mentioned figures, should include checking for typical design details where cracking has been experienced. The factors contributing to damage are to be carefully considered.

The use of high tensile steel (HTS) is an important factor. Details showing good service experience where ordinary, mild steel has been used may be more susceptible to damage when HTS, and its higher associated stresses, are utilized. There is extensive and, in general, good experience with the use of HTS for longitudinal material in deck and bottom structures. Experience in other locations, where the dynamic stresses may be higher, is less favourable, e.g. side structures.

In this respect, stress calculations of typical and important components and details, in accordance with the latest Rules or other relevant methods, may prove useful and are to be considered.

The selected areas of the structure identified during this process are to be recorded and marked on the structural drawings to be included in the Survey Programme.

3.2.2 Corrosion

To evaluate relative corrosion risks, the following information is generally to be considered:

- Usage of tanks and spaces
- Condition of coatings
- Cleaning procedures

Annex I: Z10.4 cont'd

Guidelines for Technical Assessment in Conjunction with Planning for Enhanced Surveys of Double Hull Oil Tankers Special Survey – Hull

- Previous corrosion damage
- Ballast use and time for cargo tanks
- Corrosion risk scheme (See Ref. 3, Table 2.1)
- Location of heated tanks.

Ref. 3 gives definitive examples that can be used for judging and describing coating condition, using typical pictures of conditions.

The evaluation of corrosion risks is to be based on information in Ref. 3, together with relevant information on the anticipated condition of the ship, derived from the information collected to prepare the Survey Programme, and the age of the ship.

The various tanks and spaces are to be listed with the corrosion risks nominated accordingly.

Special attention is to be given to the areas where a double hull tanker is particularly exposed to corrosion. The specific aspects addressing corrosion in double hull tankers indicated in 3.4 (Corrosion trends) of Ref.2 are to be taken into account.

3.2.3 Locations for Close-up Survey and Thickness Measurement
On the basis of the table of corrosion risks and the evaluation of design experience, the locations for initial close-up survey and thickness measurement (areas and sections) may be nominated.

The sections subject to thickness measurement are to normally be nominated in tanks and spaces where corrosion risk is judged to be the highest.

The nomination of tanks and spaces for close-up survey should, initially, be based on highest corrosion risk, and should always include ballast tanks. The principle for the selection is to be that the extent is increased by age or where information is insufficient or unreliable.

Annex I: Z10.4 cont'd

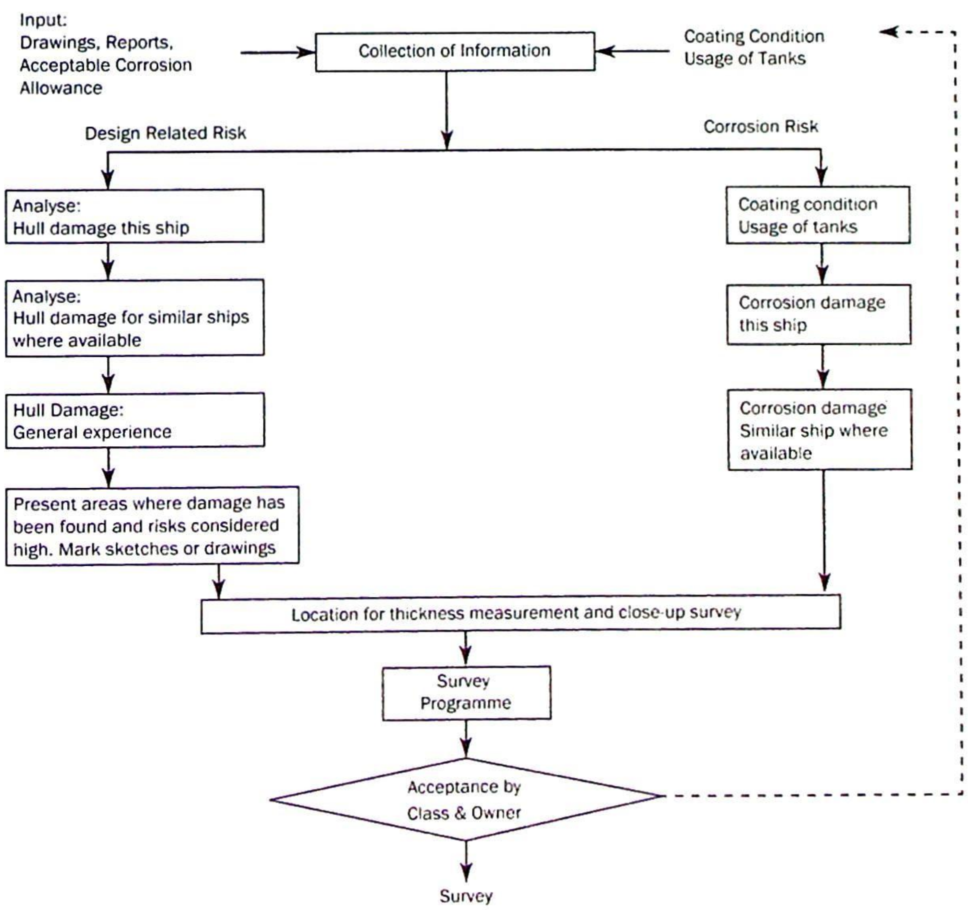
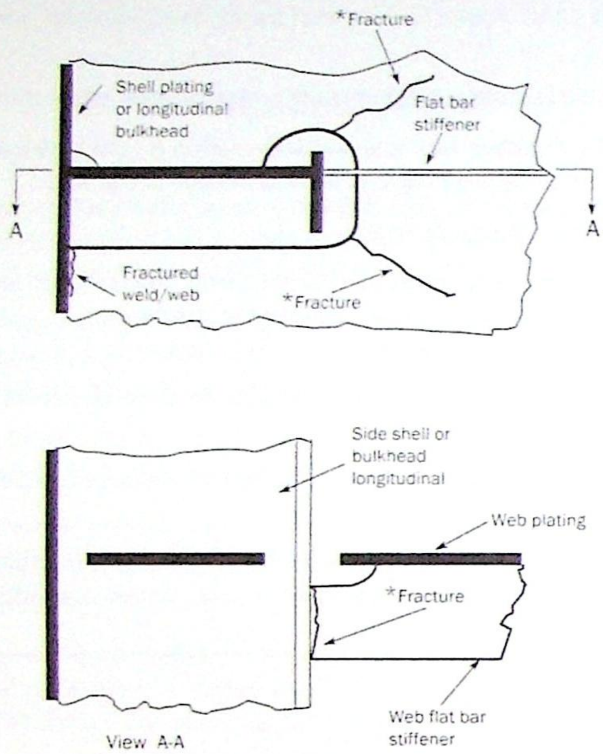


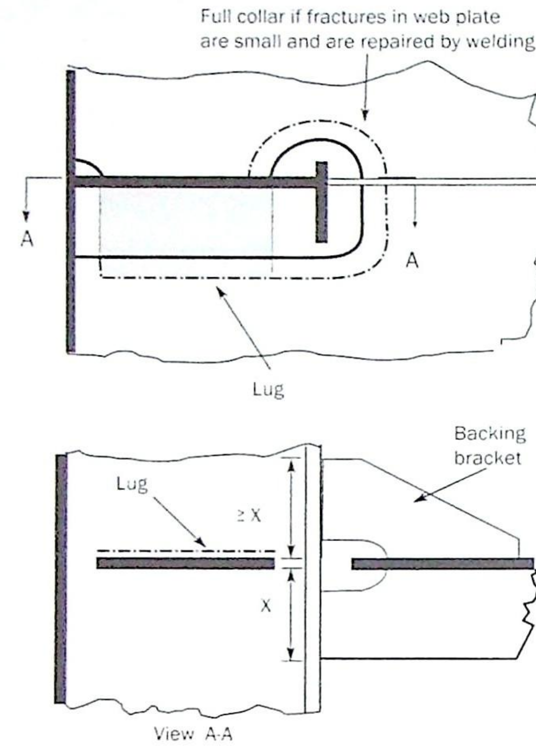
Figure 1: Technical Assessment and the Survey Planning Process

Location: Connection of longitudinals to transverse webs
Example No. 1: Web and flat bar fractures at cut-outs for longitudinal stiffener connections

Typical Damage	Proposed Repair



Note: **One or more fractures may occur*



Web and flat bar cropped and part renewed or alternatively welded

Annex I: Z10.4 cont'd

FACTORS CONTRIBUTING TO 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 area of stress connection such as flat bar stiffener connections, corners of cut-out for the longitudinal and connection of web to shell at cut-outs.
5. High stress in the web of the transverse.
6. Dynamic sea way load/ship motions.

End of Annex I

Figure 2: Catalogue of Structural Details – Tanker Structure Co-operative Forum Typical Damage and Repair Example (Reproduced from Ref. 2)

*Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers**

CONTENTS

REPORTS

GUIDANCE

* Note: Annex II is recommendatory.

Annex II: Sheet 1 Z10.4 cont'd

Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers Instructions

1. This document is to be used for recording thickness measurements as required by IACS Unified Requirement Z10.4.
2. Reporting forms TM1-DHT, TM2-DHT, TM3-DHT, TM4-DHT, TM5-DHT and TM6-DHT (sheets 4-10) are to be used for recording thickness measurements and the maximum allowable diminution is to be stated.

   The maximum allowable diminution could be stated in an attached document.
3. The remaining sheets 11-15 are guidance diagrams and notes relating to the reporting forms and the procedure for the thickness measurements.

Annex II : Sheet 2 Z10.4 cont'd

Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers
General Particulars

Ship's name:-

IMO Number:-

Class Identification number:-

Port of registry:-

Gross tons:-

Deadweight:-

Date of build:-

Classification Society:-

Name of Company performing the thickness measurement:-

Thickness measurement company certified by:-

Certificate No.:-

Certificate valid from.................. to ....

Place of measurement:-

First date of measurement:-

Last date of measurement:-

Special survey/intermediate survey due:-*

Details of measurement equipment:-

Qualification of operator:-

Report Number:- consisting of .... Sheets

Names of operator:-	....	Name of surveyor:-	....
Signature of operator:-	....	Signature of surveyor:-	....
Firm official stamp:-	....	Classification Society Official Stamp:-	....

* Delete as appropriate

Annex II: Sheet 3 Z10.4 cont'd

*Report on Thickness Measurement of All Deck Plating, All Bottom Shell Plating or Side Shell Plating**

Ship's name........................ Class Identity No. .... Report No. ....

STRAKE POSITION																	
PLATE POSITION	No. or Letter	Org. Thk. mm	Forward Reading						Aft Reading						Mean Diminution %		Maximum Allowable Diminution
			Gauged		Diminution P		Diminution S		Gauged		Diminution P		Diminution S				
			P	S	mm	%	mm	%	P	S	mm	%	mm	%	P	S	mm
12th forward																	
11th																	
10th																	
9th																	
8th																	
7th																	
6th																	
5th																	
4th																	
3rd																	
2nd																	
1st																	
Amidships																	
1st aft																	
2nd																	
3rd																	
4th																	
5th																	
6th																	
7th																	
8th																	
9th																	
10th																	
11th																	
12th																	

Operator's Signature.. NOTES – See Reverse

(* - delete as appropriate)

NOTES TO THE REPORT TM1-DHT

1. This report is to be used for recording the thickness measurement of:
   - 1.1 All strength deck plating within the cargo area.
   - 1.2 All keel, bottom shell plating and bilge plating within the cargo area.
   - 1.3 Side shell plating including selected wind and water strakes outside cargo area.
   - 1.4 All wind and water strakes within cargo area.
2. The strake position is to be clearly indicated as follows:
   - 2.1 For strength deck indicate the number of the strake of plating inboard from the stringer plate.
   - 2.2 For bottom plating indicate the number of the strake of plating outboard from the keel plate.
   - 2.3 For side shell plating give number of the strake of plating below sheerstrake and letter as shown on shell expansion.
3. Measurements are to be taken at the forward and aft areas of all and where plates cross ballast/cargo tank boundaries separate measurements for the area of plating in way of each type of tank are to be recorded.
4. The single measurements recorded are to represent the average of multiple measurements.
5. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 4 Z10.4 TM1-DHT cont'd

Report on Thickness Measurement of Shell and Deck Plating (one, two or three transverse sections)

Ship's name.......................... Class Identity No. .... Report No. ....

STRENGTH DECK AND SHEERSTRAKE PLATING

FIRST TRANSVERSE SECTION AT FRAME NUMBER

STRAKE POSITION	No. or Letter	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
Stringer Plate									
1st strake inboard									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
centre strake									
sheer strake									
TOPSIDE TOTAL									

SECOND TRANSVERSE SECTION AT FRAME NUMBER

STRAKE POSITION	No. or Letter	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
Stringer Plate									
1st strake inboard									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
centre strake									
sheer strake									
TOPSIDE TOTAL									

THIRD TRANSVERSE SECTION AT FRAME NUMBER

STRAKE POSITION	No. or Letter	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
Stringer Plate									
1st strake inboard									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
centre strake									
sheer strake									
TOPSIDE TOTAL									

Operator's Signature.. NOTES – See Reverse

NOTES TO THE REPORT TM2-DHT (i)

1. This report form is to be used for recording the thickness measurements of:

   Strength deck plating and sheerstrake plating transverse sections:

   One, two or three sections within the cargo area comprising of the structural items (0), (1) and (2) as shown on the diagrams of typical transverse sections illustrated on sheets 11 and 12 of this document.
2. The topside area comprises deck plating, stringer plate and sheerstrake (including rounded gunwales).
3. The exact frame station of measurement is to be stated.
4. The single measurements recorded are to represent the average of multiple measurements.
5. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 5 Z10.4 TM2-DHT (i) cont'd

Report on Thickness Measurement of Shell and Deck Plating (one, two or three transverse sections)

Ship's name... .... Class Identity No. .... Report No. ....

SHELL PLATING

STRAKE POSITION	FIRST TRANSVERSE SECTION AT FRAME NUMBER								
	No. or Letter	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
1st below sheer strake									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
15th									
16th									
17th									
18th									
19th									
20th									
keel strake									
BOTTOM TOTAL									

STRAKE POSITION	SECOND TRANSVERSE SECTION AT FRAME NUMBER								
	No. or Letter	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
1st below sheer strake									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
15th									
16th									
17th									
18th									
19th									
20th									
keel strake									
BOTTOM TOTAL									

STRAKE POSITION	THIRD TRANSVERSE SECTION AT FRAME NUMBER								
	No. or Letter	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
1st below sheer strake									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
15th									
16th									
17th									
18th									
19th									
20th									
keel strake									
BOTTOM TOTAL									

Operator's Signature...

NOTES – See Reverse

NOTES TO THE REPORT TM2-DHT (ii)

1. This report form is to be used for recording the thickness measurements of:

   Shell plating transverse sections:

   One, two or three sections within the cargo area comprising of the structural items (3), (4) and (5) and (6) as shown on the diagrams of typical transverse sections illustrated on sheets 11 and 12 of this document.
2. The bottom area comprises keel, bottom and bilge plating.
3. The exact frame station of measurement is to be stated.
4. The single measurements recorded are to represent the average of multiple measurements.
5. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 6 Z10.4 TM2-DHT (ii) cont'd

Report on Thickness Measurement of Longitudinal Members (one, two or three transverse sections)

Ship's name........................ Class Identity No. .... Report No. ....

STRUCTURAL MEMBER	FIRST TRANSVERSE SECTION AT FRAME NUMBER								
	Item No.	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%

STRUCTURAL MEMBER	SECOND TRANSVERSE SECTION AT FRAME NUMBER								
	Item No.	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%

STRUCTURAL MEMBER	THIRD TRANSVERSE SECTION AT FRAME NUMBER								
	Item No.	Org. Thk.	Max. Alwb. Dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%

Operators Signature.. NOTES – See Reverse

NOTES TO THE REPORT TM3-DHT

1. This report is to be used for recording the thickness measurements of:

   Longitudinal Members at transverse sections:

   One, two or three sections within the cargo area comprising of the appropriate structural items (10) to (29) as shown on the diagrams of typical transverse sections illustrated on sheets 11 and 12 of this document.
2. The exact frame station of measurement is to be stated.
3. The single measurements recorded are to represent the average of multiple measurements.
4. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 7 Z10.4 TM3-DHT cont'd

Report on Thickness Measurement of Transverse Structural Members in the Cargo, Oil and Water Ballast Tanks Within the Cargo Tank Length

Ship's name........................ Class Identity No. .... Report No. ....

TANK DESCRIPTION:

LOCATION OF STRUCTURE:

STRUCTURAL MEMBER	ITEM	Original Thickness mm	Max. Alwb. Dim. mm	Gauged		Diminution P		Diminution S	
				P	S	mm	%	mm	%

Operator's Signature.. NOTES – See Reverse

NOTES TO THE REPORT TM4-DHT

1. This report is to be used for recording the thickness measurements of:

   Transverse structural members, comprising of the appropriate structural items (30) to (36) as shown on diagrams of typical transverse sections illustrated on sheets 11 and 12 of this document.

2. Guidance for areas of measurement is indicated on sheet 14 and 15 of this document.

   The single measurements recorded are to represent the average of multiple measurements.

3. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 8 Z10.4 TM4-DHT cont'd

Report on Thickness of WT/OT Transverse Bulkheads Within the Cargo Tank or Cargo Hold Spaces

Ship's name.......................... Class Identity No. .... Report No. ....

TANK/HOLD DESCRIPTION:

LOCATION OF STRUCTURE: FRAME NO.:

STRUCTURAL COMPONENT (PLATING/STIFFENER)	Original Thickness mm	Max. Alwb. Dim. mm	Gauged		Diminution P		Diminution S	
			Port	Starboard	mm	%	mm	%

Operator's Signature.. NOTES – See Reverse

NOTES TO THE REPORT TM5-DHT

1. This report is to be used for recording the thickness measurement of:
   W.T./O.T. transverse bulkheads.
2. Guidance for areas of measurement is indicated on sheet 14 of this document.
3. The single measurements recorded are to represent the average of multiple measurements.
4. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 9 Z10.4 TM5-DHT cont'd

Report on Thickness Measurement of Miscellaneous Structural Members

Ship's name........................ Class Identity No. .... Report No. ....

STRUCTURAL MEMBER:

LOCATION OF STRUCTURE:

SKETCH

Description	Org. Thk. mm	Max. Alwb. Dim. mm	Gauged		Diminution P		Diminution S	
			P	S	mm	%	mm	%

Operator's Signature.................................... NOTES – See Reverse

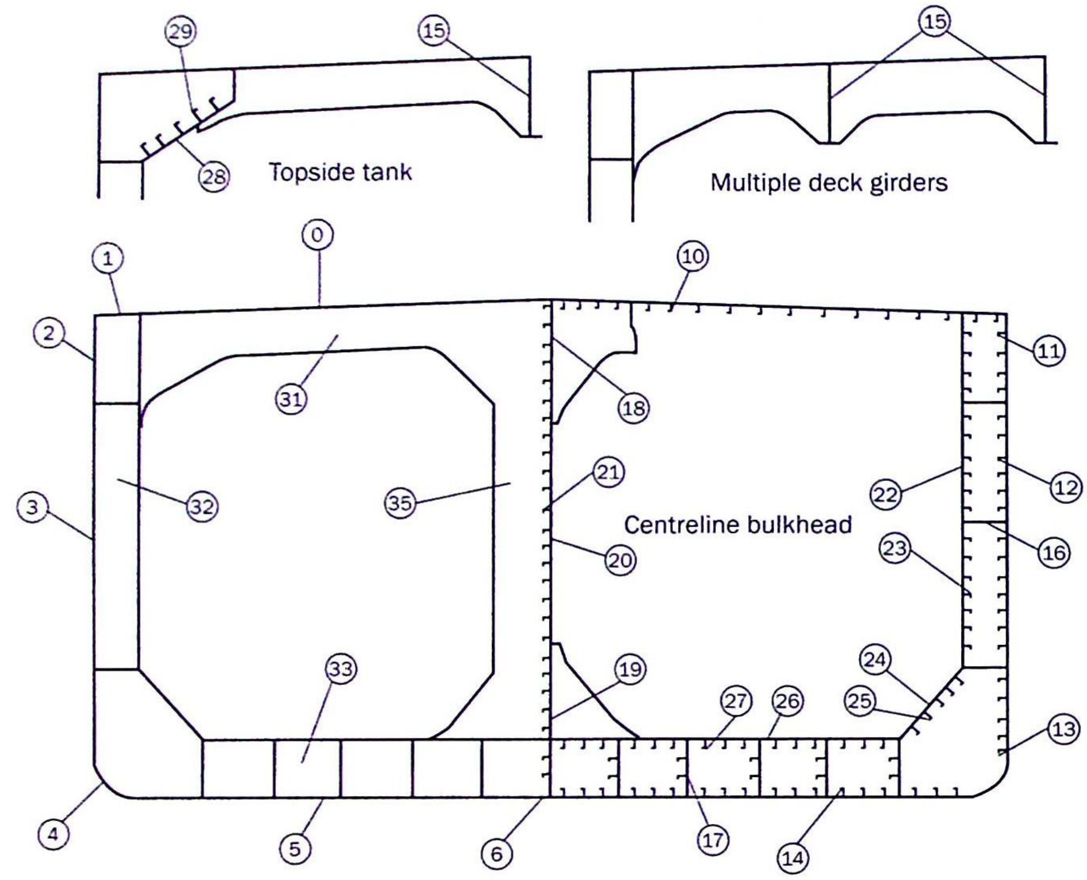
NOTES TO THE REPORT TM6-DHT

1. This report is to be used for recording the thickness measurement of:
   Miscellaneous structural members.
2. The single measurements recorded are to represent the average of multiple measurements.
3. The maximum allowable diminution could be stated in an attached document.

Annex II: Sheet 10 Z10.4 TM6-DHT cont'd

Thickness Measurement – Double Hull Oil Tankers

Typical transverse section of a double hull oil tanker up to 150,000 dwt with indication of longitudinal and transverse members



Report on TM2-DHT (i) & (ii)	
0.	Strength deck plating
1.	Stringer plate
2.	Sheerstrake
3.	Side shell plating
4.	Bilge plating
5.	Bottom shell plating
6.	Keel plate

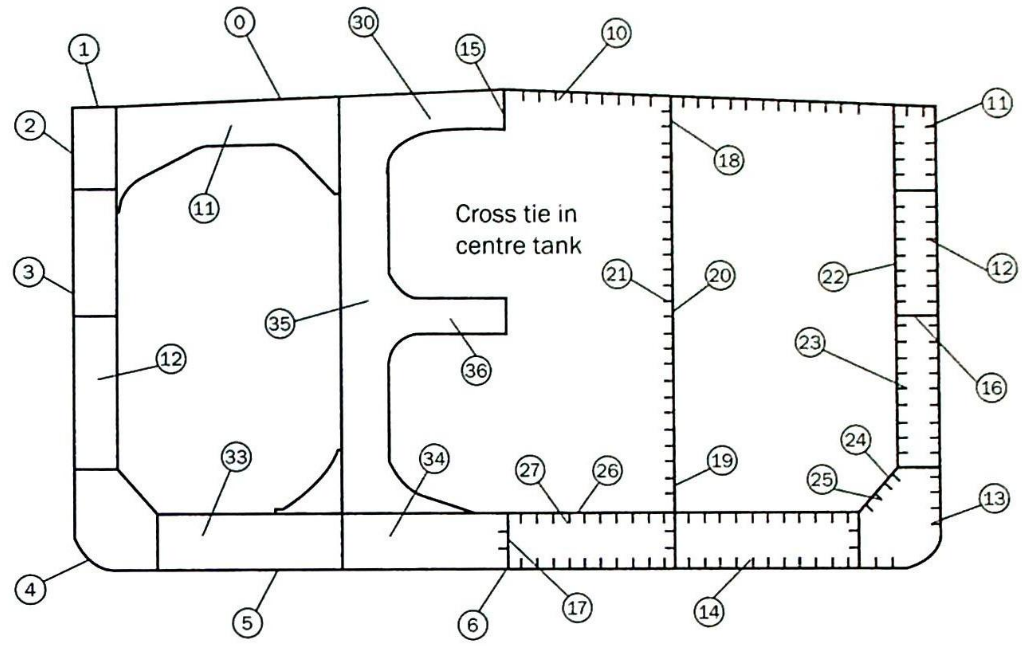
Report on TM3-DHT			
10.	Deck longitudinals	20.	Longitudinal bulkhead plating (remainder)
11.	Sheerstrake longitudinals	21.	Longitudinal bulkhead longitudinals
12.	Side shell longitudinals	22.	Inner side plating
13.	Bilge longitudinals	23.	Inner side longitudinals
14.	Bottom longitudinals	24.	Hopper plating
15.	Deck girders	25.	Hopper longitudinals
16.	Horizontal girders in wing ballast tanks	26.	Inner bottom plating
17.	Bottom girders	27.	Inner bottom longitudinals
18.	Longitudinal bulkhead top strake	28.	Topside tank plating
19.	Longitudinal bulkhead bottom strake	29.	Topside tank longitudinals

Report on TM4-DHT	
30.	Deck transverse - centre tank
31.	Deck transverse - wing tank
32.	Vertical web in wing ballast tank
33.	Double bottom floor - wing tank
34.	Double bottom floor - centre tank
35.	Longitudinal bulkhead vertical web
36.	Cross ties

Annex II: Sheet 11 Z10.4 cont'd

Thickness Measurement – Double Hull Oil Tankers

Typical transverse section of a double hull oil tanker above 150,000 dwt with indication of longitudinal and transverse members



Report on TM2-DHT (i) & (ii)	
0.	Strength deck plating
1.	Stringer plate
2.	Sheerstrake
3.	Side shell plating
4.	Bilge plating
5.	Bottom shell plating
6.	Keel plate

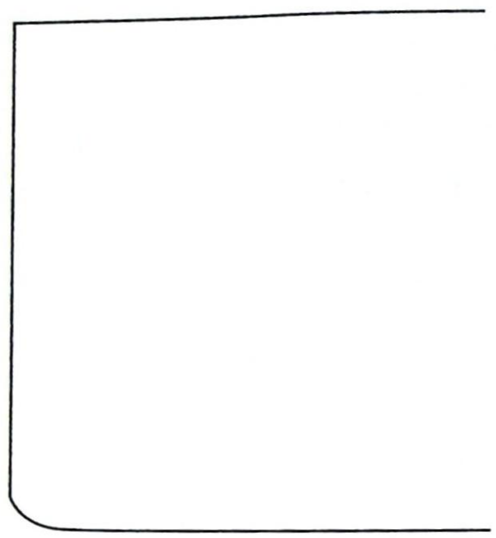
Report on TM3-DHT			
10.	Deck longitudinals	20.	Longitudinal bulkhead plating (remainder)
11.	Sheerstrake longitudinals	21.	Longitudinal bulkhead longitudinals
12.	Side shell longitudinals	22.	Inner side plating
13.	Bilge longitudinals	23.	Inner side longitudinals
14.	Bottom longitudinals	24.	Hopper plating
15.	Deck girders	25.	Hopper longitudinals
16.	Horizontal girders in wing ballast tanks	26.	Inner bottom plating
17.	Bottom girders	27.	Inner bottom longitudinals
18.	Longitudinal bulkhead top strake	28.	Topside tank plating
19.	Longitudinal bulkhead bottom strake	29.	Topside tank longitudinals

Report on TM4-DHT	
30.	Deck transverse - centre tank
31.	Deck transverse - wing tank
32.	Vertical web in wing ballast tank
33.	Double bottom floor - wing tank
34.	Double bottom floor - centre tank
35.	Longitudinal bulkhead vertical web
36.	Cross ties

Annex II: Sheet 12 Z10.4 cont'd

Thickness Measurement – Double Hull Oil Tankers Transverse section outline

The diagram may be used for those ships where the diagrams on sheet 11 and 12 are not suitable



Report on TM2-DHT (i) & (ii)	
0.	Strength deck plating
1.	Stringer plate
2.	Sheerstrake
3.	Side shell plating
4.	Bilge plating
5.	Bottom shell plating
6.	Keel plate

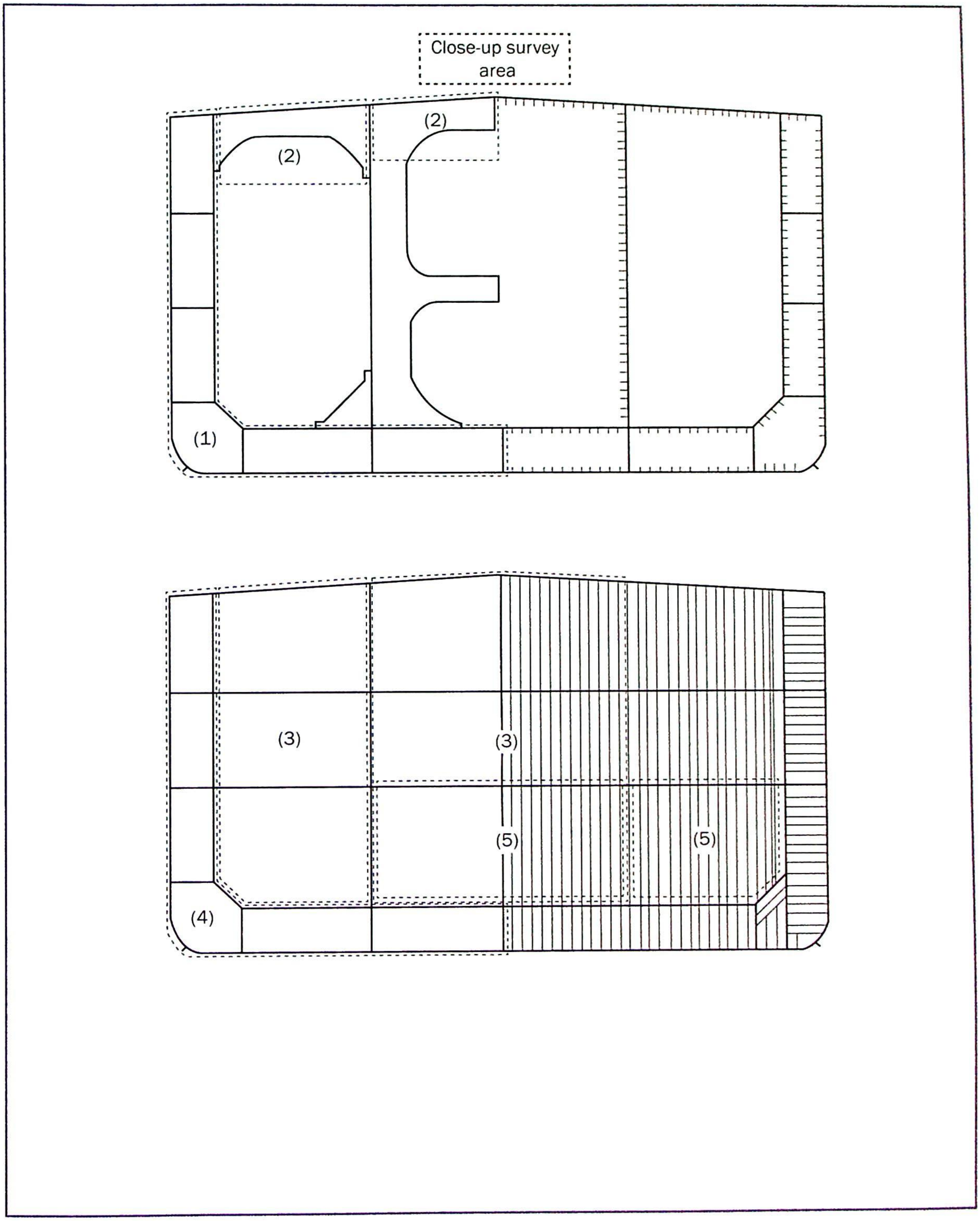
Report on TM3-DHT			
10.	Deck longitudinals	20.	Longitudinal bulkhead plating (remainder)
11.	Sheerstrake longitudinals	21.	Longitudinal bulkhead longitudinals
12.	Side shell longitudinals	22.	Inner side plating
13.	Bilge longitudinals	23.	Inner side longitudinals
14.	Bottom longitudinals	24.	Hopper plating
15.	Deck girders	25.	Hopper longitudinals
16.	Horizontal girders in wing ballast tanks	26.	Inner bottom plating
17.	Bottom girders	27.	Inner bottom longitudinals
18.	Longitudinal bulkhead top strake	28.	Topside tank plating
19.	Longitudinal bulkhead bottom strake	29.	Topside tank longitudinals

Report on TM4-DHT	
30.	Deck transverse - centre tank
31.	Deck transverse - wing tank
32.	Vertical web in wing ballast tank
33.	Double bottom floor - wing tank
34.	Double bottom floor - centre tank
35.	Longitudinal bulkhead vertical web
36.	Cross ties

Annex II: Sheet 13 Z10.4 cont'd

Close-up Survey and Thickness Measurement Areas

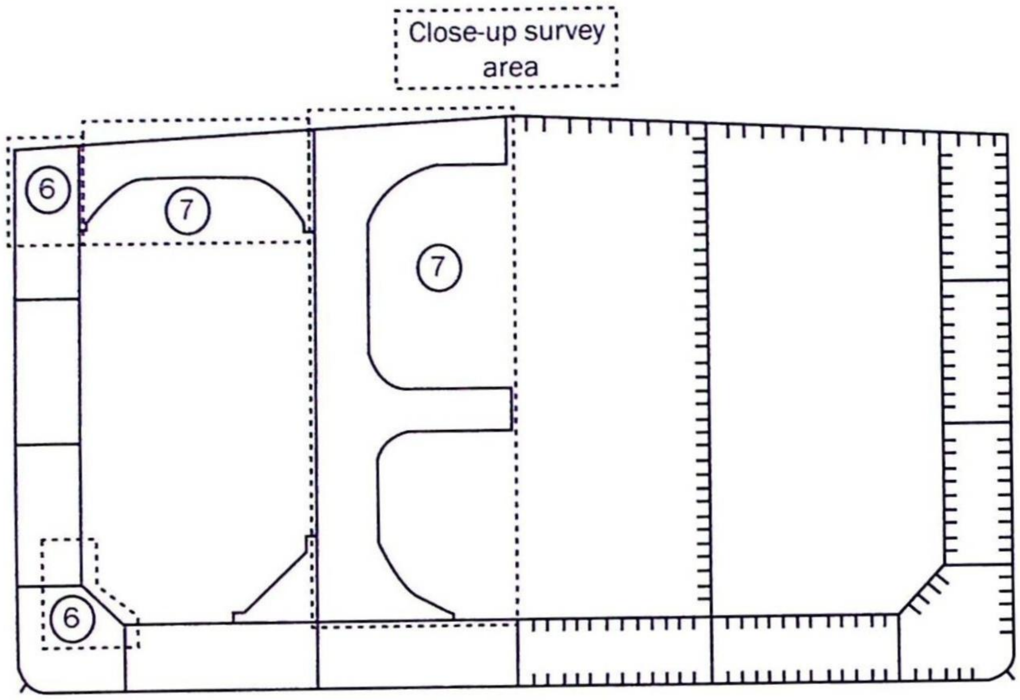
Areas subject to close-up survey and thickness measurements – areas (1) to (5) as defined in Table I of UR Z10.4 – Thickness to be reported on TM3-DHT(CSR), TM4-DHT(CSR) and TM5-DHT(CSR) as appropriate.



Annex II: Sheet 14 Z10.4 cont'd

Close-up Survey and Thickness Measurement Areas

Areas subject to close-up survey and thickness measurements – areas (6) to (7) as defined in Table I of UR Z10.4 – Thickness to be reported on TM3-DHT(CSR), TM4-DHT(CSR) as appropriate.



Annex II: Sheet 15 Z10.4 cont'd

*IACS Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers Built Under IACS Common Structural Rules**

CONTENTS

* Note: Annex II (CSR) is recommendatory.

Annex II (CSR): Sheet 1 Z10.4 cont'd

IACS Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers Built Under IACS Common Structural Rules
Instructions

1. This document is to be used for recording thickness measurements of double hull oil tankers built under IACS Common Structural Rules as required by the IACS Unified Requirement Z10.4.
2. Reporting forms TM1-DHT(CSR), TM2-DHT(CSR) (i) and (ii), TM3-DHT(CSR), TM4-DHT(CSR), TM5-DHT(CSR) and TM6-DHT(CSR) (sheets 4-10) are to be used for recording thickness measurements. The as-built thickness and the voluntary thickness addition and renewal thickness (minimum allowable thickness) are to be stated in the said forms.
3. The remaining sheets 11-15 are guidance diagrams and notes relating to the reporting forms and the procedure for the thickness measurement.

Annex II (CSR): Sheet 2 Z10.4 cont'd

IACS Recommended Procedures for Thickness Measurements of Double Hull Oil Tankers Built Under IACS Common Structural Rules
General Particulars

Ship's name:-

IMO number:-

Class identity number:-

Port of registry:-

Gross tons:-

Deadweight:-

Date of build:-

Classification Society:-

Name of firm performing thickness measurement:-

Thickness measurement firm certified by:-

Certificate No:-

Certificate valid from .... to ....

Place of measurement:-

First date of measurement:-

Last date of measurement:-

Special survey/intermediate survey due:-*

Details of measurement equipment:-

Qualification of operator:-

Report Number:- consisting of .... Sheets

Names of operator:-	....	Name of surveyor:-	....
Signature of operator:-	....	Signature of surveyor:-	....
Firm Official stamp:-	....	Classification Society Official Stamp:-	....

* Delete as appropriate

Annex II (CSR): Sheet 3 Z10.4 cont'd

*Report on Thickness Measurement of All Deck Plating, All Bottom Plating or Side Shell Plating**

Ship's name........................ Class Identity No........................ Report No........................

STRAKE POSITION																
PLATE POSITION	No. or Letter	As Built Thk. mm	Voluntary Thickness Addition mm	Renewal Thickness mm	Forward Reading				Aft Reading				Mean Remaining Corr. Addition, mm	
					Gauged Thk. mm (b1)		Remaining Corr. Addition, mm (c1)=(b1)-(a)		Gauged Thk. mm (b2)		Remaining Corr. Addition, mm (c2)=(b2)-(a)		[(c1)+(c2)]/2	
				(a)	P	S	P	S	P	S	P	S	P	S
12th forward														
11th														
10th														
9th														
8th														
7th														
6th														
5th														
4th														
3rd														
2nd														
1st														
Amidships														
1st aft														
2nd														
3rd														
4th														
5th														
6th														
7th														
8th														
9th														
10th														
11th														
12th														

Operator's Signature.. NOTES – See Reverse

(* - delete as appropriate)

NOTES TO REPORT TM1-DHT(CSR)

1. This report is to be used for recording the thickness measurement of:
   - 1.1 All strength deck plating within the cargo length area.
   - 1.2 All keel, bottom shell plating and bilge plating within the cargo length area.
   - 1.3 Side shell plating, including selected wind and water strakes outside the cargo length area.
   - 1.4 All wind and water strakes within the cargo length area.
2. The strake position is to be clearly indicated as follows:
   - 2.1 For strength deck indicate the number of the strake of plating inboard from the stringer plate.
   - 2.2 For bottom plating indicate the number of the strake of plating outboard from the keel plate.
   - 2.3 For side shell plating give number of the strake of plating sheerstrake and letter as shown on shell expansion.
3. Measurements are to be taken at the forward and aft areas of all plates cross ballast/cargo tank boundaries separate measurements for the area of plating in way of each type of tank are to be recorded.
4. The single measurements recorded are to represent the average of multiple measurements.
5. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 4 Z10.4 TM1-DHT(CSR) cont'd

Report on Thickness Measurement of Shell and Deck Plating (one, two or three transverse sections)

Ship's name.......................... Class Identity No......................... Report No.......... ....

STRENGTH DECK AND SHEERSTRAKE PLATING

STRAKE POSITION	FIRST TRANSVERSE SECTION AT FRAME NUMBER									
	No. or Letter	As Built Thk. mm	Vol. Thk. Add. mm	Ren. Thk. mm (a)	Gauged Thk. mm (b)		Remaining Corr. Addition, mm (b)-(a)			
					P	S	P		S	
Stringer Plate										
1st strake inboard										
2nd										
3rd										
4th										
5th										
6th										
7th										
8th										
9th										
10th										
11th										
12th										
13th										
14th										
centre strake										
sheer strake										
TOPSIDE TOTAL										

STRAKE POSITION	SECOND TRANSVERSE SECTION AT FRAME NUMBER									
	No. or Letter	As Built Thk. mm	Vol. Thk. Add. mm	Ren. Thk. mm (a)	Gauged Thk. mm (b)		Remaining Corr. Addition, mm (b)-(a)			
					P	S	P		S	
Stringer Plate										
1st strake inboard										
2nd										
3rd										
4th										
5th										
6th										
7th										
8th										
9th										
10th										
11th										
12th										
13th										
14th										
centre strake										
sheer strake										
TOPSIDE TOTAL										

STRAKE POSITION	THIRD TRANSVERSE SECTION AT FRAME NUMBER									
	No. or Letter	As Built Thk. mm	Vol. Thk. Add. mm	Ren. Thk. mm (a)	Gauged Thk. mm (b)		Remaining Corr. Addition, mm (b)-(a)			
					P	S	P		S	
Stringer Plate										
1st strake inboard										
2nd										
3rd										
4th										
5th										
6th										
7th										
8th										
9th										
10th										
11th										
12th										
13th										
14th										
centre strake										
sheer strake										
TOPSIDE TOTAL										

Operator's Signature.. NOTES – See Reverse

NOTES TO REPORT TM2-DHT(CSR) (i)

1. This report is to be used for recording the thickness measurement of:

   Strength deck plating and sheerstrake plating transverse sections:

   One, two or three sections within the cargo length area, comprising of the structural items (0), (1) and (2) as shown on the diagram of typical transverse sections illustrated on sheets 11 and 12 of this document.
2. The topside area comprises deck plating, stringer plate and sheerstrake (including rounded gunwales).
3. The exact frame station of measurement is to be stated.
4. The single measurements recorded are to represent the average of multiple measurements.
5. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 5 Z10.4 TM2-DHT(CSR) (i) cont'd

Report on Thickness Measurement of Shell Plating (one, two or three transverse sections)

Ship's name.......................... Class Identity No.......................... Report No..........................

SHELL PLATING

STRAKE POSITION	FIRST TRANSVERSE SECTION AT FRAME NUMBER							
	No. or Letter	As Built Thk. mm	Vol. Thk. Add. mm	Ren. Thk. mm (a)	Gauged Thk. mm (b)		Remaining Corr. Addition, mm (b)-(a)	
					P	S	P	S
1st below sheer strake								
2nd								
3rd								
4th								
5th								
6th								
7th								
8th								
9th								
10th								
11th								
12th								
13th								
14th								
15th								
16th								
17th								
18th								
19th								
20th								
Keel strake								
BOTTOM TOTAL								

STRAKE POSITION	SECOND TRANSVERSE SECTION AT FRAME NUMBER							
	No. or Letter	As Built Thk. mm	Vol. Thk. Add. mm	Ren. Thk. mm (a)	Gauged Thk. mm (b)		Remaining Corr. Addition, mm (b)-(a)	
					P	S	P	S
1st below sheer strake								
2nd								
3rd								
4th								
5th								
6th								
7th								
8th								
9th								
10th								
11th								
12th								
13th								
14th								
15th								
16th								
17th								
18th								
19th								
20th								
Keel strake								
BOTTOM TOTAL								

STRAKE POSITION	THIRD TRANSVERSE SECTION AT FRAME NUMBER							
	No. or Letter	As Built Thk. mm	Vol. Thk. Add. mm	Ren. Thk. mm (a)	Gauged Thk. mm (b)		Remaining Corr. Addition, mm (b)-(a)	
					P	S	P	S
1st below sheer strake								
2nd								
3rd								
4th								
5th								
6th								
7th								
8th								
9th								
10th								
11th								
12th								
13th								
14th								
15th								
16th								
17th								
18th								
19th								
20th								
Keel strake								
BOTTOM TOTAL								

Operator's Signature.. NOTES – See Reverse

NOTES TO REPORT TM2-DHT(CSR) (ii)

1. This report is to be used for recording the thickness measurement of:

   Shell plating transverse sections:

   One, two or three sections within the cargo length area comprising of the structural items (3), (4) and (5) and (6) as shown on the diagram of typical transverse sections illustrated on sheets 11 and 12 of this document.
2. The bottom area comprises keel, bottom and bilge plating.
3. The exact frame station of measurement is to be stated.
4. The single measurements recorded are to represent the average of multiple measurements.
5. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 6 Z10.4 TM2-DHT(CSR) (ii) cont'd

Report on Thickness Measurement of Longitudinal Members (one, two or three transverse sections)

Ship's name........................ Class Identity No........................ Report No........................

STRUCTURAL MEMBER	FIRST TRANSVERSE SECTION AT FRAME NUMBER								SECOND TRANSVERSE SECTION AT FRAME NUMBER								THIRD TRANSVERSE SECTION AT FRAME NUMBER							
	Item No.	As Built Thk mm	Vol. Thk. Add mm	Ren Thk mm (a)	Gauged Thk mm (b)		Remaining Corr. Addition, mm (b)-(a)		Item No.	As Built Thk mm	Vol. Thk. Add mm	Ren Thk. mm (a)	Gauged Thk mm (b)		Remaining Corr. Addition, mm (b)-(a)		Item No.	As Built Thk. mm	Vol. Thk. Add. mm	Ren Thk. mm (a)	Gauged Thk mm (b)		Remaining Corr. Addition, mm (b)-(a)	
					P	S	P	S					P	S	P	S					P	S	P	S

Operator's Signature.. NOTES – See Reverse

NOTES TO REPORT TM3-DHT(CSR)

1. This report is to be used for recording the thickness measurement of:

   Longitudinal Members at transverse sections:

   One, two or three sections within the cargo length area, comprising of the appropriate structural items (10) to (29) as shown on the diagram of typical transverse sections illustrated on sheets 11 and 12 of this document.

2. The exact frame station of measurement is to be stated.
3. The single measurements recorded are to represent the average of multiple measurements.
4. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 7 Z10.4 $^{TM3\text{-}DHT(CSR)}$ cont'd

Report on Thickness Measurement of Transverse Structural Members In the Cargo, Oil and Water Ballast Tanks Within the Cargo Tank Length

Ship's name........................ Class Identity No........................ Report No........................

TANK DESCRIPTION:

LOCATION OF STRUCTURE

STRUCTURAL MEMBER	ITEM	As Built Thickness mm	Voluntary Thickness Addition mm	Renewal Thickness mm (a)	Gauged Thickness mm (b)		Remaining Corr. Addition mm (b)-(a)			
					P	S	P		S	

Operator's Signature.................................... NOTES – See Reverse

NOTES TO REPORT TM4-DHT(CSR)

1. This report is to be used for recording the thickness measurement of:

   Transverse structural members, comprising of the appropriate structural items (30) to (36) as shown on diagram of typical transverse section, illustrated on sheets 11 and 12 of this document.
2. Guidance for areas if measurement is indicated on the diagrams shown on sheet 14 and 15 of this document.
3. The single measurements recorded are to represent the average of multiple measurements.
4. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 8 Z10.4 $^{TM4\text{-}DHT(CSR)}$ cont'd

Report on Thickness of WT/OT Transverse Bulkheads Within the Cargo and Ballast Tanks

Ship's name.......................   Class Identity No.......................   Report No.... ....

TANK DESCRIPTION:

LOCATION OF STRUCTURE: FRAME NO.:

STRUCTURAL COMPONENT (PLATING/STIFFENER)	As Built Thickness mm	Voluntary Thickness Addition mm	Renewal Thickness mm (a)	Gauged Thickness mm (b)		Remaining Corr. Addition mm (b)-(a)			
				P	S	P		S	

Operator's Signature..   NOTES – See Reverse

NOTES TO REPORT TM5-DHT(CSR)

1. This report is to be used for recording the thickness measurement of:
   WT/OT transverse bulkheads.
2. Guidance for areas of measurement is indicated on the diagrams shown on sheet 14 of this document.
3. The single measurements recorded are to represent the average of multiple measurements.
4. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 9 Z10.4 TM5-DHT(CSR) cont'd

Report on Thickness Measurement of Miscellaneous Structural Members

Ship's name........................ Class Identity No........................ Report No........................

STRUCTURAL MEMBER:											SKETCH
LOCATION OF STRUCTURE:											
Description	As Built Thk. mm	Voluntary Thickness Addition mm	Renewal Thickness mm (a)	Gauged Thickness mm (b)		Remaining Corr. Addition mm (b)-(a)					
				P	S	P		S			

Operator's Signature.................................... NOTES – See Reverse

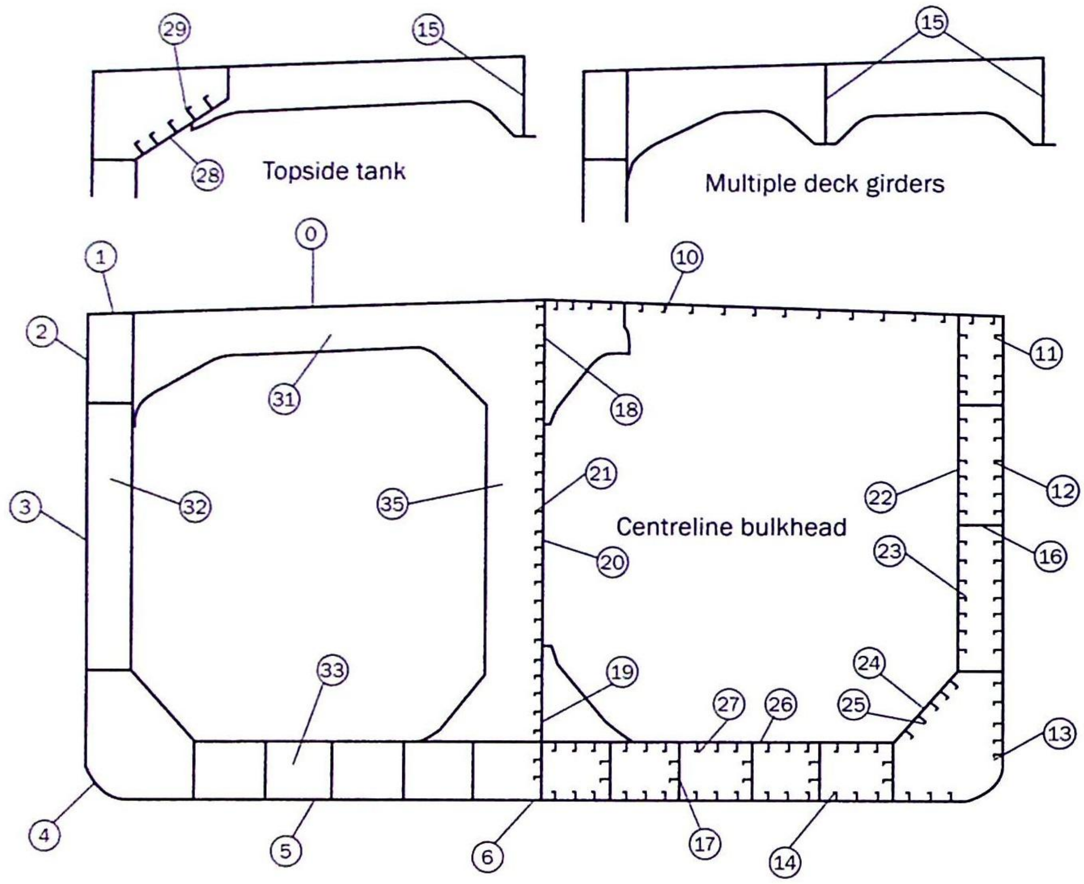
NOTES TO REPORT TM6-DHT(CSR)

1. This report is to be used for recording the thickness measurement of:
   Miscellaneous structural members.
2. The single measurements recorded are to represent the average of multiple measurements.
3. The remaining corrosion addition is to be recorded with result of gauged thickness minus renewal thickness. If the result is negative, the structure in way shall be renewed, and the mark 'R' is to be indicated in the right-hand column. If the result is between 0 and 0.5 mm (0 included), the structure in way shall be additionally gauged, and the mark 'S' is to be indicated in the right-hand column.

Annex II (CSR): Sheet 10 Z10.4 TM6-DHT(CSR) cont'd

Thickness Measurement – Double Hull Oil Tankers

Typical transverse section of a double hull oil tanker up to 150,000 dwt with indication of longitudinal and transverse members



Report on TM2-DHT(CSR) (i) & (ii)	
0.	Strength deck plating
1.	Stringer plate
2.	Sheerstrake
3.	Side shell plating
4.	Bilge plating
5.	Bottom shell plating
6.	Keel plate

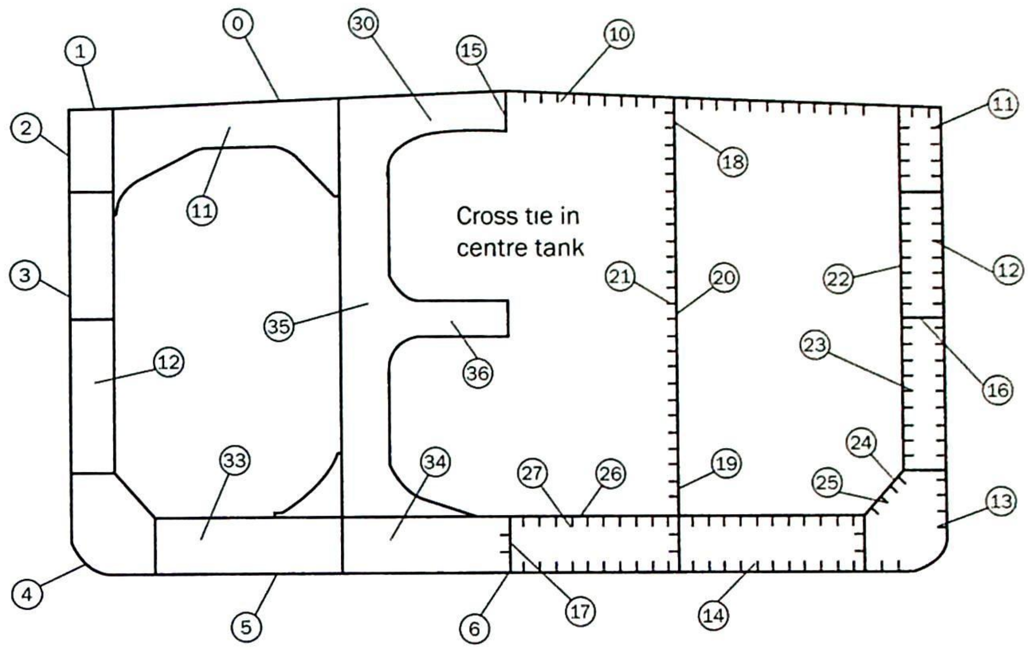
Report on TM3-DHT(CSR)			
10.	Deck longitudinals	20.	Longitudinal bulkhead plating (remainder)
11.	Sheerstrake longitudinals	21.	Longitudinal bulkhead longitudinals
12.	Side shell longitudinals	22.	Inner side plating
13.	Bilge longitudinals	23.	Inner side longitudinal
14.	Bottom longitudinals	24.	Hopper plating
15.	Deck girders	25.	Hopper longitudinal
16.	Horizontal girders in wing ballast tanks	26.	Inner bottom plating
17.	Bottom girders	27.	Inner bottom longitudinals
18.	Longitudinal bulkhead top strake	28.	Topside tank plating
19.	Longitudinal bulkhead bottom strake	29.	Topside tank longitudinals

Report on TM4-DHT(CSR)	
30.	Deck transverse - centre tank
31.	Deck transverse - wing tank
32.	Vertical web in wing ballast tank
33.	Double bottom floor - wing tank
34.	Double bottom floor - centre tank
35.	Longitudinal bulkhead vertical web
36.	Cross ties

Annex II (CSR): Sheet 11 Z10.4 cont'd

Thickness Measurement – Double Hull Oil Tankers

Typical transverse section of a double hull oil tanker above 150,000 dwt with indication of longitudinal and transverse members



Report on TM2-DHT(CSR) (i) & (ii)	
0.	Strength deck plating
1.	Stringer plate
2.	Sheerstrake
3.	Side shell plating
4.	Bilge plating
5.	Bottom shell plating
6.	Keel plate

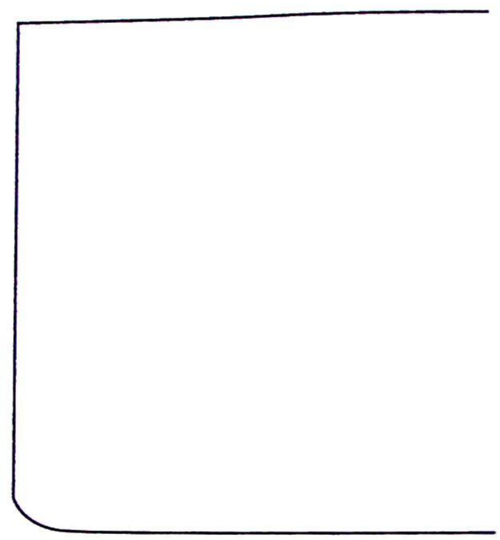
Report on TM3-DHT(CSR)			
10.	Deck longitudinals	20.	Longitudinal bulkhead plating (remainder)
11.	Sheerstrake longitudinals	21.	Longitudinal bulkhead longitudinals
12.	Side shell longitudinals	22.	Inner side plating
13.	Bilge longitudinals	23.	Inner side longitudinal
14.	Bottom longitudinals	24.	Hopper plating
15.	Deck girders	25.	Hopper longitudinal
16.	Horizontal girders in wing ballast tanks	26.	Inner bottom plating
17.	Bottom girders	27.	Inner bottom longitudinals
18.	Longitudinal bulkhead top strake	28.	Topside tank plating
19.	Longitudinal bulkhead bottom strake	29.	Topside tank longitudinals

Report on TM4-DHT(CSR)	
30.	Deck transverse - centre tank
31.	Deck transverse - wing tank
32.	Vertical web in wing ballast tank
33.	Double bottom floor - wing tank
34.	Double bottom floor - centre tank
35.	Longitudinal bulkhead vertical web
36.	Cross ties

Annex II (CSR): Sheet 12 Z10.4 cont'd

Thickness Measurement – Double Hull Oil Tankers Transverse Section Outline

The diagram may be used for those ships where the diagrams on sheet 11 and 12 are not suitable



Report on TM2-DHT(CSR) (i) & (ii)	
0.	Strength deck plating
1.	Stringer plate
2.	Sheerstrake
3.	Side shell plating
4.	Bilge plating
5.	Bottom shell plating
6.	Keel plate

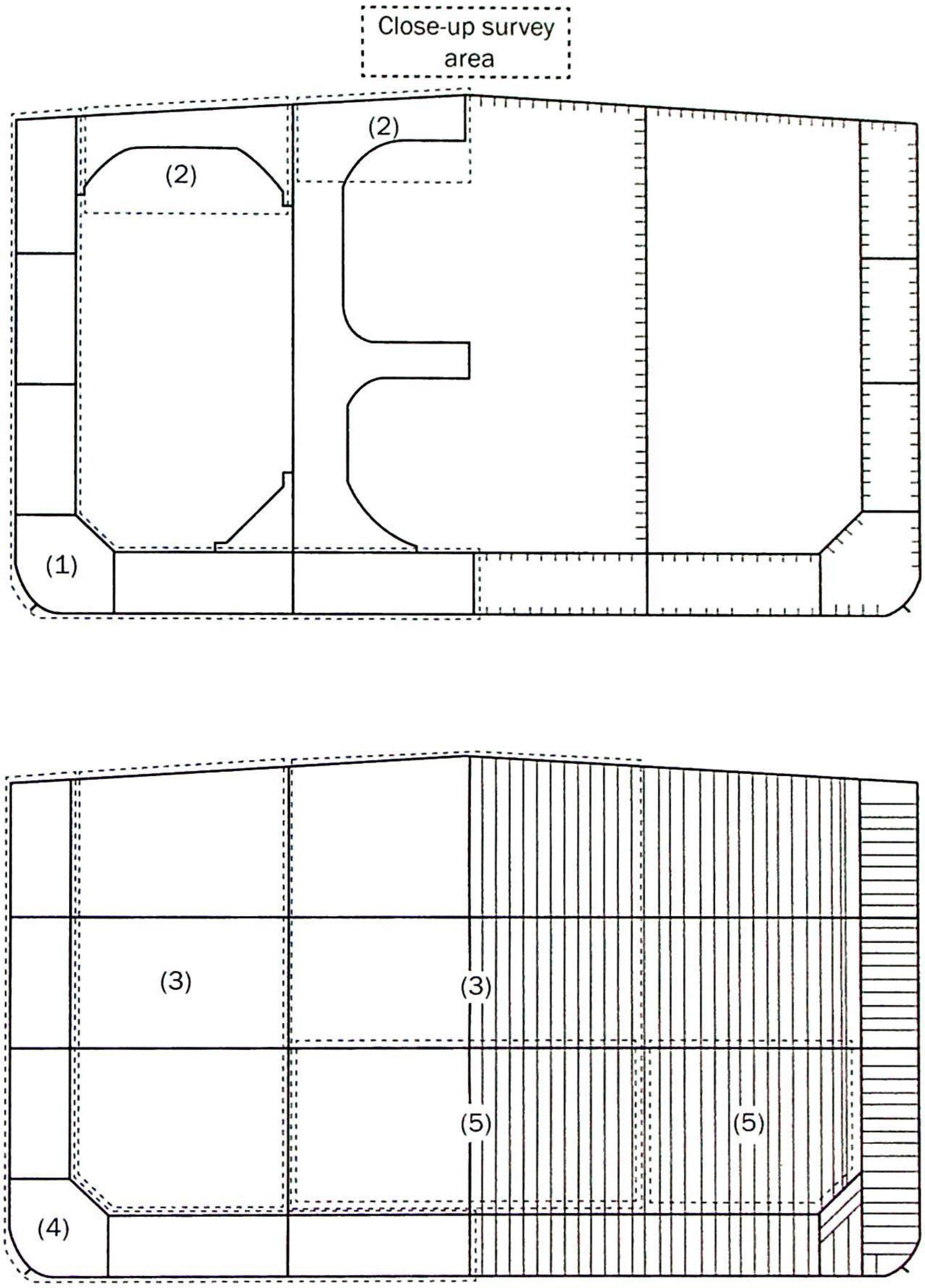
Report on TM3-DHT(CSR)			
10.	Deck longitudinals	20.	Longitudinal bulkhead plating (remainder)
11.	Sheerstrake longitudinals	21.	Longitudinal bulkhead longitudinals
12.	Side shell longitudinals	22.	Inner side plating
13.	Bilge longitudinals	23.	Inner side longitudinal
14.	Bottom longitudinals	24.	Hopper plating
15.	Deck girders	25.	Hopper longitudinal
16.	Horizontal girders in wing ballast tanks	26.	Inner bottom plating
17.	Bottom girders	27.	Inner bottom longitudinals
18.	Longitudinal bulkhead top strake	28.	Topside tank plating
19.	Longitudinal bulkhead bottom strake	29.	Topside tank longitudinals

Report on TM4-DHT(CSR)	
30.	Deck transverse - centre tank
31.	Deck transverse - wing tank
32.	Vertical web in wing ballast tank
33.	Double bottom floor - wing tank
34.	Double bottom floor - centre tank
35.	Longitudinal bulkhead vertical web
36.	Cross ties

Annex II (CSR): Sheet 13 Z10.4 cont'd

Close-up Survey and Thickness Measurement Areas

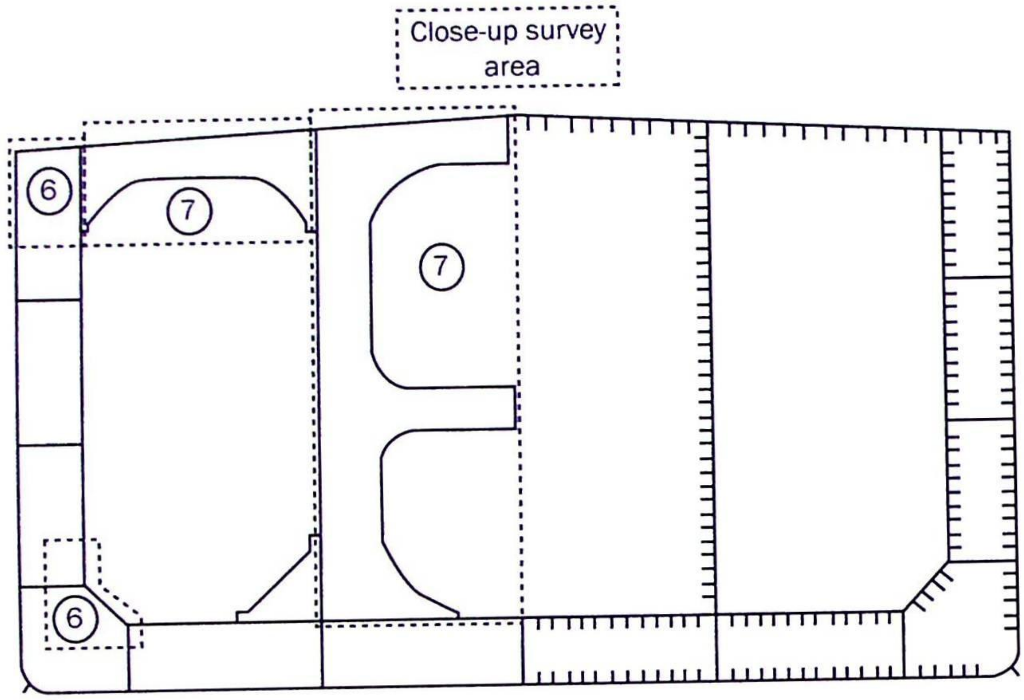
Areas subject to close-up survey and thickness measurements - areas (1) to (5) as defined in Table I of UR Z10.4 - Thickness to be reported on TM3-DHT(CSR), TM4-DHT(CSR) and TM5-DHT(CSR) as appropriate.



Annex II (CSR): Sheet 14 Z10.4 cont'd

Close-up Survey and Thickness Measurement Areas

Areas subject to close-up survey and thickness measurements - areas (6) to (7) as defined in Table I of UR Z10.4 - Thickness to be reported on TM3-DHT(CSR), TM4-DHT(CSR) as appropriate.



End of Annex II

Annex II (CSR): Sheet 15 Z10.4 cont'd

Criteria for longitudinal Strength of Hull Girder for Oil Tankers

1 General

1.1 These criteria is to be used for the evaluation of longitudinal strength of the ship's hull girder, as required by section 8.1.1.1.

1.2 In order that ship's longitudinal strength to be evaluated can be recognized as valid, fillet welding between longitudinal internal members and hull envelopes is to be in sound condition so as to keep integrity of longitudinal internal members with hull envelopes.

2 Evaluation of longitudinal strength

On oil tankers of 130 m in length and upwards and of over 10 years of age, the longitudinal strength of the ship's hull girder is to be evaluated in compliance with the requirements of this annex on the basis of the thickness measured, renewed or reinforced, as appropriate, during the special survey.

The condition of the hull girder for longitudinal strength evaluation should be determined in accordance with the methods specified in appendix 3.

2.1 Calculation of transverse sectional areas of deck and bottom flanges of hull girder

2.1.1 The transverse sectional areas of deck flange (deck plating and deck longitudinals) and bottom flange (bottom shell plating and bottom longitudinals) of the ship's hull girder is to be calculated by using the thickness measured, renewed or reinforced, as appropriate, during the special survey.

2.1.2 If the diminution of sectional areas of either deck or bottom flange exceeds 10% of their respective as-built area (i.e. original sectional area when the ship was built), either one of the following measures is to be taken:

.1 to renew or reinforce the deck or bottom flanges so that the actual sectional area is not less than 90% of the as-built area; or

.2 to calculate the actual section moduli (Z_{act}) of transverse section of the ship's hull girder by applying the calculation method specified in appendix 1, by using the thickness measured, renewed or reinforced, as appropriate, during the special survey.

2.2 Requirements for transverse section modulus of hull girder

2.2.1 The actual section moduli of transverse section of the ship's hull girder calculated in accordance with the foregoing paragraph 2.1.2.2 is to satisfy either of the following provisions, as applicable:

.1 for ships constructed on or after 1 July 2002, the actual section moduli (Z_{act}) of the transverse section of the ship's hull girder calculated in accordance with the requirements of the foregoing paragraph 2.1.2.2 should is not to be less than the diminution limits determined by the Classification Society*; or

.2 for ships constructed before 1 July 2002, the actual section moduli (Z_{act}) of the transverse section of the ship's hull girder calculated in accordance with the requirements of the foregoing paragraph 2.1.2.2 is to meet the criteria for minimum section modulus for ships in service required by the Classification Society, provided that in no case Z_{act} is to be less than the diminution limit of the minimum section modulus (Z_{mc}) as specified in appendix 2.

---

* The actual transverse section modulus of the hull girder of oil tankers calculated under paragraph 2.2.1.1 of Annex III to UR Z10.4 is not to be less than 90% of the required section modulus for new buildings specified in IACS Unified Requirements S7* or S11, whichever is the greater.

* $C = 1.0\ c_n$ is to be used for the purpose of this calculation.

Criteria for Longitudinal Strength of Hull Girder for Oil Tankers
APPENDIX 1

Calculation Criteria of Section Moduli of Midship Section of Hull Girder

1 When calculating the transverse section modulus of the ship's hull girder, the sectional area of all continuous longitudinal strength members is to be taken into account.

2 Large openings, i.e. openings exceeding 2.5 m in length or 1.2 m in breadth and scallops, where scallop welding is applied, are always to be deducted from the sectional areas used in the section modulus calculation.

3 Smaller openings (manholes, lightening holes, single scallops in way of seams, etc.) need not be deducted provided that the sum of their breadths or shadow area breadths in one transverse section does not reduce the section modulus at deck or bottom by more than 3% and provided that the height of lightening holes, draining holes and single scallops in longitudinals or longitudinal girders does not exceed 25% of the web depth, for scallops maximum 75 mm.

4 A deduction-free sum of smaller opening breadths in one transverse section in the bottom or deck area of 0.06(B - Σb) (where B = breadth of ship, Σb = total breadth of large openings) may be considered equivalent to the above reduction in sectional modulus.

5 The shadow area will be obtained by drawing two tangent lines with an opening angle of 30°.

6 The deck modulus is related to the moulded deck line at side.

7 The bottom modulus is related to the base line.

8 Continuous trunks and longitudinal hatch coamings are to be included in the longitudinal sectional area provided they are effectively supported by longitudinal bulkheads or deep girders. The deck modulus is then to be calculated by dividing the moment of inertia by the following distance, provided this is greater than the distance to the deck line at side:

$$y_t = y\left(0.9 + 0.2\frac{x}{B}\right)$$

where:

y = distance from neutral axis to top of continuous strength member.
x = distance from top of continuous strength member to centreline of the ship.
x and y to be measured to the point giving the largest value of y_t.

9 Longitudinal girders between multi-hatchways will be considered by special calculations.

Criteria for Longitudinal Strength of Hull Girder for Oil Tankers
APPENDIX 2

Diminution Limit of Minimum Longitudinal Strength of Ships in Service

1 The diminution limit of the minimum section modulus (Z_{mc}) of oil tankers in service is given by the following formula:

$$Z_{mc} = cL^2B\,(C_b + 0.7)k \quad (\text{cm}^3)$$

where

L = Length of ships. L is the distance, in metres, on the summer load waterline from the fore side of stem to the after side of the rudder post, or the centre of the rudder stock if there is no rudder post. L is not to be less than 96%, and need not be greater than 97%, of the extreme length on the summer load waterline. In ships with unusual stern and bow arrangement the length L may be specially considered.

B = Greatest moulded breadth in metres.

C_b = Moulded block coefficient at draught d corresponding to summer load waterline, based on L and B. C_b is not to be taken less than 0.60.

$$C_b = \frac{\text{moulded displacement (m}^3\text{) at draught } d}{L \times B \times d}$$

c = $0.9\,c_n$

$$c_n = 10.75 - \left(\frac{300 - L}{100}\right)^{1.5} \quad \text{for } 130\text{ m} \le L \le 300\text{ m}$$

$$c_n = 10.75 \quad \text{for } 300\text{ m} < L < 350\text{ m}$$

$$c_n = 10.75 - \left(\frac{L - 350}{150}\right)^{1.5} \quad \text{for } 350\text{ m} \le L \le 500\text{ m}$$

k = material factor, e.g.

k = 1.0 for mild steel with yield stress of 235N/mm^2 and over;
k = 0.78 for high tensile steel with yield stress of 315N/mm^2 and over;
k = 0.72 for high tensile steel with yield stress of 355N/mm^2 and over.

2 Scantlings of all continuous longitudinal members of the ship's hull girder based on the section modulus requirement in 1 are to be maintained within 0.4L amidships. However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the end of 0.4L part, bearing in mind the desire not to inhibit the ship's loading flexibility.

3 However, the above standard may not be applicable to ships of unusual type or design, e.g. for ships of unusual main proportions and/or weight distributions.

Annex III: Z10.4 cont'd

Criteria for Longitudinal Strength of Hull Girder for Oil Tankers
APPENDIX 3

Sampling Method of Thickness Measurements for Longitudinal Strength Evaluation and Repair Methods

1 Extent of Longitudinal Strength Evaluation

Longitudinal strength should be evaluated within 0.4L amidships for the extent of the hull girder length that contains tanks therein and within 0.5L amidships for adjacent tanks, which may extend beyond 0.4L amidships. 'Tanks' are ballast tanks and cargo tanks.

2 Sampling Method of Thickness Measurement

2.1 Pursuant to the requirements of section 2.4 of Z10.4, transverse sections should be chosen such that thickness measurements can be taken for as many different tanks in corrosive environments as possible, e.g. ballast tanks sharing a common plane boundary with cargo tanks fitted with heating coils, other ballast tanks, cargo tanks permitted to be filled with sea water and other cargo tanks. Ballast tanks sharing a common plane boundary with cargo tanks fitted with heating coils and cargo tanks permitted to be filled with sea water should be selected where present.

2.2 The minimum number of transverse sections to be sampled should be in accordance with Table II of Z10.4. The transverse sections should be located where the largest thickness reductions are suspected to occur or are revealed from deck and bottom plating measurements prescribed in 2.3 and should be clear of areas which have been locally renewed or reinforced.

2.3 At least two points should be measured on each deck plate and/or bottom shell plate required to be measured within the cargo area in accordance with the requirements of Table II of Z10.4.

2.4 Within 0.1D (where D is the ship's moulded depth) of the deck and bottom at each transverse section to be measured in accordance with the requirements of Table II of Z10.4, every longitudinal and girder should be measured on the web and face plate, and every plate should be measured at one point between longitudinals.

2.5 For longitudinal members, other than those specified in 2.4, to be measured at each transverse section in accordance with the requirements of Table II of Z10.4, every longitudinal and girder should be measured on the web and face plate and every plate should be measured at least in one point per strake.

2.6 The thickness of each component should be determined by averaging all of the measurements taken in way of the transverse section on each component.

3 Additional Measurements where the Longitudinal Strength is Deficient

3.1 Where one or more of the transverse sections are found to be deficient in respect of the longitudinal strength requirements given in this annex, the number of transverse sections for thickness measurement should be increased such that each tank within the 0.5L amidships region has been sampled. Tank spaces that are partially within, but extend beyond, the 0.5L region, should be sampled.

3.2 Additional thickness measurements should also be performed on one transverse section forward and one aft of each repaired area to the extent necessary to ensure that the areas bordering the repaired section also comply with the requirements of Z10.4.

4 Effective Repair Methods

4.1 The extent of renewal or reinforcement carried out to comply with this annex should be in accordance with 4.2.

4.2 The minimum continuous length of a renewed or reinforced structural member should be not less than twice the spacing of the primary members in way. In addition, the thickness diminution in way of the butt joint of each joining member forward and aft of the replaced member (plates, stiffeners, girder webs and flanges, etc.) should not be within the substantial corrosion range (75% of the allowable diminution associated with each particular member). Where differences in thickness at the butt joint exceed 15% of the lower thickness, a transition taper should be provided.

4.3 Alternative repair methods involving the fitting of straps or structural member modification should be subject to special consideration. In considering the fitting of straps, it should be limited to the following conditions:

.1 to restore and/or increase longitudinal strength;

.2 the thickness diminution of the deck or bottom plating to be reinforced should not be within the substantial corrosion range (75% of the allowable diminution associated with the deck plating);

Annex III: Z10.4 cont'd

Criteria for Longitudinal Strength of Hull Girder for Oil Tankers
APPENDIX 3
cont'd

.3 the alignment and arrangement, including the termination of the straps, is in accordance with a standard recognized by the Classification Society;

.4 the straps are continuous over the entire 0.5L amidships length; and

.5 continuous fillet welding and full penetration welds are used at butt welding and, depending on the width of the strap, slot welds. The welding procedures applied should be acceptable to the Classification Society.

4.4 The existing structure adjacent to replacement areas and in conjunction with the fitted straps, etc. should be capable of withstanding the applied loads, taking into account the buckling resistance and the condition of welds between the longitudinal members and hull envelope plating.

End of
Annex III

Survey Programme
ANNEX IVA

Basic information and particulars

Name of ship:

IMO number:

Flag State:

Port of registry:

Gross tonnage:

Deadweight (metric tonnes):

Length between perpendiculars (m):

Shipbuilder:

Hull number:

Classification Society:

Class ID:

Date of build of the ship:

Owner:

Thickness measurement firm:

1 Preamble

1.1 Scope

1.1.1 The present survey programme covers the minimum extent of overall surveys, close-up surveys, thickness measurements and pressure testing within the cargo area, cargo tanks, ballast tanks, including fore and aft peak tanks, required by UR Z10.4.

1.1.2 The arrangements and safety aspects of the survey are to be acceptable to the attending surveyor(s).

1.2 Documentation

All documents used in the development of the survey programme are to be available onboard during the survey as required by section 6.

Survey Programme
ANNEX IVA
cont'd

2 Arrangement of Tanks and Spaces

This section of the Survey Programme is to provide information (either in the form of plans or text) on the arrangement of tanks and spaces that fall within the scope of the survey.

3 List of Tanks and Spaces with Information on their use, Extent of Coatings and Corrosion Protection System

This section of the Survey Programme is to indicate any changes relating to (and is to update) the information on the use of the tanks of the ship, the extent of coatings and the corrosion protective system provided in the Survey Planning Questionnaire.

4 Conditions for Survey

This section of the Survey Programme is to provide information on the conditions for survey, e.g. information regarding cargo hold and tank cleaning, gas freeing, ventilation, lighting, etc.

5 Provisions and Method of Access to Structures

This section of the Survey Programme is to indicate any changes relating to (and is to update) the information on the provisions and methods of access to structures provided in the Survey Planning Questionnaire.

6 List of Equipment for Survey

This section of the Survey Programme is to identify and list the equipment that will be made available for carrying out the survey and the required thickness measurements.

7 Survey Requirements

7.1 Overall survey

This section of the Survey Programme is to identify and list the spaces that are to undergo an overall survey for the ship, in accordance with 2.3.1.

7.2 Close-up survey

This section of the Survey Programme is to identify and list the hull structures that are to undergo a close-up survey for the ship in accordance with 2.3.2.

8 Identification of Tanks for Tank Testing

This section of the Survey Programme is to identify and list the tanks that are to undergo tank testing for the ship in accordance with 2.5.

9 Identification of Areas and Sections for Thickness Measurements

This section of the Survey Programme is to identify and list the areas and sections where thickness measurements are to be taken in accordance with 2.4.1.

10 Minimum Thickness of Hull Structures

This section of the Survey Programme is to specify the minimum thickness for hull structures of this ship that are subject to UR Z10.4 (indicate either (a) or preferably (b), if such information is available):

(a) Determined from the attached wastage allowance table and the original thickness to the hull structure plans of the ship;

(b) Given in the following table(s):

Annex IV: Z10.4 cont'd

Survey Programme
ANNEX IVA
cont'd

Area or location	Original as- built thickness (mm)	Minimum thickness (mm)	Substantial corrosion thickness (mm)
Deck			
Plating			
Longitudinals			
Longitudinal girders			
Bottom			
Plating			
Longitudinals			
Longitudinal girders			
Ship side			
Plating			
Longitudinals			
Longitudinal girders			
Longitudinal bulkhead			
Plating			
Longitudinals			
Longitudinal girders			
Inner bottom			
Plating			
Longitudinals			
Longitudinal girders			
Transverse bulkheads			
Plating			
Stiffeners			
Transverse web frames, floors and stringers			
Plating			
Flanges			
Stiffeners			
Cross ties			
Flanges			
Webs			

Note: The wastage allowance tables are to be attached to the survey programme.

For ships built under IACS Common Structural Rules, the renewal thickness of the hull structure elements is indicated in the appropriate drawings.

11 Thickness Measurement firm

This section of the Survey Programme is to identify changes, if any, relating to the information on the thickness measurement firm provided in the Survey Planning Questionnaire.

Annex IV: Z10.4 cont'd

Survey Programme
ANNEX IVA
cont'd

12 Damage Experience Related to the Ship

This section of the Survey Programme is to, using the tables provided below, provide details of the hull damages for at least the last three years in way of the cargo and ballast tanks and void spaces within the cargo area. The damages are subject to survey.

Hull Damages Sorted by Location for the Ship

Tank or space number or area	Possible cause, if known	Description of the damages	Location	Repair	Date of repair

Hull Damages for Sister or Similar Ships (if available) in the Case of Design Related Damage

Tank or space number or area	Possible cause, if known	Description of the damages	Location	Repair	Date of repair

13 Areas Identified with Substantial Corrosion from Previous Surveys

This section of the Survey Programme is to identify and list the areas of substantial corrosion from previous surveys.

14 Critical Structural Areas and Suspect Areas

This section of the Survey Programme is to identify and list the critical structural areas and the suspect areas, if such information is available.

15 Other Relevant Comments and Information

This section of the Survey Programme is to provide any other comments and information relevant to the survey.

Annex IV: Z10.4 cont'd

Survey Programme
ANNEX IVA
cont'd

Appendices

Appendix 1 – List of Plans

Paragraph 5.1.3.2 requires that main structural plans of cargo and ballast tanks (scantling drawings), including information regarding use of high tensile steel (HTS), are to be available. This appendix of the Survey Programme is to identify and list the main structural plans that form part of the Survey Programme.

Appendix 2 – Survey Planning Questionnaire

The Survey Planning Questionnaire (annex IVB), which will have been submitted by the owner, is to be appended to the Survey Programme.

Appendix 3 – Other Documentation

This part of the Survey Programme is to identify and list any other documentation that forms part of the plan.

Prepared by the owner in cooperation with the Classification Society for compliance with 5.1.3.

Date:....................................... (name and signature of authorized owner's representative)

Date:....................................... (name and signature of authorized representative of the Classification Society)

Survey Planning Questionnaire
ANNEX IVB

The following information will enable the owner, in cooperation with the Classification Society, to develop a Survey Programme complying with the requirements of UR Z10.4. It is essential that the owner provides, when completing the present questionnaire, up to date information. The present questionnaire, when completed, is to provide all information and material required by UR Z10.4.

Particulars

Ship's name:
IMO number:
Flag State:
Port of registry:
Owner:
Classification Society:
Class ID:
Gross tonnage:
Deadweight (metric tonnes):
Date of build:

Information on Access Provision for Close-up Surveys and Thickness Measurement:

The owner is to indicate, in the table below, the means of access to the structures subject to close-up survey and thickness measurement. A close-up survey is an examination where the details of structural components are within the close visual inspection range of the attending surveyor, i.e. normally within reach of hand.

Tank No.	Structure	C(Cargo)/ B(Ballast)	Permanent means of access	Temporary staging	Rafts	Ladders	Direct access	Other means (please specify)
FP	Fore peak							
AP	Aft peak							
Wing Tanks	Under deck							
	Side shell							
	Bottom transverse							
	Longitudinal							
	Transverse							
Centre Tanks	Under deck							
	Bottom transverse							
	Transverse							

Survey Planning Questionnaire
ANNEX IVB
cont'd

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, Safety Data Sheets (SDS)*

* Refer to resolution MSC. 150(77) on Recommendation for material safety data sheets for MARPOL Annex I cargoes and marine fuel oils.

Survey Planning Questionnaire
ANNEX IVB
cont'd

Owner's Inspections

Using a format similar to that of the table below (which is given as an example), the owner is to provide details of the results of their inspections for the last 3 years on all cargo and ballast tanks and void spaces within the cargo area, including peak tanks.

Tank No.	Corrosion protection (1)	Coating extent (2)	Coating condition (3)	Structural deterioration (4)	Tank damage history (5)
Cargo centre tanks					
Cargo wing tanks					
Slop					

Survey Planning Questionnaire
ANNEX IVB
cont'd

Tank No.	Corrosion protection (1)	Coating extent (2)	Coating condition (3)	Structural deterioration (4)	Tank damage history (5)
Ballast tanks					
Aft peak					
Fore peak					
Miscellaneous spaces					

Note: Indicate tanks which are used for oil/ballast.

1) HC = hard coating SC = soft coating
SH = semi-hard coating NP = no protection

2) U = upper part M = middle part
L = lower part C = complete

3) G = good F = fair P = poor
RC = recoated (during the last 3 years)

4) N = no findings recorded Y = findings recorded
(description of findings is to be attached to the questionnaire)

5) DR = damage & repair L = leakages
CV = conversion
(description is to be attached to this questionnaire)

Name of owner's representative:

Signature:

Date:

Survey Planning Questionnaire
ANNEX IVB
cont'd

Reports of Port State Control inspections

List the reports of Port State Control inspections containing hull structural related deficiencies and relevant information on rectification of the deficiencies:

Safety Management System

List non-conformities related to hull maintenance, including the associated corrective actions:

Name and address of the approved thickness measurement firm:

Owner's Inspection Report
ANNEX IVC
cont'd

Structural Condition

Ship's name:

For tank No:

Grade of steel: deck: side:

bottom: longitudinal bulkhead:

Elements	Cracks	Buckles	Corrosion	Coating condition	Pitting	Modification/ repair	Other
Deck							
Bottom							
Side							
Longitudinal bulkhead							
Transverse bulkhead							

Repairs carried out due to:

Thickness measurements carried out (Dates):

Results in general:

Overdue surveys:

Outstanding conditions of Class:

Comments:

Date of inspection:

Inspected by:

Signature:

Annex IV end
Document end

Annex IV: Z10.4 cont'd

Appendix III

IACS Rec No. 72: Confined Space Safe Practice

No. 72

(2000)
(Rev.1
Oct 2003)
(Rev.2
Apr 2007)
(Corr.1
Sep 2017)
(Rev.3
Dec 2018)

Introduction

This Guideline is intended to assist Societies in developing Confined Space Entry procedures or technical instructions for the Surveyors, according to a common reference standard of good practice.

The Guideline is structured in two parts. In the first part, general information concerning definitions and requirements to safely enter and work in Confined Spaces are summarized.

The second part helps the worker to recognize the hazards associated with confined spaces and gives detailed guidelines for a safe survey preparation and entry.

A Checklist for Entry into Confined Space is also included.

PART ONE – Confined Space Practices

1 Definitions

1.1 Confined Space

Confined space means a space that has any of the following characteristics:

- limited openings for entry and exit;
- unfavourable natural ventilation;
- not intended for continuous worker occupancy.

It may include, but is not limited to, boilers, pressure vessels, cargo spaces (cargo holds or cargo tanks), cargo space stairways, ballast tanks, double bottoms, double hull spaces, fuel oil tanks, lube oil tanks, sewage-tanks, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases, excavations and pits.

1.2 Confined Space Entry

Confined space entry is the process of entering, working in and exiting a confined space.

1.3 Competent Person

Competent Person means a person with sufficient theoretical knowledge and practical experience to make an informed assessment of the likelihood of a oxygen deficient/enriched or a dangerous atmosphere being present or subsequently arising in the space. Competent persons must be trained and qualified in the hazards of Confined Spaces and in use of atmospheric monitoring devices. The Competent Persons role may be performed by a Marine Chemist.

1.4 Responsible Person

Responsible person means a person authorised to permit entry into a confined space and having sufficient knowledge of the procedure to be followed and other activities that are being undertaken that could impact on the safety of those in a confined space.

1.5 Attendant (may also be referred to as 'Standby Person')

Attendant is a person who is suitably trained and responsible for maintaining a watch over those entering the confined space, for maintaining communications with those inside the space and for initiating the emergency procedures in the event of an incident occurring.

1.6 Marine Chemist

A Marine Chemist is a person holding a valid and suitably recognised qualification as a marine chemist or equivalent.

1.7 Adjacent Space

An Adjacent Space is any space bordering the confined space in any directions, including all points of contact, corners, diagonals, decks, tank tops and bulkheads.

1.8 Toxic Product

A Toxic Product means any chemical liquid, gas or solid material, which can give toxic vapour and which is assigned with suffix "T" in column "k" of table given in Chapter 17 of IBC Code, or assigned with suffixes "T" or "F+T" in column "f" of table given in Chapter 19 of IGC Code, or classified as a Toxic Substance (Class/Division 6.1) within Part 2 of the IMDG Code, or any other product which has a toxic symbol in the data sheet or is a hazard classified as a toxic.

1.9 Surveyor

A surveyor is any person employed by the classification society conducting activities within a confined space on behalf of this classification society.

1.10 Permit to Enter/Permit to Work

A Permit to Enter or Permit to Work is a documented authorization that has been signed and dated, including time of issue by the Responsible Person, which states that the space has been tested by a Competent Person and the space is safe for entry; what precautions, equipment, etc. are required and what works is to be done.

2 General Hazards

Entry to and working within confined spaces presents the possibility of fatalities, severe injuries and illness. The key hazards associated with confined spaces are:

- serious risk of fire or explosion;
- loss of consciousness from asphyxiation arising from dust, gas, fumes, vapour or lack of oxygen;
- drowning arising from increased fluid levels;
- loss of consciousness arising from a change in body temperature;
- asphyxiation or suffocation arising from free flowing solid (engulfment) or the inability to reach a breathable atmosphere due to entrapment.

Surveyors will routinely enter confined spaces that are difficult to access due to small and/or narrow openings. There may be physical constraints within the space which must be considered, and the dimensions of the space itself may allow only restricted mobility.

Given the usual enclosed and darkened nature of a confined space this activity ideally should not be carried out by personnel suffering from phobias (such as claustrophobia) or who are susceptible to panic or anxiety attacks.

For further details regarding hazards in confined spaces see Part Two.

3 Requirements

3.1 Training

All surveyors who are expected to enter and work in confined spaces should be trained in Occupational Safety and Health requirements for such activities. This should include the following:

- Recognising a confined space
- Role of the Competent Person, Responsible Person, Attendant and Marine Chemist
- How to recognise the hazards and manage the risks associated with Confined Space Entries
- PERMIT TO ENTER (PTW or PTE) systems/control procedures at the workplace
- Requirements for atmosphere testing and the interpretation of their results
- Use of personal multi gas meter
- Access, exit and safe working requirements
- Emergency arrangements.

Competency in the areas covered by the training identified above should be periodically assessed and appropriate refresher training should be provided.

3.2 Confined Space Entry Policy

A confined space should be entered only when a PERMIT TO ENTER (PTW or PTE) has been issued and if it is safe to do so. Surveyors should remain inside a confined space only for as long as it is necessary to perform the related work.

It is the full responsibility of the Owner or Owner Representative of the confined space (i.e. Ship, Shipyard) to ensure that the confined space is safe to enter.

- Surveyors should not enter a space alone unless the physical dimensions of the space prevent entry by more than one person.

3.3 Confined Space Entry Procedures

3.3.1 General

Societies should include in their procedures the requirements that Surveyors should refuse to enter a confined space (or should exit the space) if:

- Safe entry procedures (such as entry permit, "safe for workers" certificate, "safe for hot work" certificate, etc.) are not in place, have time expired or are not being followed
- The Responsible and Competent Persons are not identified
- The access and exit arrangements to and within the confined space are not considered safe

(where available, multiple entry and exits ways should be opened)

- Communications arrangements are not adequate
- The confined space is not adequately clean to allow safe working
- Lighting is not adequate for entry and exit and to allow safe working in the confined space
- The atmosphere has not been demonstrated as being safe (safe limits are: atmospheric oxygen the range of 20.6% to 22% by volume, combustible gases less than 5% of lower explosive limit, toxics within acceptable limits)
- Adequate ventilation arrangements are not in place or not functioning
- Isolation of the confined space, as applicable, from other tanks, cargo spaces, pipes, etc. and of machinery in the space, is not confirmed
- They are required to wear breathing apparatus
- The surveyor may wear a respirator or other escape device if required by an Owner's policy but only if sufficiently trained in the use of such equipment. However, the space should be safe first
- Effective communication is adversely impacted by the surrounding noise
- Extreme temperature effects are not adequately considered
- Electrical equipment in the confined space is not suitable or not in acceptable condition
- Toxic Product is contained in an adjacent space, until the followings are carried out:
    1) A risk assessment is completed by the vessel's Management Company and the risk is mitigated.
    2) All identified controls are confirmed in place prior to tank entry.
- A dedicated Attendant is not provided by the vessel's management or the management of the facility where the surveyor's activities are carried out for the complete duration of the time spent working in the confined space and/or the Attendant does not have suitable means of initiating emergency response
- Adequate emergency response arrangements are not in place
- In any other situation where the surveyor has a valid concern over the safety of the confined space.

The points addressed above should be considered and reviewed as changes occur during any Confined Space Entry.

No surveyor should be the first to enter a confined space, and they should be accompanied at all times where the size of the space permits.

No surveyor should be part of a rescue team.

Surveyors should immediately leave a confined space, by the nearest safe exit, if any alarms sound, or any physical impairment or distress is experienced by the surveyor.

In addition to the above prior to entry into a confined space the following procedure should be adopted:

(a) A Safety meeting should be held prior to the survey to discuss all aspects of safety measures.

(b) Entry Permit should be obtained for the space to be entered.

(c) Identify potentially unsafe conditions by reviewing the following information provided by the owner:

- Latest content of the spaces to be surveyed.
- Contents of adjacent spaces.
- For Gas Carriers: a data sheet for the last cargo.
- For Chemical Tankers: a data sheet for the previous three cargoes.

(d) Evaluate ventilation of the space:

- Check that the confined space or tank is empty, cleaned and ventilated.

(e) Evaluate need for isolation of the space.

(f) Ensure that an Attendant is in place.

(g) Ensure that a standby person and/or a rescue team is in place.

(h) It is strongly recommended that Emergency Escape Breathing Devices (EEBD) are placed at the entry points of the space to be entered for use in emergency situation or recovery of a surveyor from the space.

(i) Check and evaluate gas measurements taken by the Owner Representative. For testing limit values see item 4 below.

- as a minimum, oxygen measurements should be carried out before entry into the enclosed space. The Surveyor may request to carry out measurements under his supervision, when deemed necessary.
- a set of additional control measures should be evaluated depending on what type of confined space is to be surveyed. See Annex, Checklist for Entry into Confined Spaces.

The surveyor should always use their personal gas measuring equipment during the survey, but this is not intended to substitute the measurements taken by the Owner or Owner Representative.

(j) Evaluate need for precaution against extreme temperature. See Part Two.

(k) Evaluate the lighting arrangements. See Part Two.

(l) Evaluate if special clothing and/or equipment is required.

A checklist with the items above is recommended to be used for evaluation if the space is safe to enter.

If extensive work is to be carried out within a large space, such as a cargo tank, it is recommended that a full assessment of the tank atmosphere is undertaken after the initial tests have been satisfactorily carried out and recorded. The tank atmosphere should be checked frequently during this entry, with particular attention being placed on testing the work location(s) and places that are inaccessible for testing from the entry point.

3.3.2 Entering confined spaces adjacent to loaded tanks

It is important to be aware that confined spaces may be, or have been, subject to leakage from the adjacent space. The risk is that such leakage often remains undetected because the space is not subject to regular gas measurements and ventilation.

Confined spaces adjacent to loaded tanks may be entered provided the procedure for entry as given in item 4 below is completed.

Spaces adjacent to cargo tanks, like cofferdams and double bottom tanks may contain accumulated residues from previous cargoes and information about these cargoes is needed to determine proper test methods for the atmosphere in the adjacent spaces.

If a tank is loaded with cargoes having a toxic product hazard identified, or with a toxic symbol in the Data Sheet, no survey should be carried out in a confined space adjacent to that tank.

Be aware that toxicants produced by work (like coating, sandblasting and hydro blasting) in the area of a confined space can enter and accumulate in the confined space.

3.3.3 Entering confined spaces adjacent to inerted tanks

When other tanks in an inert condition are either adjacent or interconnected (e.g. pipeline) to the space to be entered, personnel should be alert to the possibility of inert gas leaking into that space through, for example, bulkhead fractures or defective valves. The risk of this occurring can be minimized by maintaining a small but positive pressure in the space to be entered relative to the inert gas pressure. At all times the procedures on the vessel are to be followed.

3.3.4 Entering confined spaces adjacent to loaded tanks on double hull tankers – additional requirements

The compartmentalized structure in double hull and double bottom tanks makes them more difficult to gas free than conventional tanks and particular care should be taken to monitor the tank atmosphere.

Although entry into double hull or double bottom tanks with adjacent tanks loaded should be kept to a minimum, tank entry will on occasion be required for such purpose as tank inspections.

In relation to the entry procedure above, the following additional recommendations should be strictly enforced.

Once the tank atmosphere meets the entry criteria at each sampling point, actual entry by personnel should be undertaken in two stages.

First stage

The first stage should be for the purpose of atmosphere verification and a general safety review. The Owner personnel making the entry should be equipped with:

- an emergency escape breathing set,
- personal gas detector capable of monitoring at least hydrocarbon and oxygen,
- portable radio,
- emergency light source,
- a retrieval harness,
- an alternative means of attracting attention, e.g. a whistle.

Second stage

Only after the first stage has verified that the atmosphere throughout the tanks is safe for the surveyor may enter the confined space for survey activities.

3.3.5 Permit-to-work and permit-to-enter

The ISM code requires the Company to establish safe practices in ship operation and a safe working environment. This is commonly provided for by a permit-to-work system that is drawn up to provide a formal written safety control system. Non convention vessels, new construction shipyards and repair facilities, etc. not covered by ISM code may have a similar permit-to-work system.

A permit-to-work should:

- set out the work to be done, the location and the precautions to be taken;
- predetermine safe methods of work;
- provide a clear record that all foreseeable risks have been considered;
- define the precautions to be taken and their sequence;
- provide written authority for the confined space to be entered and the work to start and the time when the work should cease.

Entry into a confined space should only be allowed after a separate permit-to-enter has been issued. This permit should only be issued after tests have taken place to ensure that the atmosphere is safe for entry.

> *Note:*
>
> ***Use of non-explosion proof equipment like cameras, torches, chipping hammers, may be allowed provided that it is stated in the Entry permit issued and the space is safe for hot work or safe for workers and LEL is measured to 0%.***

4 Confined Space Entry

4.1 Testing of the Atmosphere

Initial testing should be carried out by a certified "Marine Chemist" or a "Competent person" or similar accredited person who will issue a certificate stating whether the space is 'safe for man' and/or work, and if any special conditions should be observed.

On a vessel this may be the Chief Officer, or a Competent person onboard. If in doubt of the officer's qualification, documentation should be shown. In no case should the surveyor be considered to be a "Competent Person" – even if the surveyor is equipped with own personal testing equipment.

Ventilation should be stopped about 10 minutes before tests are made and not restarted until the tests are completed.

The testing should be carried out immediately before entry into the confined space and in the following sequence:

- Oxygen-deficient or -enriched atmospheres
- Flammable atmospheres
- Toxic atmospheres when considered necessary.

To evaluate the measurements taken, the following limit values should be used.

Testing for oxygen

Any atmosphere with less than 20.6% or greater than 22% oxygen by volume should not be entered.

Testing for flammable atmosphere

A space with an atmosphere with more than 5% of the "Lower Flammable Limit" (LFL) or "Lower Explosive Limit" (LEL), on a combustible gas indicator should not be entered.

The Flammability indicator shows the percentage within a safety range of 0–10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Combustible gas detectors have normally two measuring ranges 0–100% LEL and 0–10% LEL.

Testing for toxic atmospheres

Toxins are, in general, measured in parts per million (PPM). Under no circumstances should the surveyor enter a confined space exceeding the limits specified by national or international regulations. Different testing bodies throughout the world may, however, have different acceptance limits. Value limits are included below for three substances found often by the surveyors in the field:

Gas	Limit 8 Hour work shift [ppm]	Limit 15 min working [ppm]
Benzene (C_6H_6)	1	5
Hydrogen Sulphide (H_2S)	5	10
Carbon Monoxide (CO)	35	50

Sources: IMO-MSC/Circ.1095; OCIMF; National Institute for Occupational Safety and Health (NIOSH)

> ***Note:***
>
> ***Never trust one's own senses to determine if the air in a confined space is safe! Many toxic gases and vapours can neither be seen nor smelled, nor can the level of oxygen present be determined.***

Be aware that some chemicals have a lower "Threshold Limit Value" (TLV) than odour value. Gases from these substances will not be traceable by smell before they are dangerous to health.

De-ballasting a tank does not guarantee a safe atmosphere. Testing of the atmosphere is still required.

Testing instruments

For further details, see Personal Protection Equipment (PPE), Part One, section 4.3, and Testing Instruments, Part Two, section 3.2.

> ***Note:***
>
> ***In all cases testing instruments should be operated in line with manufacturer's instructions.***

4.2 Preparation for Entering Confined Spaces

4.2.1 Ventilation

Ventilation should be continuous where possible because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped. All openings should be opened for ventilation including emergency exit.

The inert gas fans should not be used to provide fresh air ventilation because contaminants from the inert gas lines could be introduced into the tanks.

For further details, see Part Two, section 4, Ventilation.

4.2.2 Isolation of space

The surveyor should confirm that the isolation of the space has been considered and performed where necessary.

For further details regarding isolation of spaces from service, see Part Two, section 5, Isolation of space.

Ballast and cargo operations should be stopped when personnel are entering ballast and cargo tanks.

4.2.3 Attendant rescue team

An attendant should be assigned to remain on the outside of the confined space and be in constant contact (visual or two-way voice communication e.g. walkie-talkie) with the survey team inside. Routines for communication intervals with the survey team should be established.

The attendant:

- should not have any other duties than to serve as standby and know who should be notified in case of emergency;
- should never leave his post even after help has arrived and is a key communication link to others on board;
- should be able to communicate effectively in a relevant common language.

Communication between watch personnel (Bridge, Cargo Control Room or Engine Control Room) and attendant should be established.

Rescue

Rescuers should be trained in and follow established emergency procedures and use appropriate equipment and techniques (such as EEBD, lifelines, respiratory protection).

Emergency and evacuation procedures should be agreed and understood by all parties involved in a potential rescue operation. Steps for safe rescue should be included in all confined space entry procedures. Rescue should be well planned and evidence should be made available that indicates drills have been frequently conducted on emergency procedures.

> ***Note:***
>
> ***Unplanned rescue, such as when someone instinctively rushes in to help a downed co-worker, can easily result in a double fatality or even multiple fatalities if there is more than one would-be rescuer.***
>
> ***A significant number of fatalities in confined spaces occur when an unprotected crew member is attempting to rescue another.***
>
> ***An unplanned rescue could be the last!***

4.3 Personal Protection Equipment (PPE)

PPE is traditionally regarded as the last line of protection with the emphasis being placed on avoidance and appropriate managerial control methods. However, the potentially hazardous nature and isolated position of those entering a confined space means that, for the surveyor, PPE may be the first line of protection.

Each confined space will present different hazards and degrees of risk to health and safety, the final provision of PPE should therefore be based on an assessment of risk.

As a general rule the following guidance is offered.

Basic surveyor PPE should include:

- Body protection (hard wearing overalls with suitable pockets for notebook, etc.)
- Foot protection (steel toecaps (200 joules), steel midsoles, good grip, oil resistant)
- Head protection (hard hat with chinstraps if required)
- Hand protection (hard wearing gloves)
- Eye protection (protective glasses, goggles)
- Ear protection (ear defenders or ear plugs – worn subject to communication system)
- Gas meter – multi-gas meter[1] for measuring of LEL, H_2S, CO, O_2 (in good working order, serviced and calibrated as per the manufacturer's instructions)
- A flashlight, appropriate to the nature of the confined space to be entered, and in good working order
- Respiratory protection (e.g. dust mask).

4.3.1 The surveyor should always use the necessary personal safety equipment according to the specific conditions and the survey being carried out.

Reference list

- ISGOTT International Safety Guide for Oil Tankers and Terminals, fifth edition
- Tanker Safety Guide Chemicals, third edition
- Tanker Safety Guide Liquid Gas, second edition 1995
- OCIMF – Health, Safety and Environment at New-building and Repair Shipyards and During Factory Acceptance Testing (01 July 2003)
- IACS Recommendation No. 39 – Safe use of Rafts or Boats for Survey.

PART TWO – Guidelines for Safe Entry of Confined Spaces

1 General

If a Survey is required to be carried out in a:

- boiler or pressure vessel,
- cargo tank,
- ballast tank,
- double hull space,
- fuel oil tank,

1 Referring to ISO 19891-1:2017(en) "Ships and marine technology — Specifications for gas detectors intended for use on board ships — Part 1: Portable gas detectors for atmosphere testing of enclosed spaces".

- lube oil tank,
- cargo hold,
- void space, or
- similar type of enclosure,

the work will take place in a confined space.

How to identify a confined space?

A confined space is a space that has any one of the following characteristics:

- limited openings for entry and exit;
- unfavourable natural ventilation;
- not designed for continuous worker occupancy.

Limited openings for entry and exit

Confined space openings are limited primarily by size or location. Openings are usually small in size, perhaps as small as 450 mm (18 inches) in diameter, and are difficult to move through easily. Small openings may make it very difficult to get needed equipment in or out of the spaces, especially life-saving equipment when rescue is needed. However, in some cases openings may be very large, for example open-topped spaces such as ships' holds. Access to open-topped spaces may require the use of ladders, hoists, or other devices, and escape from such areas may be very difficult in emergency situations.

Unfavourable natural ventilation

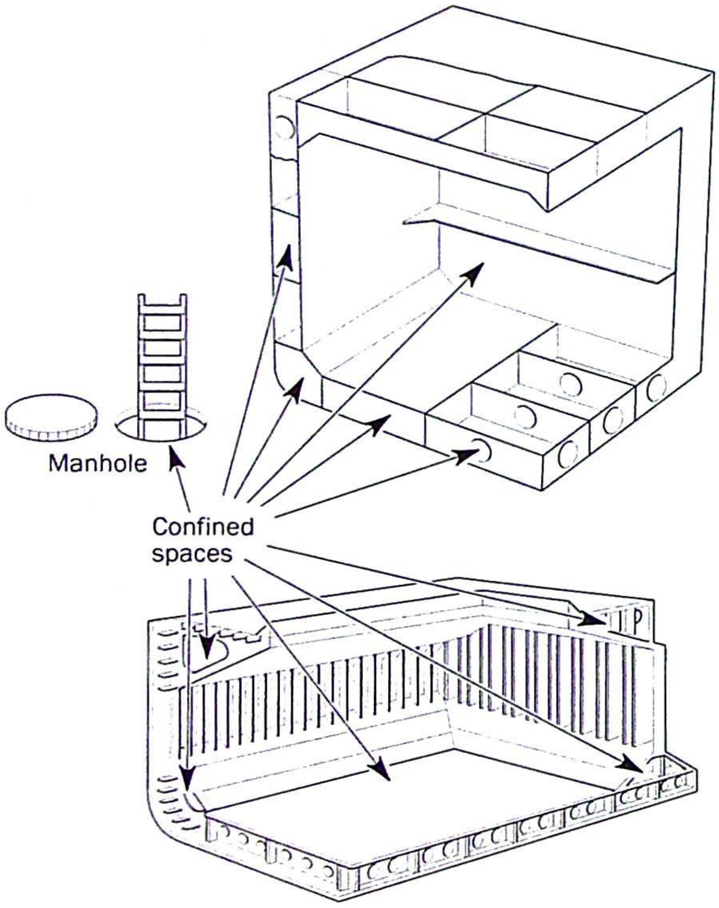
Because air may not move in and out of confined spaces freely due to the design, the atmosphere inside a confined space can be very different from the atmosphere outside. Deadly gases may be trapped inside, particularly if the space is used to store or process chemicals or organic substances which may decompose. There may not be enough oxygen inside the confined space to support life, or the air could be so oxygen-rich that it is likely to increase the chance of fire or explosion if a source of ignition is present.

Not designed for continuous worker occupancy

Most confined spaces are not designed for workers to enter and work in them on a routine basis. They are designed to store a product, enclose materials and processes, or transport products or substances. Therefore, occasional worker entry for survey, inspection, maintenance, repair, cleanup, or similar tasks is often difficult and dangerous due to chemical or physical hazards within the space.

A confined space found in the workplace may have a combination of these three characteristics, which can complicate working in and around these spaces as well as rescue operations during emergencies.

> ***Note:***
>
> **If a survey requires entry to one or more work spaces with the characteristics listed above, read the following information – someday it may save life.**



2 Confined Space Hazards

2.1 Hazardous Atmospheres from the Containment in the Tank

The atmosphere in a confined space may be extremely hazardous because of the lack of natural air movement. This characteristic of confined spaces can result in:

- oxygen-deficient atmosphere,
- flammable atmospheres, including oxygen enrichment, and/or
- toxic atmospheres.

2.1.1 Oxygen-deficient atmosphere

General

The health effects and consequences because of lack of oxygen in a confined space are listed in the table below. These effects will take place without any warning such as odour or physical symptoms.

Health effects from lack of oxygen	
O_2 level	Effects
20.8%	Normal level – Safe for Entry (± 0.2%)
19.5%	Oxygen deficient atmosphere
16%	Impaired judgement and breathing
14%	Rapid fatigue and faulty judgement
11%	Difficult breathing and death in a few minutes

Lack of oxygen leads very quickly to unconsciousness and death. Lack of oxygen may be a problem in all kinds of confined spaces, it is therefore considered as the most dangerous factor when considering dangers in a confined space.

The oxygen level in a confined space can decrease because of work being done, such as welding, cutting, or brazing; or, it can be decreased by certain chemical reactions like: rusting, paint drying or through bacterial action (fermentation).

In tanks and/or voids of complicated geometry with high possibility of "pockets of atmosphere" with low O_2 content, and where rescue operations may be difficult, the use of a portable oxygen meter with audible alarm is strongly recommended.

Inert gas, N_2 and exhaust

Inert gas is a non-reactive gas used to prevent possible explosive atmosphere from different cargo vapours.

On Oil Tankers the most common inert gas is the exhaust from oil fired boilers, main- or auxiliary engines. On Chemical Tankers the most common inert gas is nitrogen.

Pure nitrogen is not poisonous itself, but it causes displacement of the natural breathing environment.

Exhaust contains hundreds of chemical compositions. Main components are: carbon monoxide, oxygen, nitrogen, water vapour, sulphur dioxide, nitrogen oxides and hydrocarbons. The exhaust as described above may cause reduced lung capacity and increased respiratory in addition to irritating mucous membrane in eye, nose and throat. Total dilution of oxygen by another gas, such as carbon dioxide, will result in unconsciousness, followed by death.

Bulk cargoes

A number of bulk cargoes may cause low level of oxygen in the cargo hold. This is mainly with cargoes like vegetables, grain, timber, forestry products, iron metals, metal sulphide concentrates and coal.

Some bulk cargoes may oxidize which may result in reduced level of oxygen, poisonous gases, or self ignition. Other bulk cargoes may produce poisonous gases without oxidation, especially when they are wet.

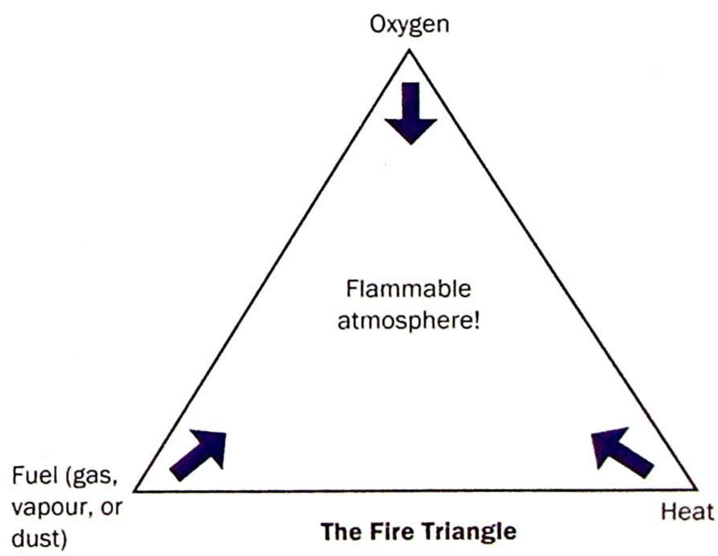
2.1.2 Flammable atmospheres

Two things make an atmosphere flammable:

- the oxygen in air, and
- a flammable gas, vapour, chemical reaction or dust in a proper mixture.

Different gases have different flammable ranges. If a source of ignition (e.g. a sparking or electrical tool, static electricity, sand blasting) is introduced into a space containing a flammable atmosphere, an explosion will result. An oxygen-enriched atmosphere (above 22%) will cause flammable materials, such as clothing and hair, to burn violently when ignited. Therefore, never use pure oxygen to ventilate a confined space. Ventilate with normal air.

Some bulk cargoes may produce health toxic dust which also will represent an explosive hazard, especially during cargo handling and cleaning.



The Fire Triangle

2.1.3 Toxic atmosphere

Unless a certified Marine Chemist or a competent person has certified a space as safe, assume that any substance (liquids, vapours, gases, mists, solid materials and dust) in a confined space can be hazardous. Toxic substances may range from fast acting poisons to long term cancer causing carcinogens. Toxic substances can come from the following:

- the product stored in the space;
- the work being performed in a confined space;
- areas adjacent to the confined space.

Some bulk cargoes will act in a corrosive manner on skin, eye and mucous membrane.

Products stored in the space

Chemical products

In cargo tanks for chemicals it is possible to find all types of chemicals. It is very important that the customer provides a Data Sheet for the product that has been stored in the tank and follows the instructions for safety measures according to this.

Health effects as a result of exposure from chemicals in general may cause immediate headache, nausea, fainting and possible death. Long-term exposure to benzene can result in serious blood disorders such as allergy, anaemia and leukaemia.

Chemicals can be absorbed into the structure and/or tank coatings and give off toxic gases at a later stage. When removed or when cleaning out the residue of a stored product, toxic gases can be given off.

It is very important to follow the marking and recommendations as given in the Data Sheet to reduce immediate damage as well as the risk for long term damage.

Petroleum products

Most petroleum products are distilled from crude oil which is a product with very high complexity regarding composition of different substances. The composition of crude oil and the products distilled from crude may vary depending on what part of the world the production of crude took place.

Petroleum products may be absorbed into the body by inhalation, absorbed through skin or ingested. Effects to health will depend on how high exposure and for how long. Immediate effects of high exposure can include headaches, tiredness, nausea and dizziness. Unconsciousness may occur if exposure is very high. Long-term exposure can result in serious blood disorders such as anaemia and leukaemia.

Be aware that several of the fuels on the market have different additives to prevent e.g. bacteria growth in diesel. These additives may be highly toxic. When the additives are above a certain percentage they are supposed to be included in the Data Sheet. If the amount of additives is very small it does not need to be a part of the Data Sheet.

Be aware that several of the fuel producers are very reluctant to reveal what kind of additives they are using in fuels, because this is considered to be business sensitive. Extra care should then be taken with respect to cleaning and measuring for the correct toxic product in diesel and fuel oil tanks.

When testing for toxins in a confined space that has contained petroleum products, it may be very difficult to decide what toxic gas to measure for. In general, testing for the most dangerous toxic product in the composition should be carried out.

If not otherwise stated on the Data Sheet, benzene is the most toxic part in petroleum products and measuring for this product should be done. If the readings for benzene are within the limits, all the other natural parts of the petroleum product should be within the acceptance limits.

Hydrogen sulphide, H_2S

Hydrogen sulphide is highly toxic and also flammable and is created by the decay of organic matter that is found in sewers and sewage treatment plants. H_2S may also be found in crude oil tanks, ballast tanks, void spaces and other tanks that have been empty and decomposition of organic material has taken place.

Hydrogen sulphide is heavier than air and has no colour but does have a strong "rotten egg" odour at low concentrations.

Hydrogen sulphide can affect when inhaled and when passed through the skin. Contact can irritate the eyes. Long-term exposure to low levels can cause pain and redness of the eyes with blurred vision. Breathing hydrogen sulphide can irritate the nose, throat and irritate the lungs causing coughing and/or shortness of breath.

Higher exposures can cause a build-up of fluid in the lungs (pulmonary oedema), a medical emergency with severe shortness of breath. Exposure can cause nausea, dizziness, confusion, headache and trouble with sleeping. Very high levels can cause immediate death.

Hydrogen Sulphide is a highly flammable gas and a dangerous fire hazard.

At high concentrations H_2S paralyses neurons inside the nose and the odour cannot be smelled, hence smelling should not be used as an indicator that the tank is free from hydrogen sulphide.

Example: Removal of sludge or mud from a tank-decomposed material can give off deadly hydrogen sulphide gas and/or methane gas.

Benzene

Benzene is a highly flammable liquid which occurs naturally in crude oil, natural gas and some ground waters. It is also manufactured from crude oil and is present in crude oil vapours.

Benzene evaporates easily, and most people can just detect its distinctive smell at concentrations between 2.5 and 5 ppm in air. Exposure to benzene may occur in oil refineries, chemical and petrochemical plants including offshore installations. Benzene can be absorbed into the body by inhalation, absorbed through skin or ingested.

Benzene can affect human beings when inhaled and when passed through the skin. It can irritate the eyes and skin with drying and scaling of the skin. Exposure can irritate the nose and throat. Benzene can cause symptoms of dizziness, light-headedness, headache and vomiting. Convulsions and coma, or sudden death from irregular heart beat, may follow high exposure. Repeated exposure can cause damage to the blood cells (aplastic anaemia).

Methane

Methane is an odourless, colourless gas, or liquid under pressure. It is used as a fuel and in the manufacture of organic chemicals, acetylene, hydrogen cyanide, and hydrogen. Methane is a highly flammable gas and a dangerous fire and explosion hazard.

In addition to being an explosion hazard, very high levels of methane can cause suffocation from lack of oxygen. Skin contact with liquid methane can cause frostbite.

Solvents

Many solvents, such as kerosene, gasoline, paint strippers, degreasers, are not only flammable, but if inhaled at high concentrations can cause central nervous system (CNS) effects. CNS effects can include dizziness, drowsiness, lack of concentration, confusion, headaches, coma and death.

Solvents should never be used as cleaners for the purpose of removing paint or similar from hands.

If liquid solvents are in contact with skin, they are absorbed through the skin 10 times more efficiently compared to high content solvent gas absorbed into the body through breathing.

LSAs

Naturally occurring radioactive materials have been known to be present in varying concentrations in hydrocarbon reservoirs in a number of areas of the world. It is now recognised that these materials can give rise to radioactive scales (and sludge), which are usually referred to as Low Specific Activity (LSA) scale.

The scales tend to be barium sulphate and strontium sulphate, which co-precipitate with naturally occurring radium leached out of the reservoir rock; such scales emit alpha, beta and gamma radiation and this, together with the physical properties of the LSA scale, can give rise to problems if such scales or sludge have to be removed, handled or disposed.

Levels of radioactivity can vary from just above background radiation to those requiring restricted areas and classified workers.

Others

Fibre: Synthetic mineral fibre is a common description for fibrous inorganic products mainly represented from rock, clay, slag and/or glass. These fibres can be classified as follows:

- fibre glass (glass wool/fibreglass);
- mineral wool (rock wool/slag-wool);
- ceramic fibre.

Long term exposure in high concentrations may increase risk of lung cancer. This is observed among workers fabricating such products. Surveyors will normally not be exposed to concentration levels or time periods which are considered to be of high risk. However, low concentrations may lead to skin and respiratory irritation.

Leakage of refrigerating system

Ammonia: Ammonia is used as refrigerant, distributed within cooling system for fish-factory vessel and hold area. Normal pressure is approximately 20 bars. Ammonia does have a characteristic odour, even for low concentration levels. The health effect and consequences of ammonia are listed in the table below:

Concentration (ppm)	Health effect
20–50	Characteristic odour
40–100	Eye and respiratory irritation
400–700	Serious eye and respiratory irritation – possible irreparable damage
1,700	Convulsive coughing, bronchial spasm, deadly after ½ hr exposure
5,000–10,000	Deadly

CO_2: CO_2 is natural occurrence in exhaled air, however high concentrations can be hazardous. CO_2 is odourless and is heavier than normal air. Concentrations may occur in the lower part of the tanks, close to the bottom. Low concentrations – below 5% are not considered as hazardous. Concentrations above 5% may lead to increased breath intensity and death. Also long term exposure may lead to unconsciousness and death.

Propane/butane: Because of huge fire hazard related to these two products, they will normally not be found onboard vessels except from vessels carrying high risk fire hazardous products i.e. gas carriers. Inhalation of high concentrations may lead to heart arrhythmia (heart rate interruption), and feel suffocating.

Group 1 refrigerant: These refrigerants are non-poisonous and non-fire hazardous. The most common name for these products is Freon. Group 1 refrigerants consist of a number of chlorofluorocarbon combinations. Distribution onboard vessels are mainly within cooling system for fish factory and hold area.

CFC = chlorofluorocarbon (i.e. R-11, R-12). These refrigerants are no longer allowed onboard new-buildings, but still exist onboard existing vessels.

HCFC = hydro-chlorofluorocarbon (i.e. R-22). These refrigerants may still be found onboard, but a phase-out program has started.

HFC = hydro-fluoro-carbon (i.e. R-134a, R-404a, R410a, R-507). These refrigerants are presently used for most new refrigerating plant installations.

Exposure to Group 1 refrigerant may cause eye and/or skin irritation. High concentrations may cause dizziness, spasm and may affect the central nervous system and lead to heart rate interruption. Be aware of the fact that refrigerants will displace O_2. Refrigerant gases are odourless.

Ammonia in fish holds

Note the hazards of ammonia in fish holds where nets are stored when in a period of refit or from fish, and/or by fish products in fishing vessel bilge wells.

Hydrogen emission from anodes and/or accumulators

Hydrogen gas (H_2) is produced from an electrolytic reaction from zincous-/carbon and alkaline accumulators. A mix of hydrogen gas (H_2) and oxygen (O_2) may form a highly explosive mixture. Hydrogen gas (H_2) is a light gas which displaces oxygen (O_2). Oxygen measuring equipment is recommended to be used when entering accumulator room and other enclosures where accumulators are kept.

2.2 Work being Performed in a Confined Space

Examples of such include welding, cutting, brazing, painting, scraping, sand blasting and degreasing. Toxic atmospheres are generated in various processes. For example, cleaning solvents are used in many industries for cleaning/degreasing. The vapours from these solvents are very toxic in a confined space. It is also important to be aware that hot work carried out consumes oxygen.

Welding

Hot work on all surfaces with coating will create several gases which may be very toxic. This gas may come from hot work being carried out in a tank adjacent to the space being surveyed.

Coating

Special attention should be paid when spray coating is carried out in the area of the survey. Spray coating where small size particles are mixed with air will lead to high toxic exposure if inhaled.

Grinding

Grinding may cause miscellaneous compositions of dust. Absorption of metal dust into the body through inhalation is dependent on the physical and chemical properties and the size of the particles. Dust like this may cause metal fume fever and bronchitis.

Sandblasting

The dangers connected to sandblasting very much depend on the object's substance and the size and containment of grit. Several grits used for sandblasting contain carcinogenic substances like quartz, nickel, lead and lead compound.

During sandblasting the containment of carcinogenic chemicals may increase depending on the surface of the sandblasted area.

Hydro blasting

Hydro blasting may create aerosols. Aerosols are dispersion of solid or liquid particles in air which are small enough to stay in the air for a long period of time. Aerosols may transport reactive chemicals deep into the lungs in a way that causes very high exposure.

Aerosols may be produced from dust, dirt and cleaning chemicals in the process of high-pressure cleaning of miscellaneous surfaces.

NDT operations

Chemicals from NDT operations may also be dangerous. Most ultrasonic thickness measuring equipment is not intrinsically safe.

3 Testing

3.1 General

It is important to understand that some gases or vapours are heavier than air and will settle to the bottom of a confined space. Also, some gases are lighter than air and will be found around the top of the confined space.

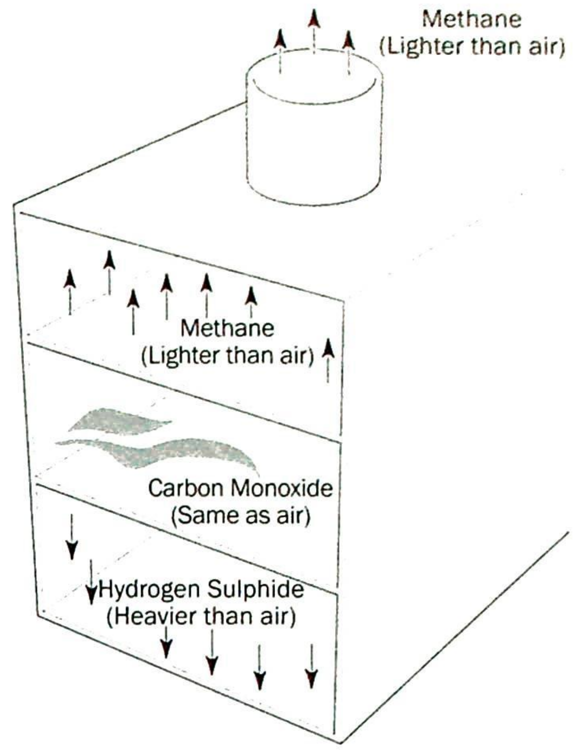
Therefore, it is necessary to test all areas (top, middle and bottom) of a confined space with properly calibrated testing instruments to determine what gases are present. Atmospheres may be different in individual bays of the same tank. If testing reveals oxygen-deficiency, or the presence of toxic gases or vapours, the space must be ventilated and re-tested before entering.

If in doubt whether the gas to be measured is lighter or heavier than air, consider the properties for the possible gas in question and compare it with the molecule weight of air.

Weight of air: 28.8 mol.

Methane, CH_4 is lighter than air.

All gases from liquids under normal conditions are heavier than air (except ammonia).



No tank is to be entered until the tank atmosphere has been thoroughly tested with approved and calibrated instruments. Following tests are to confirm that all areas of the tank, bottom in particular, are safe for entry, i.e.:

- oxygen-deficient atmosphere,
- flammable atmospheres, and/or
- toxic atmospheres.

It is important to start the measurement of the tank atmosphere by measuring the HC (Hydrocarbon) content in % by volume and that the combustible gas detector is not used before the atmosphere content is less than Lower Explosive Limit (LEL). If measurement is started at a higher level the catalytic metal filament in the combustible gas detector may be destroyed. Combination instruments are available with a measuring range 0–100% by volume and 0–100% LEL.

3.2 Testing Instruments

Testing instruments for oxygen and flammability read in percent. The oxygen meter should indicate 20.6% to 22% oxygen in the space being tested. The flammability indicator shows the percent within a safety range of 0–10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Testing instruments are available in several different forms, hand powered by squeezing a rubber bulb or bellows, and battery powered giving the indication either on an analogue gauge or digital read-out.

Be aware that in cases where Draeger tube or equal is used for detecting toxic gases the sampling gas should have sufficient time to pass through the sampling hose. It is important to follow the instructions for use given by the manufacturer of the instrument.

As a rule, if a manual hand rubber pump is used, approximately 4 squeezes are needed for each metre of the sampling hose. If battery driven pumps are used, approximately 10 seconds for each metre of sampling hose should be sufficient.

4 Ventilation

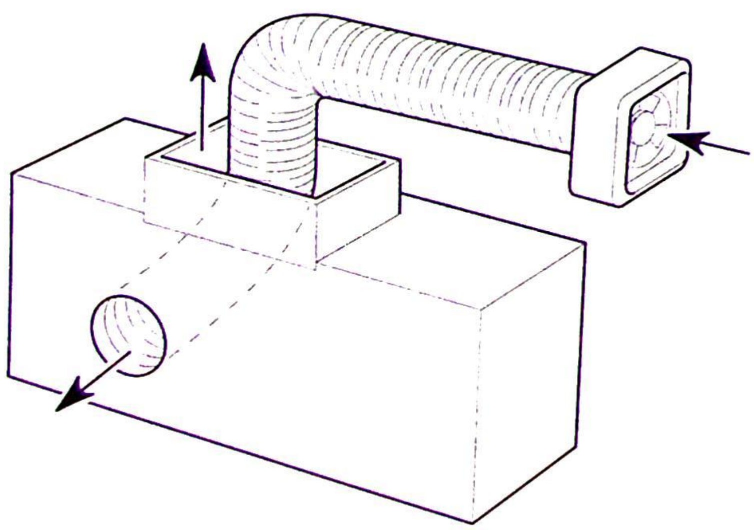
Ventilation by a blower, eductor or fan may be necessary to remove harmful gases and vapours from a confined space. There are several methods for ventilating a confined space. The method and equipment chosen are dependent upon the size of the confined space openings, the gases to be diluted (e.g. are they flammable?), and the source of make-up air.

Under certain conditions where flammable gases or vapours have displaced the oxygen level, but are too rich to burn, forced air ventilation may dilute them until they are within the explosive range. Also, if inert gases (e.g. carbon dioxide, nitrogen) are used in the confined space, the space should be well ventilated and re-tested before a surveyor may enter.

A common method of ventilation requires a large hose, one end attached to a fan and the other lowered into a manhole or opening. For example, a manhole would have the ventilating hose run to the bottom (see figure) to dilute or displace all harmful gases and vapours.

The air intake should be placed in an area that will draw in fresh air only.

Schematic principles for ventilation:



Ventilation should be continuous where possible, because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped.

All openings are to be opened for ventilation and emergency exit.

5 Isolation of Space

Isolation of a confined space is a process where the space is removed from service by one or more of the following.

Locking out

Electrical sources, preferably at disconnect switches remote from the equipment.

Blanking and bleeding, securing valves

Cargo, ballast, IGS, pneumatic and hydraulic lines. The inert gas branch should be blanked off. The appropriate blanking is to be checked at each tank if entry is required while inerting, or gas freeing of other tanks is taking place, or if any other tanks are inerted or contain hydrocarbons. An alternative to pipe blanking would be to remove a section of the branch line.

Disconnecting

Mechanical linkages on shaft-driven equipment where possible.

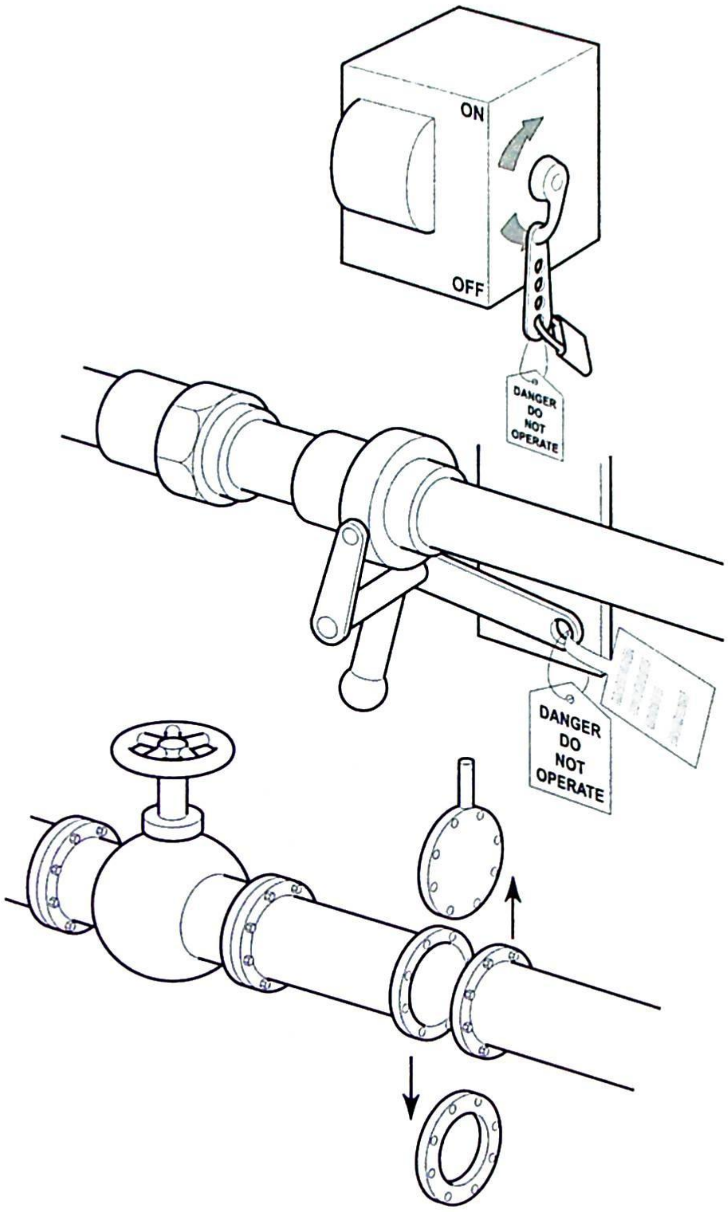
Securing

Mechanical moving parts within confined spaces with latches, chains, chocks, blocks, or other devices.

Notice boards

Appropriate notices, which clearly specify which space and prevailing requirements agreed upon for confined space entry, should be displayed in prominent locations such as bridge, cargo control room, and/or engine control room.

Blanking, locking and securing of equipment:



6 General and Physical Hazards

6.1 Temperature Extremes

Extremely hot or cold temperature can present problems for the surveyor.

Cold temperature: At very cold temperatures, the most serious concern is the risk of hypothermia or dangerously low body temperature. Another serious effect of cold exposure is frostbite or freezing of the exposed extremities such as fingers, toes, nose and ear lobes. Hypothermia could be fatal in absence of immediate medical attention.

Warning signs of hypothermia can include complaints of nausea, fatigue, dizziness, irritability or euphoria. Surveyors can also experience pain in their extremities (for example hands, feet, ears) and severe shivering. Surveyors should be moved to a heated shelter and seek medical advice when appropriate.

Heat: A person working in a very hot environment loses water and salt through sweat. This loss should be compensated by water and salt intake. Fluid intake should equal fluid loss. On average, about one litre of water each hour may be required to replace the fluid loss. Plenty of drinking water should be available on the job site and persons should be encouraged to drink water every 15 to 20 minutes even if they do not feel thirsty. Drinks specially designed to replace body fluids and electrolytes may be taken. Alcoholic drinks should never be taken as alcohol dehydrates the body.

An acclimatized surveyor loses relatively little salt in their sweat and therefore the salt in the normal diet is usually sufficient to maintain the electrolyte balance in the body fluids. For un-acclimatized surveyors who may sweat continuously and repeatedly, additional salt in the food may be used. Salt tablets are not recommended because the salt does not enter the body system as fast as water or other fluids. Too much salt can cause higher body temperatures, increased thirst and nausea. Persons on salt-restricted diets should discuss the need for supplementary salt with their doctor.

When working at extreme temperatures the working hours should be adjusted to avoid the most extreme temperatures during the day. Working in the evenings and early in the morning is often a good solution to avoid the most extreme conditions. How the body reacts to extreme temperatures is very individual. Never take any chances and pay careful attention when performing work in an extreme temperature environment. Working speed and rest schedule should be adjusted according to the temperature.

6.2 Engulfment Hazards

Loose, granular material stored in holds or tanks, such as grain, sand, coal, or similar material, can engulf and suffocate a person. The loose material can crust or bridge over and break loose under the weight of a person.

6.3 Noise

Noise within a confined space can be amplified by the design and acoustic properties of the space. Excessive noise cannot only damage hearing, but can also affect communication, such as causing a shouted warning to go unheard.

6.4 Falling Objects

Workers in confined spaces should be mindful of the possibility of falling objects, particularly in spaces, which have a topside opening for entry, and where work is being done above the worker.

6.5 Slick/Wet Surfaces

Slips and falls can occur on a wet surface causing injury or death to workers. Also, a wet surface will increase the likelihood for and effect of electric shock in areas where electrical circuits, equipment, and tools are used.

7 Guidelines for Use of Personal Gas Detectors

For detection of any local pockets of gas or lack of oxygen the surveyor should use his portable oxygen or multi-gas meter with audible alarm features.

This is especially important when entering tanks and/or voids of complicated geometry with high possibility of "pockets of atmosphere" with low O_2 content, and where rescue operations may be difficult.

Preferably a multi-gas meter should be used, capable of simultaneous monitoring of oxygen, combustible gases and hydrogen sulphide and carbon monoxide.

Note that CO sensors may also be sensitive to low concentrations of hydrogen (H_2) therefore it is important to evaluate the possibility for CO/hydrogen in the space. Anodes will generate hydrogen when in use.

Most measuring equipment is sensitive apparatus with limitations for the range they are capable of measuring. Sensors in all measuring equipment may be destroyed if exposed to extreme measurements (e.g. above 100% LEL), clogged filters or catalyst poison (silicone, lead, sulphur and chlorous).

The personal protective instrument should be turned on before tank entry.

7.1 Function Test and Full Calibration

The difference between a function (bump) test and a full calibration:

- A function (bump) test is defined as a means of verifying calibration by using a known concentration of test gas to demonstrate that an instrument's response to the test gas is within acceptable limits.
- A full calibration is defined as the adjustment of an instrument's response to match desired value compared to a known concentration of test gas.

A function (bump) test or full calibration of direct reading portable gas monitors should be made before each day's use in accordance with the manufacturer's instructions using appropriate test gas.

Any instrument that fails a function (bump) test must be adjusted by means of a full calibration procedure before further use.

Various standard types of calibration gases are available in handy size bottles. For calibration of all gas measuring equipment at least 2 points along the measuring range are needed to determine the accuracy.

Note: Surveyors should never use their personal gas detectors to test a space for entry. Owner is responsible to make the space safe for entry.

8 Survey Preparations

8.1 Cleaning

Tanks and spaces to be surveyed must be sufficiently clean and free from water, scale, dirt and oil residues to reveal excessive corrosion, significant deformation, fractures, damage and other structural deterioration. There is no point in entering a tank if the bottom of the tank is not visible and the intention of the survey is to survey those areas. Tank cleaning can be performed with an existing fixed tank cleaning system.

However, in shadow areas portable washing machines may have to be used in order to achieve sufficient degree of cleanliness.

Generally, tank surveys should be avoided in tanks in which de-sludging operations are taking place since these operations can potentially raise gas levels.

When entering into a HFO, lube oil or diesel fuel tank, extra care should be taken when considering cleanliness and atmosphere. Long term effects of exposure to substances found in these tanks are not well documented.

8.2 Lighting

Whenever possible, natural lighting should be provided in the tank during inspection by opening all tank hatches. A flashlight should be carried when working in confined spaces. Lighting in confined spaces may not be good and will normally be temporary arrangements cabled into the space or by torchlight.

Annex – Checklist for Entry into Confined Spaces

DO NOT ENTER A CONFINED SPACE UNTIL YOU HAVE CONSIDERED EVERY QUESTION AS WELL AS ANY OTHER ITEM OF CONCERN, AND HAVE DETERMINED THE SPACE TO BE SAFE.

THE FINAL DECISION IS YOURS.

YES	NO	1. SAFETY MEETING
❑	❑	Safety meeting is carried out prior to survey to discuss all aspects of safety measures?
❑	❑	Will someone accompany you into the space?
		2. PERMIT
		(The permit is an authorization, usually in writing, that states that the space has been tested by a Competent or Responsible person and that the space is safe for entry; what precautions, equipment, etc. are required; and what work is to be done.)
❑	❑	Has a confined space entry permit been issued?
❑	❑	Is the permit up to date?
		3. VERIFICATION
❑	❑	Are the instruments used in atmospheric testing properly calibrated?
❑	❑	Was the person performing the tests a certified Marine Chemist, a Competent Person, or equivalent?
❑	❑	Was the atmosphere in the confined space tested?
		4. TESTING
❑	❑	Has the monitor been calibrated before any reading is performed?
❑	❑	Was Oxygen at least 20.6 % but not more than 22%?
❑	❑	Were toxic, flammable, or oxygen-diluting gases/vapours present? • Hydrogen sulphide • Carbon monoxide • Methane • Benzene • Other (list) ____________________
		5. MONITORING
❑	❑	Will the atmosphere in the space be monitored while the space is occupied and after work breaks?
		Remember – atmospheric changes occur due to the work procedure or the product stored and vessel movements and temperature changes. The atmosphere may change very quickly.
		6. VENTILATION
❑	❑	Has the space been ventilated before entry?
❑	❑	Will ventilation be continued during entry?
❑	❑	Is the air intake for the ventilation system located in an area that is free of combustible dusts and vapours and toxic substances?
❑	❑	If atmosphere was found unacceptable and then ventilated, was it re-tested before entry?
		7. ISOLATION
❑	❑	Has the space been cleaned up before entry?
❑	❑	Has the space been isolated from other systems?
❑	❑	Has electrical equipment been locked out?
❑	❑	Have disconnects been used where possible?
❑	❑	Has mechanical equipment been blocked, chocked, and disengaged where necessary?

❑	❑	Have lines under pressure been blanked and bled?
❑	❑	Have the necessary Notice boards been placed in the operations locations and at the confined space entry point?
		8. CLOTHING/EQUIPMENT (PPE)
❑	❑	Is special clothing required (boots, chemical suits, glasses, etc.)?
❑	❑	Is special equipment required (e.g. rescue equipment, communications equipment, heavy duty raft, life vests, etc.)?
❑	❑	Are special tools required (e.g. spark proof, intrinsically safe)?
		9. TRAINING
❑	❑	Have you been trained in confined space entry and do you know what to look for?
		10. STANDBY/RESCUE
❑	❑	Is an attendant on the outside in constant visual or auditory communication with the person on the inside?
❑	❑	Will the attendant be able to see and/or hear the person inside at all times?
❑	❑	Are rescue EEBD in place at the space entry point?
❑	❑	Is there a rescue team in place?

Note:

The surveyor shall not enter a tank, a compartment or a confined space if air supplied breathing apparatus is required.

Appendix IV

Catalogue of Structural Detail Failures

Extract of the Work of Project 200 Group

Introduction

The Forum members were requested to supply information on their experiences of structural detail failures, forward of the engine room on tankers over 20,000 tonnes deadweight. These location and size limitations were chosen to restrict the study to typical tanker structure and also to exclude smaller vessels where the structure is not so sensitive to detail design. Most of the data submitted, however, related to VLCC type ships.

Members were also requested to advise known or suspected factors contributing to the failures and, where possible, the repairs effected and their degree of success.

The response resulted in approximately 210 sketches. Whilst a large number of failure examples were given, in some cases the actual repair carried out was not reported and could not subsequently be confirmed. Furthermore, a number of the repairs which were reported had accumulated relatively little service experience to date. In only a very few cases were alternative or unsuccessful repairs given. For this reason the proposals also incorporate the combined experiences of the project members.

It was apparent from the submitted data that many of the problems experienced were common to most members. The data was, therefore, divided up into a number of different groups each identified by the general location within the hull structure. It was considered this would provide a convenient method of grouping for the catalogue when used as a reference document. A total of 14 structural groups were established in this way from the submitted data. No classification of the relative frequency of occurrence of the various types of failures was attempted due to limited information in this respect.

Within each such structural group, one or more examples of detail failure are included. In compiling these examples, the project members have, in some cases, combined similar failures submitted by different Forum members to show a single example of general application.

Presentation Format

It was agreed that the catalogue should include the following information on each type of structural detail failure:

1. Standard designs of bracket connections.
2. Sketch illustrating the failure.
3. Sketch illustrating the proposed repair.
4. List of factors contributing to the failure.
5. Repair notes to provide more detailed recommendations.
6. Alternative repair methods where appropriate.
7. Unsuccessful repairs where known.
8. Implications for new designs.

Whilst it is desirable to provide as much information as possible, the project group members have been mindful of the need to ensure that any reference work is simple and clear to follow. Therefore, two standard format sheets were devised to present the above information. For each example of a detail failure, the first three of the items above have been presented on the first standard sheet with the sketch of the failure and the proposed repair arranged side by side for comparison. The remaining items, which are mainly descriptive, are all presented on supplementary standard sheets entitled 'Additional Notes'.

Where possible, only one set of Additional Notes has been included, relating to a number of examples of failure within any structural group in order to avoid repetition.

The Catalogue of Structural Detail Failures

The catalogue is included in this Appendix. It is emphasised that this catalogue has been based almost entirely on the data submitted by Forum members and cannot, therefore, be considered a comprehensive list of all types of structural failures occurring on tankers. Furthermore, the proposed repairs reflect only the members' general experiences and cannot be taken as firm guidelines applicable in all cases. When considering individual cases of failure and the appropriate repair method, it is believed the catalogue will provide valuable guidance. In some cases, depending on the circumstances, more economic repair methods may be available. However, in each case the repairs should be completed to the satisfaction of the Owner's representative and the Classification Surveyor.

A list of the 14 structural groups is included, and also a complete index of all the failure examples and associated notes within each structural group. In addition, Group 0 has been included which provide guidance applicable together with cases shown in the other groups, as indicated in each case, or as a general guidance.

Standard Format Sheet

1. **Sketch of detail failure.** Each sketch shows a typical example of the failure concerned. Scantlings and actual dimensions have been excluded to make the application general.

2. **Sketch of the proposed repair.** This sketch illustrates and describes briefly the repair proposed, adopting shading to highlight renewed structure and reinforcements. These proposed repairs do not in all cases coincide with the actual repairs submitted by the Forum members, particularly where insufficient service experience has been accumulated. They do, however, reflect the combined judgement of the project members. The references to Group 0 are for guidance only and may not apply directly in all cases.

3. **Factors contributing to damage.** These factors are numbered for reference purposes only, and this numbering does not imply any order of importance. In any particular case, not all these factors may be present and their relative importance can vary from case to case. The purpose of this list is to assist in looking for probable causes of failure in any particular instance.

Supplementary Standard Format Sheet (Additional Notes)

1. **Repair Notes.** This section includes more detailed recommendations relating to the proposed repair method which cannot be included on the repair sketch.

2. **Alternative Repairs.** In some cases, it has been found appropriate to include an alternative repair to that proposed on the first standard format sheet. The choice of repair in each case will depend upon the failure and the actual structural arrangements.

3. **Unsuccessful Repairs.** Where it is known that a particular repair has been attempted and subsequently found to be unsuccessful this has been noted.

4. **New Construction.** Although the catalogue relates directly only to detail failures found in service and corresponding repair methods, these failures provide valuable information which should be considered in developing new designs. The detail repair methods proposed will not necessarily be appropriate or cost effective for a new building and, therefore, a list of general recommendations are given for guidance in order to highlight unsatisfactory aspects of detail design.

Note in Connection with Revision of the Manual in 1995

Since the Manual was published in 1986 the experience with vessels with a higher utilisation of Higher Tensile Steels has increased and the need for improved detail design when such steels are utilised has become evident. This appendix has been revised in order to accommodate these changes.

Application of the Sketches

These sketches have been prepared for guidance only and are not necessarily drawn to scale therefore should not be copied directly. Repair of structural damages should be considered on an individual basis and approved by the appropriate Classification Society.

Note regarding Group 0

In Group 0 standard sketches showing design of structural details have been provided. It should be noted that these details are generally considered adequate for repairs. However, in special instances closer analysis by FEM or other means may be required. The Classification Society may also impose different requirements based on experience and result of calculations.

List of Structural Groupings

Group No.	Description of Structural Detail Group
0	Recommended design of bracket connections.
1	Connection of longitudinals to transverse webs.
2	Connection of longitudinals to plane transverse bulkheads.
3	Connection of longitudinals to corrugated transverse bulkheads.
4	Connection of longitudinals to floors in the double bottom.
5	Fore peak structure.
6	Longitudinal girder end brackets.
7	Transverse web frame end brackets.
8	Primary web face plate end connection.
9	Cross-ties and their end connections.
10	Transverse bulkhead horizontal stringer.
11	Transverse bulkhead stiffener/primary web intersection.
12	Lightening holes and openings in primary webs and swash bulkheads.
13	Bilge keel.
14	Miscellaneous.

Index of Structural Details

Group 0	Recommended Design of Bracket Connections	
Figure No.	Title	Figure No.
A	Web frame/side longitudinal, connection bracket.	A
B	Web frame/side longitudinal, connection bracket.	B
C	Web frame/side longitudinal, connection bracket/reverse side of tripping bracket.	C
D	Web frame/side longitudinal, web stiffener.	D
E	Web frame/side longitudinal, bracket toe, symmetrical flange plate.	E
F	Web frame/side longitudinal, bracket toe, asymmetrical flange plate.	F

Group 1	Connection of Longitudinals to Transverse Webs	
Example No.	Title	Figure No.
1	Web and flat bar fractures at cut-outs for longitudinal stiffener connections.	1
2	Side shell fractures at cut-outs for longitudinal stiffener connections.	2
3	Side shell fractures as example no. 2 but due to single lug on underside.	3
4	Web and flat bar fractures as example no. 1 but with face plate attached to underside of web. Flat bar lap welded.	4
5	Web and longitudinal fractures. Face plate attached to underside of web. Flat bar lap welded.	5
6	Web and flat bar fractures as example no. 1 but with face plate attached to underside of web. Flat bar butt welded.	6
7	Web and longitudinal fractures. Face plate attached to underside of web. Flat bar butt welded.	7
8	Fractured side shell longitudinal at tripping bracket connection. No backing bracket.	8
9	Fractured side shell at tripping bracket. Backing bracket too small.	9
10	Bottom web and flat bar fractures at the cut-out for the longitudinal connections.	10
1–10	Additional notes.	11–12

Group 2	Connection of Longitudinals to Plane Transverse Bulkheads	
Example No.	Title	Figure No.
1	Fractured side shell longitudinal. Bulkhead horizontally stiffened.	13
2	Fractured bulkhead end bracket at side shell. Bulkhead horizontally stiffened.	14
3	Fractured side shell longitudinal at forward transverse bulkhead.	15
4	Fractured side shell longitudinal at transverse bulkhead buttress.	16
1–4	Additional notes.	17

Group 3	Connection of Longitudinals to Corrugated Transverse Bulkheads	
Example No.	Title	Figure No.
1	Bulkhead fractured at toe of horizontal flat bar stiffener. Vertically corrugated bulkhead.	18
1	Additional notes.	18
2	Bulkhead fractured at passage of side longitudinal. Bulkhead horizontally corrugated.	19
2	Additional notes.	20

Group 4	Connection of Longitudinals to Floors in the Double Bottom	
Example No.	Title	Figure No.
1	Fractured stiffener connection to bottom and inner bottom longitudinals.	21
1	Additional notes.	21

Group 5	Fore Peak Structure	
Example No.	Title	Figure No.
1	Fractured vertical web at longitudinal stiffener ending in way of the parabolic bow structure.	22
2	Fractured stringer end connection in way of the parabolic bow structure.	23
3	Fracture at end of longitudinal at bow structure.	24
4	Fracture at toe of web frame bracket connection to stringer platform bracket.	25
5	Fractured and buckled bow transverse web frame in way of longitudinal cut-outs.	26
6	Buckled and tripped breasthooks.	27
3–6	Additional notes.	24–27

Group 6	Longitudinal Girder End Brackets	
Example No.	Title	Figure No.
1	Fractured bottom centreline girder at the end bracket connection to O.T. bulkhead.	28
2	Fractured and buckled buttress in way of bracket connection to O.T. bulkhead.	29
1–2	Additional notes.	28–29
3	Fractured vertical web bracket connection to bottom centreline girder.	30
3	Additional notes.	30
4	Buckled and fractured vertical web and bottom centreline girder bracket connection.	31
4	Additional notes.	31
5	Fractured bottom girder brackets in way of pipe opening.	32
5	Additional notes.	32
6	Fractured and buckled bottom side girder in way of end connection to O.T. bulkhead.	33
6	Additional notes.	33
7	Fractured intercostal bottom girder fitted without an end bracket in way of the wash bulkhead.	34
7	Additional notes.	34

Group 7	Transverse Web Frame End Brackets	
Example No.	Title	Figure No.
1	Fractured wing tank deck transverse bracket. Continuous face plate.	35
2	Fractured wing tank deck transverse bracket. Face plate sniped.	36
1–2	Additional notes.	37
3	Fractured centre tank bottom transverse end bracket. Asymmetrical face plate.	38
4	Fractured centre tank bottom transverse end bracket. Symmetrical face plate.	39
5	Fractured wing tank bottom transverse end bracket. Asymmetrical face plate.	40
3–5	Additional notes.	38–40

Group 8	Primary Web Face Plate End Connection	
Example No.	Title	Figure No.
1	Fractured centre tank deck transverse.	41
2	Fractured centre tank bottom transverse.	42
1–2	Additional notes.	43
3	Fractured centre girder at intersection with the bottom transverse.	44
3	Additional notes.	45

Group 9	Cross-Ties and Their End Connections	
Example No.	Title	Figure No.
1	Fractured and buckled web plate and fractured face plate.	46
1	Additional notes.	47

Group 10	Transverse Bulkhead Horizontal Stringer	
Example No.	Title	Figure No.
1	Fractured face plate and web at the radiused end brackets. Vertically corrugated bulkheads.	48
2	Fractured web of stringer at the radiused bracket in way of centreline vertical web.	49
1–2	Additional notes.	50
3	Fractured centre tank stringer bracket connection to the longitudinal bulkhead.	51
4	Fractured wing tank stringer bracket and side shell longitudinal.	52
4	Additional notes.	53
5	Fractured web of buttress at connection to shell.	54
5	Additional notes.	54
6	Fractured bulkhead in way of stringer bracket connection.	55

Group 11	Transverse Bulkhead Stiffener/Primary Web Intersection	
Example No.	Title	Figure No.
1	Fractured web at cut-outs for vertical stiffener.	56
1	Additional notes.	56
2	Fractured flat bar connection to vertical stiffener.	57
2	Additional notes.	57

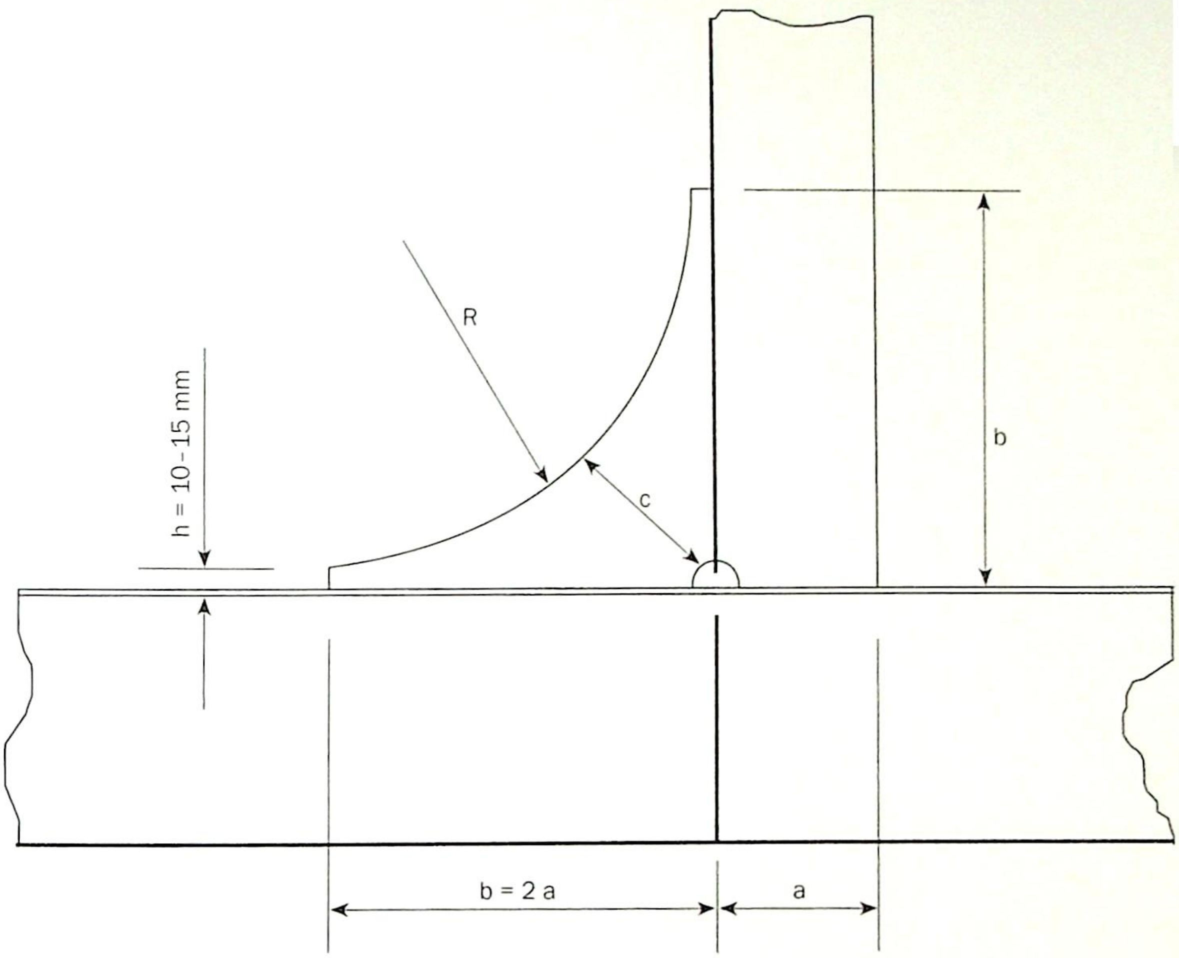
Group 12	Lightening Holes and Openings in Primary Webs and Swash Bulkheads	
Example No.	Title	Figure No.
1	Buckled and fractured centreline vertical web and stringer in way of intersection.	58
2	Fractures in way of lightening hole in stringer platform.	59
3	Fractured web of bottom transverse in way of lightening holes.	60
4	Fractures of longitudinal flume/swash bulkhead plating at openings.	61
5	Fracture at corner of flume opening in longitudinal bulkhead.	62
1–5	Additional notes.	58–62

Group 13	Bilge Keel	
Example No.	Title	Figure No.
1	Fracture in continuous bilge keel and ground bar.	63
2	Fracture in continuous bilge keel and flat bar.	64
3	Fracture in continuous scalloped flat bar for intermittent bilge keel.	65
1–3	Additional notes.	63–65

Group 14	Miscellaneous	
Example No.	Title	Figure No.
1	Shell fracture at sniped ends of bilge longitudinals.	66
1	Additional notes.	67
2	Fractured butt welds in shell and bottom longitudinals.	68
2	Additional notes.	68
3	Fractures in bottom plating in way of drainage openings.	69
4	Fractures in docking brackets.	70

GROUP No. 0 (Refer to index on Page 177)	*Typical location: Web Frame/Side Longitudinal*
	Detail type: Connection Bracket

Recommended Design



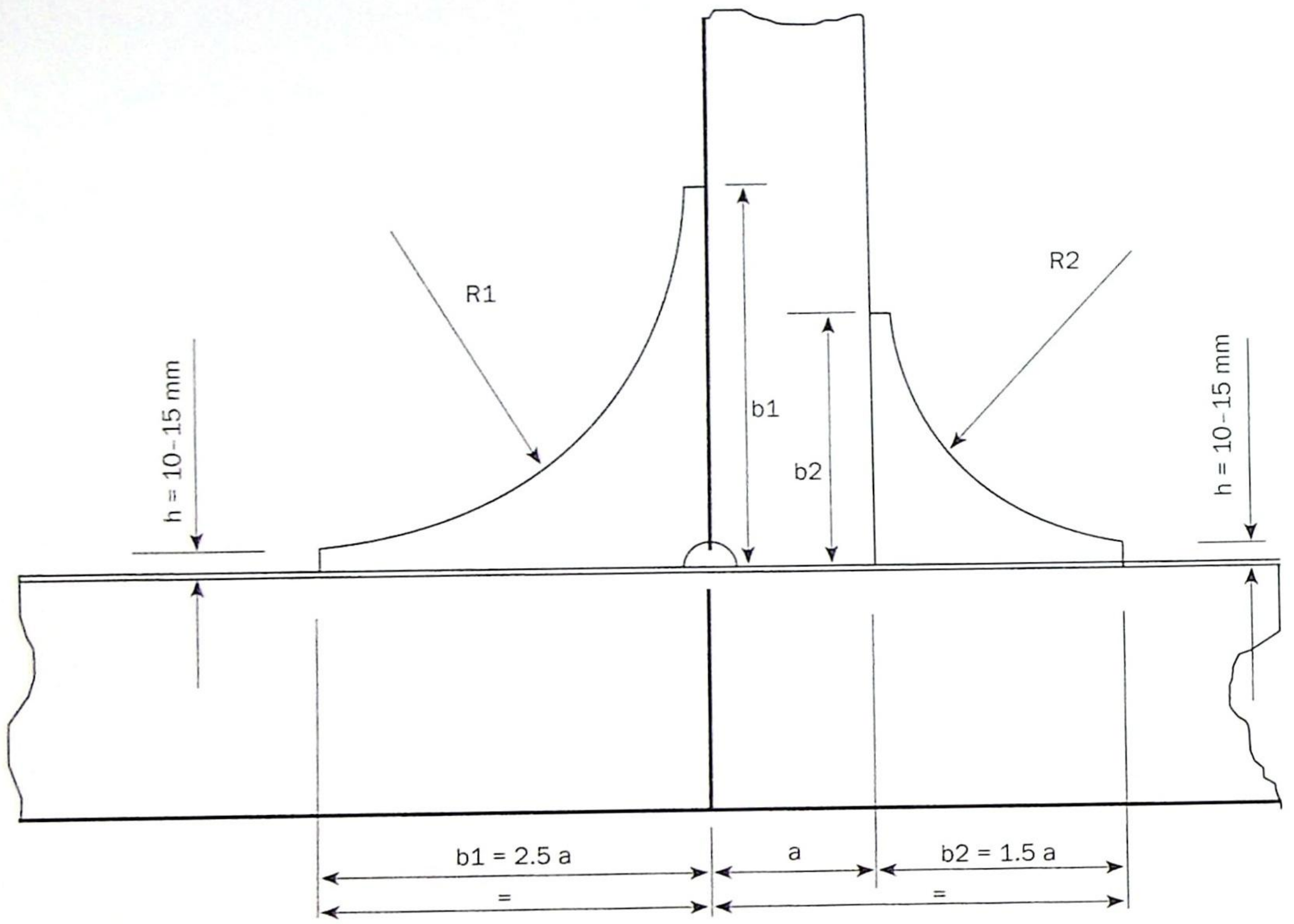
NOTES

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. 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.
6. Toe height to be as small as possible (10–15 mm).
7. If necessary 'b' is to be increased to obtain cross section of bracket at 'c' equivalent to that of the stiffener.

Figure A:	*Catalogue of Structural Details*

GROUP No. 0 (Refer to index on Page 177)	*Typical location:* *Web Frame/Side Longitudinal*
	Detail type: *Connection Bracket*

Recommended Design



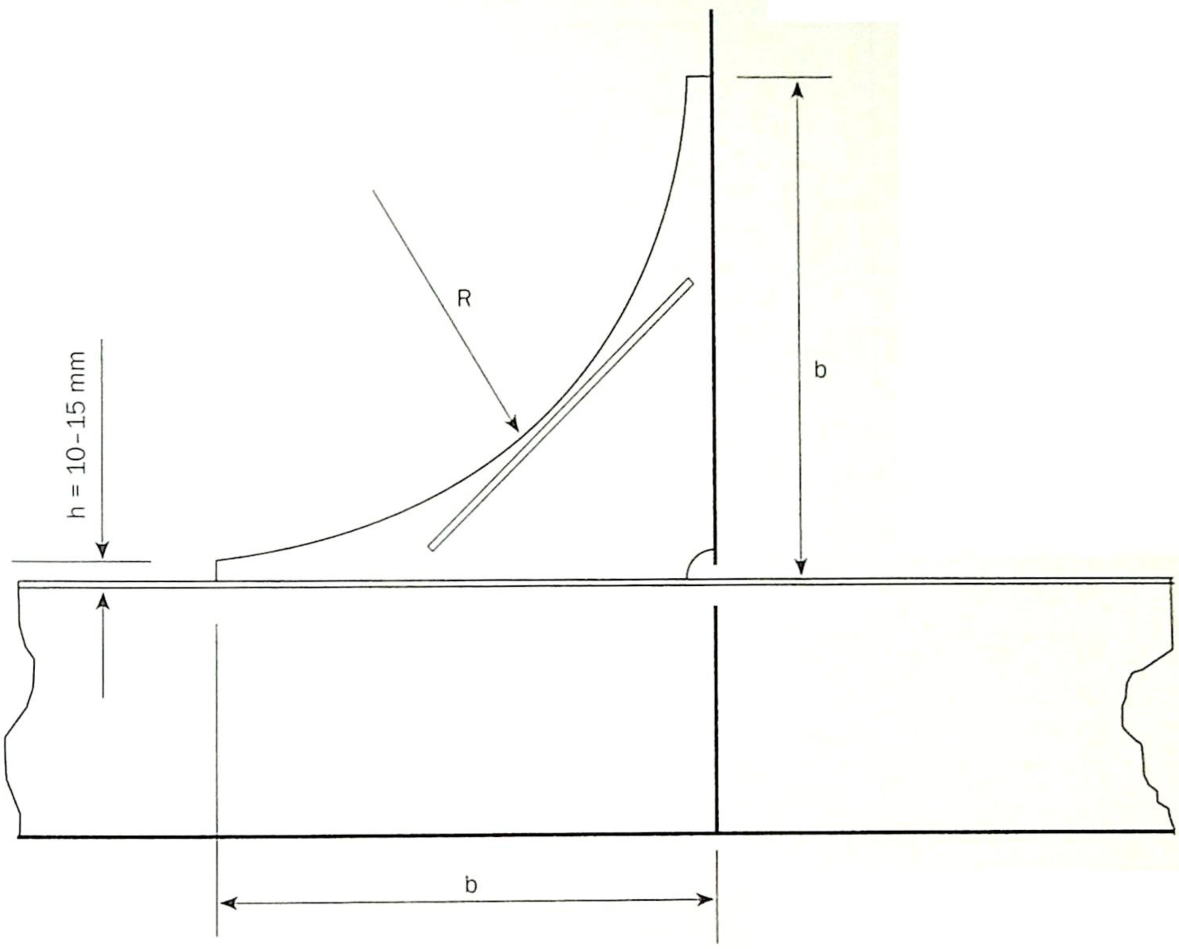
NOTES

1. For a slope at toes max. 1:3, R1 = (b1 - h) × 1.6 and R2 = (b2 - 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. 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.
6. Toe height to be as small as possible (10–15 mm).

Figure B:	*Catalogue of Structural Details*

GROUP No. 0 (Refer to index on Page 177)	*Typical location: Web Frame/Side Longitudinal*
	Detail type: Connection Bracket/Reverse Side of Tripping Bracket

Recommended Design



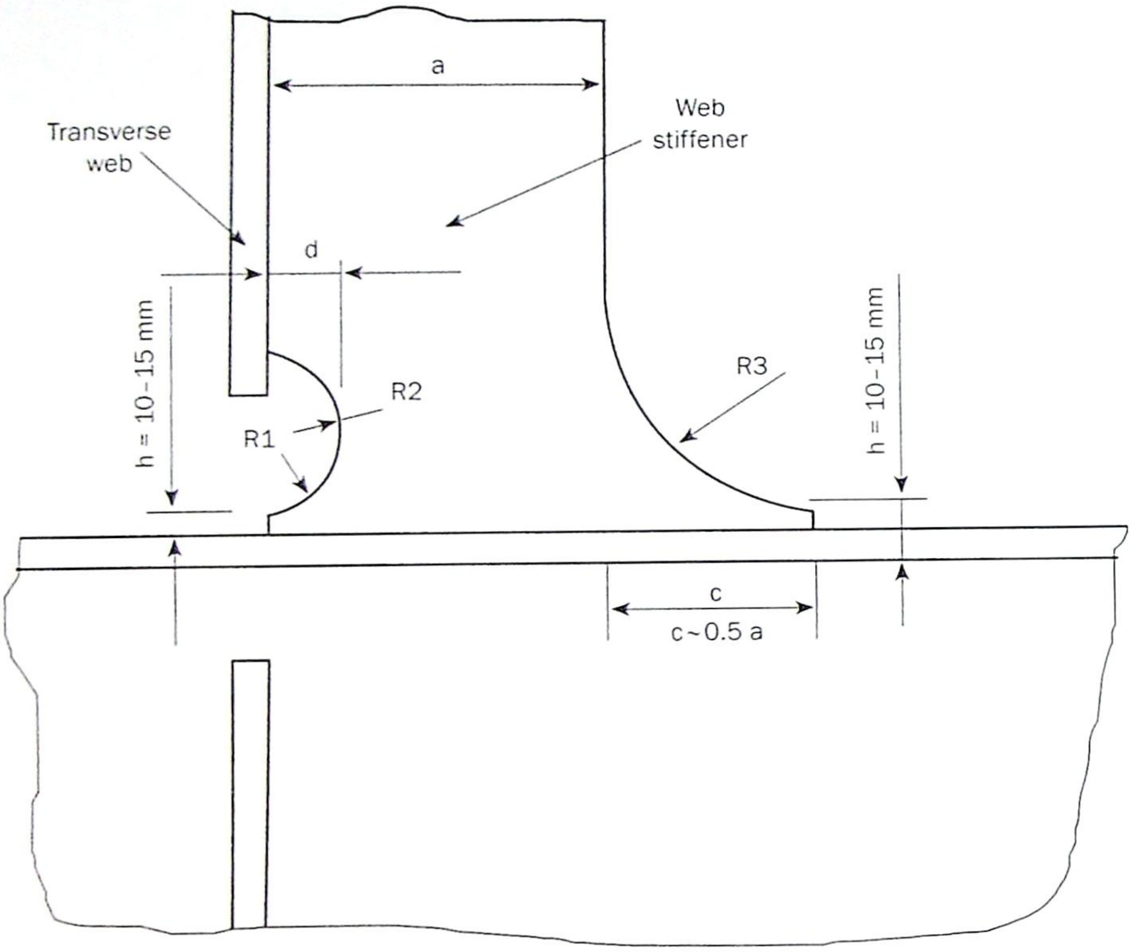
NOTES

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. If toes of brackets are ground smooth, full penetration welds in way to be provided.
5. Toe height to be as small as possible (10–15 mm).
6. Maximum length/thickness ratio of unsupported bracket edge 50:1. Edge stiffener to be sniped.

Figure C: *Catalogue of Structural Details*

GROUP No. 0 *(Refer to index on Page 177)*	*Typical location: Web Frame/Side Longitudinal*
	Detail type: Web Stiffener

Recommended Design



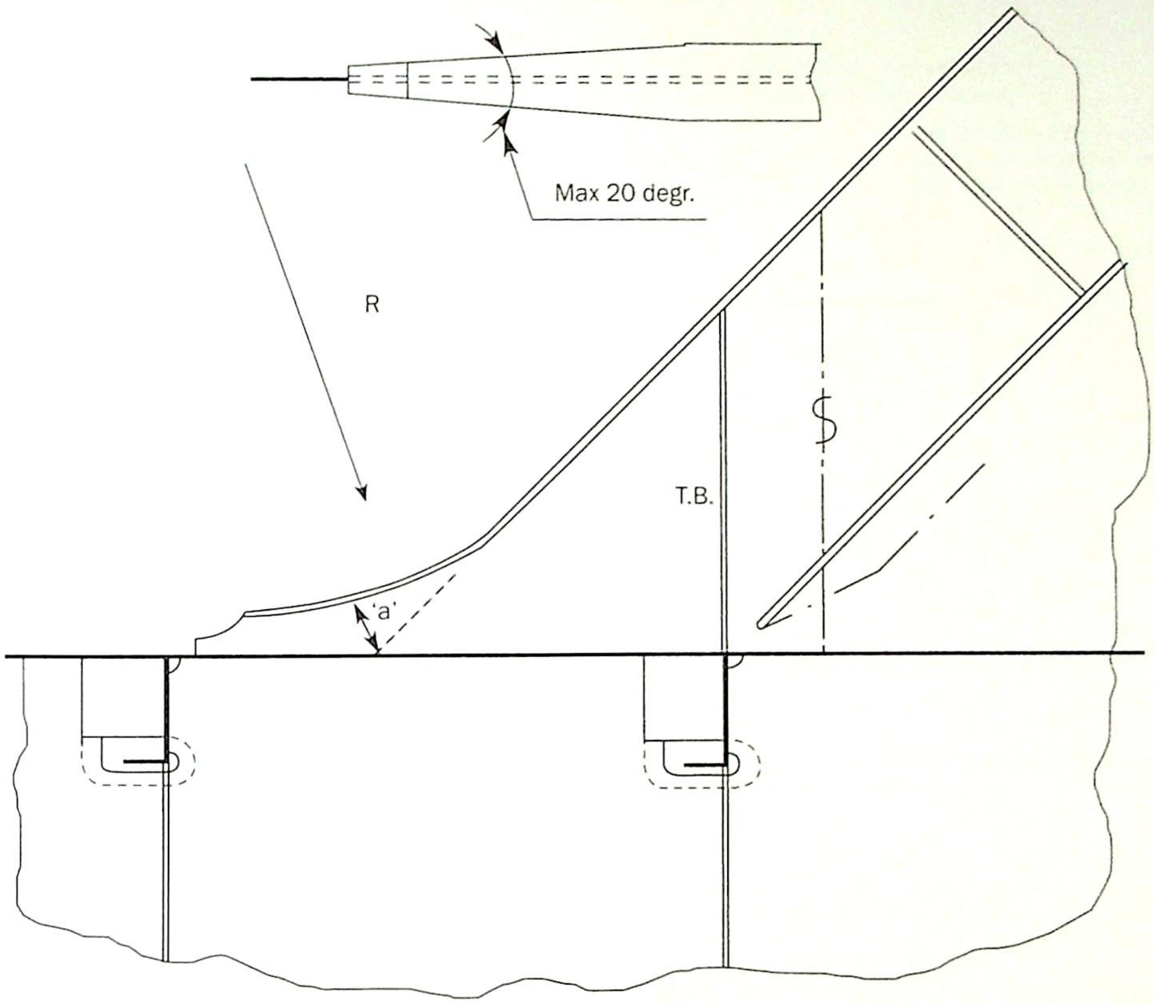
NOTES

1. Toe height as small as possible (h = 10–15 mm).
2. For a slope at toe max. 1:3, R1 = 1.5 × d and R3 = 1.5 × c.
3. Depth 'd' of key hole notch as small as possible, max. 30 mm.

Figure D:	*Catalogue of Structural Details*

GROUP No. 0 (Refer to index on Page 177)	*Typical location: Web Frame/Side Longitudinal*
	Detail type: Bracket Toe, Symmetrical Flange Plate

Recommended Design



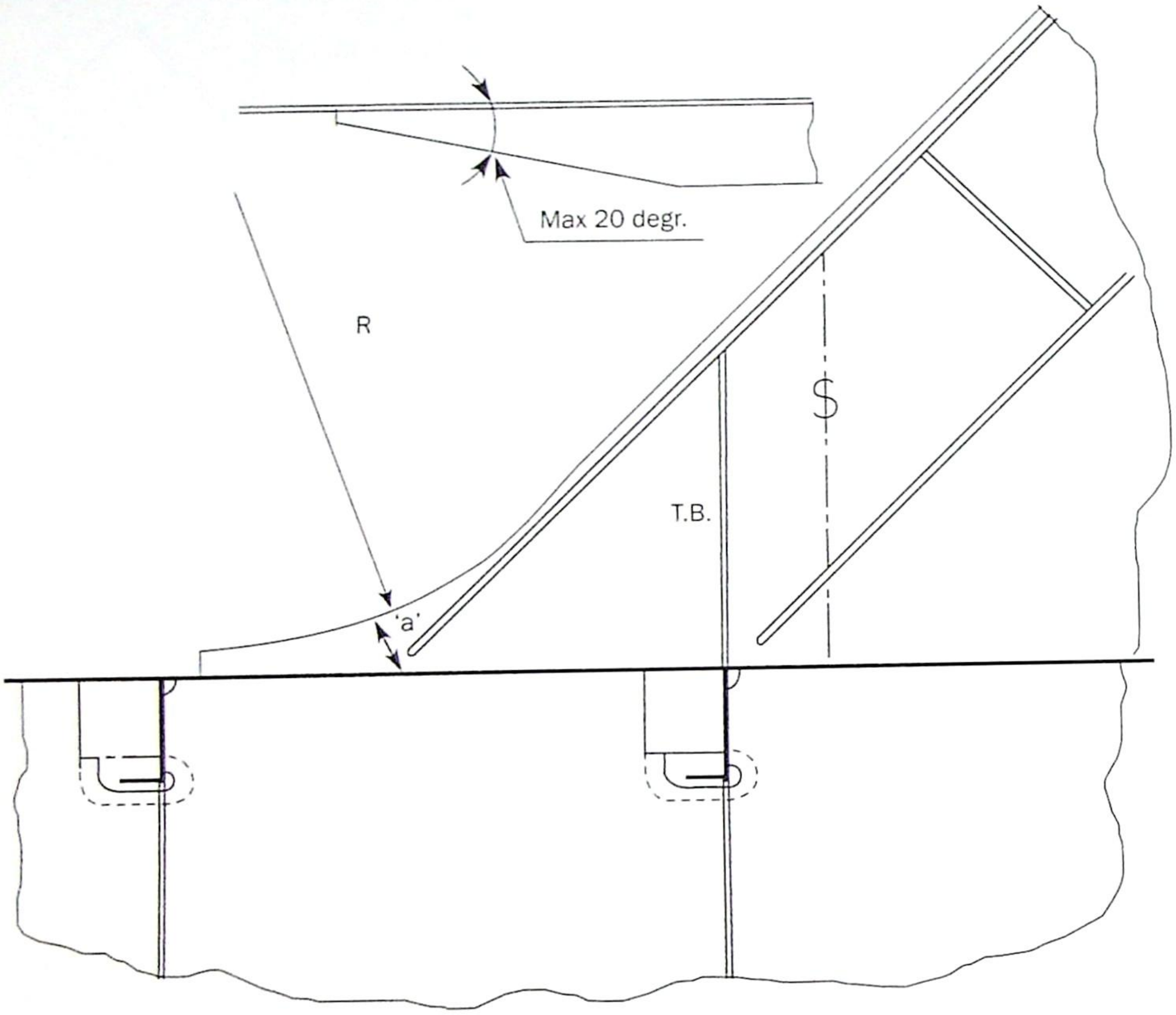
NOTES

1. Face plate should be tapered with a total angle of 20 degree or less (i.e. taper 1:3).
2. Breadth of face plate at tip should be as small as possible (approx. t + 20 mm, t= toe thickness).
3. Face plate tip should be tapered in thickness down to 10 mm with a max slope of 1:3.
4. Toe of web should be of increased thickness.
5. Toe height should be as small as possible (10–15 mm).
6. Toe cross sectional area, ref. measure 'a' should be approx. 60% of flange cross sectional area.
7. Welds connecting toe web to plating and to face plate to be full penetration over the length of the snipe or radiused part, whichever is greater, and grinding flush of toe recommended.
8. Tripping bracket should be fitted as indicated to reduce flexing of the bracket and face plate.
9. 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.
11. Correct alignment of bracket with web on the other side is essential.

Figure E: *Catalogue of Structural Details*

GROUP No. 0 (Refer to index on Page 177)	*Typical location:* Web Frame/Side Longitudinal
	Detail type: Bracket Toe, Asymmetrical Flange Plate

Recommended Design



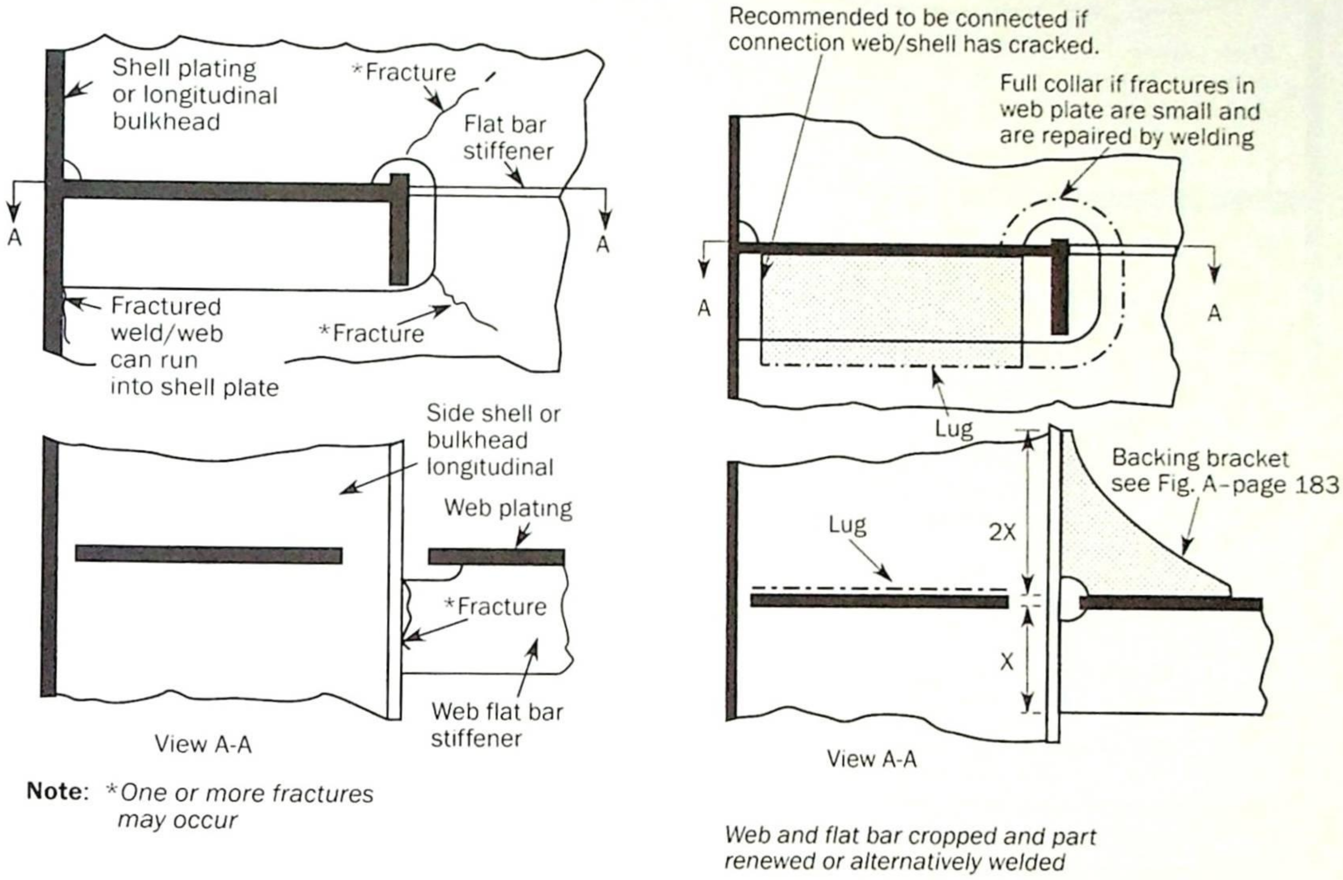
NOTES

1. Face plate should be tapered with a total angle of 20 degree or less (i.e. taper 1:3).
2. Face plate toe to be as small as possible (10–15 mm).
3. Toe of web should be of increased thickness.
4. Toe height should be as small as possible (10–15 mm).
5. Toe cross sectional area, ref. measure 'a' should be approx. 60% of flange cross sectional area.
6. Welds connecting toe web to plating and to face plate to be full penetration over the length of the snipe or radiused part whichever is greater and grinding flush of toe recommended.
7. Tripping bracket should be fitted as indicated to reduce flexing of the bracket and face plate.
8. Collar plates welded to the plating should be fitted in way of toe. Tip of toe clear of cut-outs.
9. Slope of toe to be max 1:3 at face plate end.
10. Correct alignment of bracket with web on the other side is essential.

Figure F:	*Catalogue of Structural Details*

GROUP No. 1 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Transverse Webs*
	Example No. 1: Web and Flat Bar Fractures at Cut-outs for Longitudinal Stiffener Connections

Typical Damage	*Proposed Repair*



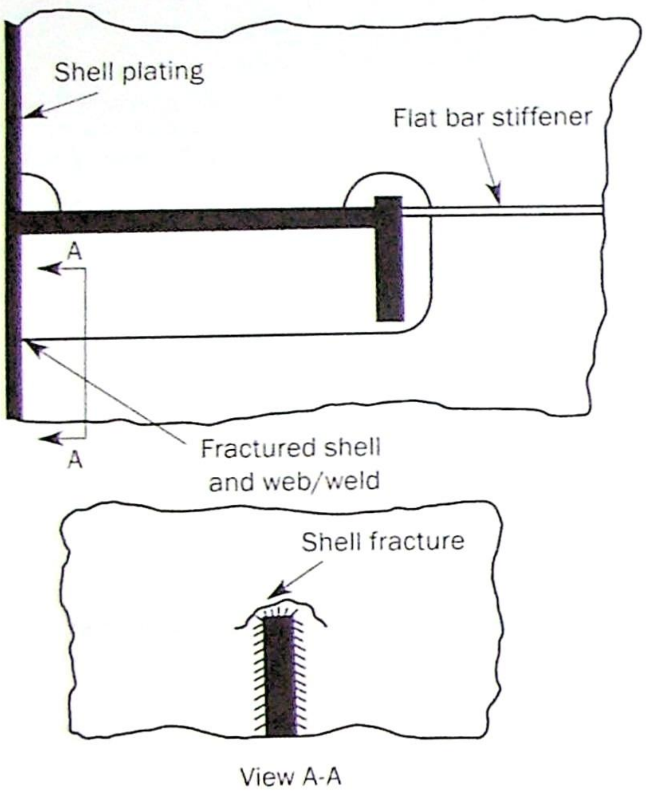
FACTORS CONTRIBUTING TO DAMAGE

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.

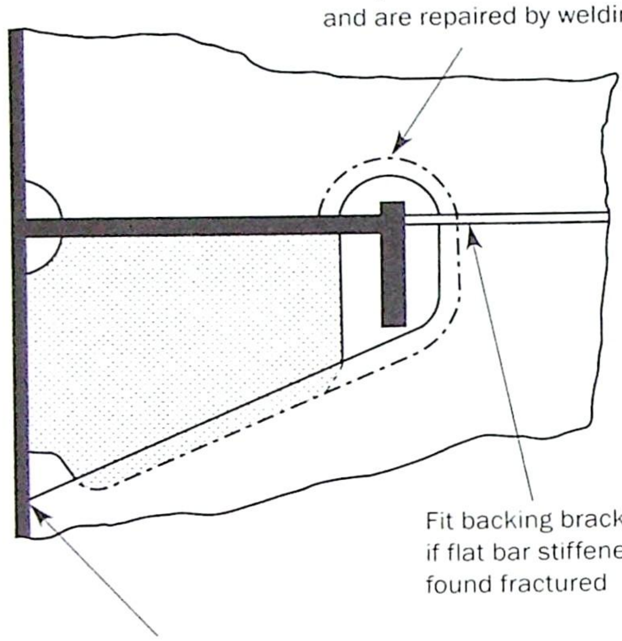
Figure 1:	*Catalogue of Structural Details*
1 of 12	

GROUP No. 1 (Refer to index on Page 178)	Location: Connection of Longitudinals to Transverse Webs
	Example No. 2: Side Shell Fractures at Cut-outs for Longitudinal Stiffener Connections

Typical Damage	Proposed Repair



Note: *Fractures initiate at inner surface of shell and propagate through to outer surface*



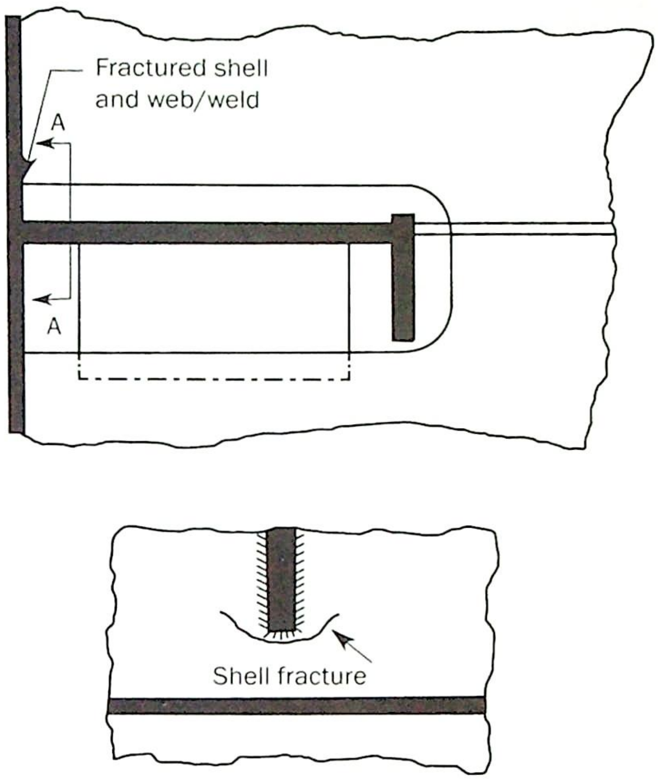
Shell plate cropped and part renewed.
Alternatively where fractures are small they may be repaired by welding (see additional notes under 'alternative repairs', 2.3)

FACTORS CONTRIBUTING TO DAMAGE

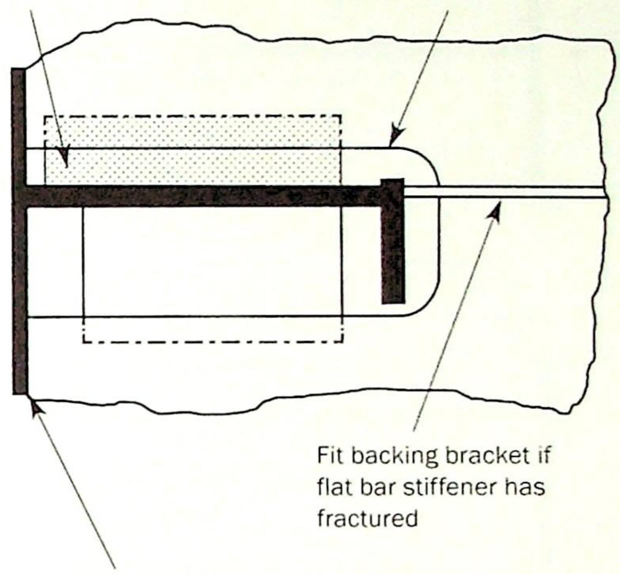
1. Insufficient area of connection of longitudinal to web plates.
2. Defective weld at return around the plate thickness.
3. Localised corrosion associated with the stress concentrations in way of the longitudinal connection of web to shell.
4. Dynamic sea way loads/ship motions.
5. High shear stress in the transverse web.

Figure 2:	*Catalogue of Structural Details*
2 of 12	

GROUP No. 1 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Transverse Webs*	
	Example No. 3: Side Shell Fractures as Example No. 2 but Due to Single Lug on Underside	
	Typical Damage	*Proposed Repair*



View A-A



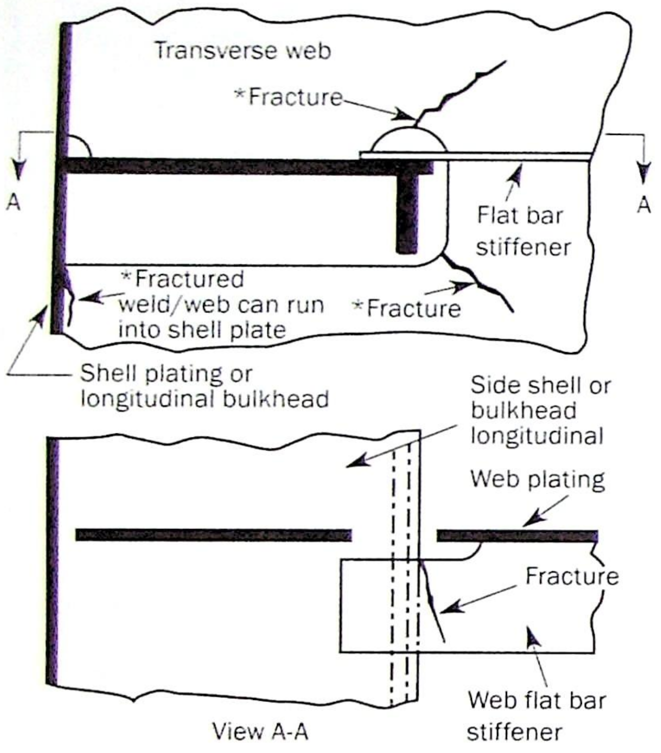
FACTORS CONTRIBUTING TO DAMAGE

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.

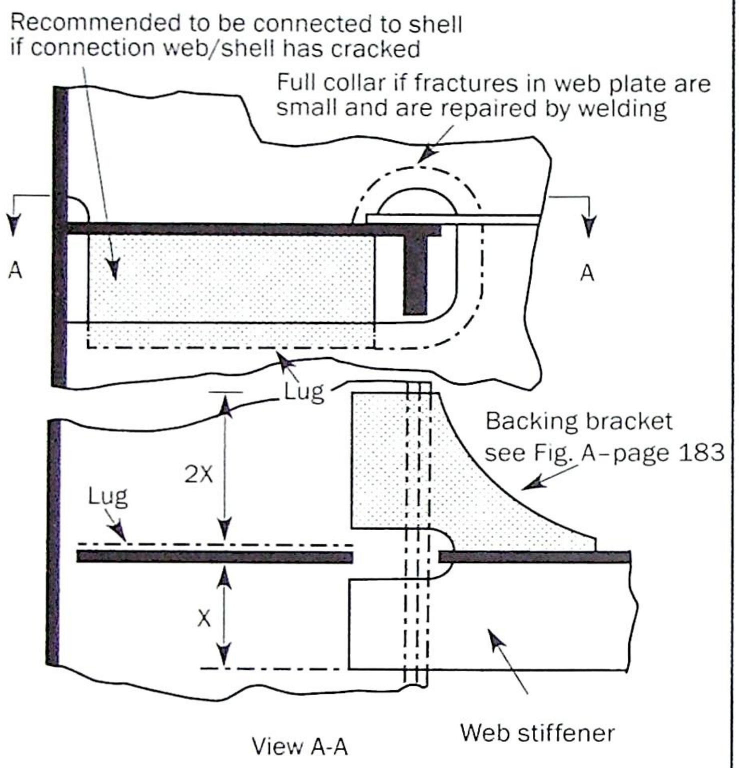
Figure 3:	*Catalogue of Structural Details*
3 of 12	

GROUP No. 1 *(Refer to index on Page 178)*	*Location: Connection of Longitudinals to Transverse Webs*
	Example No. 4: Web and Flat Bar Fractures as Example No. 1 but with Face Plate Attached to Underside of Web. Flat Bar Lap Welded

Typical Damage	*Proposed Repair*



Note: **One or more fractures may occur*



Longitudinal cropped and part renewed, web and flat bar cropped and part renewed or welded

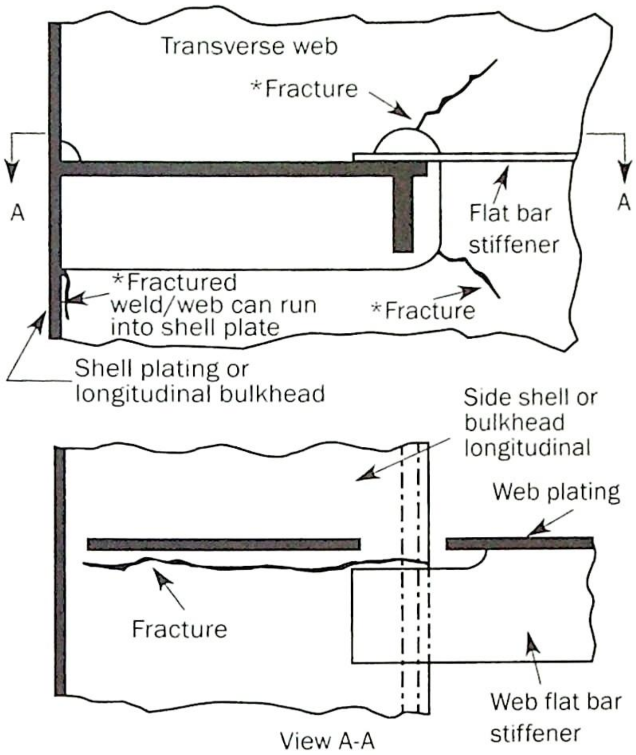
FACTORS CONTRIBUTING TO DAMAGE

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.

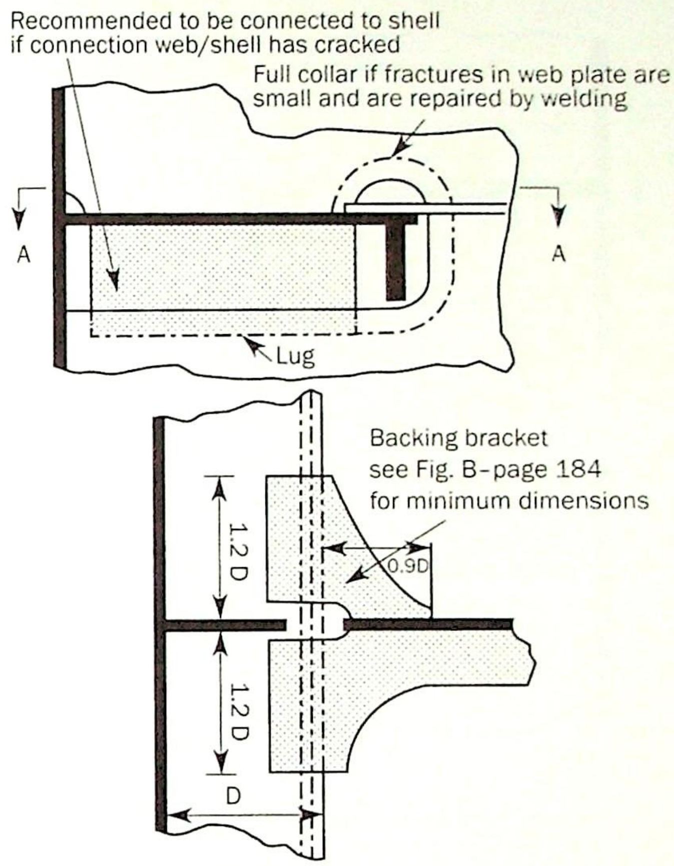
Figure 4:	*Catalogue of Structural Details*
4 of 12	

GROUP No. 1 (Refer to index on Page 178)	*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

Typical Damage	*Proposed Repair*



Note: **One or more fractures may occur*



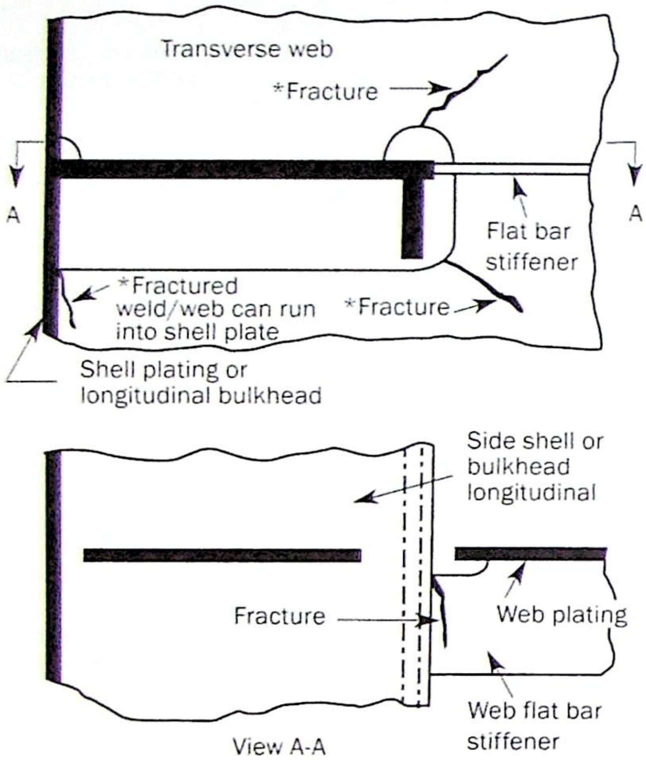
FACTORS CONTRIBUTING TO DAMAGE

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.

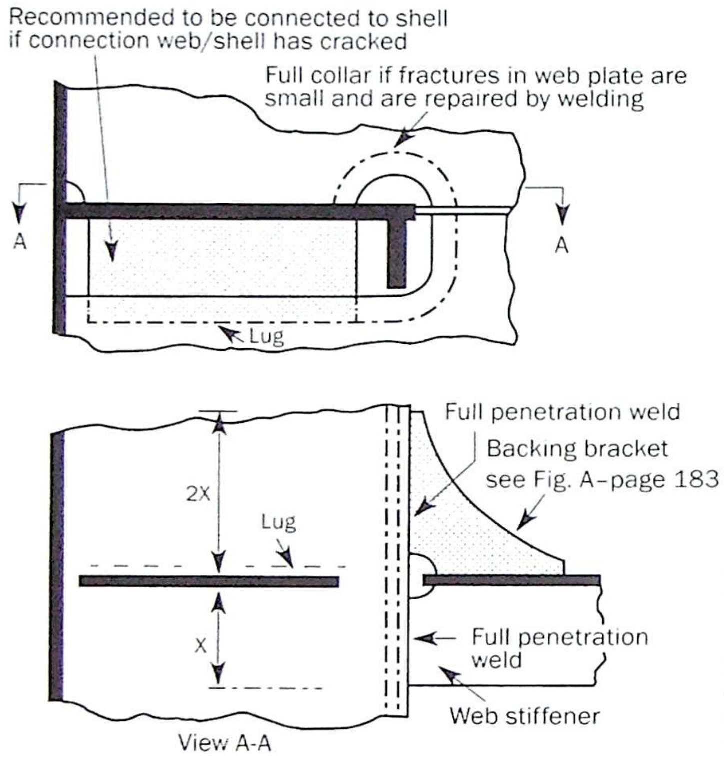
Figure 5:	*Catalogue of Structural Details*
5 of 12	

GROUP No. 1 *(Refer to index on Page 178)*	*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 Underside of Web. Flat Bar Butt Welded

Typical Damage	*Proposed Repair*



Note: **One or more fractures may occur*



Longitudinal cropped and part renewed, web and flat bar cropped and part renewed or welded

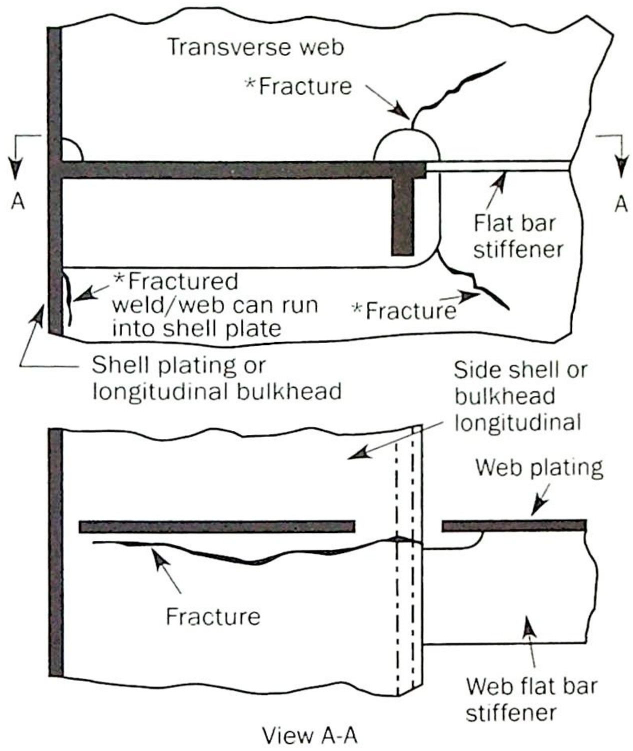
FACTORS CONTRIBUTING TO DAMAGE

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.

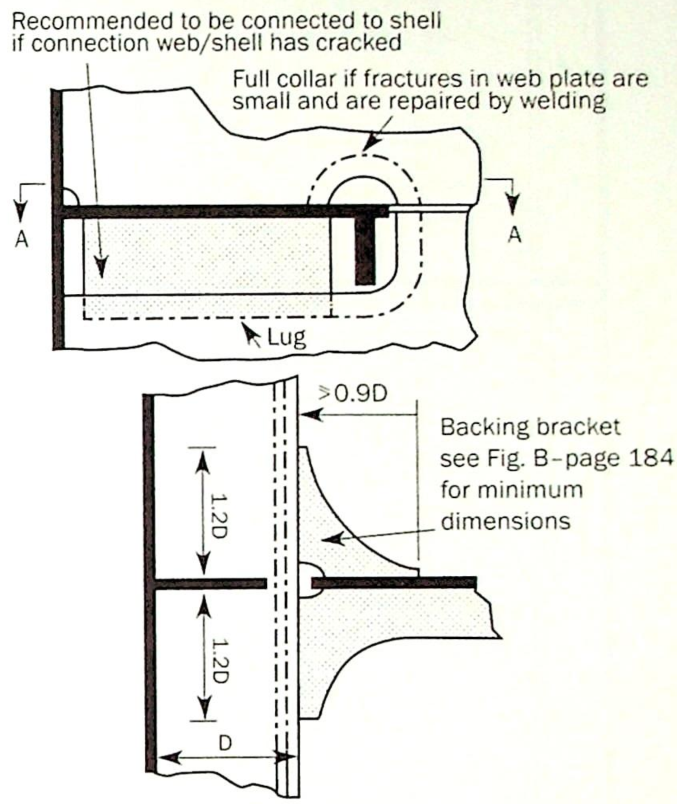
Figure 6:	*Catalogue of Structural Details*
6 of 12	

GROUP No. 1 (Refer to index on Page 178)	*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

Typical Damage	*Proposed Repair*



Note: **One or more fractures may occur*



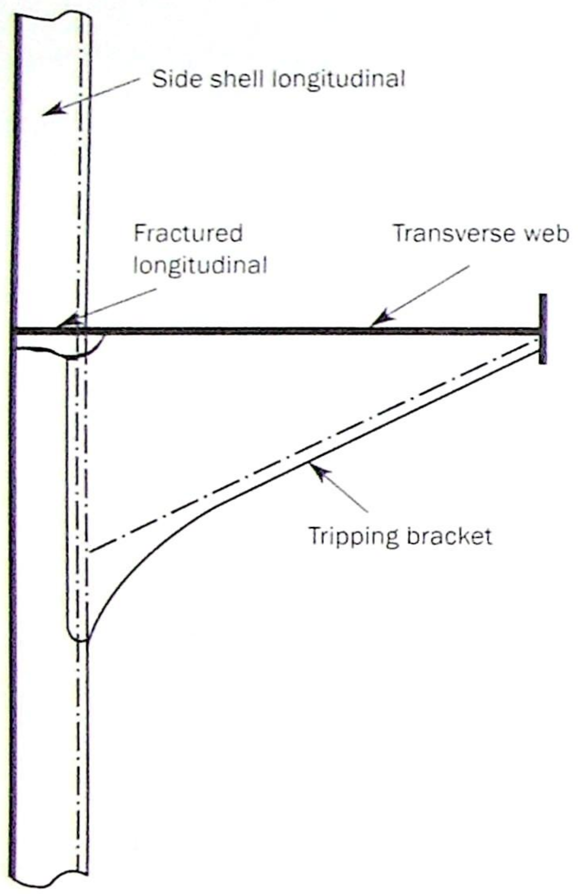
FACTORS CONTRIBUTING TO DAMAGE

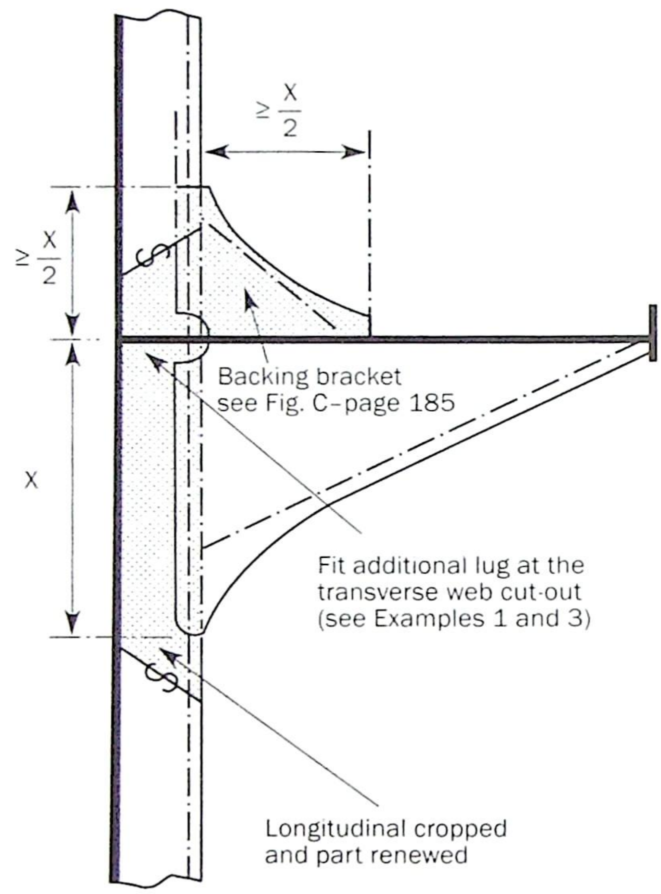
1. Asymmetrical connection of flat bar stiffener resulting in high peak stresses at the heel of the stiffener under fatigue loading.
2. Higher tensile steel longitudinal resulting in greater stresses.
3. Fabricated longitudinal with welding onto the exposed edge of the web resulting in poor fatigue strength 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.

Figure 7:	*Catalogue of Structural Details*
7 of 12	

GROUP No. 1 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Transverse Webs*
	Example No. 8: Fractured Side Shell Longitudinal at Tripping Bracket Connection. No Backing Bracket

Typical Damage	*Proposed Repair*





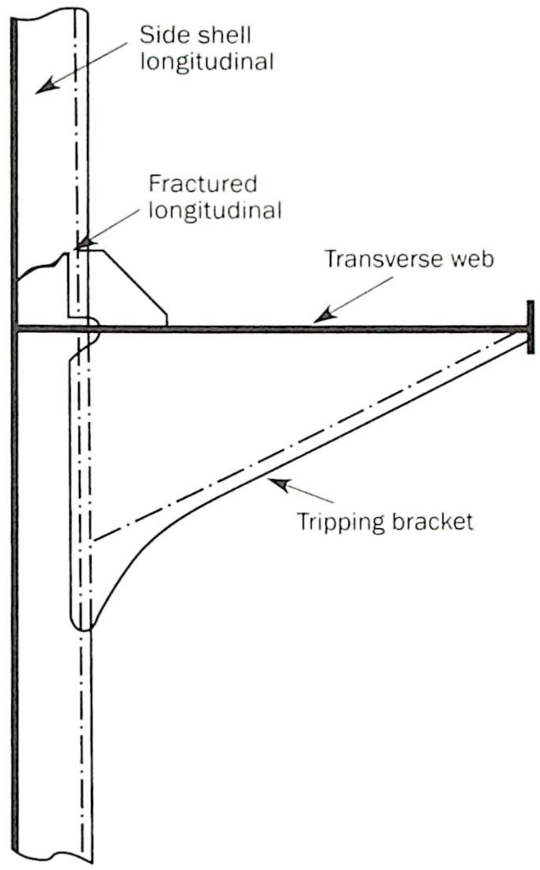
FACTORS CONTRIBUTING TO DAMAGE

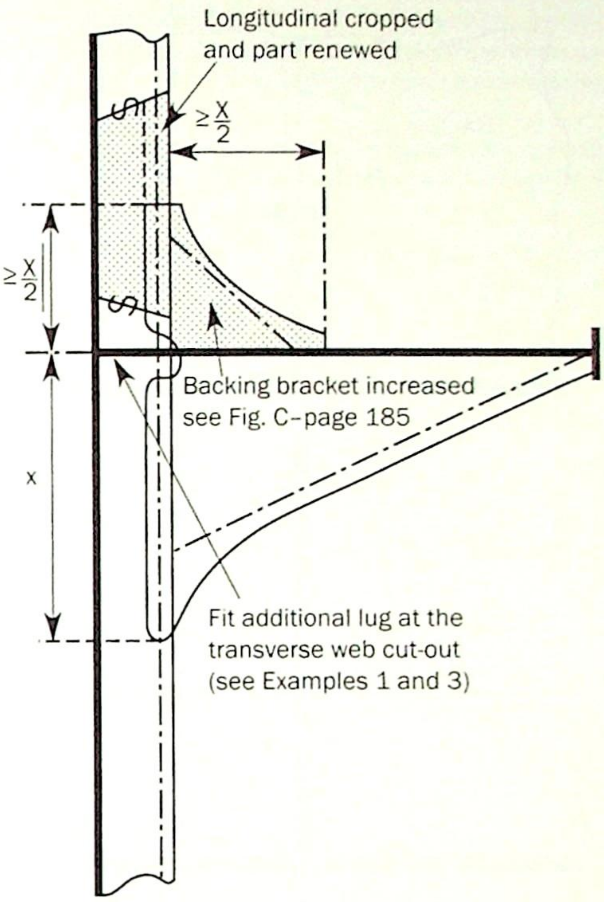
1. Asymmetrical connection of bracket resulting in high peak stresses at the heel of the single large bracket under fatigue loading.
2. Higher tensile steel longitudinal resulting in greater stresses.
3. Fabricated longitudinal having the face plate attached to the underside of the web (where fitted) 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. See Examples Nos. 4 and 5.
4. Asymmetric longitudinals resulting in additional torsional stresses.
5. Defective weld at return around the plate thickness.
6. Increased stress if only a single connection is employed in way of the transverse web cut-outs. See Examples Nos. 1 and 3.
7. Dynamic sea way loads/ship motion.

Figure 8:	*Catalogue of Structural Details*
8 of 12	

GROUP No. 1 (Refer to index on Page 178)	Location: Connection of Longitudinals to Transverse Webs
	Example No. 9: Fractured Side Shell at Tripping Bracket. Backing Bracket too Small

Typical Damage	Proposed Repair





FACTORS CONTRIBUTING TO DAMAGE

1. Asymmetrical connection of bracket in association with a backing bracket that is too small. This results in high stress at the toe of the smaller bracket under fatigue loading.
2. Higher tensile steel side 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. See Example No. 4.
4. Asymmetric longitudinals resulting in additional torsional stresses.
5. Defective weld at return around the plate thickness.
6. Increased stress if only a single connection is employed in way of the transverse web cut-outs. See Examples Nos. 1 and 3.
7. Dynamic sea way loads/ship motion.

Figure 9:	Catalogue of Structural Details
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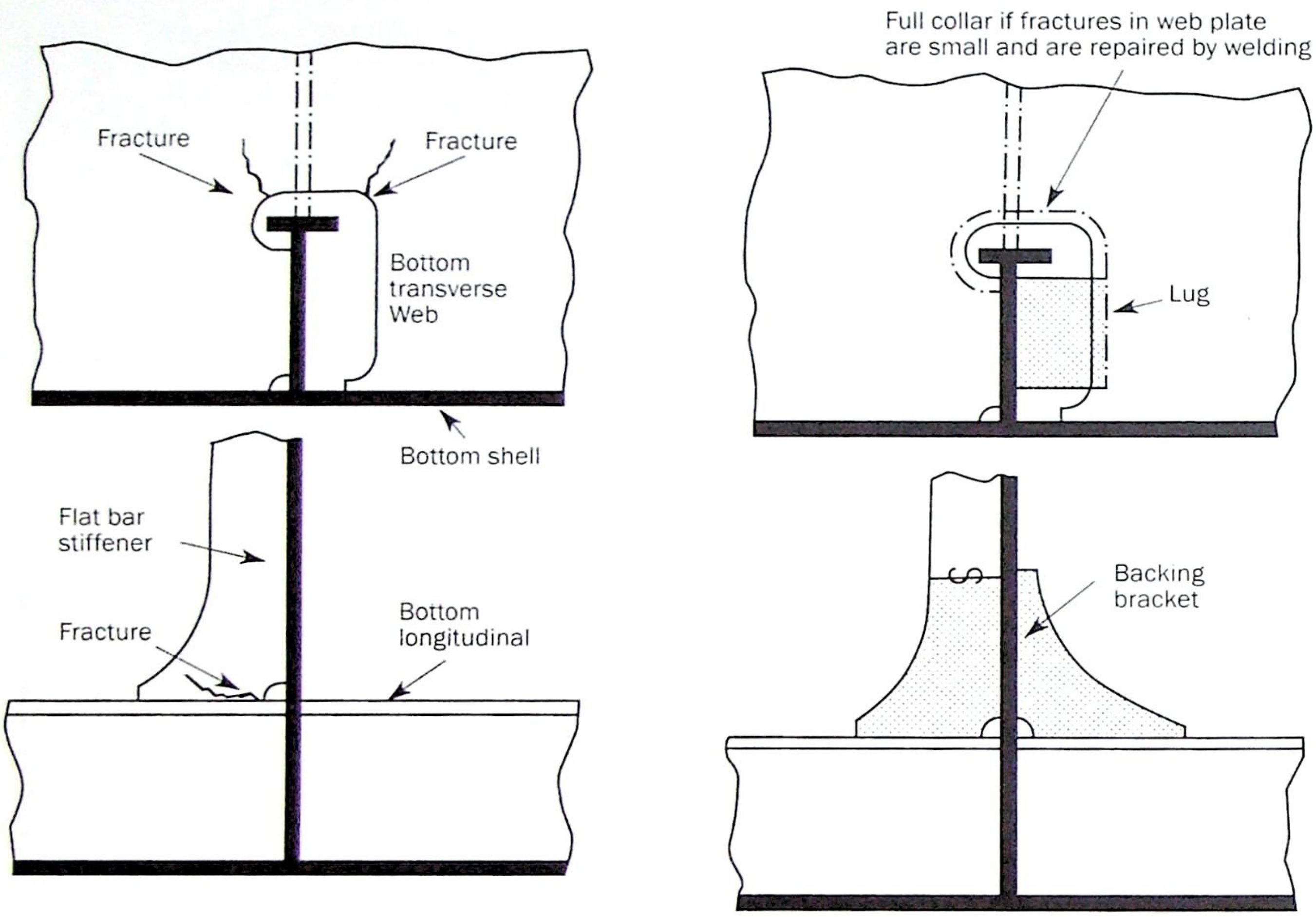
GROUP No. 1 (Refer to index on Page 178)	Location: Connection of Longitudinals to Transverse Webs
	Example No. 10: Bottom Web and Flat Bar Fractures at the Cut-out for the Longitudinal Connections

Typical Damage	Proposed Repair



FACTORS CONTRIBUTING TO 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.

Figure 10:	Catalogue of Structural Details
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GROUP No. 1 (Refer to index on Page 178)	Location: Connection of Longitudinals to Transverse Webs
	Example No.: 1 Through 10

Additional Notes

1. **REPAIR NOTES**

1. Fractured web plates and flat bar stiffeners are generally cropped and part renewed. Smaller fractures may be repaired by welding after the ends of the fractures have been located by NDT (and optionally stop drilled). In some instances it may be necessary for welds to be ground flush and checked by NDT. A full collar should be fitted to remove stress concentration associated with the cut-out corners.

1.2 Larger shell plating fractures will normally be repaired by cropping and part renewing. Where smaller fractures are welded, the fracture should be gouged out, with the ends located by dye penetrant. Internal structural details contributing to the fractures must be dealt with. The quality of the welding should be checked by NDT.

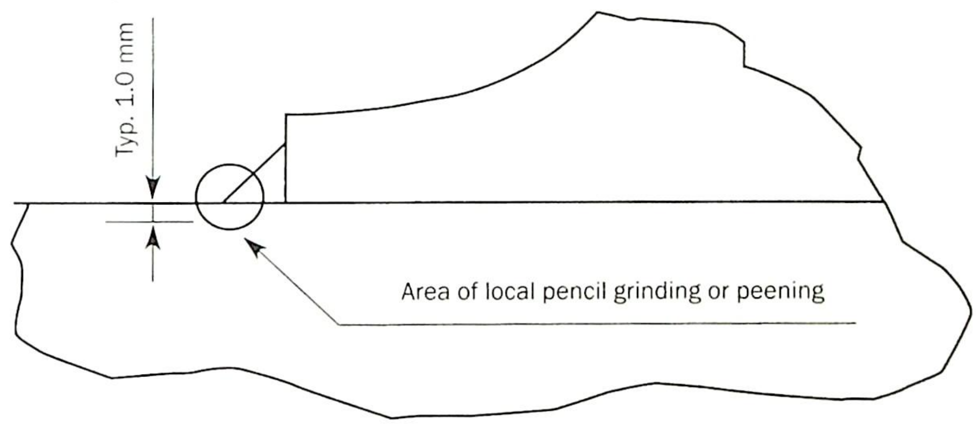
1.3 Fractured longitudinals should be cropped and part renewed. However, welding may be considered where peak stress location is changed due to the fitting of additional/larger bracket provided that a proper weld is possible. The quality of the welding should be checked by NDT.

1.4 The connection of the additional lug to the longitudinal should be as long as possible consistent with obtaining good access around the lug for welding.

1.5 Backing brackets should be of the indicated standard design or equivalent.

1.6 Particular attention should be paid to quality of welding, especially at return of welds around plate thicknesses.

1.7 Grinding or peening of welds at toes and corners will improve fatigue life.



1.8 To improve welding, square corners on lapped lug connections in highly stressed areas should be avoided.

2. **ALTERNATIVE REPAIRS**

2.1 If the flat bar stiffener requires to be cropped and part renewed, this may be replaced by a bracket incorporating a soft nose at the longitudinal together with the recommended backing bracket.

2.2 Where the transverse web plate requires part renewal in way of the cut-out a larger radius may be incorporated into the corner of the cut-out to reduce the stress concentration.

2.3 In Example No. 2 where the shell fractures are repaired by welding in accordance with 1.2, the lower edge of the web cut-out may not require to be modified and a smaller lug may be fitted.

Figure 11:	Catalogue of Structural Details
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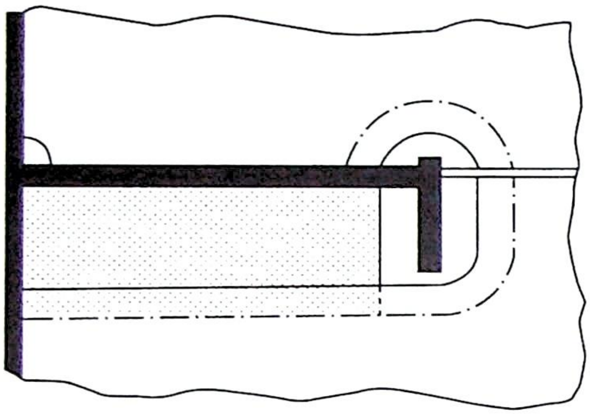
GROUP No. 1 (Refer to index on Page 178)	Location: Connection of Longitudinals to Transverse Webs
	Example No.: 1 Through 10

Additional Notes

ALTERNATIVE REPAIRS FOR EXAMPLE NO. 2



2.4 In cases where fractures have initiated at the heel of tripping brackets (Examples Nos. 6 and 7) the stress concentration may be further reduced by increasing the radius at the top of the notch in the bracket.

2.5 In Example No. 8 the additional lug may be omitted if required for drainage, provided sufficient area of connection can be maintained through the use of the backing bracket, provided there is no fracture in the web of the transverse indicating too high shear stresses in it.

3. UNSUCCESSFUL REPAIRS

3.1 Rewelding of fractures without reinforcement. In this case the fatigue fracture may re-occur in a shorter time interval than the original fractures.

3.2 Reinforcement fitted, but fractures from the cut-out corner are rewelded without a full collar being fitted. In this case the stress concentration at the corner radius still exists and is made worse by the addition of a new weld. Thus in spite of the reinforcement, and therefore lower nominal stresses, the fractures may re-occur.

3.3 Additional brackets fitted to the flat bar stiffener, but on the same side as the stiffener instead of on the reverse side as a backing bracket. In this case, although the nominal area of connection of a stiffener to longitudinal is increased, the asymmetry of the connection is also increased which may make the extra bracket ineffective, leading to a re-occurrence of fractures. This is similar to cases where fractures have occurred in way of tripping bracket connections (see Example No. 6).

4. NEW CONSTRUCTION

4.1 Adopt generous radii at corners of cut-outs.

4.2 Provide top and bottom connections of side shell longitudinals to web frames at least within the ballast to deep load line draughts.

4.3 Incorporate a generous area of flat bar to provide a good connection to absorb pillar load from the longitudinal or, alternatively, fit backing brackets.

4.4 Avoid fabricated longitudinals having the face flat welded to the underside of the web (where this type is adopted a backing bracket is recommended). Longitudinal of bulb plate or symmetric T-bar are preferred to angle bars for side shell to avoid fatigue problems due to additional torsional stress for unsymmetrical profiles.

4.5 Provide adequate panel stiffening of transverse web plating in the region of longitudinal cut-outs to minimise flexing.

4.6 Ensure properly completed weld returns around the plate thickness at stiffener and wed/lug connections.

4.7 For higher tensile steel longitudinal positioned in areas of high dynamic stresses, backing brackets are recommended.

4.8 Provide a keyhole notch at heel of flat bar stiffener or tripping bracket, see Figure D.

Figure 12:	Catalogue of Structural Details
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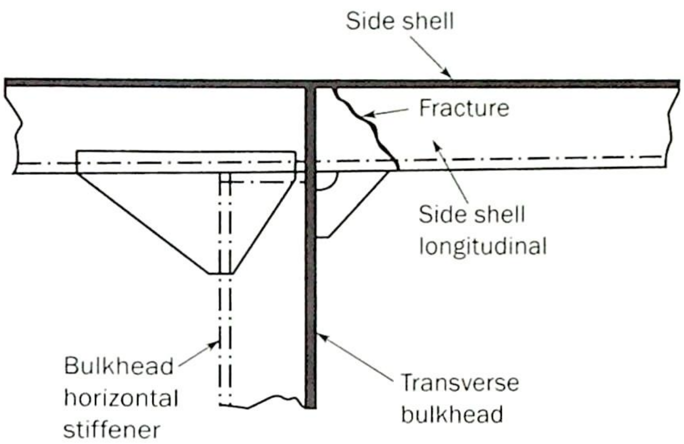
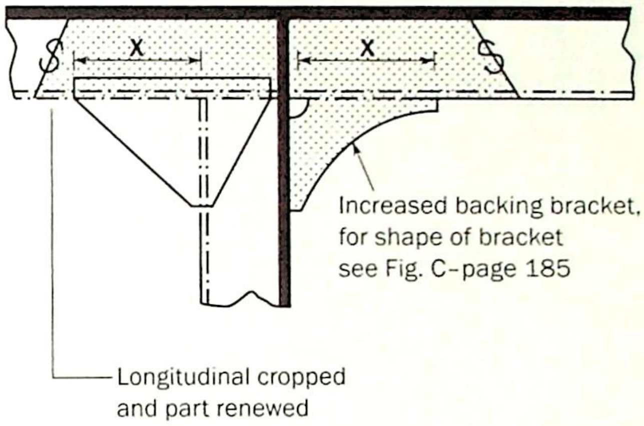
GROUP No. 2 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Plane Transverse Bulkheads*
	Example No. 1: Fractured Side Shell Longitudinal. Bulkhead Horizontally Stiffened

Typical Damage	*Proposed Repair*





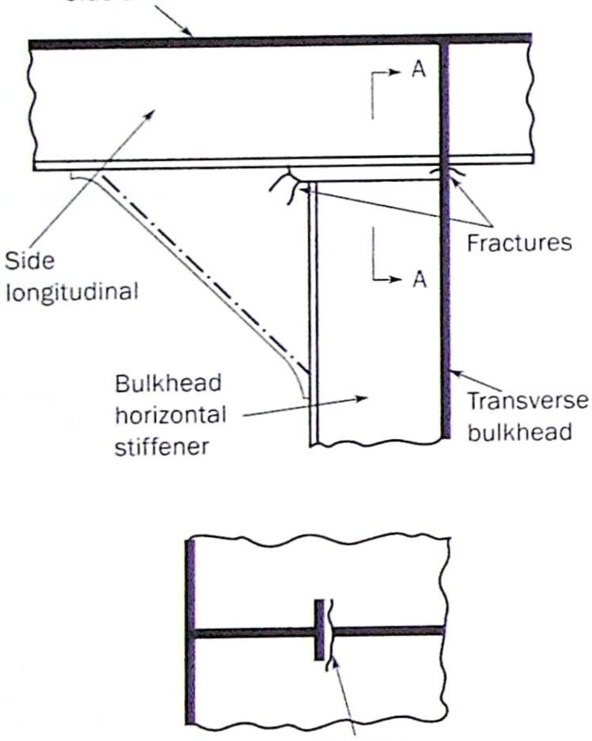
FACTORS CONTRIBUTING TO DAMAGE

1. Asymmetrical connection of bracket in association with a backing bracket that 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. 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. Asymmetric longitudinal resulting in additional torsional stresses.
5. Horizontally stiffened transverse bulkhead causing increased end moments at the side shell longitudinal connection resulting from loading on the transverse bulkhead.
6. Deflection of the adjacent side shell transverse under load.
7. Defective weld at return around the plate thickness.
8. Dynamic sea way loads/ship motions.

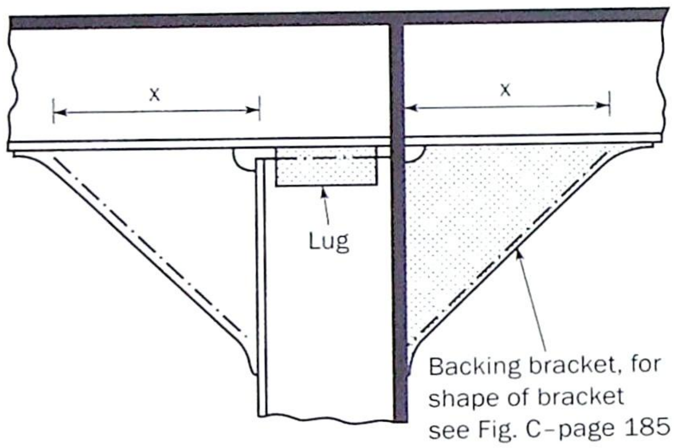
Figure 13:	*Catalogue of Structural Details*
1 of 5	

GROUP No. 2 *(Refer to index on Page 178)*	*Location: Connection of Longitudinals to Plane Transverse Bulkheads*
	Example No. 2: Fractured Bulkhead End Bracket at Side Shell. Bulkhead Horizontally Stiffened

Typical Damage	*Proposed Repair*



View A-A



Bulkhead fracture welded and fractured bracket renewed

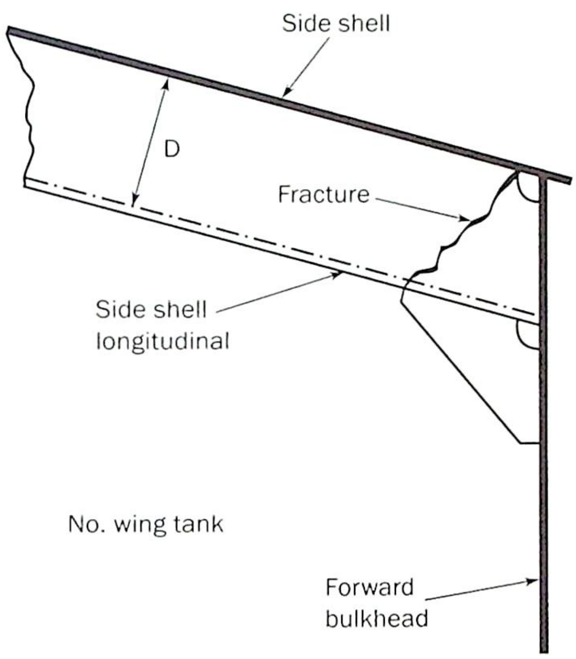
FACTORS CONTRIBUTING TO DAMAGE

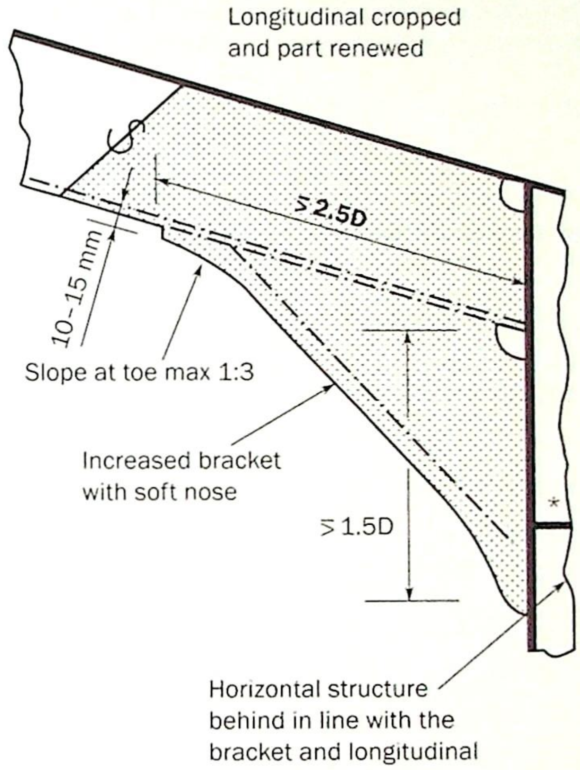
1. Large unconnected ending of bulkhead stiffener associated with an asymmetrical connection resulting in high stresses at the heel of the stiffener and the bracket.
2. Horizontally stiffened transverse bulkheads causing increased end moment at the side shell longitudinal connection resulting from loading 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.

Figure 14:	*Catalogue of Structural Details*
2 of 5	

GROUP No. 2	*Location: Connection of Longitudinals to Plane Transverse Bulkheads*
(Refer to index on Page 178)	*Example No. 3: Fractured Side Shell Longitudinal at Forward Transverse Bulkhead*

Typical Damage	*Proposed Repair*





Note: **Stiffening to be incorporated to support toe of bracket*

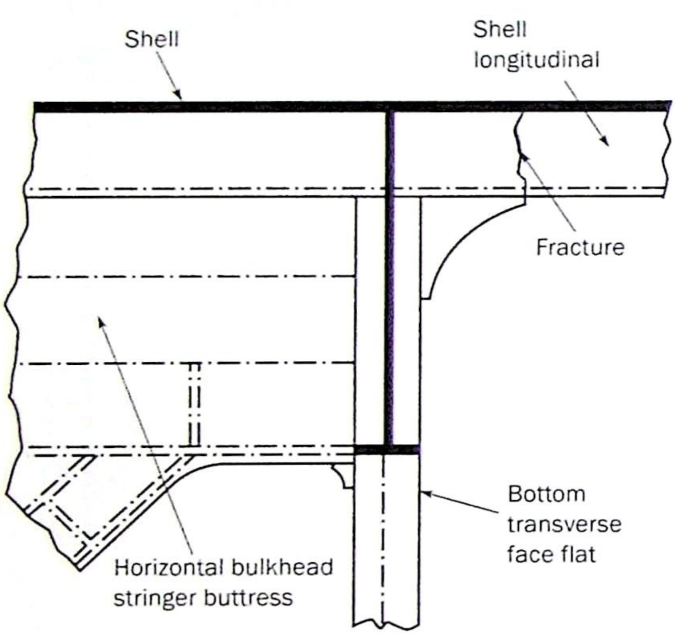
FACTORS CONTRIBUTING TO DAMAGE

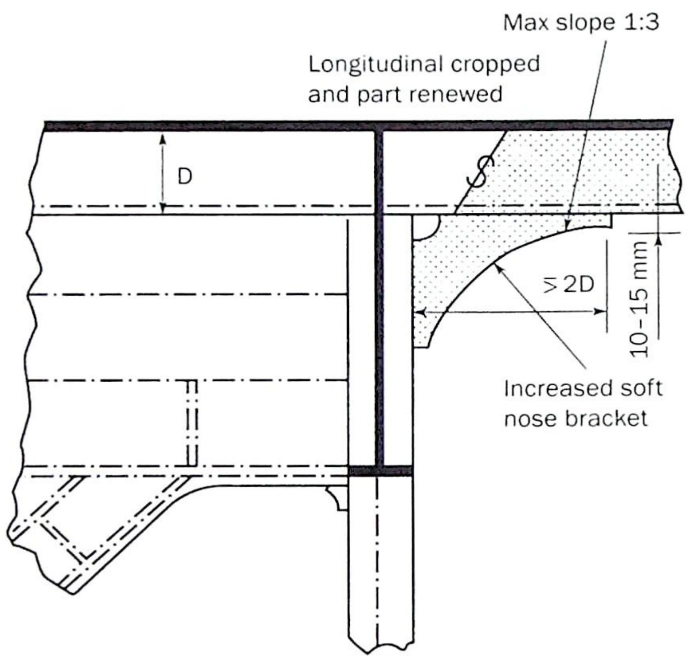
1. Under-designed end bracket.
2. Higher tensile steel side shell longitudinal resulting in greater stresses.
3. Fabricated longitudinal having the face plate attached to the underside of the web (where fitted) and with welding onto the exposed edge of the web. This results in poor fatigue strength of 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.

Figure 15:	*Catalogue of Structural Details*
3 of 5	

GROUP No. 2 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Plane Transverse Bulkheads*
	Example No. 4: Fractured Side Shell Longitudinal at Transverse Bulkhead Buttress

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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.

Figure 16:	*Catalogue of Structural Details*
4 of 5	

GROUP No. 2 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Plane Transverse Bulkheads*
	Example No.: 1 Through 4

Additional Notes

1. REPAIR NOTES

1.1 Fractured longitudinals should be cropped and part renewed. However, welding may be considered where peak stress location is changed due to the fitting of additional/larger bracket provided that a proper weld is possible. The quality of the welding should be checked by NDT.

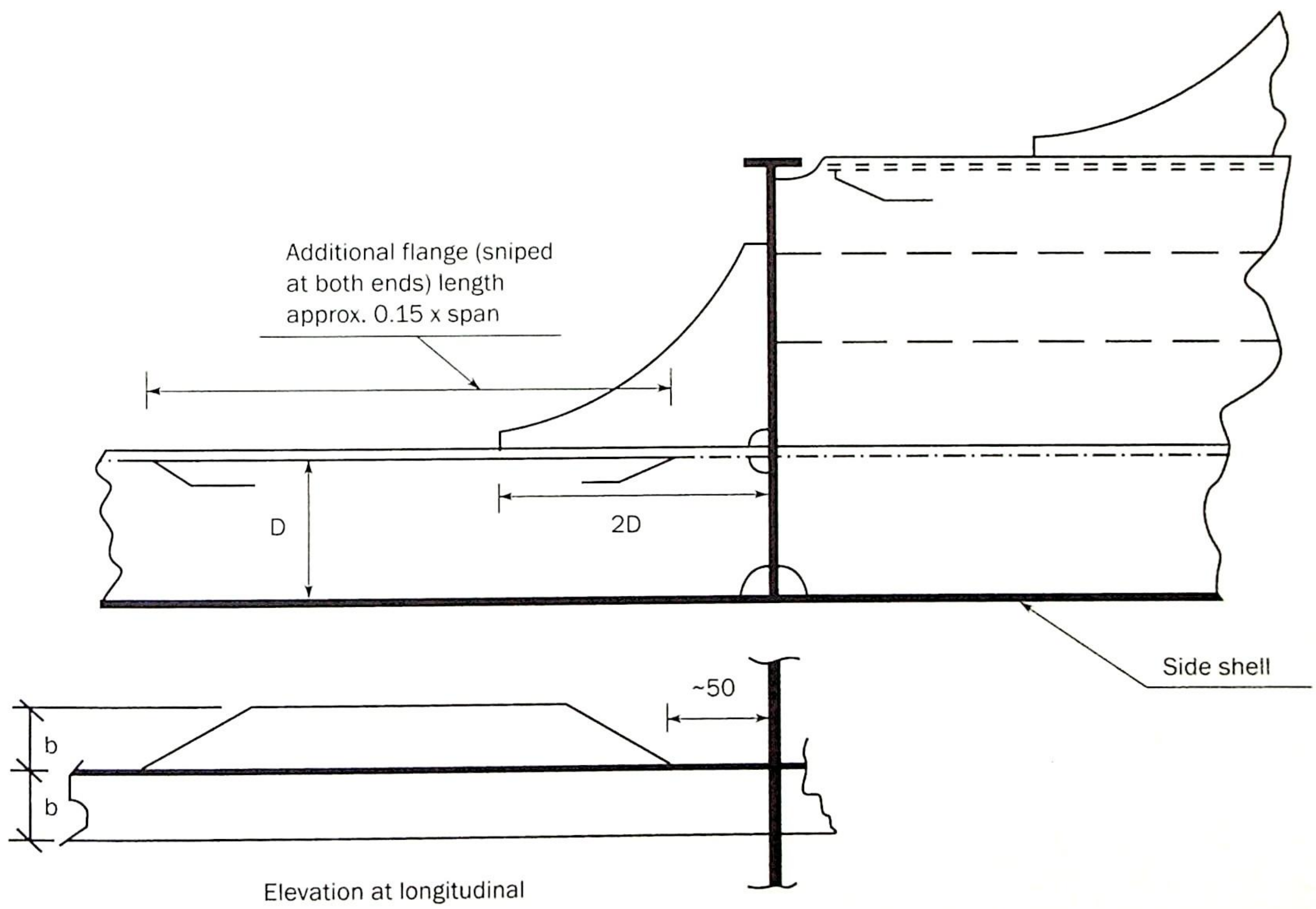
1.2 Backing brackets should be of the indicated standard design or equivalent. Grinding of welds at toes recommended, ref. Figure 11.

1.3 Backing brackets in Example nos. 1 and 2 should be aligned with the horizontal bulkhead stiffeners.

2. ALTERNATIVE REPAIRS

2.1 In Example no. 4 an additional reinforcement may be to fit a flat bar to the unsymmetrical longitudinal and thereby make the profile symmetrical in the critical location, see figure below.

2.2 In Example No. 2 where the fractures at the notch in the bracket are small, consideration may be given to removing them using an enlarged notch. The end of the fractures are to be located using NDT.



3. UNSUCCESSFUL REPAIRS

3.1 Rewelding of fractures without adequate reinforcement can lead to a re-occurring of the fractures.

3.2 Backing brackets which are too small or do not incorporate a soft nose design may initiate fracture from the bracket toe.

4. NEW CONSTRUCTION

4.1 Provide generous backing and end brackets.

4.2 Ensure that the webs of horizontal transverse bulkhead stiffeners are connected to the side shell longitudinals.

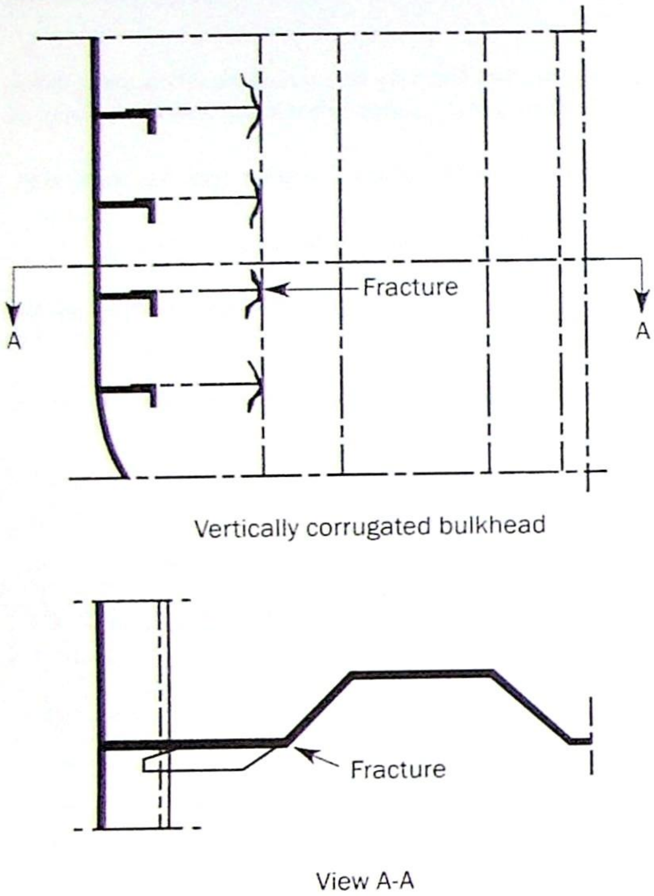
Figure 17:	*Catalogue of Structural Details*
5 of 5	

GROUP No. 3
(Refer to index on Page 178)

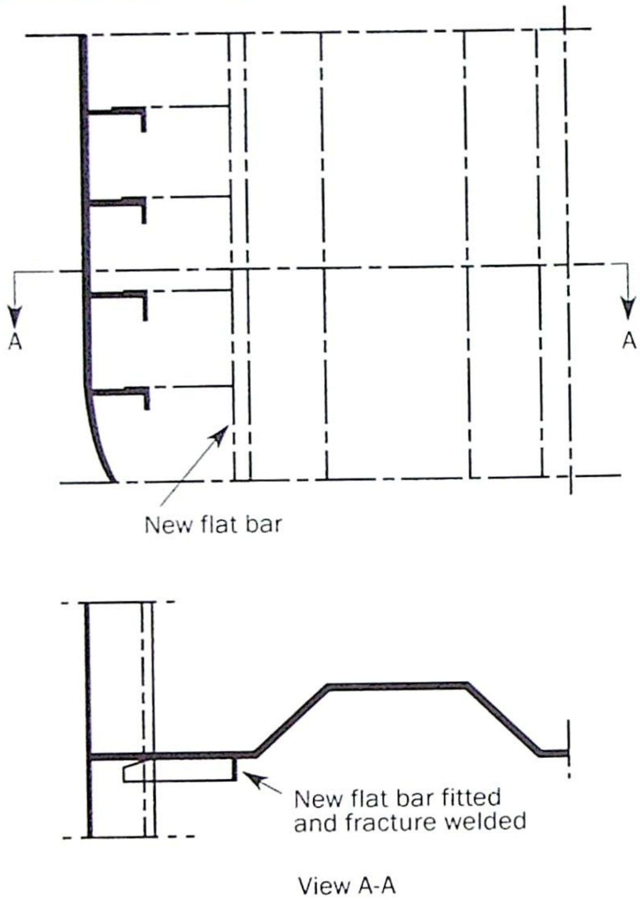
***Location:* Connection of Longitudinals to Corrugated Transverse Bulkheads**

***Example No. 1:* Bulkhead Fractured at Toe of Horizontal Flat Bar Stiffener. Vertically Corrugated Bulkhead**

Typical Damage



Proposed Repair



FACTORS CONTRIBUTING TO 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.

Additional Notes

1. REPAIR NOTES

1.1 The fracture is to be gouged out and welded, then checked by NDT. In the case of several fractures in the same area the bulkhead should be cropped and part renewed.

1.2 Horizontal stiffener to be cropped back in way of sniped end. Alternatively stiffener may be renewed or part renewed.

1.3 Horizontal stiffener to be welded to new vertical flat bar stiffener.

2. ALTERNATIVE REPAIRS

2.1 None known.

3. UNSUCCESSFUL REPAIRS

3.1 Welding of fractures without modifications will probably lead to re-occurrence.

4. NEW CONSTRUCTION

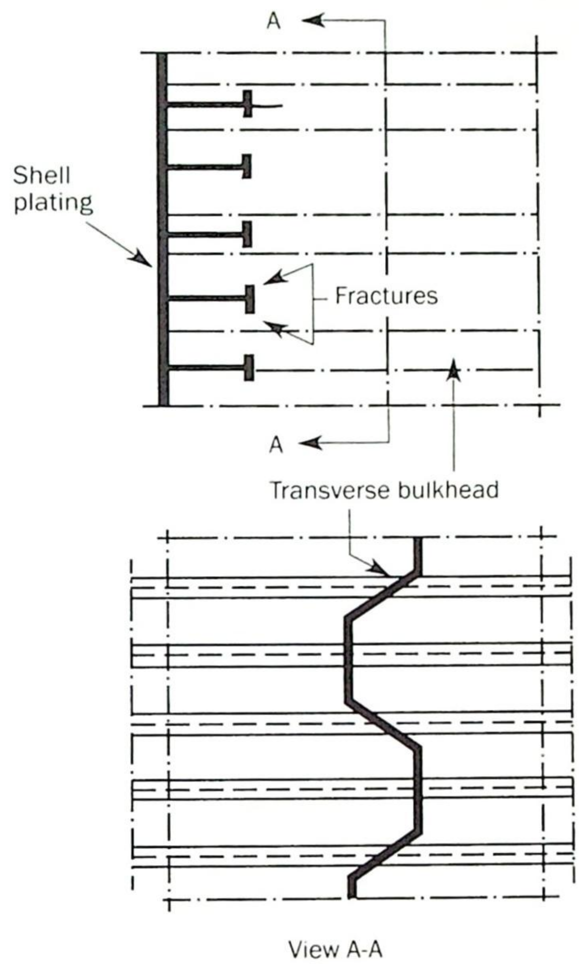
4.1 Arrange vertical flat bar stiffeners at an appropriate distances between the longitudinal and the first corrugation to support the toes of horizontal flat bars or brackets fitted to the longitudinals.

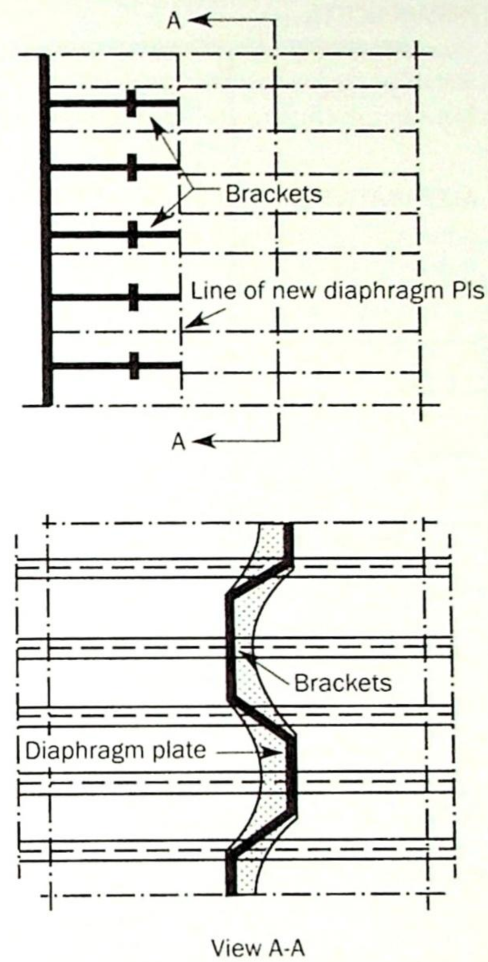
Figure 18: ***Catalogue of Structural Details***

1 of 3

GROUP No. 3 (Refer to index on Page 178)	*Location: Connection of Longitudinals to Corrugated Transverse Bulkheads*
	Example No. 2: Bulkhead Fractured at Passage of Side Longitudinal. Bulkhead Horizontally Corrugated

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Inadequate connection between side longitudinal and horizontal corrugation.
2. Large span of horizontal corrugation.
3. Dynamic seaway loads/ship motions.

Figure 19:	*Catalogue of Structural Details*
2 of 3	

GROUP No. 3 (Refer to index on Page 178)	Location: Connection of Longitudinals to Corrugated Transverse Bulkheads
	Example No. 2: Bulkhead Fractures at Toe of Horizontal Flat Bar Stiffener, Horizontally Corrugated

Additional Notes

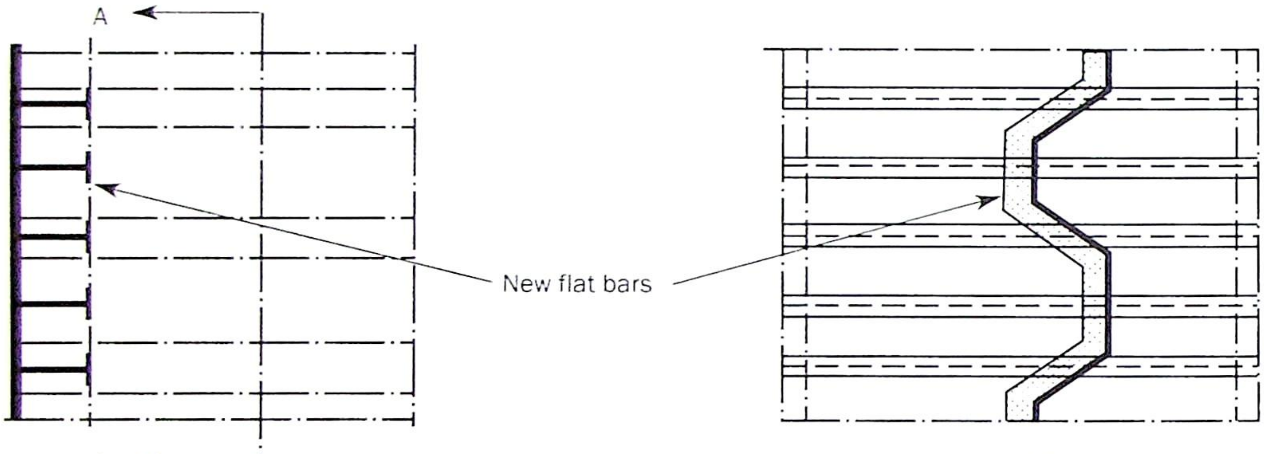
1. **REPAIR NOTES**

1.1 Fractures to be gouged out carefully welded and checked by NDT. In case of several cracks in the same area, bulkhead should be cropped and part renewed.

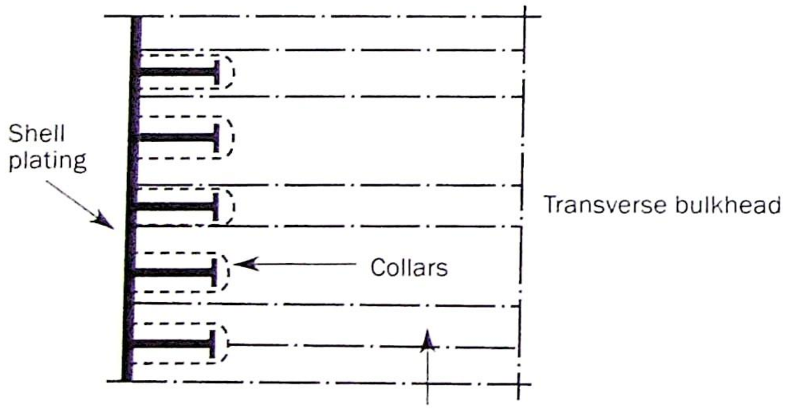
1.2 Flat bars to be fitted and welded between shell longitudinal.

2. **ALTERNATIVE REPAIRS**

2.1 Where side longitudinal and corrugation spacings are not aligned and longitudinal pass close to corrugation, consideration may be given to fitting flat bars lap welded on the longitudinal face plates as shown below:



2.2 Add collar plates (closing plates) with 25% thickness increase around the longitudinals.



3. **UNSUCCESSFUL REPAIRS**

3.1 Rewelding of fractures without reinforcement will probably lead to re-occurrence.

4. **NEW CONSTRUCTION**

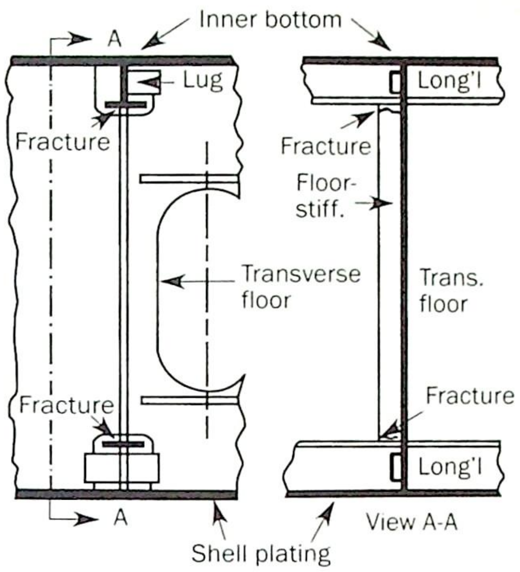
4.1 Attach side longitudinals by brackets to a line of vertical diaphragm plates fitted into the bosom of the corrugations. This will provide an efficient connection between the longitudinals and the horizontal corrugations.

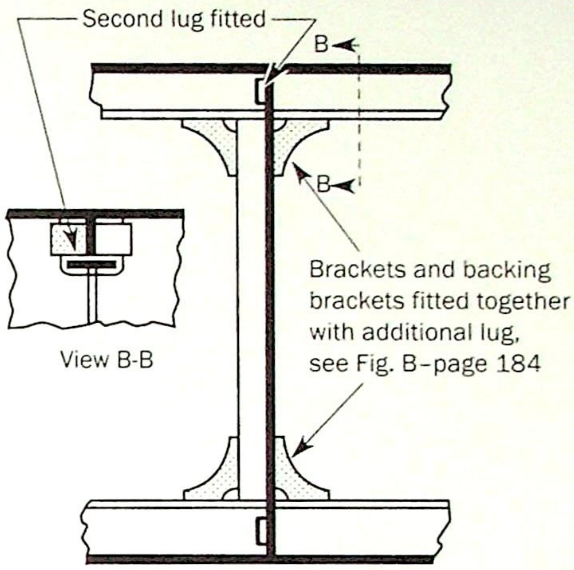
4.2 Align where possible the longitudinal and bulkhead corrugations to avoid longitudinals passing through the bulkhead near to knuckles. Welding in cold deformed zone in way of knuckles may cause ageing of material, i.e. material becomes brittle and prone to fractures.

Figure 20:	Catalogue of Structural Details
3 of 3	

GROUP No. 4	*Location: Connection of Longitudinals to Floors in the Double Bottom*
(Refer to index on Page 179)	*Example No. 1: Fractured Stiffener Connection to Bottom and Inner Bottom Longitudinals*

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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. Wide slot for longitudinal leads to inefficient lug connection.
2. Sharp corners or flame-cut edges producing a notch effect.
3. Incomplete/defective weld at stiffener connection to the longitudinals.
4. Dynamic sea way loads/ship motions.

Additional Notes

1. REPAIR NOTES

1.1 Where fractures in the toe of the stiffeners follow the line of weld to the longitudinal, repair by arc gouging to beyond end of crack and rewelding will be required. In case of larger fractures into the parent material of the stiffener, the material will be either cropped and part renewed or renewed completely. Particular attention should be paid to the welding at the stiffener.

1.2 Additional lugs should be added similar to group 1 repairs.

1.3 Brackets of equal thickness to the vertical stiffener will be required between the longitudinal and transverse floor in the same plane as the floor stiffening. All edges must be ground smooth including the scallop cut-outs.

2. ALTERNATIVE REPAIRS

None known.

3. UNSUCCESSFUL REPAIRS

3.1 Rewelding of cracks without reinforcement brackets may lead to a rapid re-occurrence of fractures.

3.2 Fittings of a single large bracket to the transverse floor and longitudinal on the side opposite to the vertical stiffener may lead to a migration of the region of high stress to the opposite edge of the stiffener toe connection to the longitudinal.

3.3 Single brackets fitted on the side of the vertical stiffener will reduce the stress peaks but fatigue fractures may still occur, particularly at the heel of the flat bar stiffener.

3.4 A vertical single lug connecting the longitudinal to the transverse floor does not reduce the high stress concentration sufficiently in view of the wide slot on this arrangement.

4. NEW CONSTRUCTION

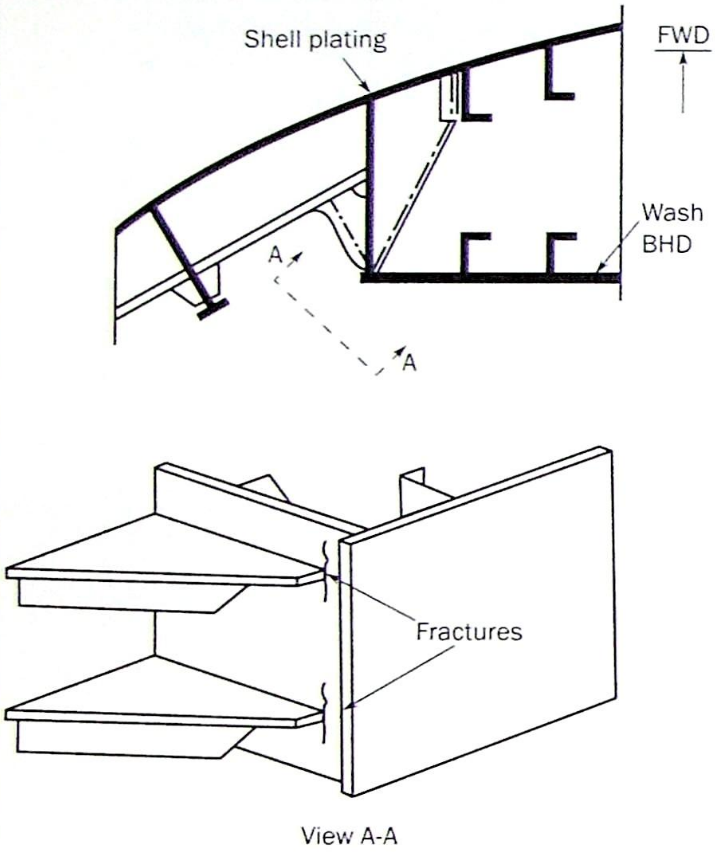
4.1 Provide double lugs for all inner bottom and bottom connections of floors to longitudinals. Cut-outs for longitudinals in floors should be kept as small as possible.

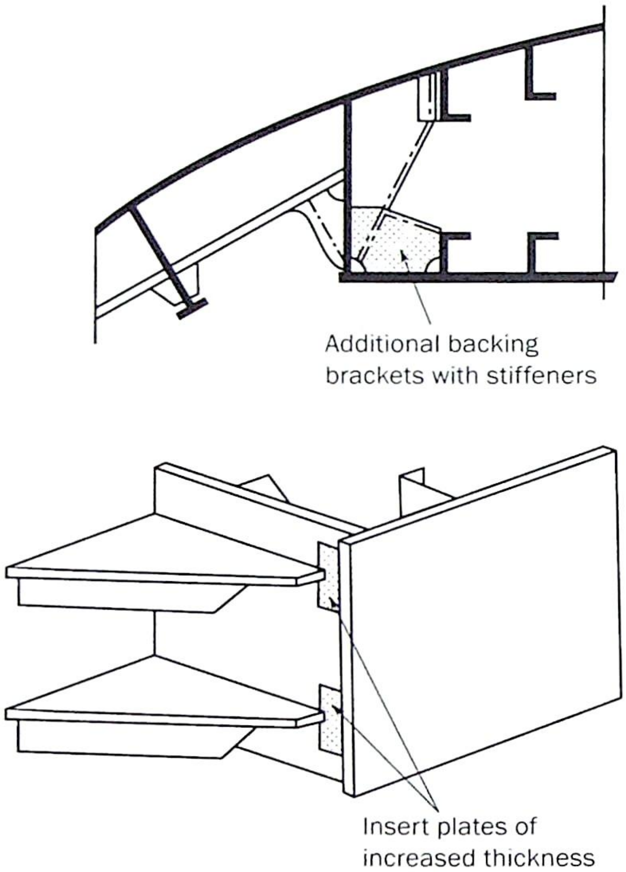
4.2 Ensure flat bar stiffening provides a good connection onto the longitudinals. Alternatively, consider adopting brackets with ground cut-outs and generous radii.

Figure 21:	*Catalogue of Structural Details*
1 of 1	

GROUP No. 5 *(Refer to index on Page 179)*	*Location: Fore Peak Structure*
	Example No. 1: Fractured Vertical Web at the Longitudinal Stiffener Ending in Way of the Parabolic Bow Structure

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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.

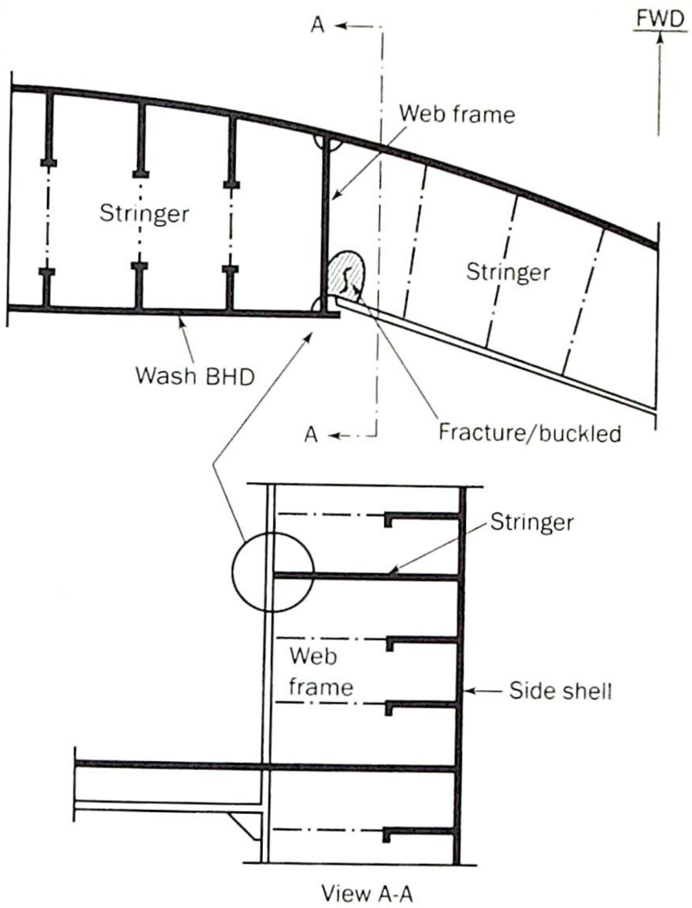
Figure 22:	*Catalogue of Structural Details*
1 of 6	

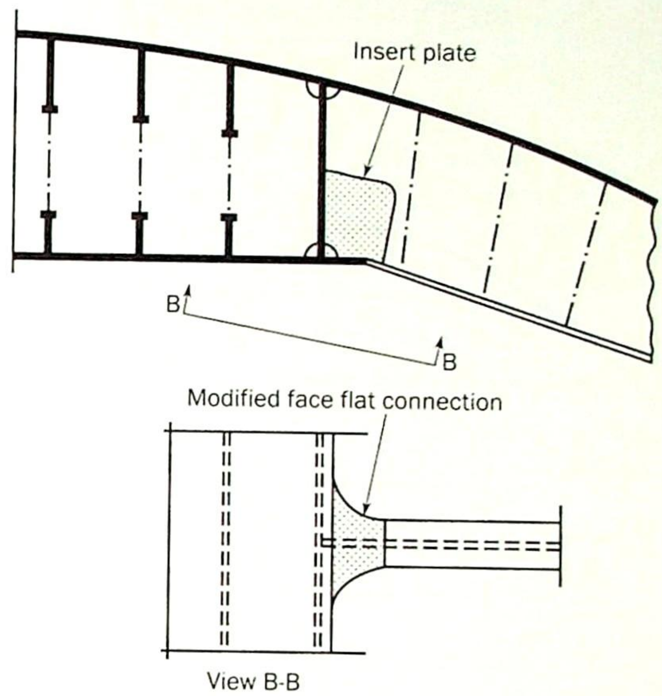
GROUP No. 5
(Refer to index on Page 179)

Location: Fore Peak Structure

Example No. 2: Fractured Stringer End Connection in Way of the Parabolic Bow Structure

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

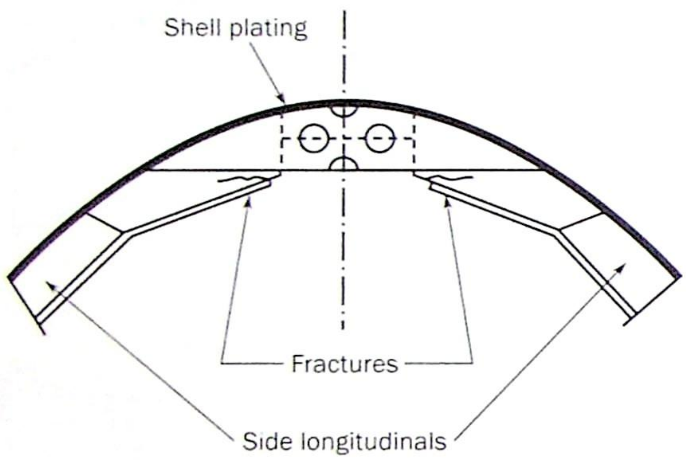
1. High stress concentration at connection of stringer to stiff girder/deep web intersection due to discontinuity of face plate.
2. Localised thinning in way of coating failure at stringer connection due to flexing of the structure.
3. Dynamic seaway loadings at bow causing flexing in way of detail.

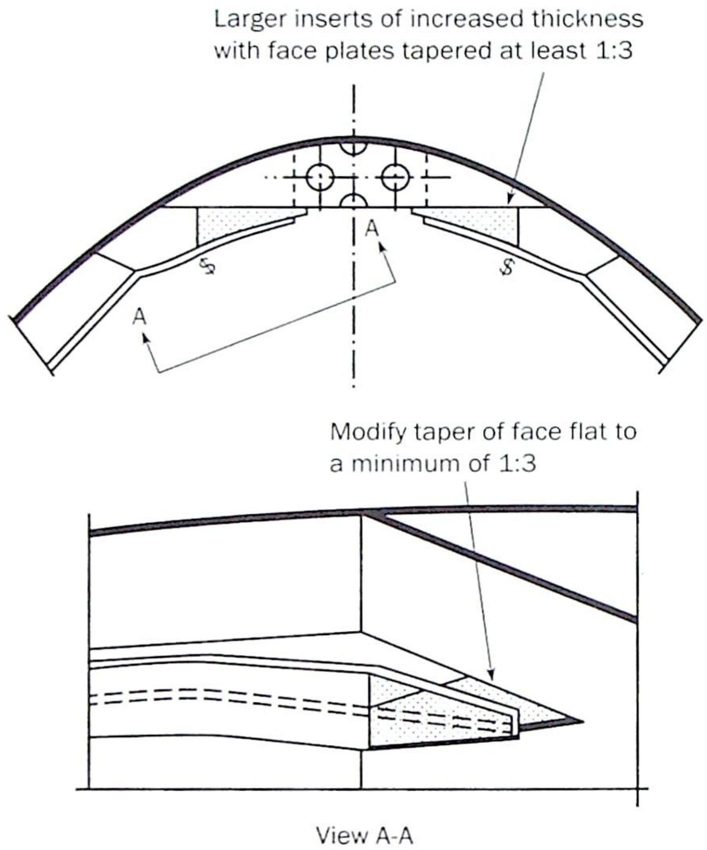
Figure 23: *Catalogue of Structural Details*

2 of 6

GROUP No. 5 (Refer to index on Page 179)	*Location: Fore Peak Structure*
	Example No. 3: Fracture at End of Longitudinal at Bow Structure

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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.

Additional Notes

1. REPAIR NOTES

1.1 Plating in way of fractures should be cropped and renewed. Where corrosion losses have contributed to the fracturing, increased thickness of plating should be considered.

1.2 Particular attention should be paid to the quality of welding especially at return of welds around the plate thickness.

1.3 Where sniped flat bar endings are fitted, the snipe should be reviewed to ensure a gradual taper of at least 1:3.

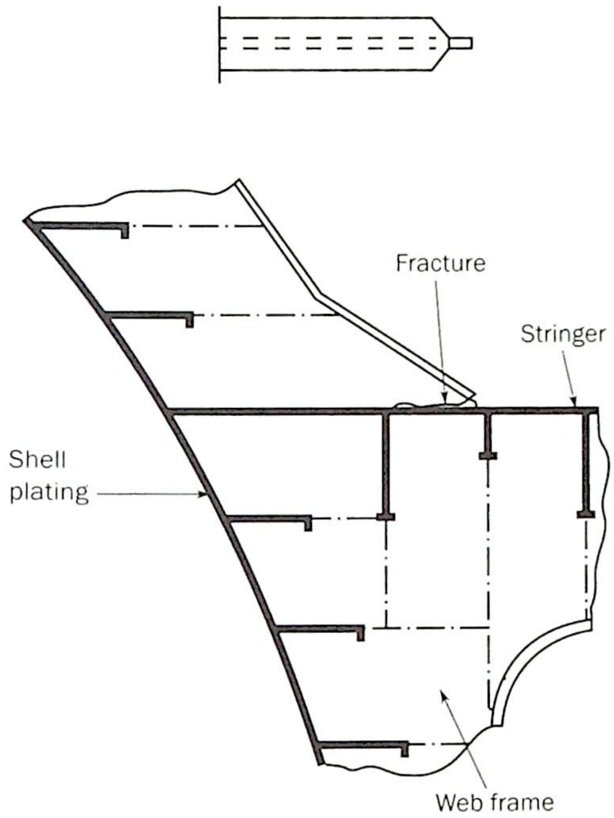
1.4 Additional tripping bracket prevents flexing.

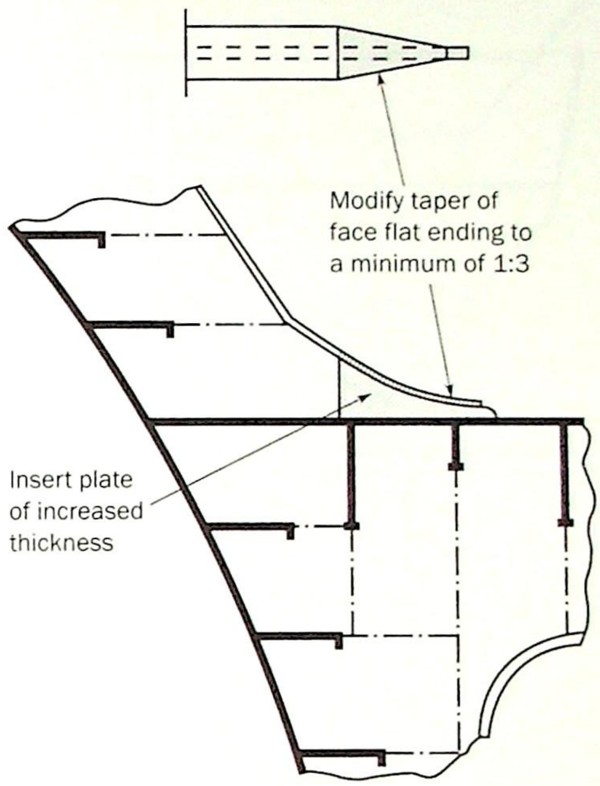
1.5 Protective coatings in way of repairs should be restored.

Figure 24:	*Catalogue of Structural Details*
3 of 6	

GROUP No. 5 (Refer to index on Page 179)	*Location: Fore Peak Structure*
	Example No. 4: Fracture at Toe of Web Frame Bracket Connection to Stringer Platform Bracket

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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.

Additional Notes

2. ALTERNATIVE REPAIRS

2.1 For Example No. 2, the face flat bracket can be lapped onto the web frame plating rather than butted. Overlap should be about 50 mm.

2.2 For Example No. 3, the ends of the longitudinals can be tied together using a continuous web and face flat across the web frame.

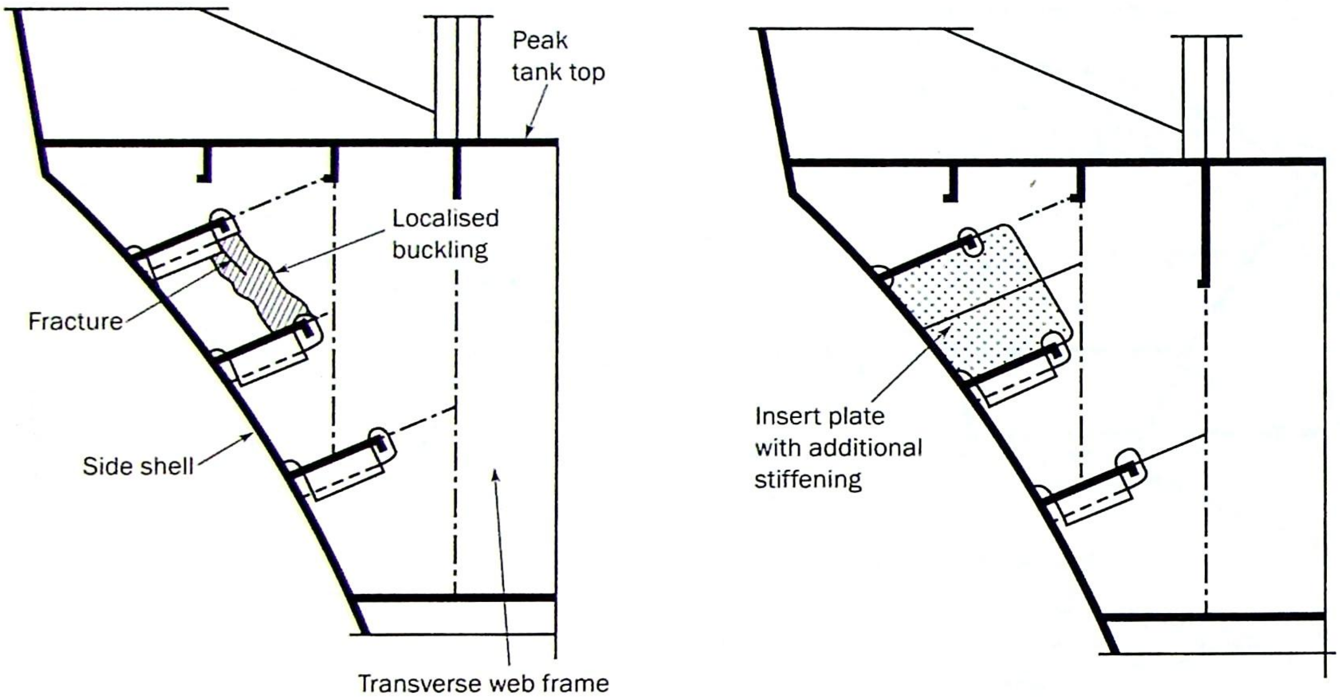
Figure 25:	*Catalogue of Structural Details*
4 of 6	

GROUP No. 5
(Refer to index on Page 179)

Location: Fore Peak Structure

Example No. 5: Fractured and Buckled Bow Transverse Web Frame in Way of Longitudinal Cut-outs

Typical Damage | *Proposed Repair*



FACTORS CONTRIBUTING TO 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.

Additional Notes

3. UNSUCCESSFUL REPAIRS

3.1 Gouging and welding of the fractures without the indicated modifications may lead to re-occurrences of the fractures.

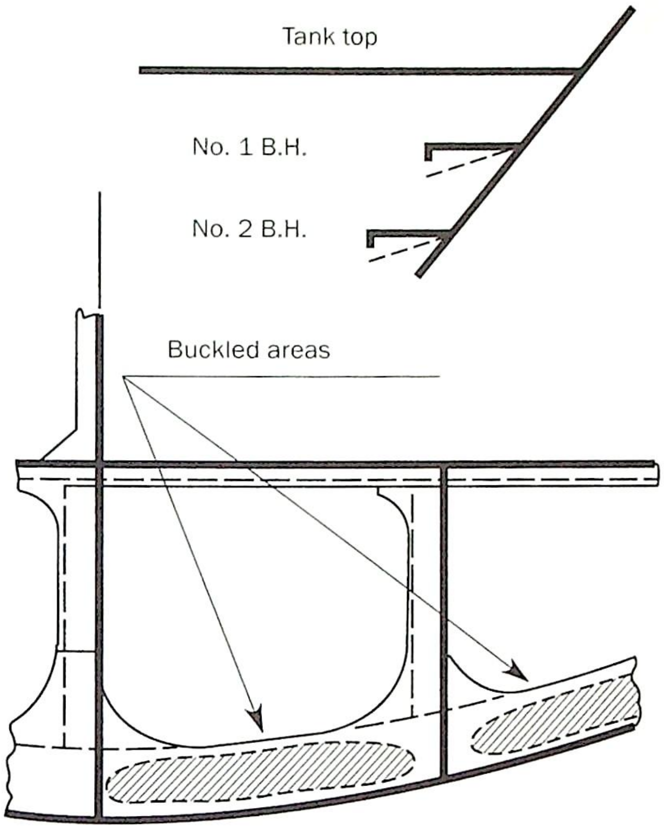
3.2 Gouging and welding of the fractures instead of plate renewal, even with the indicated modifications, will provide improved performance but re-occurrences of the fractures can be expected due to additional stress concentrations in way of the weld-up.

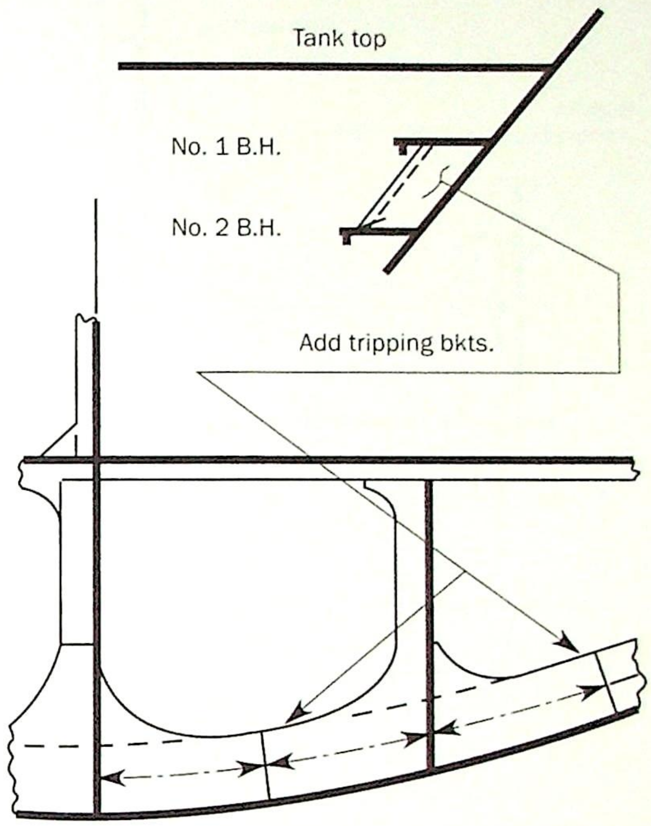
Figure 26: *Catalogue of Structural Details*

5 of 6

GROUP No. 5 (Refer to index on Page 179)	*Location: Fore Peak Structure*
	Example No. 6: Buckled and Tripped Breasthooks

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Bow impact load.
2. Low buckling resistance.

Additional Notes

4. NEW CONSTRUCTION

4.1 For Example No. 1, provide adequate support for the bracket endings.

4.2 For Example No. 2, avoid ending face plates short of web plating at the intersections of stiff girders and deep webs and ensure a proper bracketed ending is provided to the stringers.

4.3 For Examples Nos. 3 and 4, provide adequate soft nose bracket endings with a face plate taper of at least 1:3.

4.4 For Example No. 5, provide sufficient attachment and web panel stiffening to absorb dynamic loads enhanced by bow flare shape.

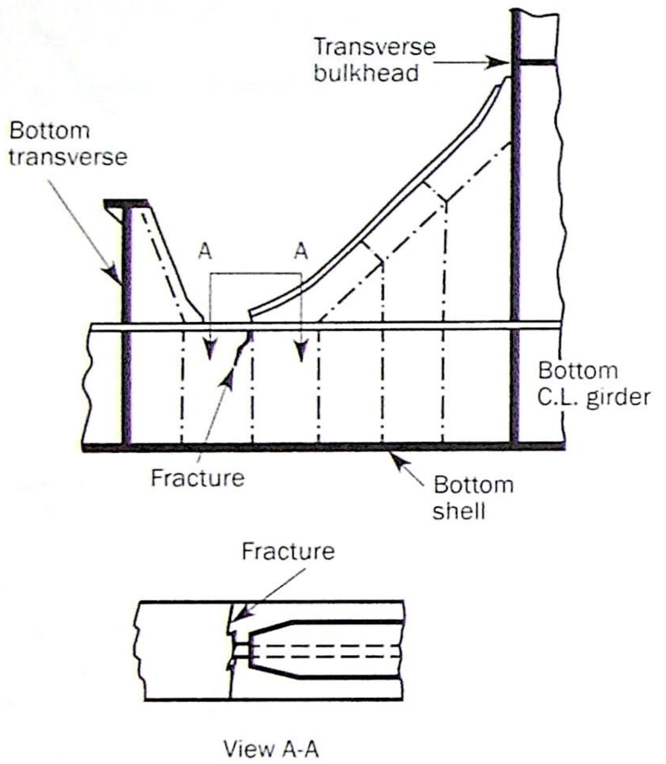
4.5 For Example No. 6, provide tripping brackets at mid-span of breasthook webs and additional stiffening.

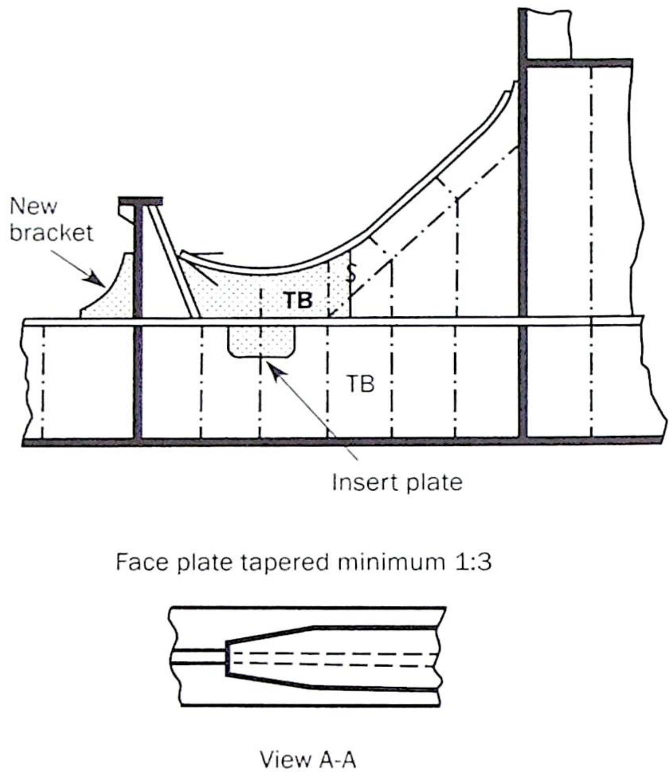
4.6 Dimensioning of diaphragm plates in bow to be specially considered on basis of dynamic loading and adequate support of longitudinals.

Figure 27:	*Catalogue of Structural Details*
6 of 6	

GROUP No. 6 (Refer to index on Page 179)	*Location: Longitudinal Girder End Brackets*
	Example No. 1: Fractured Bottom Centreline Girder at the End Bracket Connection to O.T. Bulkhead

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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 to stringer reaction.

Additional Notes

1. REPAIR NOTES

1.1 Toe of bottom girder end bracket should be cropped back and a larger radiused toe insert fitted. Where close to the bottom transverse tripping bracket, insert should connect to tripping bracket (see Example No. 1). Face plate taper should be at least 1:3.

1.2 Fractured web plate of bottom girder should be cropped and an insert fitted.

1.3 Fractured face plate of bottom girder should be cropped and part renewed.

1.4 Panel stiffening should be fitted to new insert to line up with tripping brackets and panel stiffening of centreline girder.

1.5 Where the panel stiffening of the girder web is insufficient additional stiffening should be fitted to align with toe of bracket.

2. ALTERNATIVE REPAIRS

2.1 If fracturing of the web of bottom girder is not extensive, the fracture may be stop drilled, gouged and welded and then checked by NDT.

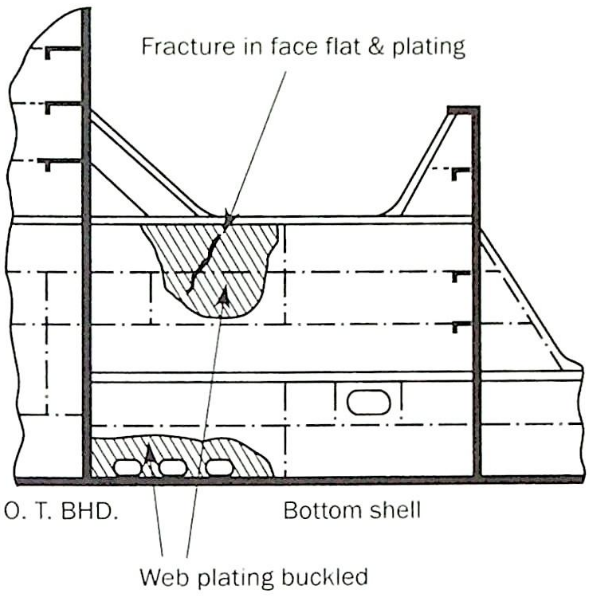
2.2 Increased thickness inserts may be fitted to provide additional reinforcement.

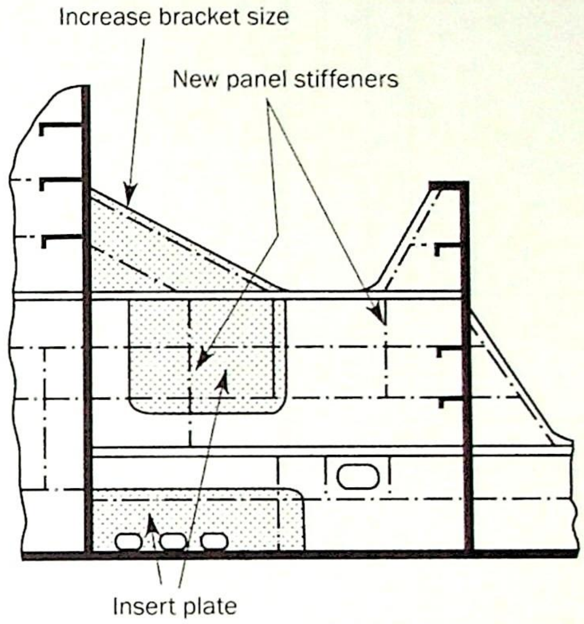
2.3 Existing bracket may be increased in size rather than renewed.

Figure 28:	*Catalogue of Structural Details*
1 of 7	

GROUP No. 6 (Refer to index on Page 179)	*Location: Longitudinal Girder End Brackets*
	Example No. 2: Fractured and Buckled Buttress in Way of Bracket Connection to O.T. Bulkhead

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Panel stiffening on girder web not fitted in way of bracket toe.
2. Stress concentration at bracket toe.
3. Local drydocking loads.

Additional Notes

3. UNSUCCESSFUL REPAIRS

3.1 Doubler plate in lieu of insert plate at face plate under toe of bracket.

3.2 Inserts or doubler plates without modification to bracket to reduce stress concentration effect.

4. NEW CONSTRUCTION

4.1 Minimise stress concentration by gradual change in section of primary members.

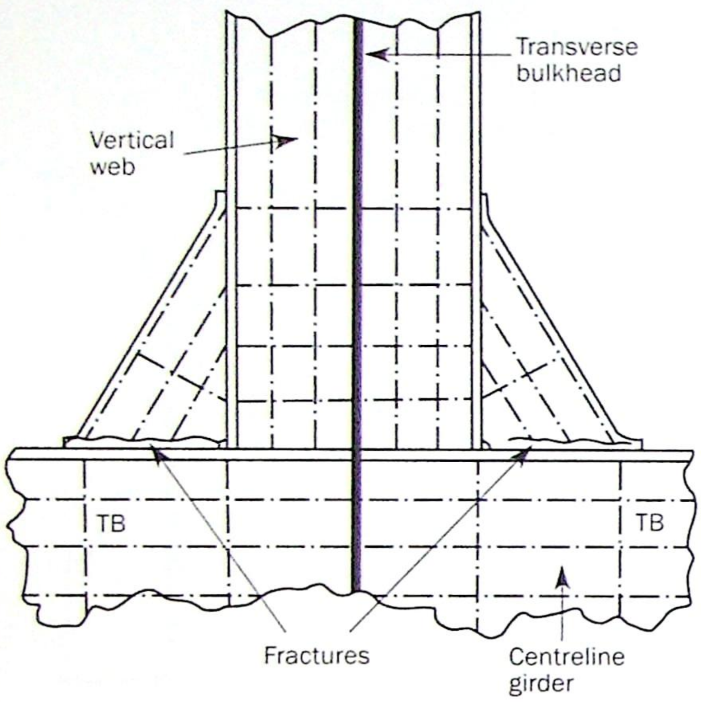
4.2 Avoid abrupt bracket toe ending and provide face plate tapers of at least 1:3.

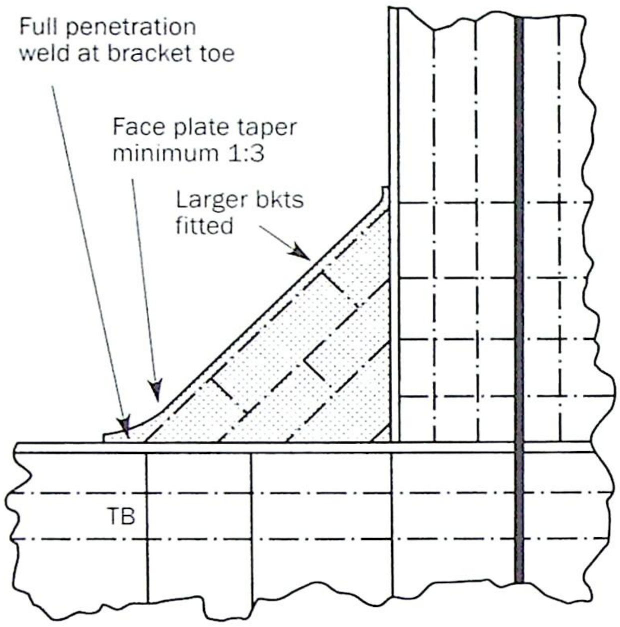
4.3 Compensation for holes by insert of increased thickness plate in the web or longitudinal.

Figure 29:	*Catalogue of Structural Details*
2 of 7	

GROUP No. 6 (Refer to index on Page 179)	*Location: Longitudinal Girder End Brackets*
	Example No. 3: Fractured Vertical Web Bracket Connection to Bottom Centreline Girder

Typical Damage	*Proposed Repair*





See Fig. F-page 188

FACTORS CONTRIBUTING TO 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.

Additional Notes

1. REPAIR NOTES

1.1 Leg of bracket connecting to bottom girder should be extended to align with existing panel stiffening on bottom girder and incorporate a generous soft nose. Face plate taper should be at least 1:3.

1.2 Bracket toe to bottom girder face plate to be attached by full penetration weld.

1.3 Panel stiffening of bracket should be incorporated as necessary. Panel on girder immediately in way of new bracket toe should have an additional vertical stiffener fitted.

1.4 Size of face plate to be checked for buckling based on the increased span.

2. ALTERNATIVE REPAIRS

2.1 Sniped face plate of bracket may be cropped back and connected to girder face plate by full penetration welds. A vertical tripping bracket should then be fitted to the girder (see Example No. 4).

2.2 Bracket may be cropped back and part renewed to provide a larger bracket.

3. UNSUCCESSFUL REPAIRS

3.1 Toe of bracket cropped back and insert fitted without modification to bracket connection.

3.2 Fractures welded up without modification.

4. NEW CONSTRUCTION

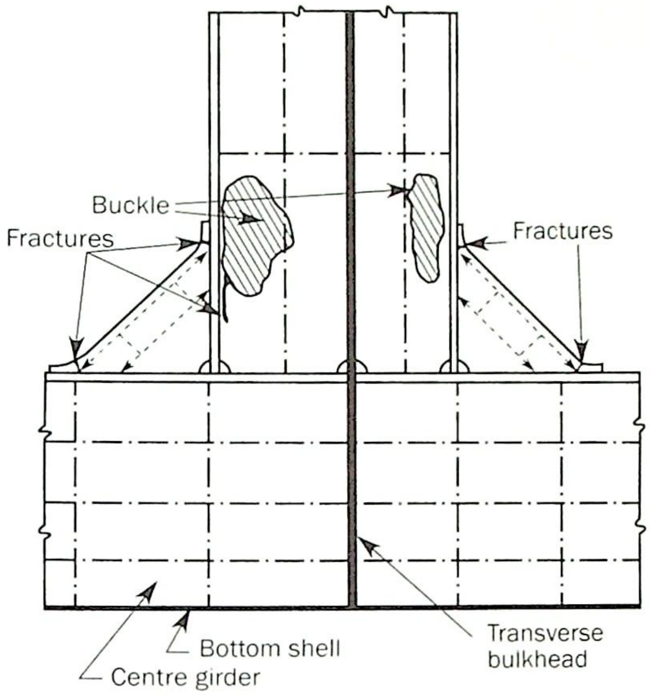
4.1 Confirm bracket sizes by calculation.

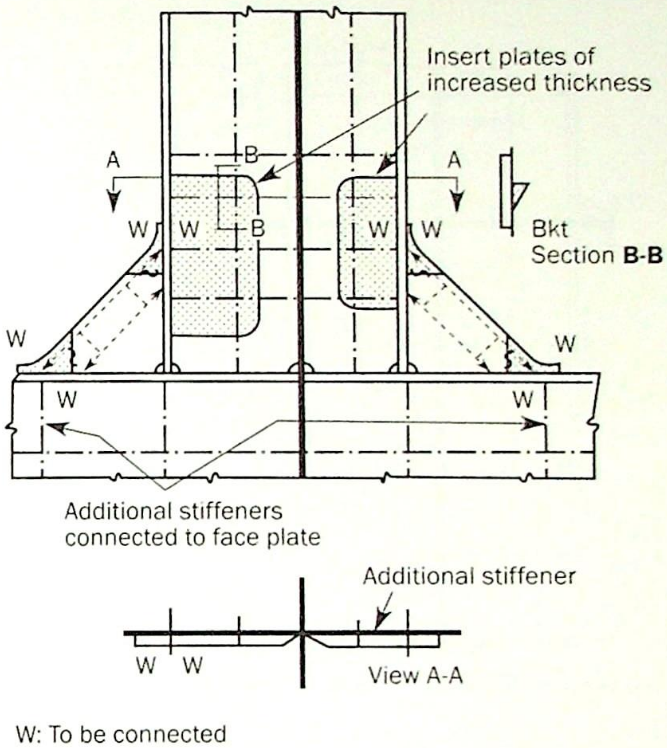
4.2 Provide generous soft nose connection with face plate taper of at least 1:3.

Figure 30:	*Catalogue of Structural Details*
3 of 7	

GROUP No. 6	*Location: Longitudinal Girder End Brackets*
(Refer to index on Page 179)	*Example No. 4: Buckled and Fractured Vertical Web and Bottom Centreline Girder Bracket Connection*

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Insufficient panel stiffening on vertical web.
2. Stress concentration at bracket toes with sniped face plate.

Additional Notes

1. REPAIR NOTES

1.1 Buckled and fractured area of vertical web should be cropped and an insert fitted.

1.2 Additional horizontal panel stiffening should be fitted to the vertical web, particularly in way of bracket toes.

1.3 Fractures in bracket toes should be cropped out and part renewed in way with the bracket face plate attached by full penetration welding to the girder/vertical web face plate. Backing stiffeners in way should be connected to the face plate to provide continuity for the connection bracket face plate.

2. ALTERNATIVE REPAIRS

2.1 For the fractures in the brackets, larger brackets may be fitted retaining the sniped face plate (see Example No. 3).

3. UNSUCCESSFUL REPAIRS

3.1 Web cropped and insert fitted without panel stiffening.

4. NEW CONSTRUCTION

4.1 Fit adequate panel stiffening, particularly at web plates adjacent to bracket toes.

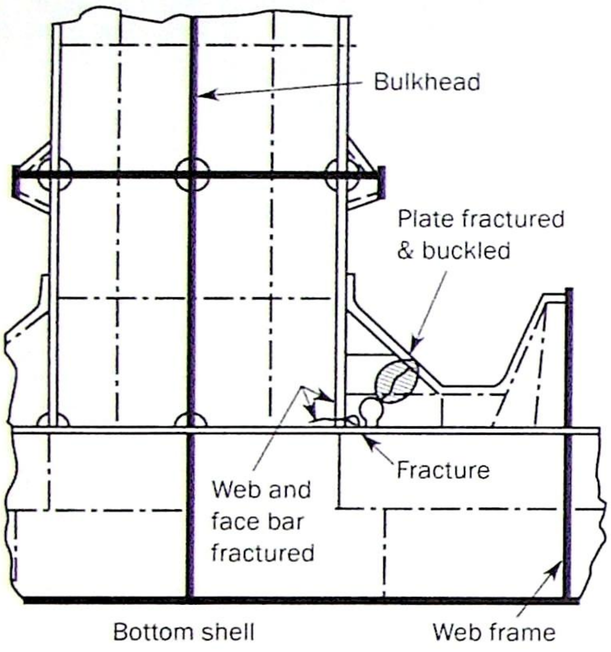
4.2 Confirm bracket sizes by calculation.

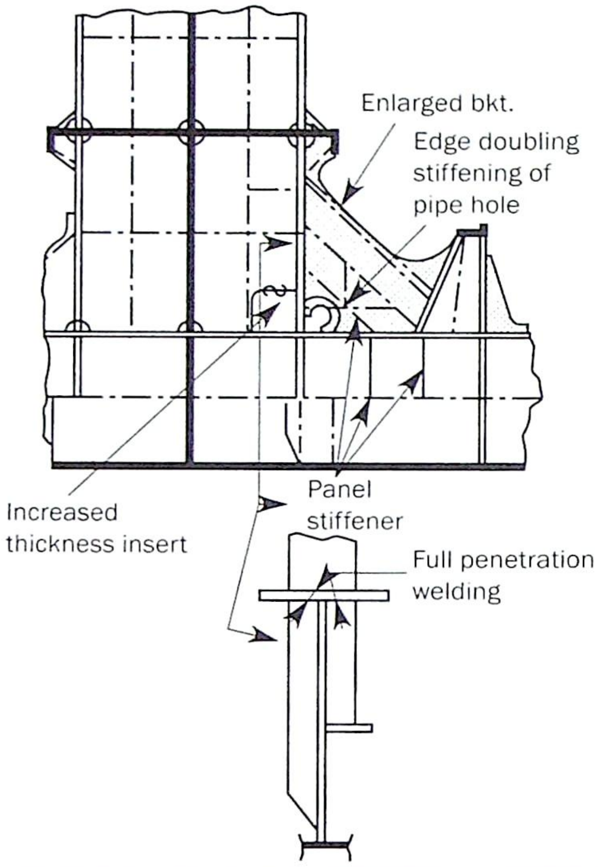
4.3 Provide generous soft nose connection with face plate taper of at least 1:3 or connect bracket face plates to remove stress concentrations and include suitable backing stiffener to ensure continuity.

Figure 31:	*Catalogue of Structural Details*
4 of 7	

GROUP No. 6 (Refer to index on Page 179)	Location: Longitudinal Girder End Brackets
	Example No. 5: Fractured Bottom Girder Brackets in Way of Pipe Opening

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Insufficient throat through bracket in way of pipe opening.
2. Stress concentration at pipe opening.

Additional Notes

1. REPAIR NOTES

1.1 Bracket should be cropped and replaced with bracket of longer leg and greater throat in way of pipe opening.

1.2 Fractures at vertical web face plate should be cropped and insert fitted. Where the girder face plate is fractured this should be cropped and part renewed. Face plate of vertical girder should be continued below horizontal face plate.

1.3 New bracket should incorporate adequate panel stiffening and edge stiffening around the hole in the form of a doubler.

1.4 Shape of hole should be arranged with soft nose endings such that stress concentration is minimised.

1.5 Panel stiffening should be fitted to girder web in way of bracket.

2. ALTERNATIVE REPAIRS

None known.

3. UNSUCCESSFUL REPAIRS

3.1 Fractured bracket replaced with one of similar size with pipe opening.

3.2 Fractures welded and doubler plate fitted to the bracket.

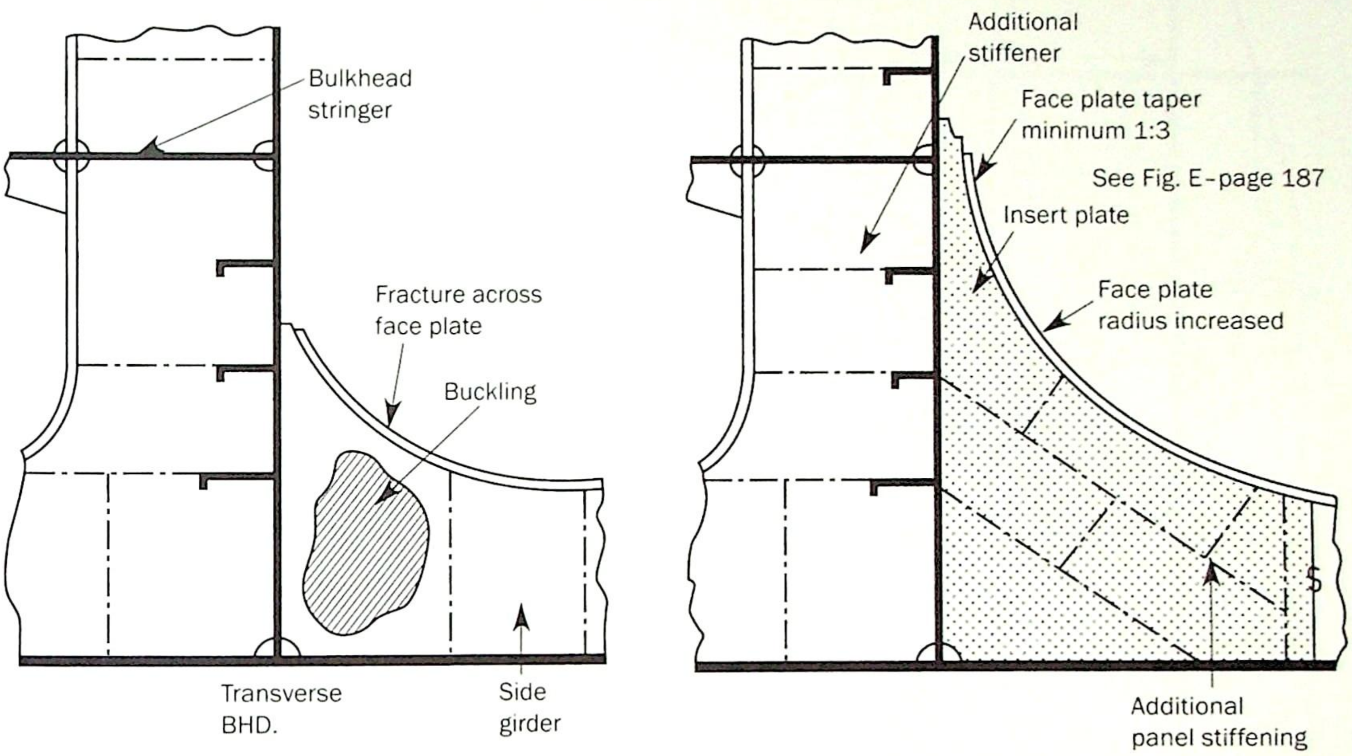
4. NEW CONSTRUCTION

4.1 Pay particular attention to the location of pipe openings and the structural configuration to ensure adequate bracket size and stiffening.

Figure 32:	*Catalogue of Structural Details*
5 of 7	

GROUP No. 6 (Refer to index on Page 179)	*Location: Longitudinal Girder End Brackets*
	Example No. 6: Fractured and Buckled Bottom Side Girder in Way of End Connection to O.T. Bulkhead

Typical Damage	*Proposed Repair*



FACTORS CONTRIBUTING TO DAMAGE

1. Inadequately sized bracket connection at end of girder.
2. Insufficient panel stiffening on girder web in way of end bracket.

Additional Notes

1. REPAIR NOTES

1.1 End connection should be modified by cropping buckled area and fitting new insert with larger radius to give increased size of end bracket.

1.2 Panel stiffening should be fitted vertically and diagonally in way of new end bracket.

1.3 Face plate taper at bracket toe should have a minimum taper of 1:3.

1.4 Vertical web in adjacent tank should be properly stiffened in way of new extended girder bracket toe.

2. ALTERNATIVE REPAIRS

2.1 Web of girder and face plate may be cropped and inserts fitted and additional panel stiffening together with a new radiused bracket fitted above existing face plate to give increased connection.

3. UNSUCCESSFUL REPAIRS

3.1 Additional panel stiffening only or fitting of a new insert to web without increasing the size of the bracket.

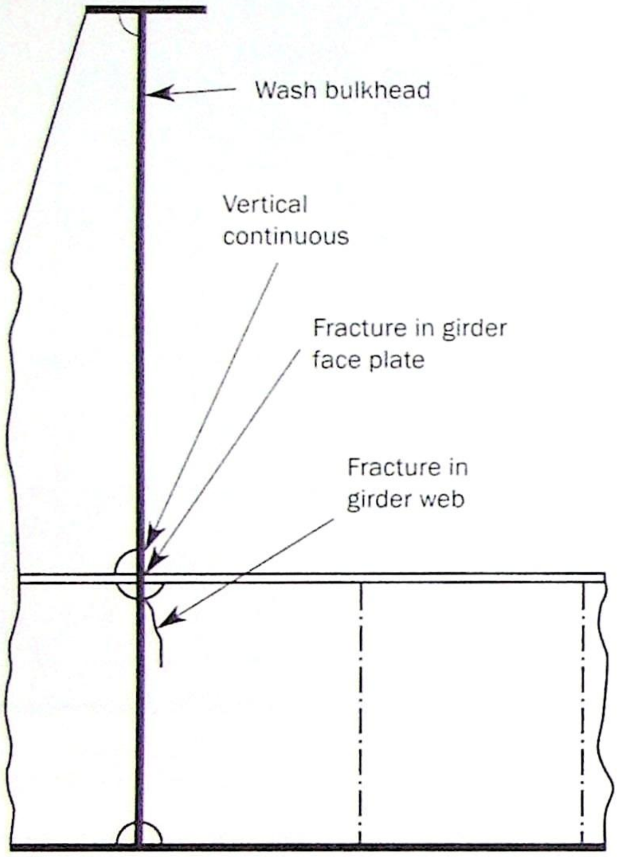
4. NEW CONSTRUCTION

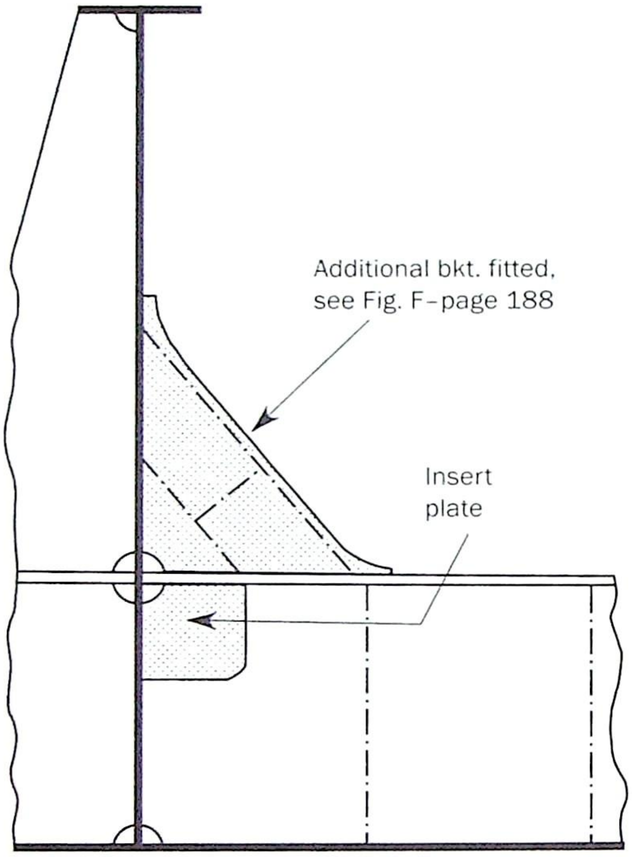
4.1 Girder bracket end connections should be confirmed by calculation and be adequately stiffened.

Figure 33:	*Catalogue of Structural Details*
6 of 7	

GROUP No. 6 (Refer to index on Page 179)	*Location: Longitudinal Girder End Brackets*
	Example No. 7: Fractured Intercostal Bottom Girder Fitted Without an End Bracket in Way of the Wash Bulkhead

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Inadequate end connection of girder to the wash bulkhead.

Additional Notes

1. REPAIR NOTES

1.1 Fractured face plate should be cropped and an insert fitted.

1.2 Fractured web of the girder should generally be cropped and insert fitted.

1.3 Additional radiused bracket with edge and panel stiffening should be fitted to give a larger bracket connection of girder end to the wash bulkhead.

2. ALTERNATIVE REPAIRS

2.1 Where the fractured weld connection of girder web is small this may be gouged out and welded with full penetration weld then confirmed by NDT and bracket fitted.

3. UNSUCCESSFUL REPAIRS

3.1 Gouging out and welding fractured face plate and web without additional bracket.

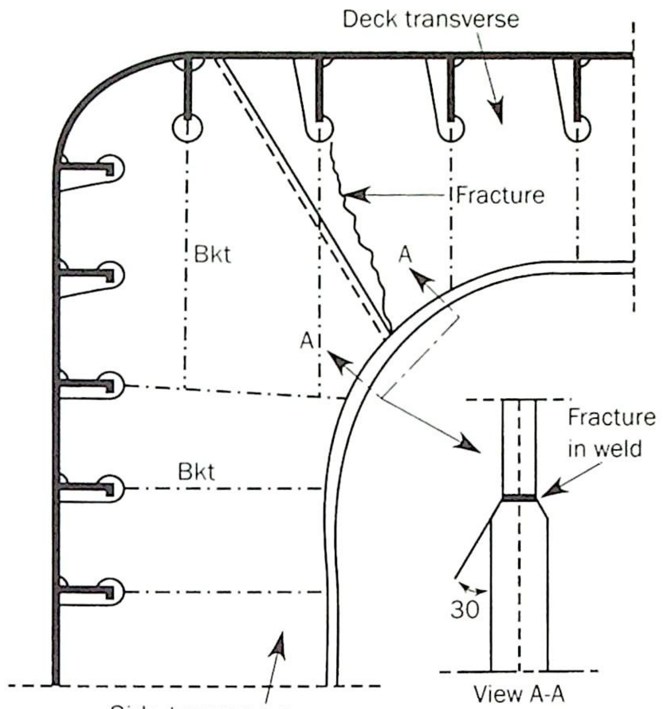
4. NEW CONSTRUCTION

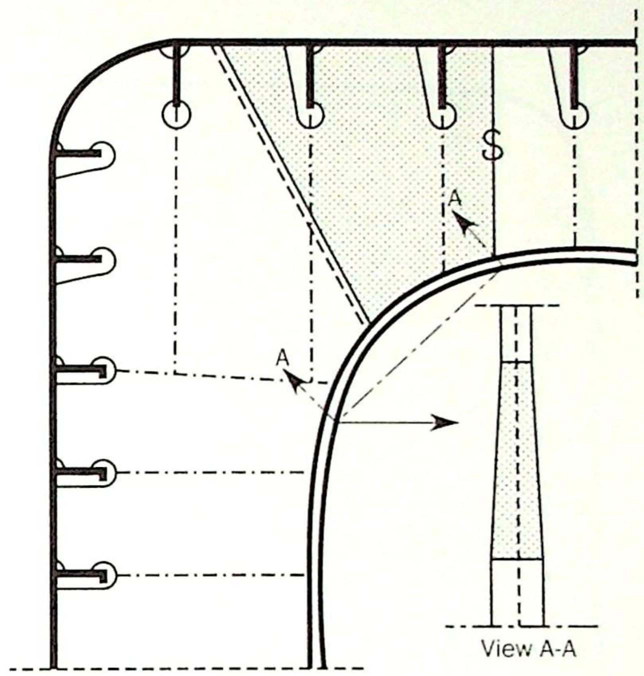
4.1 Provide end brackets to intercostal girders at connections to all transverse supporting members.

Figure 34:	*Catalogue of Structural Details*
7 of 7	

GROUP No. 7 (Refer to index on Page 180)	*Location: Transverse Web Frame End Brackets*
	Example No. 1: Fractured Wing Tank Deck Transverse Bracket. Continuous Face Plate

Typical Damage	*Proposed Repair*





Web cropped and part renewed. Face plate cropped back and part renewed with long taper

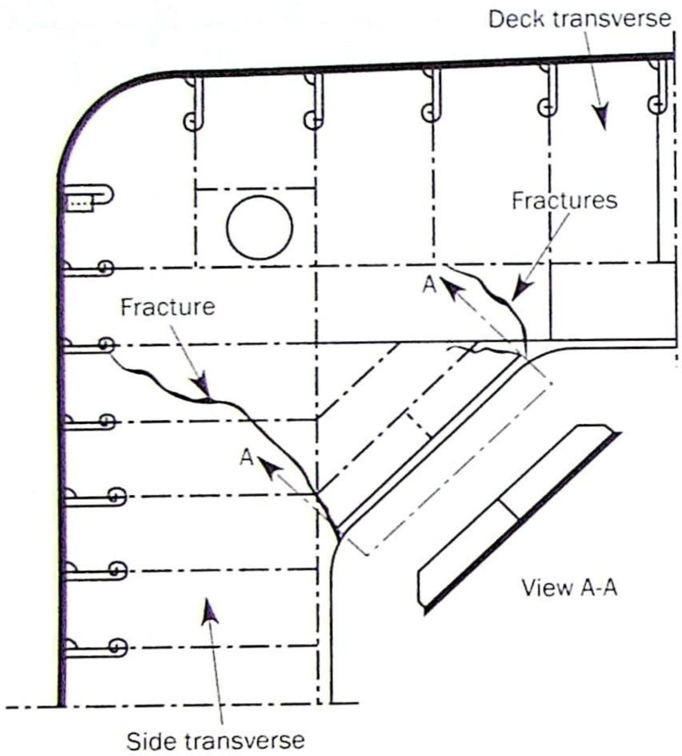
FACTORS CONTRIBUTING TO DAMAGE

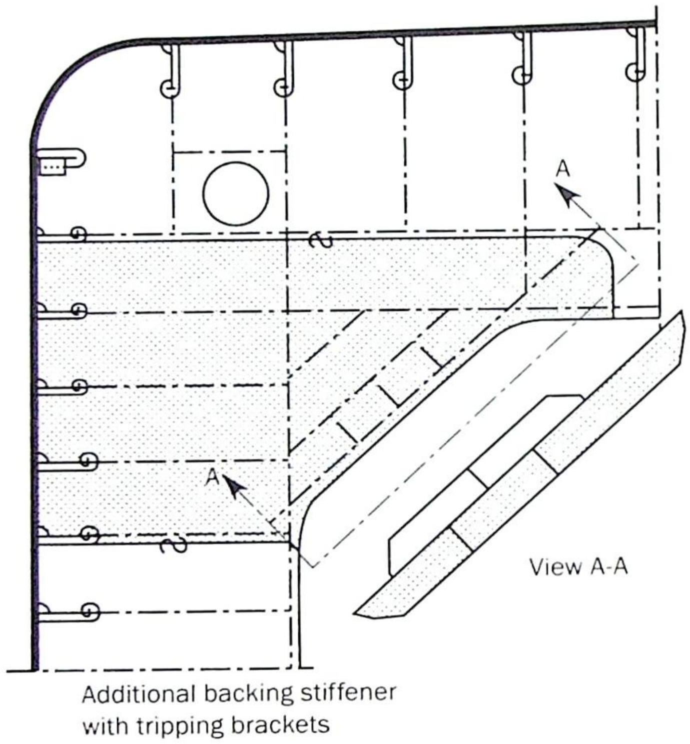
1. Abrupt reduction of face plate thickness and width.
2. Taper and butt weld in face plate located in corner radius where high stresses exist.
3. Stress concentration due to scallop in the web plate.
4. Defective butt weld at face plate taper.

Figure 35:	*Catalogue of Structural Details*
1 of 6	

GROUP No. 7 (Refer to index on Page 180)	*Location: Transverse Web Frame End Brackets*
	Example No. 2: Fractured Wing Tank Deck Transverse Bracket. Face Plate Sniped

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Stress concentration at bracket face plate sniped end.
2. Defective weld or material at the face plate snipe.

Figure 36:	*Catalogue of Structural Details*
2 of 6	

GROUP No. 7

(Refer to index on Page 180)

Location: Transverse Web Frame End Brackets

Example No. : 1 and 2

Additional Notes

1. **REPAIR NOTES**

1.1 It is recommended that the web plate in way of the fracture be cropped and part renewed.

1.2 Example No. 1:

New butt welds in the face plate should be kept clear of the bracket radius.

1.3 Example No. 2:

New backing stiffener to be in line with the existing stiffener. The same applies to tripping brackets.

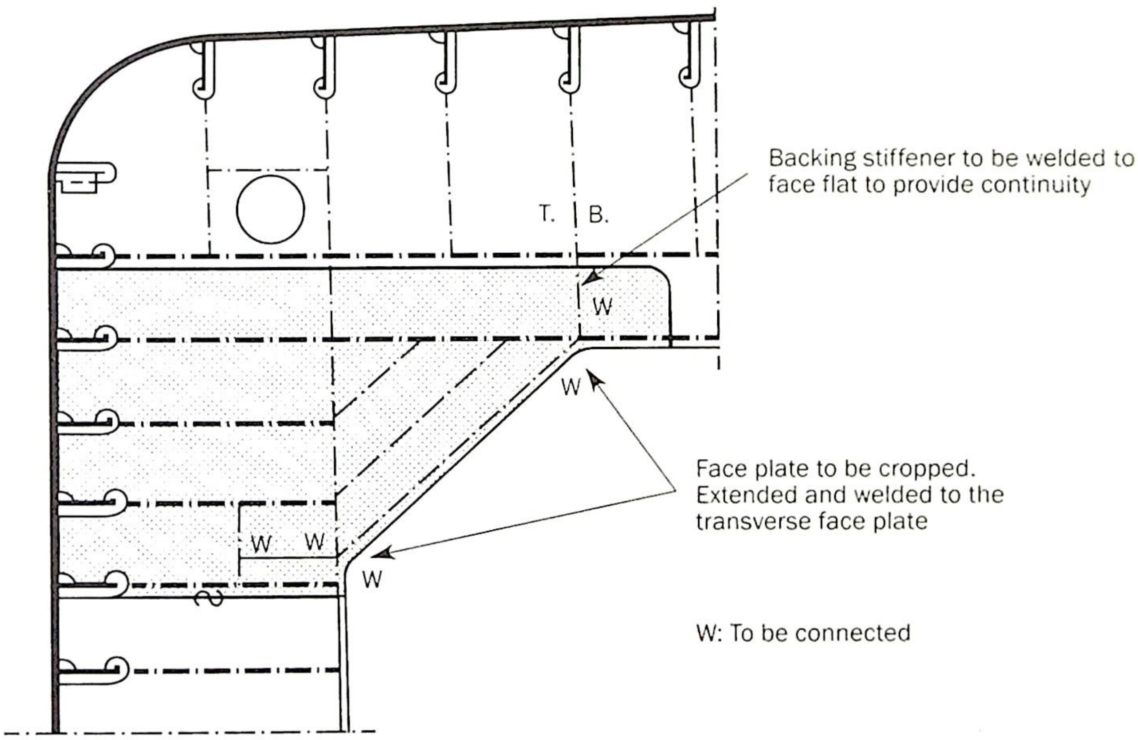
2. **ALTERNATIVE REPAIRS**

2.1 Example No. 1:

In addition to cropping and part renewing, the heavier face plate may be carried fully around the bracket radius and connected with a 1:3 taper to the smaller face plate.

2.2 Example No. 2:

Consideration can be given to cropping the sniped bracket face plate and connecting it to the deck transverse if the existing structural arrangement permits the necessary backing stiffener to be incorporated.



3. **UNSUCCESSFUL REPAIRS**

3.1 Rewelding of fractures without adequate reinforcement can lead to re-occurrence.

4. **NEW CONSTRUCTION**

4.1 Example No. 1:

Locate tapered part of the face plate with butt weld away from the bracket radius where the highest stresses exist.

4.2 Example No. 2:

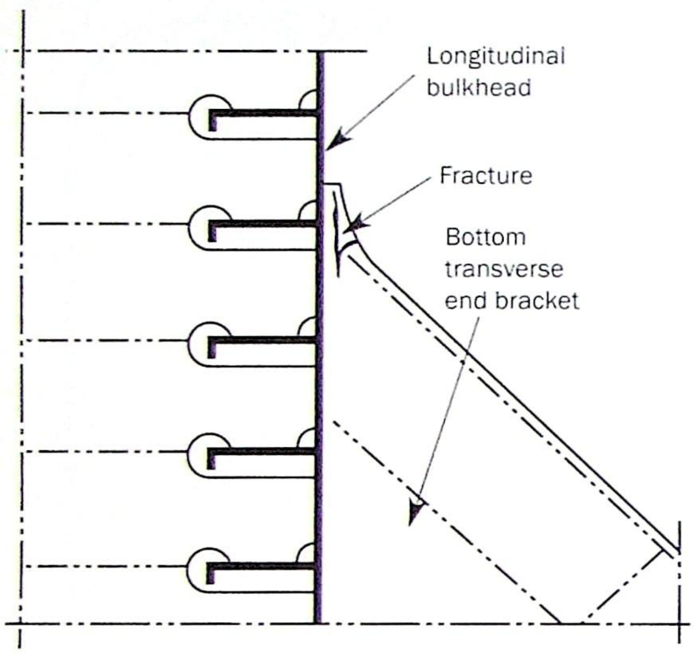
Connect bracket face plate to the face plate of the main transverse member with suitable backing brackets/stiffener to provide continuity.

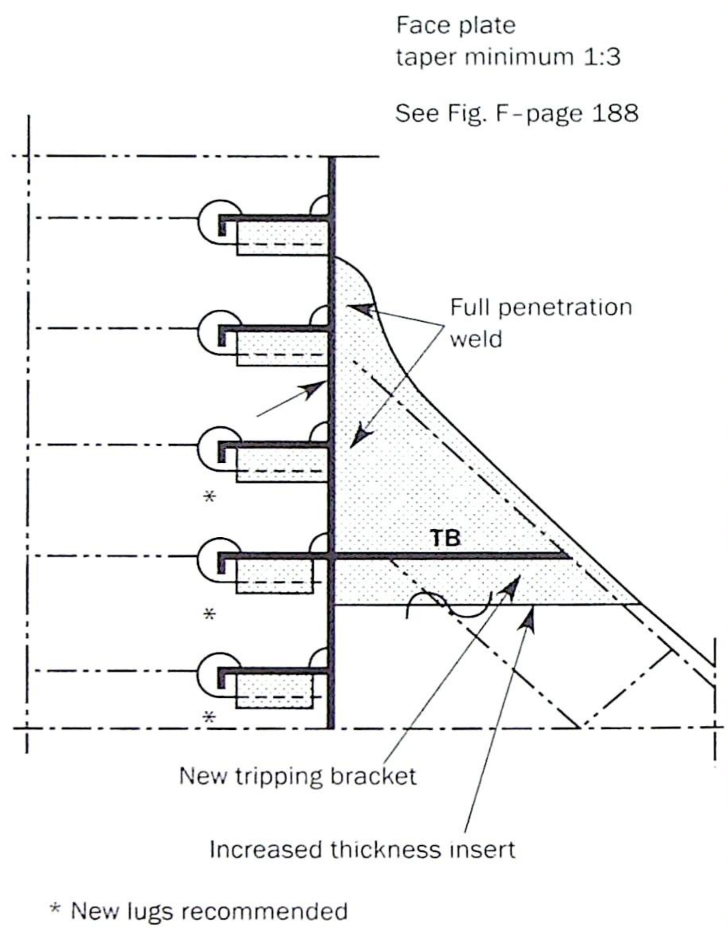
Figure 37: Catalogue of Structural Details

3 of 6

GROUP No. 7 *(Refer to index on Page 180)*	*Location: Transverse Web Frame End Brackets*
	Example No. 3: Fractured Centre Tank Bottom Transverse End Bracket. Asymmetrical Face Plate

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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.

Additional Notes

1. REPAIR NOTES

1.1 Brackets should be cropped and part renewed at fractured toe with plate of increased thickness. The increased insert should extend over the full length of the face plate taper and where possible beyond any new tripping brackets fitted.

1.2 Bracket toe should end beyond the adjacent bulkhead longitudinal cut-out in way.

1.3 Examples Nos. 3 and 4:

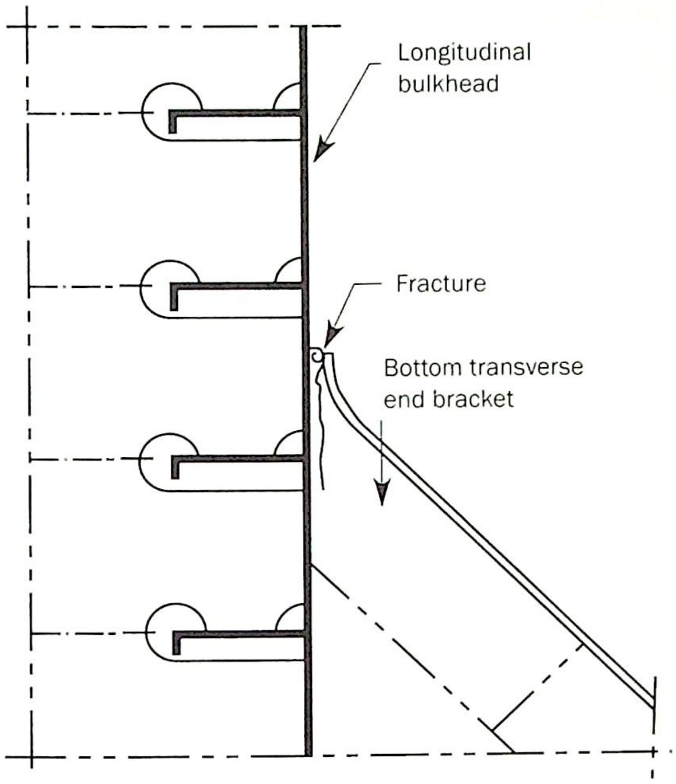
Full penetration weld is recommended for the connection in way of the longitudinal bulkhead for the bracket toe insert.

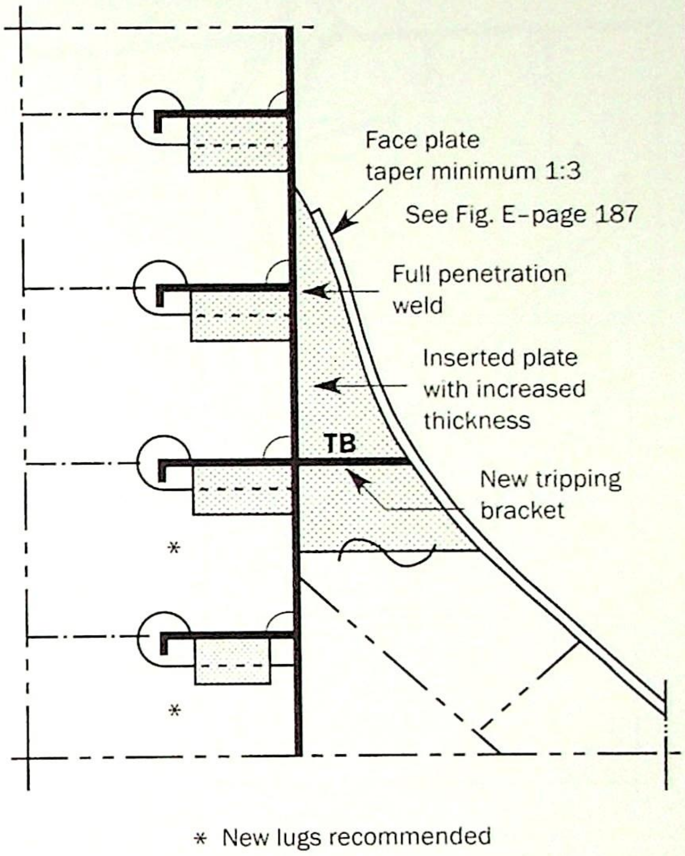
It is recommended that consideration be given to fitting additional lug connections to longitudinal in the wing tank in way of the centre tank bracket toe.

Figure 38:	*Catalogue of Structural Details*
4 of 6	

GROUP No. 7 (Refer to index on Page 180)	Location: Transverse Web Frame End Brackets
	Example No. 4: Fractured Centre Tank Bottom Transverse End Bracket. Symmetrical Face Plate

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO 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.

Additional Notes

2. ALTERNATIVE REPAIRS

2.1 Example No. 5:

Bracket face plate may be cropped back and an insert fitted connected to the transverse face plate. The transverse tripping bracket in way should also be connected to the face plate to provide continuity.

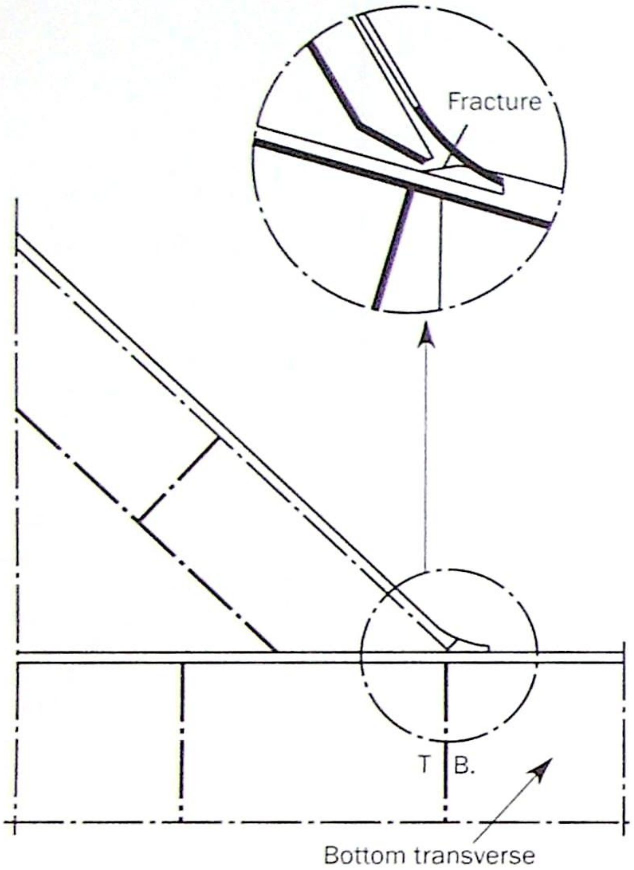
3. UNSUCCESSFUL REPAIRS

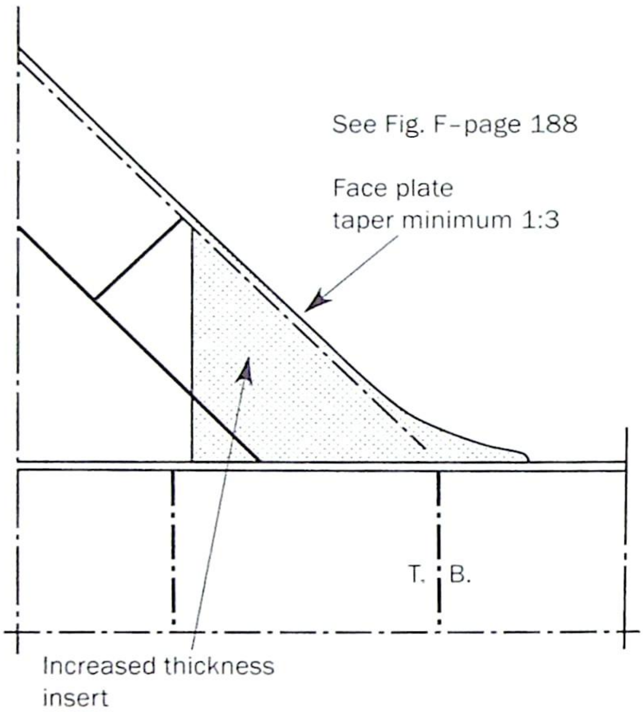
3.1 Rewelding of fracture only will in general lead to re-occurrence.

Figure 39:	*Catalogue of Structural Details*
5 of 6	

GROUP No. 7 (Refer to index on Page 180)	*Location: Transverse Web Frame End Brackets*
	Example No. 5: Fractured Wing Tank Bottom Transverse End Bracket. Asymmetrical Face Plate

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Bracket flange 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.

Additional Notes

4. NEW CONSTRUCTION

4.1 Arrange brackets with generous soft nose having the face plate tapered a minimum of 1:3 and with adequate area (a) at the bracket toe.

4.2 Confirm bracket sizes by calculation. Where high local stress is anticipated, consideration should be given to including a thicker insert at the bracket toe with full penetration welding.

4.3 Arrange, where possible, small tripping brackets adjacent to the start of the bracket face plate taper to both support the face plate and absorb some of the face plate load before the taper.

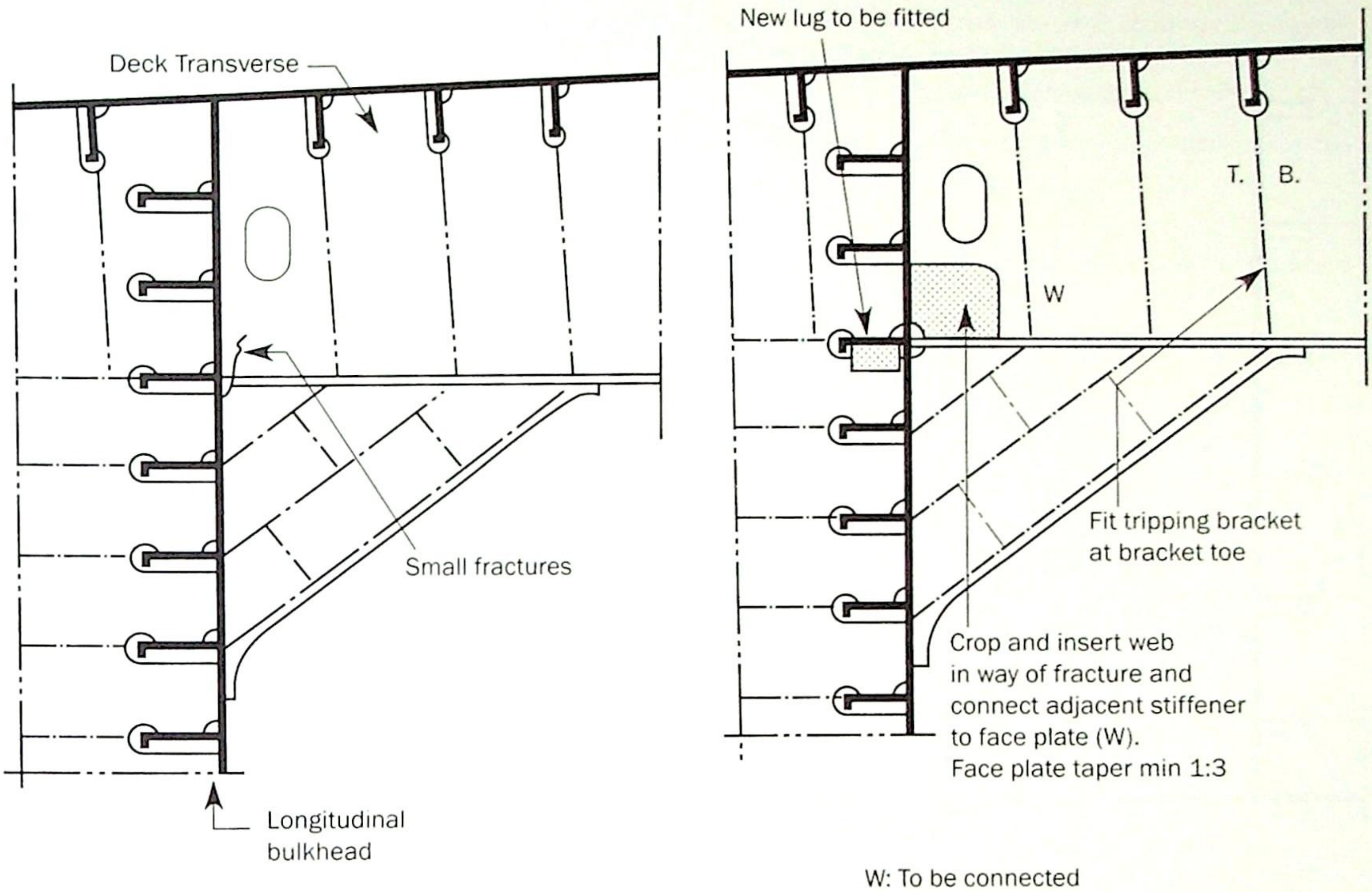
4.4 For bracket toe connection to primary member face plates, consideration may be given to welding the bracket face plate direct without a snipe, provided suitable backing is provided in way or the transverse.

4.5 See Figures E and F.

Figure 40:	*Catalogue of Structural Details*
6 of 6	

GROUP No. 8 (Refer to index on Page 180)	*Location: Primary Web Face Plate End Connection*
	Example No. 1: Fractured Centre Tank Deck Transverse

Typical Damage	*Proposed Repair*



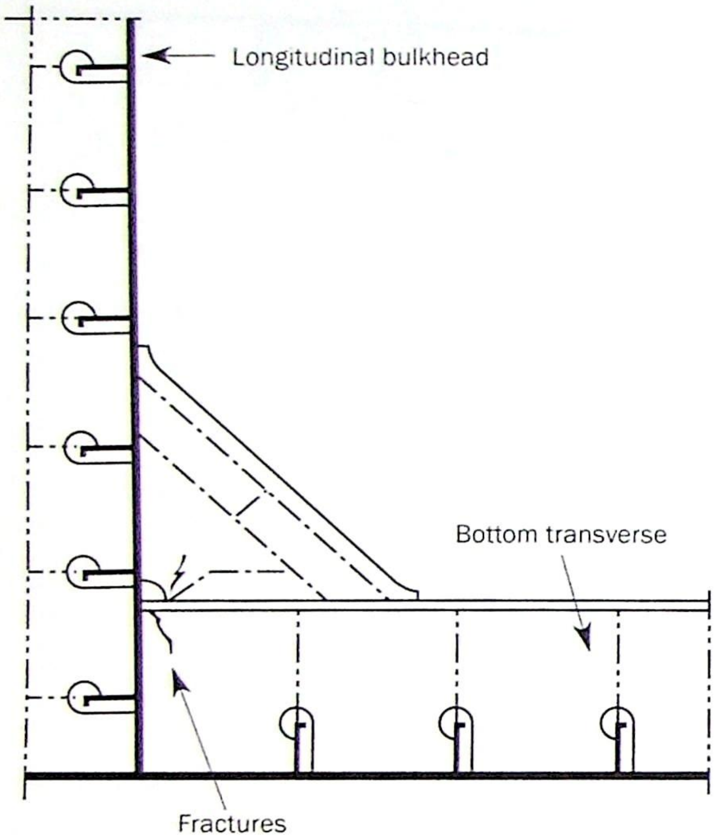
FACTORS CONTRIBUTING TO DAMAGE

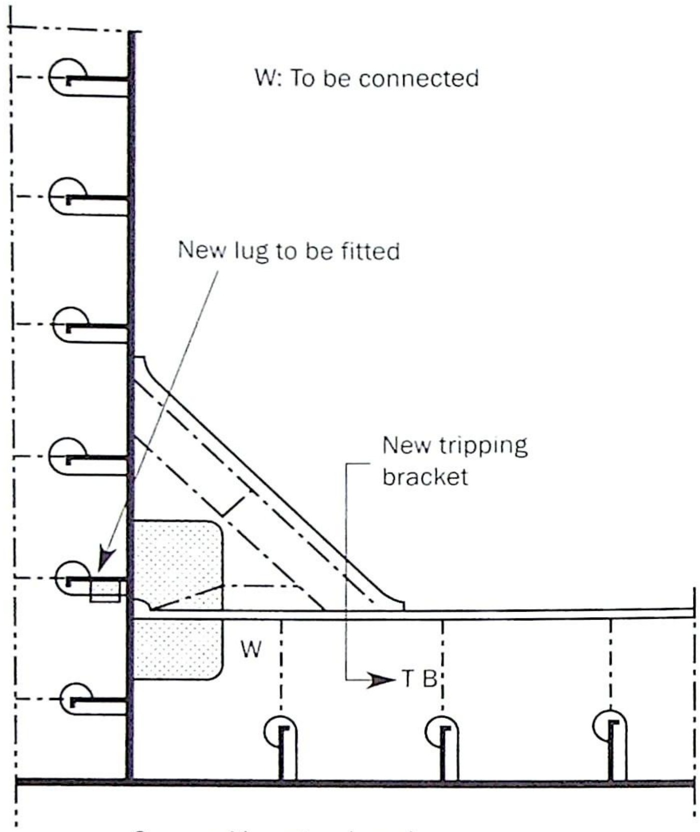
1. Sloshing loads on deck transverse.
2. Vibration.
3. Distance between the longitudinal bulkhead and the deck transverse tripping bracket too long.
4. Defective weld at the face plate taper.
5. Insufficient taper at deck transverse face plate.

Figure 41:	*Catalogue of Structural Details*
1 of 5	

GROUP No. 8 *(Refer to index on Page 180)*	*Location: Primary Web Face Plate End Connection*
	Example No. 2: Fractured Centre Tank Bottom Transverse

Typical Damage	*Proposed Repair*





Crop and insert web and bracket in way of fracture and connect adjacent stiffener to face plate (W). Fit tripping bkt. Face plate taper min. 1:3

FACTORS CONTRIBUTING TO 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.

Figure 42:	*Catalogue of Structural Details*
2 of 5	

GROUP No. 8 (Refer to index on Page 180)	*Location: Primary Web Face Plate End Connection*
	Example No.: 1 and 2

Additional Notes

1. **REPAIR NOTES**

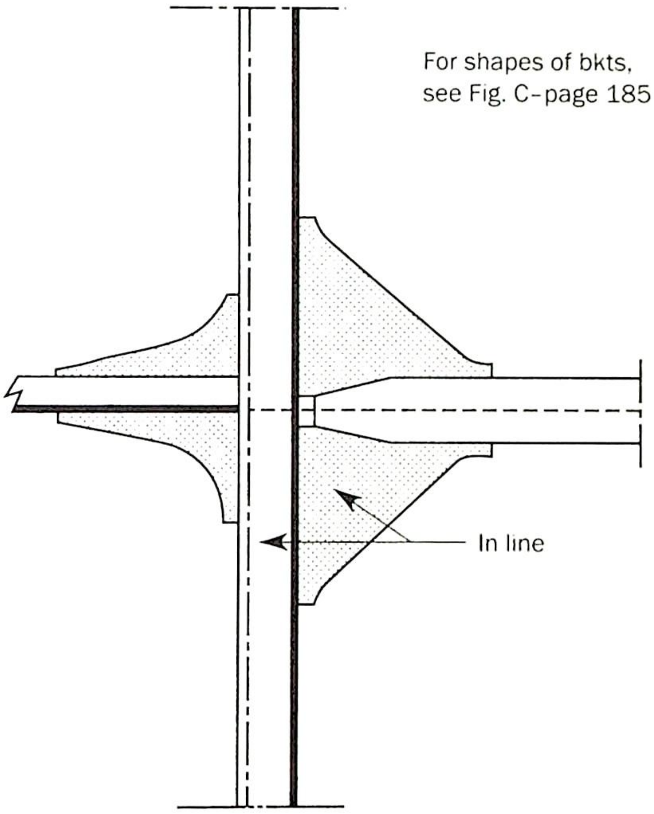
1.1 In general, fractured web plates should be cropped and part renewed. Where fractures are small, consideration may be given to a weld repair after locating ends of fractures by NDT. Completed weld should also be confirmed by NDT.

1.2 Face plate taper should be a minimum of 1:3.

1.3 When practicable it is recommended that a double lug be fitted in way of cut-out for bulkhead longitudinal in the wingtank.

2. **ALTERNATIVE REPAIRS**

2.1 Where the longitudinal in the wing tank is aligned with the transverse face plate in the centre tank a double bracketed connection may be made as follows:



3. **UNSUCCESSFUL REPAIRS**

3.1 Rewelding of fractures without proper cut-out in way of face plate end can lead to re-occurrence.

4. **NEW CONSTRUCTION**

4.1 Fit tripping brackets to primary webs at toe of end brackets.

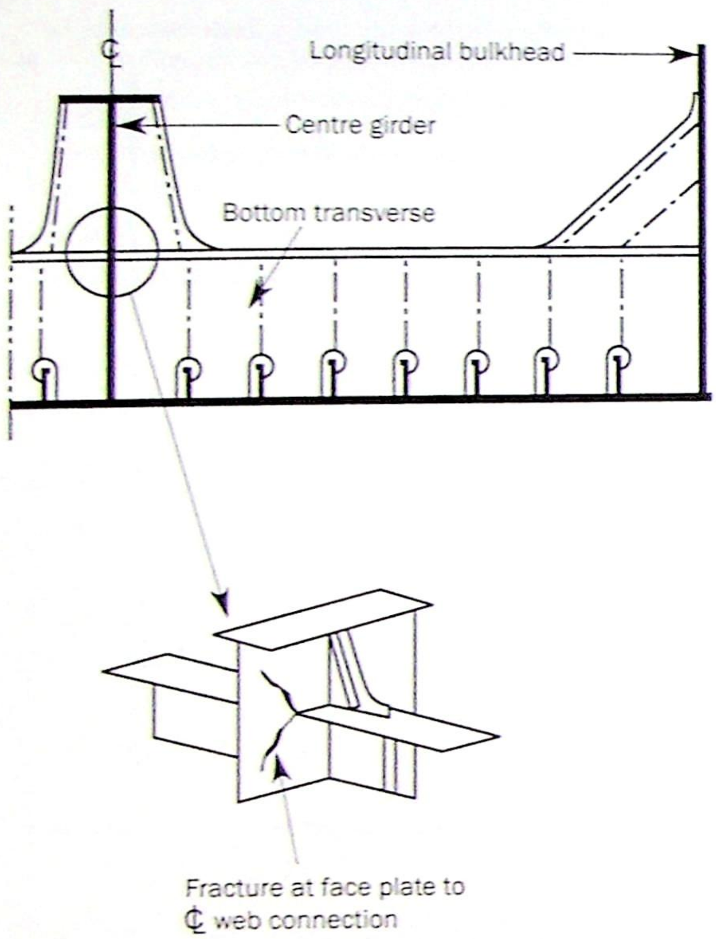
4.2 Connect the first panel stiffener to the transverse face plate.

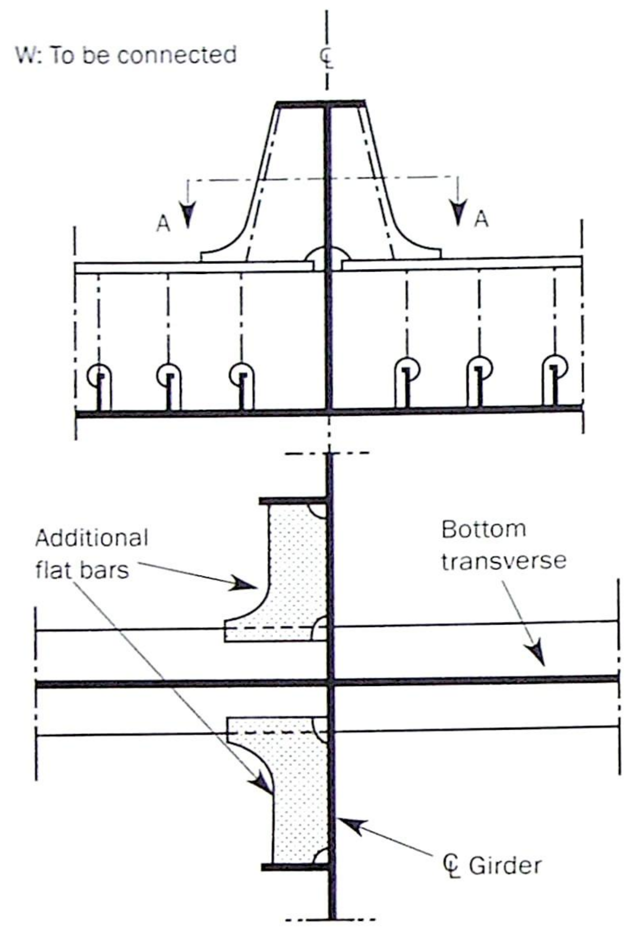
4.3 Provide double lug connections to longitudinal in way of face plate ending of primary structures.

Figure 43:	*Catalogue of Structural Details*
3 of 5	

GROUP No. 8 (Refer to index on Page 180)	Location: Primary Web Face Plate End Connection
	Example No. 3: Fractured Centre Girder at Intersection with the Bottom Transverse

Typical Damage	Proposed Repair





FACTORS CONTRIBUTING TO 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.

Figure 44:	*Catalogue of Structural Details*
4 of 5	

GROUP No. 8 (Refer to index on Page 180)	Location: Primary Web Face Plate End Connection
	Example No. 3: Fractured Centre Girder at Intersection with the Bottom Transverse

Additional Notes

1. **REPAIR NOTES**

1.1 Fractured web plate should be cropped and part renewed.

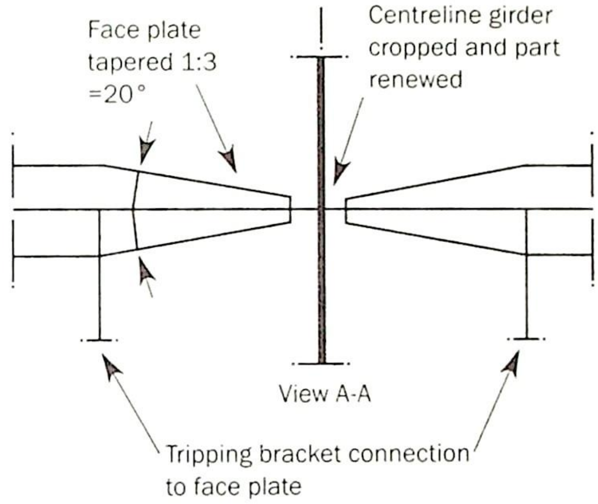
1.2 Face plate should be cropped and part renewed continuous through the girder.

1.3 Horizontal flat bars should be added to connect the girder flat to the web of the longitudinal girder.

2. **ALTERNATIVE REPAIRS**

2.1 Face plate may be cropped and part renewed continuous through the girder with the girder cropped.

2.2 Face plate may be cropped and part renewed tapered 1:3. Additional tripping brackets should be added to connect the girder flat to the bottom longitudinals (see sketch below).



3. **UNSUCCESSFUL REPAIRS**

3.1 Gouging out and welding only without modification can lead to re-occurrence.

4. **NEW CONSTRUCTION**

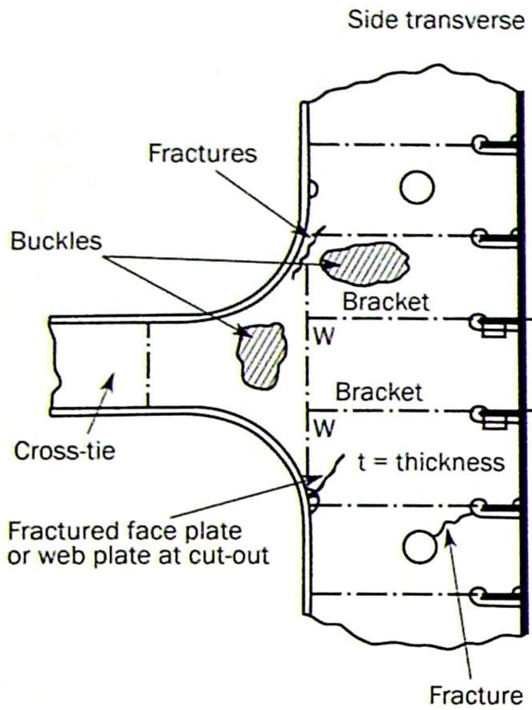
4.1 Ensure proper continuity and alignment of face plate where this is welded either side of the girder. Alternatively snipe this face plate with a minimum 1:3 taper either side and cover continuity with a sufficiently sniped end bracket either side of the girder.

4.2 Fit tripping bracket at the toe of the bottom transverse end bracket connected to the face plate.

Figure 45:	Catalogue of Structural Details
5 of 5	

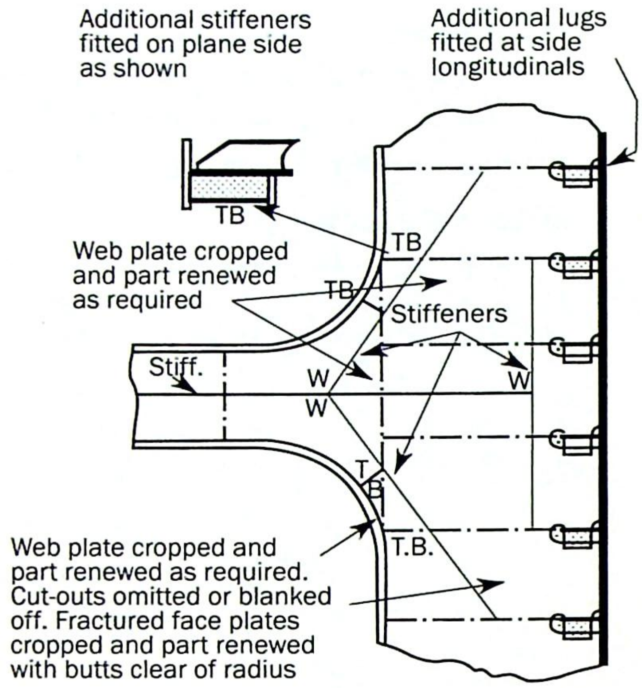
GROUP No. 9 (Refer to index on Page 180)	Location: Cross-ties and Their End Connections
	Example No. 1: Fractured and Buckled Web Plate and Fractured Face Plate

Typical Damage



Note: *Fractures & buckles not necessarily occurring together*

Proposed Repair



W: To be connected

FACTORS CONTRIBUTING TO 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.

Additional Notes

1. REPAIR NOTES

1.1 In cases where there are no fractures and only slight buckling that requires reinforcement, which should be fitted as indicated.

1.2 Where plating is fractured or requires renewal due to thinning over the full area, the following thickness guidance is given to ensure adequate panel buckling stability:

a) When two or three cross-ties are fitted, the upper cross-tie and the centre cross-tie of three should have a panel breadth ratio B/t equal to or less than 60.

b) The lower cross-tie of two or three or when only one is fitted should have a panel breadth ratio B/t equal to or less than 55.

Where plating is renewed to these thicknesses, the additional stiffening shown can be omitted.

1.3 In cases where plating is not adversely affected by corrosion and fractures are isolated, then a repair by cropping and local insert plates could be made in way of the fracture.

1.4 Where transverse tripping brackets to cross-ties are not connected to face plates, opportunity should be taken to connect these brackets, whether or not fractures have occurred.

1.5 Lightening holes and notches in the vicinity of the cross-ties should be filled in.

1.6 Additional lugs should be attached to the side shell and longitudinal bulkhead longitudinals (see proposed repairs under Group 1).

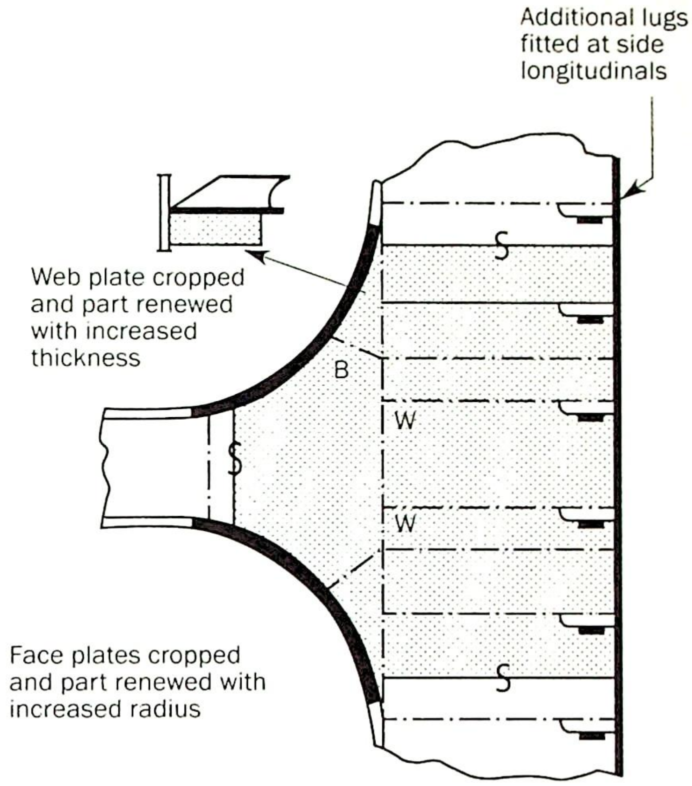
Figure 46:	Catalogue of Structural Details
1 of 2	

GROUP No. 9 (Refer to index on Page 180)	*Location: Cross-ties and Their End Connections*
	Example No. 1: Fractured and Buckled Web Plate and Fractured Face Plate

Additional Notes

2. ALTERNATIVE REPAIRS

2.1 Renew web with increased thickness and face with increased radius.



W: To be connected

3. UNSUCCESSFUL REPAIRS

3.1 Rewelding of cracks without additional stiffening or lugs, as described above, may lead to re-occurrence of the fractures.

3.2. Repairs to fractured plating at the ends of sniped stiffeners or tripping brackets connecting the brackets to the cross-tie face plates may lead to repeated fractures.

4. NEW CONSTRUCTION

4.1 Arrange large radii at the cross-tie face plates in way of the connection to the web frames to reduce stress concentrations, with butt welds in the face plate arranged clear of the radius.

4.2 Connect tripping brackets to the face plates in preference to sniping them clear.

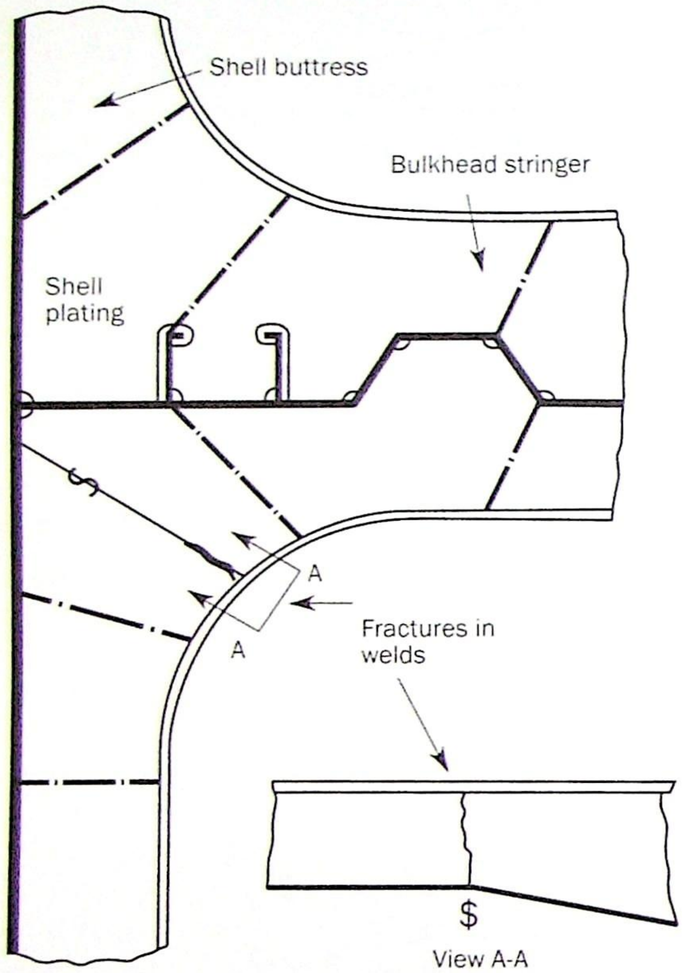
4.3 Provide sufficient web thickness and panel stiffening to absorb the bending stresses induced at the ends of cross-ties.

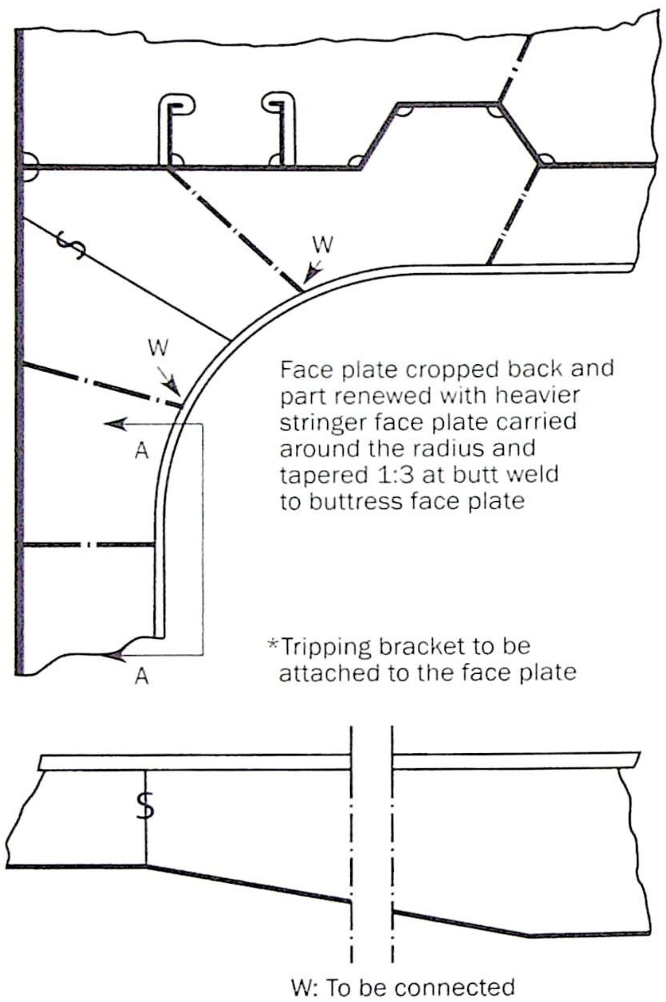
4.4 Fit double lugs connecting the longitudinals with the web frames in the vicinity of the cross-ties.

4.5 Avoid lightening holes, particularly in the area of cross-tie connections.

GROUP No. 10 *(Refer to index on Page 181)*	*Location: Transverse Bulkhead Horizontal Stringer*
	Example No. 1: Fractured Face Plate and Web at the Radiused End Brackets. Vertically Corrugated Bulkheads

Typical Damage	*Proposed Repair*





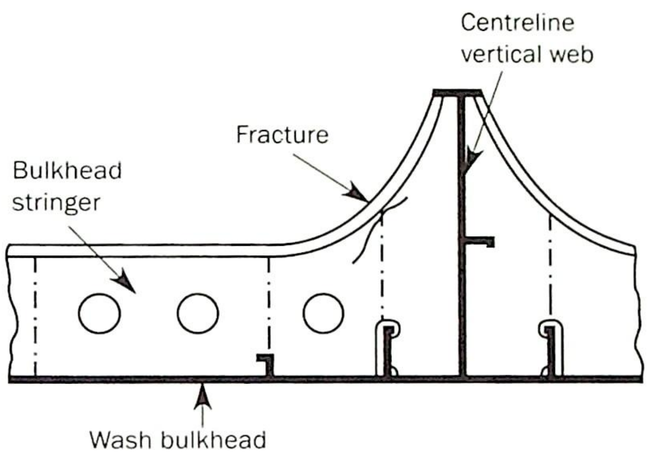
FACTORS CONTRIBUTING TO DAMAGE

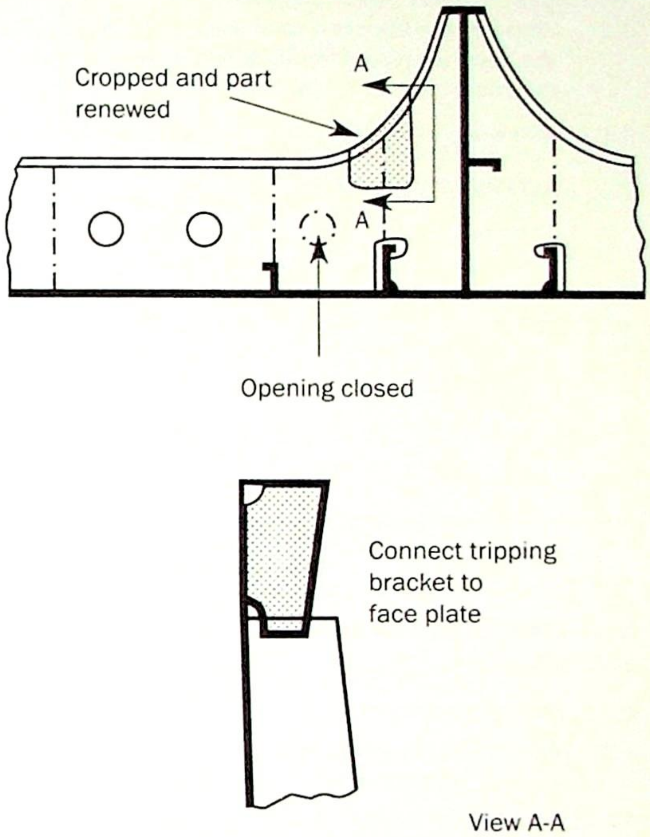
1. Stress concentration in the web plate due to discontinuity in the face plate size and to increased general stress level at the radius.
2. Butt welds and notches in area of high stress concentration.
3. Inadequate size of stringer end bracket resulting in high general stress levels.
4. Dynamic loads on the bulkhead.
5. Localised corrosion at area of stress concentration.

Figure 48:	*Catalogue of Structural Details*
1 of 8	

GROUP No. 10 (Refer to index on Page 181)	Location: Transverse Bulkhead Horizontal Stringer
	Example No. 2: Fractured Web of Stringer at the Radiused Bracket in Way of Centreline Vertical Web

Typical Damage	Proposed Repair





FACTORS CONTRIBUTING TO 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.

Figure 49:	Catalogue of Structural Details
2 of 8	

GROUP No. 10 (Refer to index on Page 181)	Location: Transverse Bulkhead Horizontal Stringer
	Example No.: 1 and 2

Additional Notes

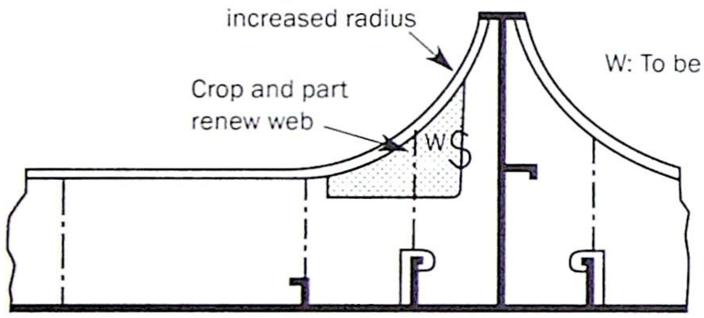
1. REPAIR NOTES

1.1 Fractured web plates and/or face plates should be cropped and part renewed. Cut-out at notches should be blanked off.

1.2 Where in the fractured zone there is an abrupt variation of cross-sectional area of the face bar width and/or thickness, the new face plate is to be carried around the radius at the heavier section. At the butt weld to the smaller face plate a minimum taper of 1:3 should be arranged.

1.3 Butt welds in the face plate are to be shifted clear of the radius and notches avoided.

2. ALTERNATIVE REPAIRS



3. UNSUCCESSFUL REPAIRS

3.1 Welding of cracks without reinforcement will lead to a rapid re-occurrence of fractures.

4. NEW CONSTRUCTION

4.1 Adopt, as far as practicable, a large radius to reduce stress concentration in the web plates where the stringer is designed with a rounded continuous face bar.

4.2 Adopt a soft nose design of the bracket toe where the stringer is designed with a straight continuous face bar. If the stringer is highly loaded, a thicker inset should be fitted at bracket toe.

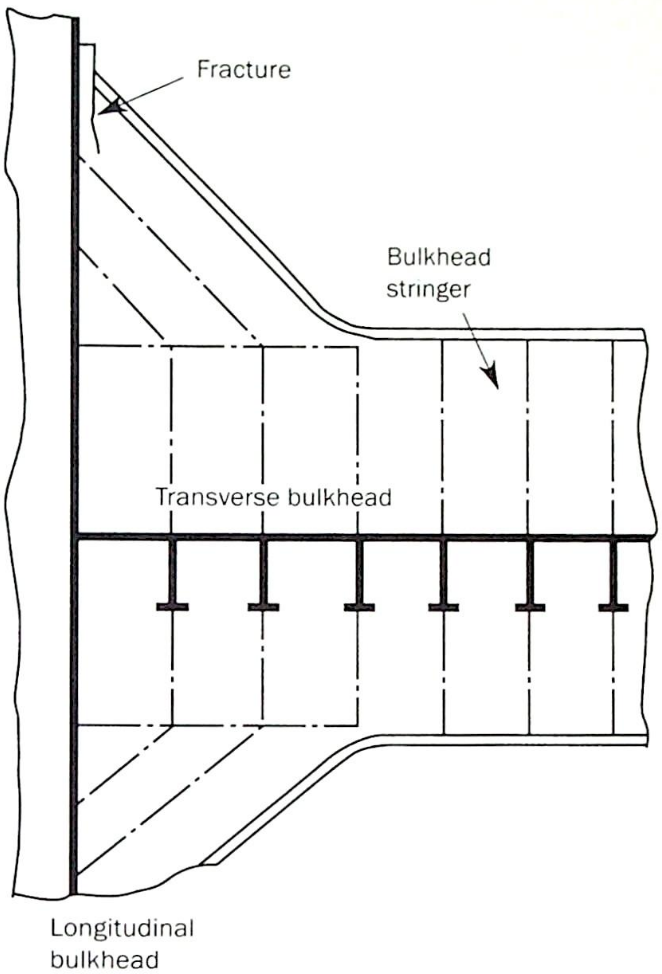
4.3 Avoid welds and notches at areas of stress concentration.

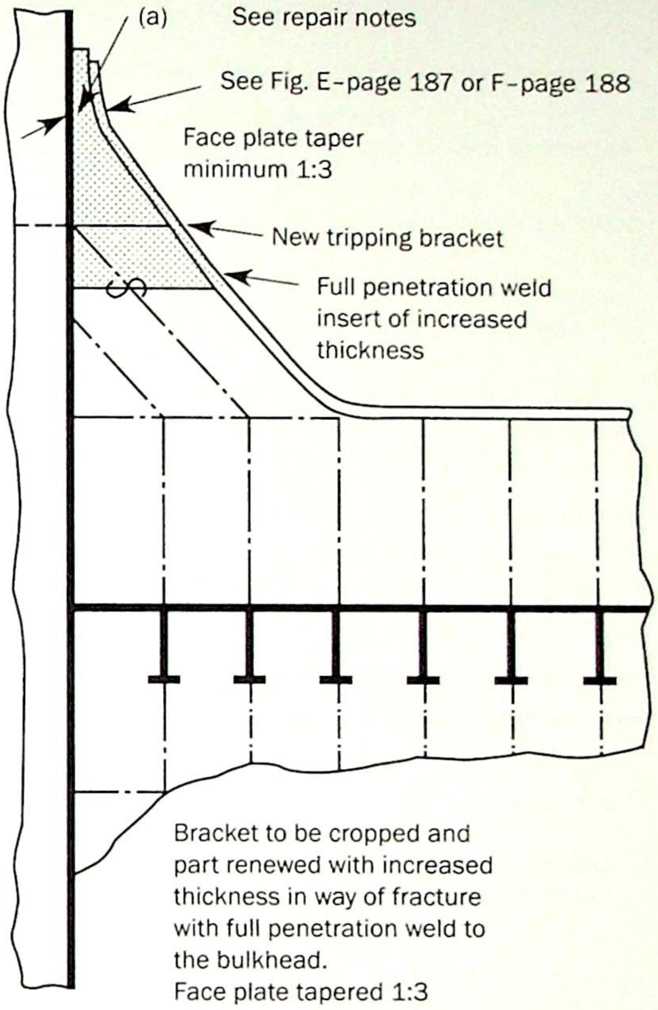
4.4 Incorporate a smooth variation of section where cross-sectional area of the flange is reduced. The flange width should be tapered to a minimum of 1:3.

Figure 50:	Catalogue of Structural Details
3 of 8	

GROUP No. 10 (Refer to index on Page 181)	Location: Transverse Bulkhead Horizontal Stringer
	Example No. 3: Fractured Centre Tank Stringer Bracket Connection to the Longitudinal Bulkhead

Typical Damage	Proposed Repair





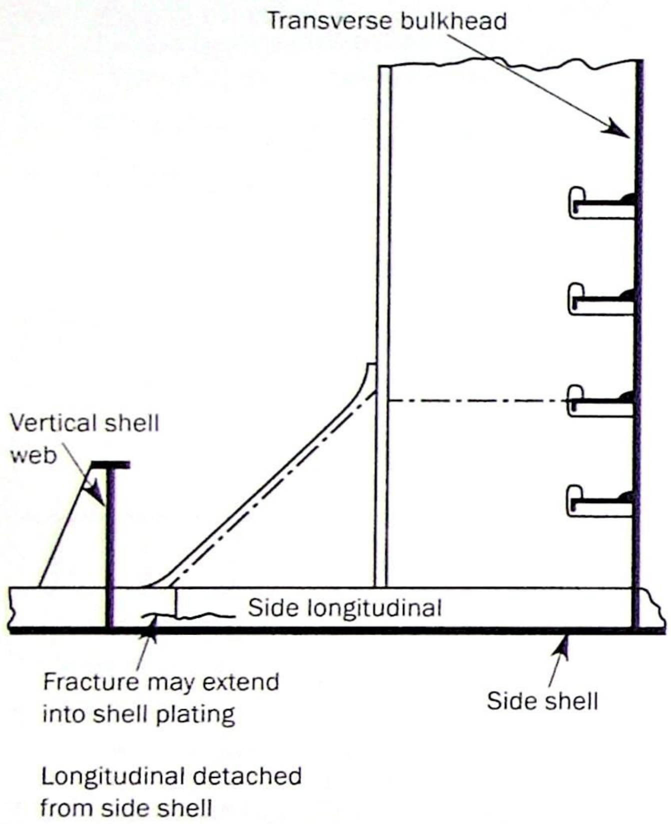
FACTORS CONTRIBUTING TO DAMAGE

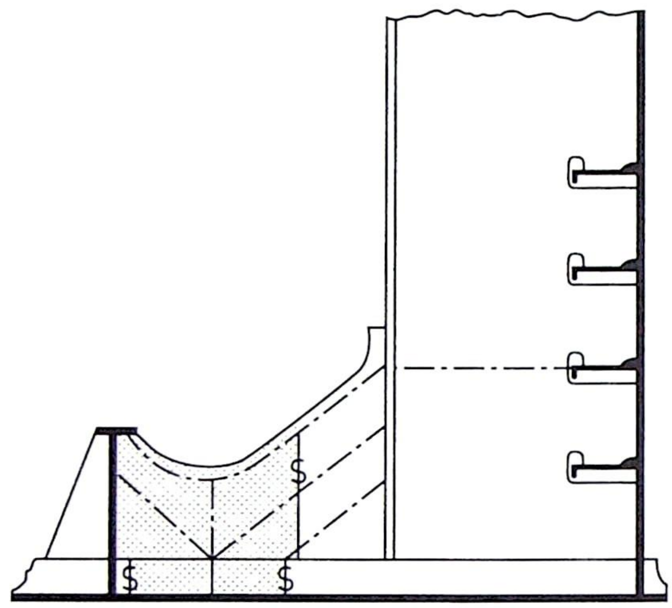
1. Stress concentration in the web of bracket where face plate is sniped, particularly where taper is inadequate.
2. Insufficient radius of bracket toe.
3. Insufficient thickness of web plating.
4. Dynamic loads on the bulkhead.
5. Localised corrosion at bracket toe in area of stress concentration.
6. Misalignment of bracket toe in way of longitudinal bulkhead.
7. Defective weld around plate thickness at bracket toe and at face plate snipe.

Figure 51:	Catalogue of Structural Details
4 of 8	

GROUP No. 10 (Refer to index on Page 181)	*Location: Transverse Bulkhead Horizontal Stringer*
	Example No. 4: Fractured Wing Tank Stringer Bracket and Side Shell Longitudinal

Typical Damage	*Proposed Repair*





Bracket cropped back and full buttress added with suitable panel stiffening

FACTORS CONTRIBUTING TO 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.

Figure 52:	*Catalogue of Structural Details*
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GROUP No. 10 (Refer to index on Page 181)	*Location: Transverse Bulkhead Horizontal Stringer*
	Example No. 4: Fractured Wing Tank Stringer Bracket and Side Shell Longitudinal

Additional Notes

1. **REPAIR NOTES**

1.1 Fractured web plate of the longitudinal should, in general, be cropped and part renewed. Small fractures may be repaired by welding provided they are ground flush and checked by NDT.

1.2 The bracket should be part renewed in order to connect it to the nearest transverse web frame to form an effective buttress as indicated with suitable stiffening.

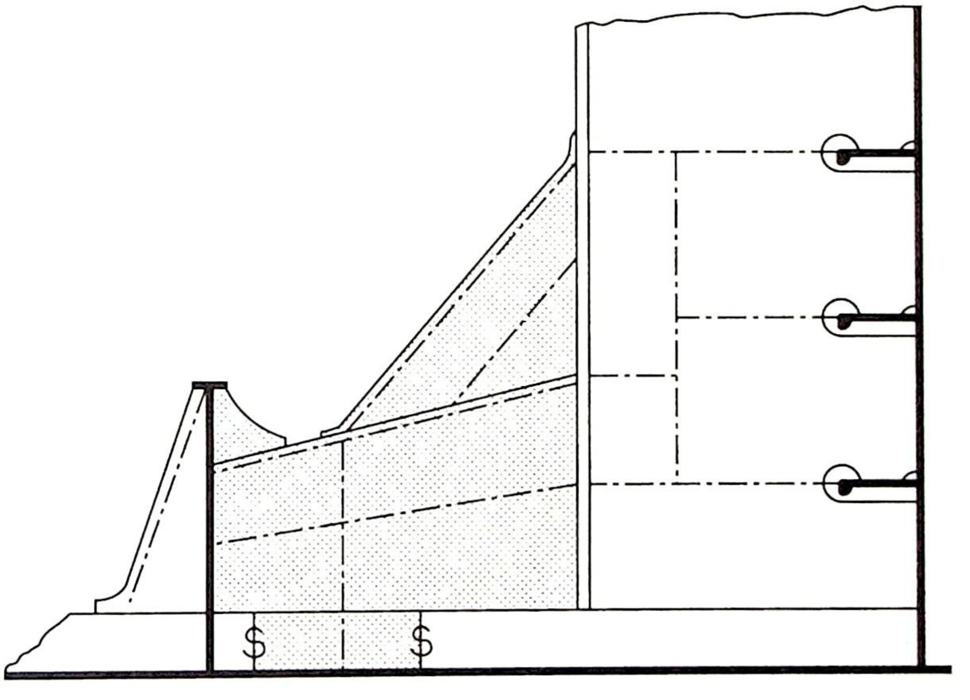
1.3 A backing bracket should be added on the reverse side of the web frame connected to the side longitudinal if this is not already present.

1.4 Larger shell plating fractures will normally be repaired by cropping and part renewing. Where smaller fractures are welded, the fracture should be gouged out, with the ends located by dye penetrant. Internal structural details contributing to the fractures must be dealt with. The quality of the welding should be checked by NDT.

1.5 Fractured longitudinals should be cropped and part renewed. However, welding may be considered where peak stress location is changed due to the fitting of additional/larger bracket provided that a proper weld is possible. The quality of the welding should be checked by NDT.

2. **ALTERNATIVE REPAIRS**

2.1 Existing bracket may be cropped away and a new full buttress and end bracket fitted as shown below:



3. **UNSUCCESSFUL REPAIRS**

3.1 Renewal of the longitudinal stiffener with no modification of the bracket design.

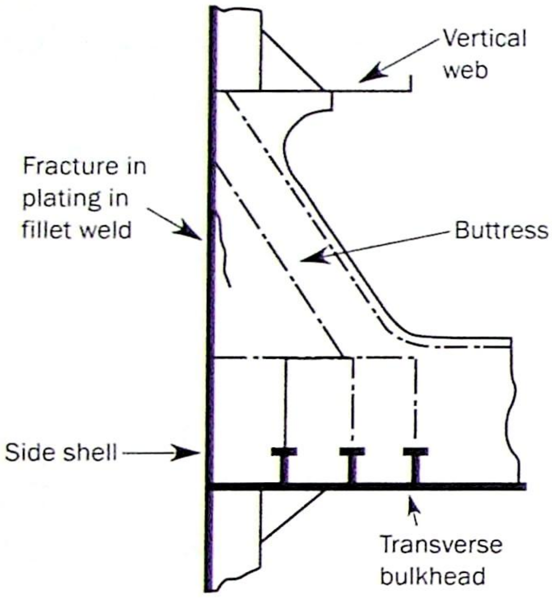
4. **NEW CONSTRUCTION**

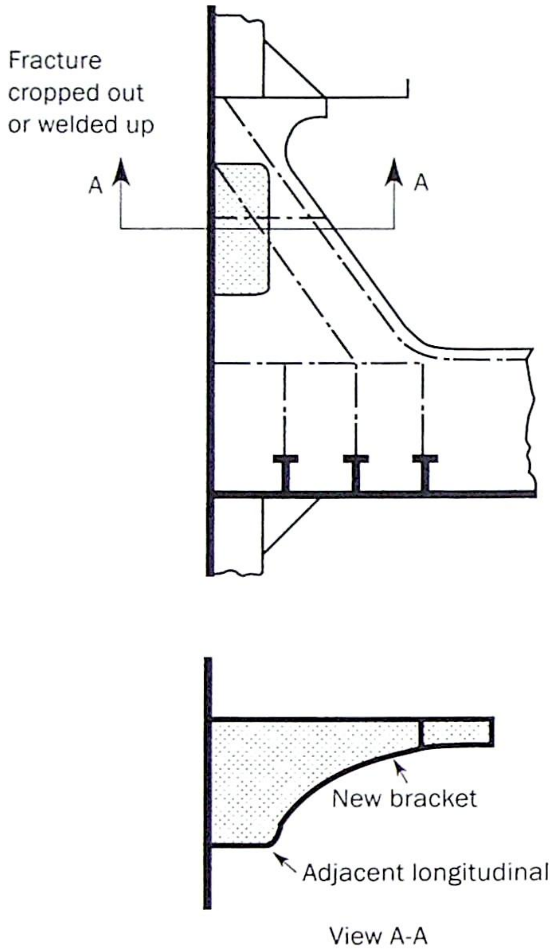
4.1 Ensure an effective buttress is arranged to transmit the end load from stringers to the adjacent vertical webs. Buttress to be sized on basis of calculated loads. Efficient panel stiffeners should be fitted.

Figure 53: 6 of 8	*Catalogue of Structural Details*

GROUP No. 10 (Refer to index on Page 181)	*Location: Transverse Bulkhead Horizontal Stringer*
	Example No. 5: Fractured Web of Buttress at Connection to Shell

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Vibration of stringer web.

Additional Notes

1. REPAIR NOTES

1.1 Fractured area should be cropped and part renewed and an insert fitted. Small fractures can be repaired by welding.

1.2 Additional bracket should be fitted to improve vibration stability of the buttress.

2. ALTERNATIVE REPAIRS

2.1 None known.

3. UNSUCCESSFUL REPAIRS

3.1 Web cropped out and insert fitted without reinforcement.

4. NEW CONSTRUCTION

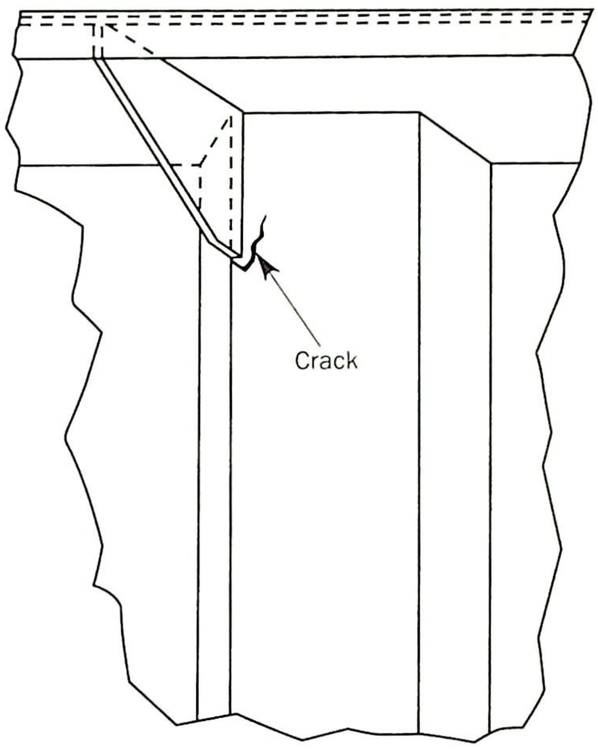
4.1 Fit adequate panel stiffening where vibration may be anticipated.

Figure 54:	*Catalogue of Structural Details*
7 of 8	

GROUP No. 10 (Refer to index on Page 181)	*Location: Transverse Bulkhead Horizontal Stringer*
	Example No. 6: Fractured Bulkhead in Way of Stringer Bracket Connection

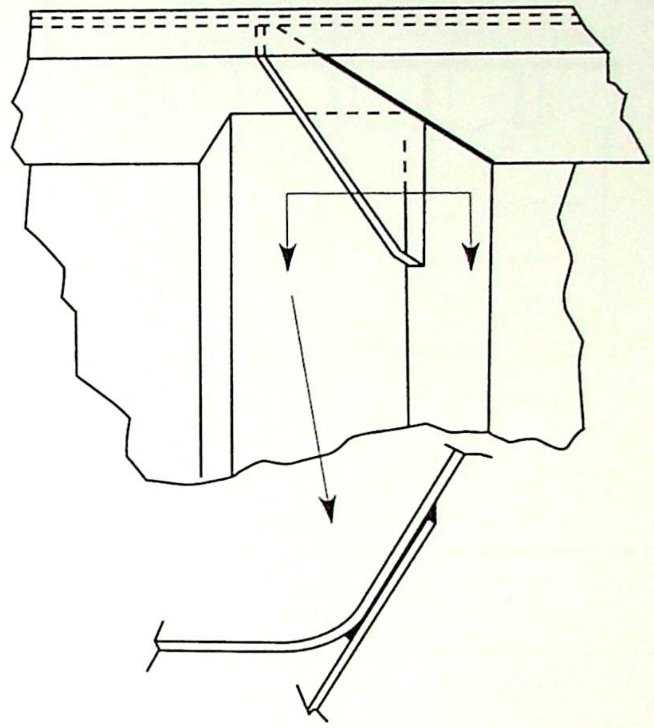
Typical Damage	***Proposed Repair***

Horizontal girder



Transverse BHD

Horizontal girder



Transverse BHD

Crack repaired by gouging and welding or plate cropped and renewed

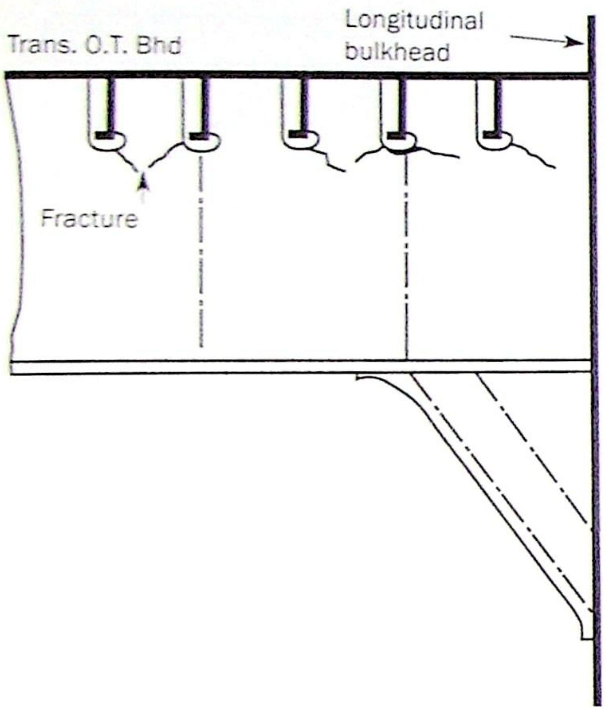
FACTORS CONTRIBUTING TO DAMAGE

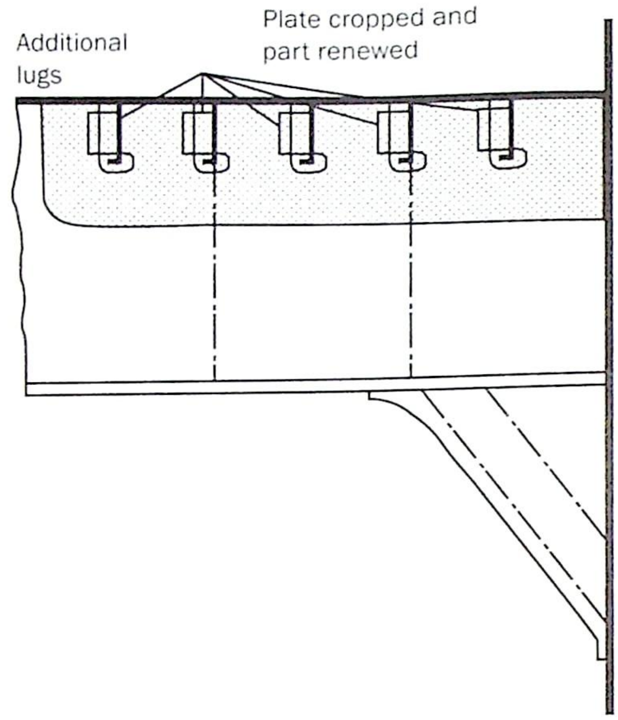
1. Excessive stress concentration around the toe of tripping bracket led to the fatigue cracks.
2. Excessive local stress due to the discontinuity of rigidity because of absence of reinforcement member led to the fatigue cracks.

Figure 55:	***Catalogue of Structural Details***
8 of 8	

GROUP No. 11 (Refer to index on Page 181)	*Location: Transverse Bulkhead Stiffener/Primary Web Intersection*
	Example No. 1: Fractured Web at Cut-outs for Vertical Stiffener

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Dynamic internal loads in full tanks due to ship motion.
2. Sloshing loads where tanks are partially filled.
3. High peak stresses in way of cut-out corners.
4. Insufficient area of connection for vertical stiffener.
5. Localised corrosion at areas of stress concentration.
6. High shear stress in the horizontal stringer web plate.

Additional Notes

1. REPAIR NOTES

1.1 Fractured plates should in general be cropped and part renewed. However, small fractures may be repaired by welding provided they are ground flush and a collar plate fitted to remove the stress concentration associated with the cut-out corners (see also Example No. 1 of Group 1).

1.2 The additional lug fitted should be as large as possible to improve the area of connection.

1.3 Particular attention should be paid to quality of welding especially at return of welds around the plate thickness.

2. ALTERNATIVE REPAIRS

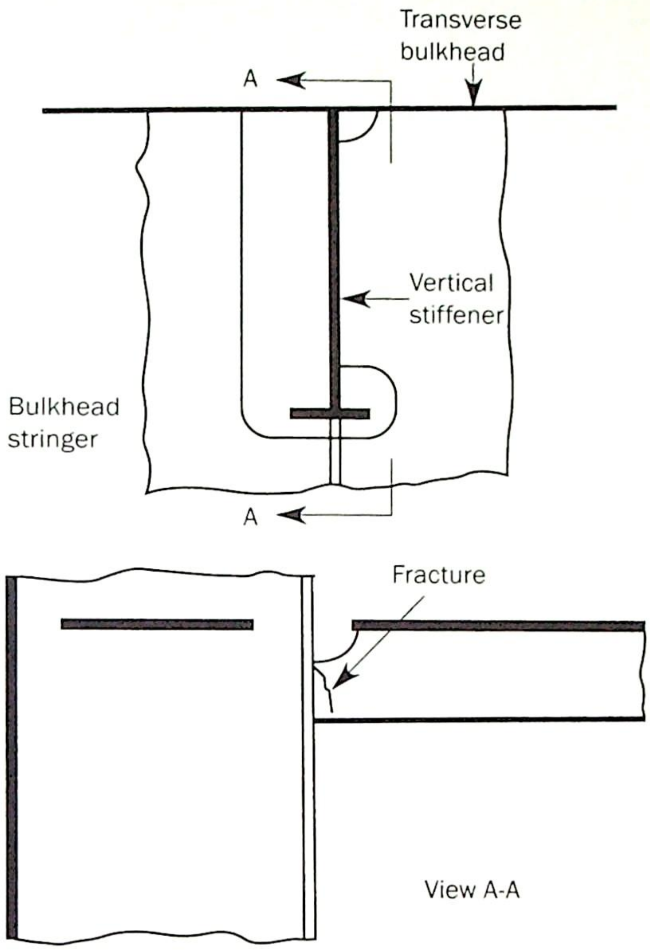
2.1 The partly renewed flat bar may be replaced by a bracket incorporating a soft nose together with the backing bracket recommended.

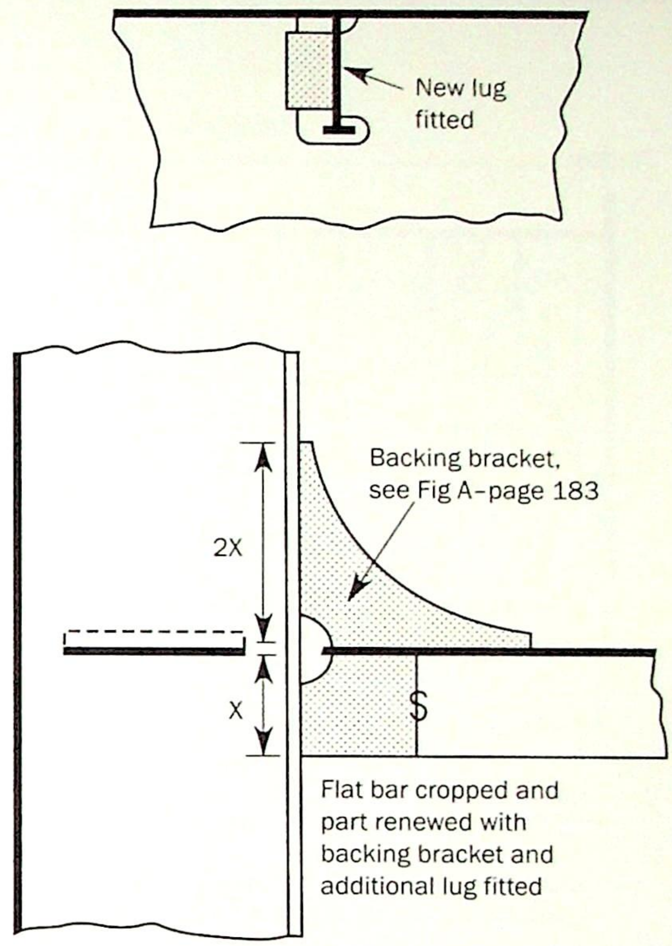
2.2 Where the stringer web plate is to be partly renewed in way of the cut-out, a larger radius may be incorporated into the corner of the cut-out to reduce the stress concentration.

Figure 56:	*Catalogue of Structural Details*
1 of 2	

GROUP No. 11 (Refer to index on Page 181)	Location: Transverse Bulkhead Stiffener/Primary Web Intersection
	Example No. 2: Fractured Flat Bar Connection to Vertical Stiffener

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Dynamic internal loads in full tanks due to ship motion.
2. Sloshing loads where tanks are partially filled.
3. Insufficient area of stringer web stiffener.
4. Insufficient area of connection of vertical stiffener.
5. Bad return of weld around the stiffener plate thickness.
6. Asymmetrical connection with flat bar stiffener.

Additional Notes

3. UNSUCCESSFUL REPAIRS

3.1 Welding the fracture or renewal of stringer web without reinforcement. In this case re-occurrence of the fatigue fracture will take place.

3.2 Additional collar plate or additional backing bracket may be not sufficient to reduce stress concentrations at the cut-out corners. According to the level of dynamic loads it may be necessary to fit both forms of reinforcement.

4. NEW CONSTRUCTION

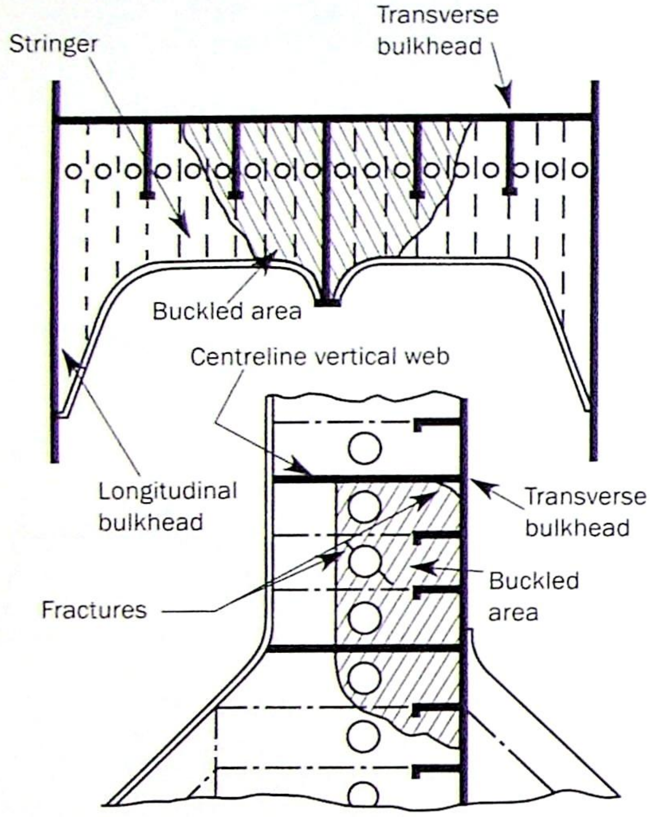
4.1 Adopt generous radii at corners of cut-outs.

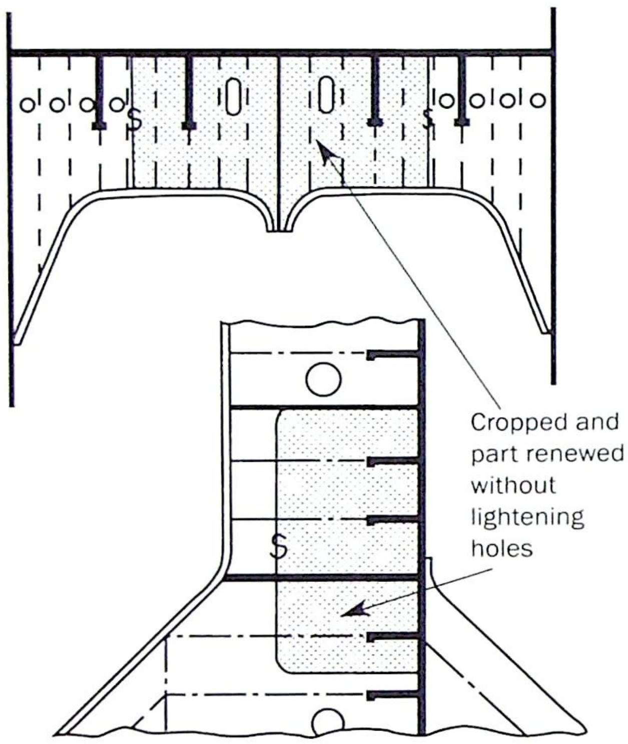
4.2 Connect vertical stiffeners to horizontal stringers with flat bar or bulb flat stiffeners. Where high shear stresses and/or high dynamic loads are anticipated add additional lugs to the stiffeners.

Figure 57:	*Catalogue of Structural Details*
2 of 2	

GROUP No. 12 *(Refer to index on Page 181)*	***Location: Lightening Holes and Openings in Primary Webs and Swash Bulkheads***
	Example No. 1: Buckled and Fractured Centreline Vertical Web and Stringer in Way of Intersection

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Corrosion losses in way of openings, leading to buckling of stringer and centreline girder, with fracturing in way of openings.
2. Stress concentrations in way of lightening holes.
3. Inadequate shear area in the vertical web.

Additional Notes

1. REPAIR NOTES

1.1 In general, plating in way of fractures should be cropped and renewed.

However, when the fractures are judged to be of a minor nature, gouging, welding and fitting of a doubler ring is acceptable (see Examples Nos. 2 and 4).

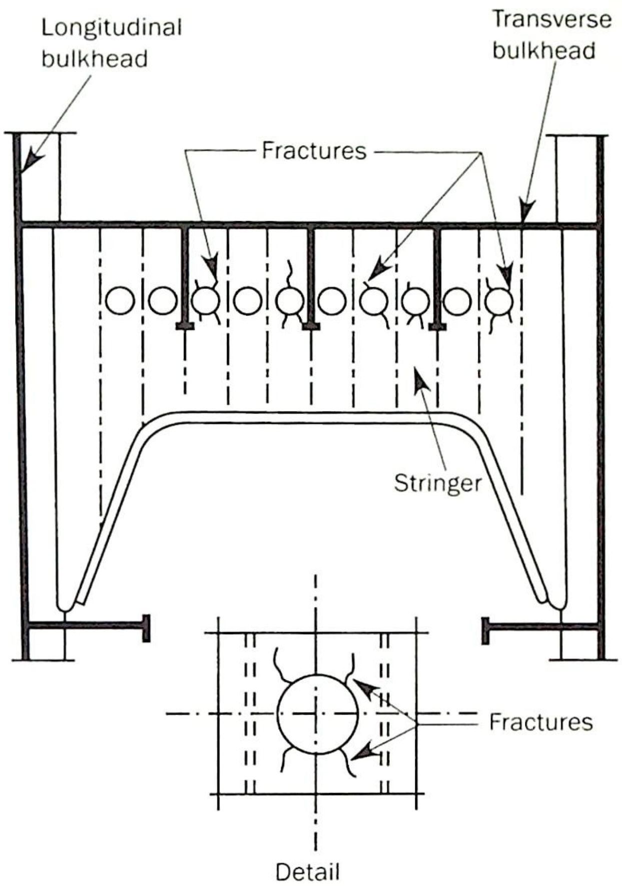
1.2 At the large opening (see Example No. 5) the opportunity should be taken to increase the radius at the corners to reduce the stress concentration. Care should be taken to ensure that any weld butts in inserts do not occur within a radius corner.

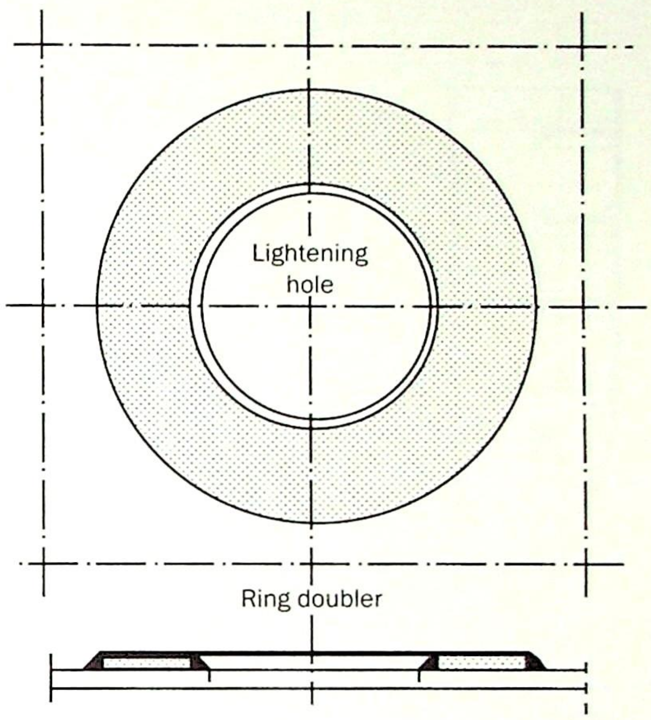
1.3 Where doubler rings are fitted, any knife-edging around the opening should be cropped, and the doubler ring sized to fit the larger opening. The inner radius of the ring should be 10 mm larger than the radius of the opening to allow a proper fillet weld.

Figure 58:	***Catalogue of Structural Details***
1 of 5	

GROUP No. 12 (Refer to index on Page 181)	*Location: Lightening Holes and Openings in Primary Webs and Swash Bulkheads*
	Example No. 2: Fractures in Way of Lightening Hole in Stringer Platform

Typical Damage	*Proposed Repair*





Severe knife-edging cropped and fractures welded. Ring doubler fitted around opening

FACTORS CONTRIBUTING TO 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.

Additional Notes

1.4 Where the openings in the structure are not essential for drainage, access, passage or flume performance, they should be plated over (see Examples Nos. 1 and 3). Depending on the arrangement and location, additional stiffening may be required.

1.5 Particular attention should be paid to the quality of welding especially at return of welds.

1.6 For recurrent fractures, notch tough steel should be considered.

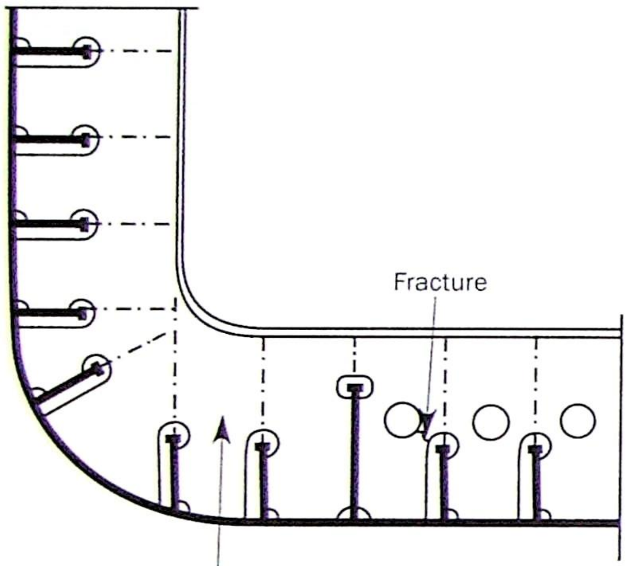
1.7 Protective coatings in way of repairs should be restored.

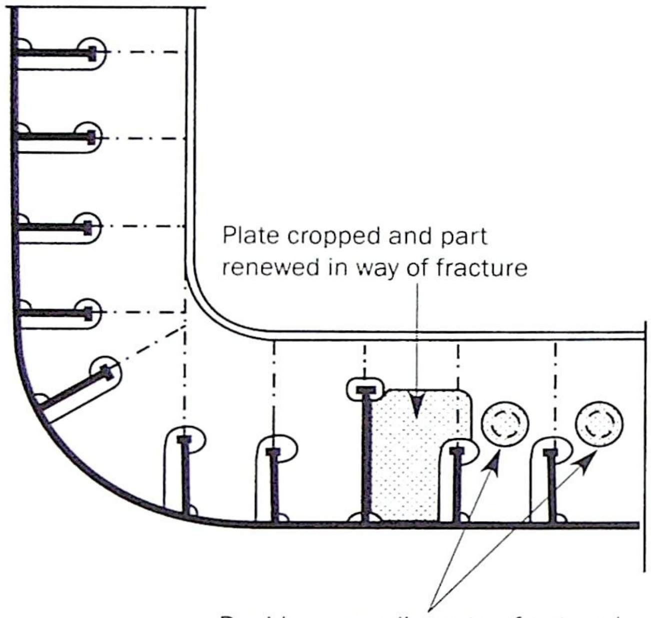
1.8 Structure as shown in Examples Nos. 1 to 4 were encountered on older vessels (15 years plus), and are generally not used in present practice. Fracturing was quite common especially when corrosion losses affected the material in way of openings.

Figure 59:	*Catalogue of Structural Details*
2 of 5	

GROUP No. 12 (Refer to index on Page 181)	Location: Lightening Holes and Openings in Primary Webs and Swash Bulkheads
	Example No. 3: Fractured Web of Bottom Transverse in Way of Lightening Holes

Typical Damage	Proposed Repair





FACTORS CONTRIBUTING TO DAMAGE

1. Unstiffened lightening holes too close to longitudinal cutouts causing stress concentrations in web plating.
2. Corrosion losses on edges of openings.

Additional Notes

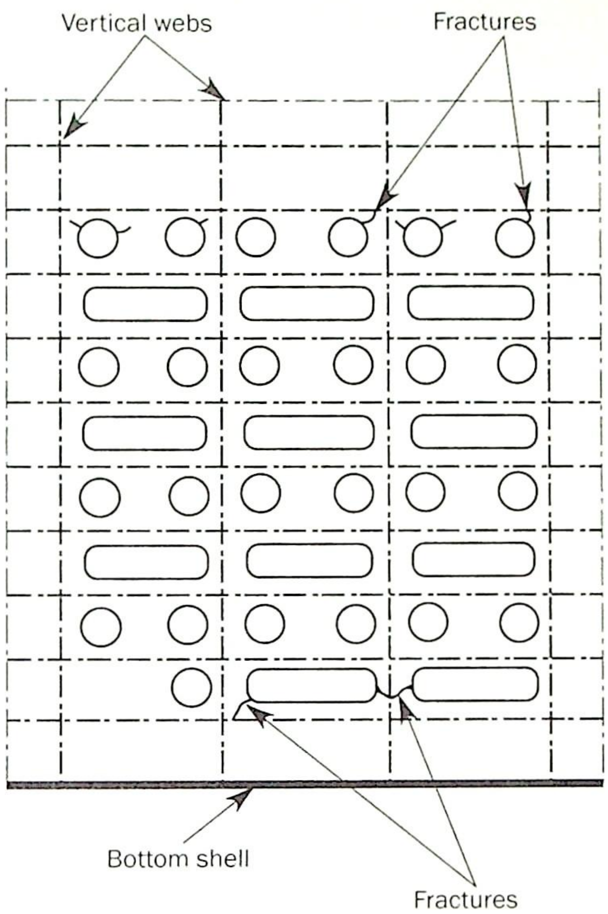
2. ALTERNATIVE REPAIRS

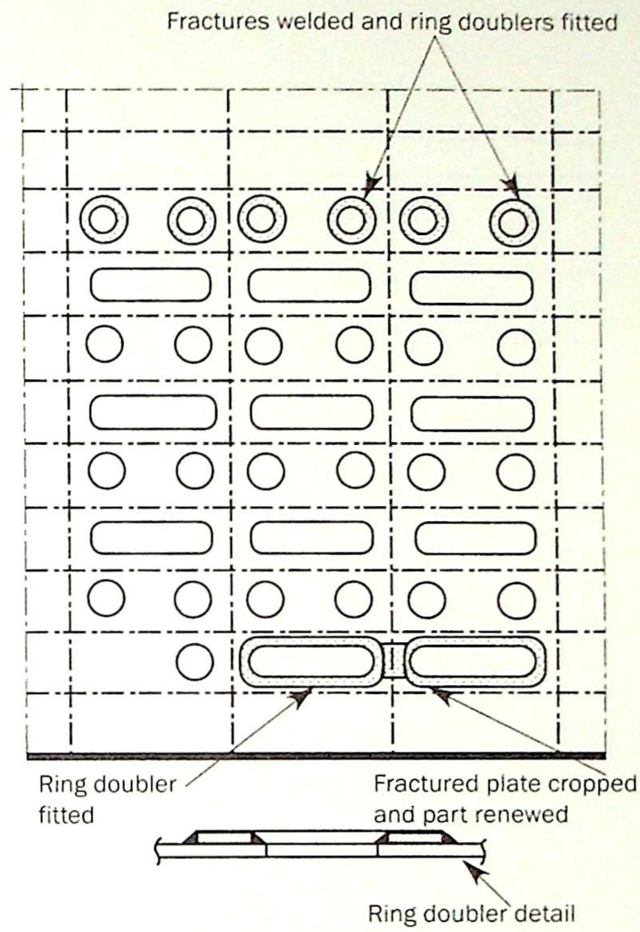
2.1 Instead of doubler rings, the holes can be plated over or new plating can be fitted in way of multiple openings such as those in Examples Nos. 1, 2 and 4. Increased thickness of plating, notch tough steel and/or additional stiffening should be considered to prevent re-occurrence of the cracking.

Figure 60:	Catalogue of Structural Details
3 of 5	

GROUP No. 12 (Refer to index on Page 181)	*Location: Lightening Holes and Openings in Primary Webs and Swash Bulkheads*
	Example No. 4: Fractures of Longitudinal Flume/Swash Bulkhead Plating at Openings

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Corrosion losses (aided by flume/swash action) causing thinning and knife-edging of plating surrounding openings.
2. Stress concentration at openings placed too close together.
3. Flexing of structure due to flume/swash action.
4. Lack of suitable stiffening around openings.
5. Inadequate shear strength and stiffness in the bulkhead.

Additional Notes

3. UNSUCCESSFUL REPAIRS

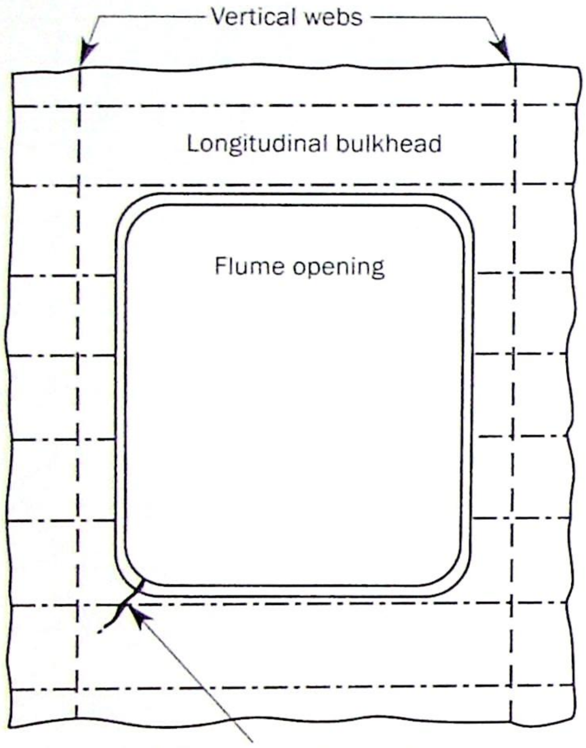
3.1 Simple gouging and rewelding of fractures will lead to re-occurrence of the fractures.

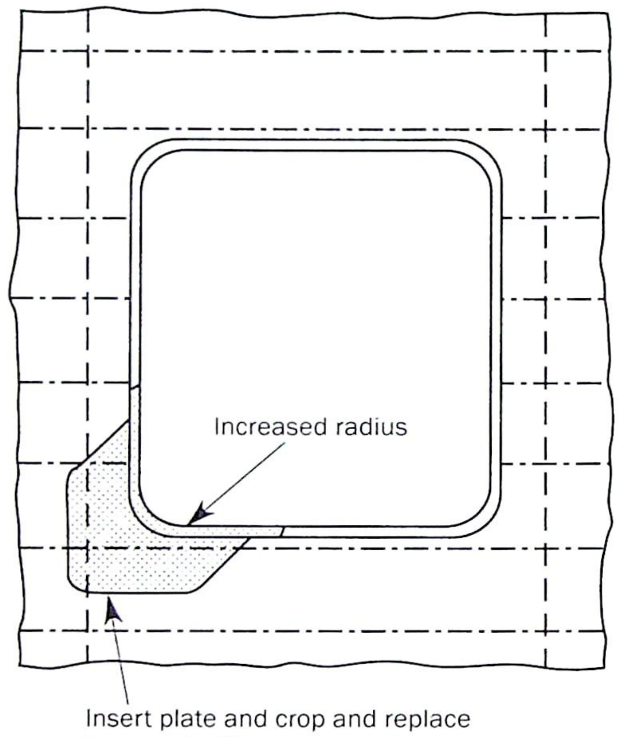
3.2 For Example No. 5, repairs utilising smaller sized insert plates resulting in butts within the radius, corner were not successful, and resulted in fractures along the weld of the insert plate and into existing plating.

Figure 61:	*Catalogue of Structural Details*
4 of 5	

GROUP No. 12 (Refer to index on Page 181)	*Location: Lightening Holes and Openings in Primary Webs and Swash Bulkheads*
	Example No. 5: Fracture at Corner of Flume Opening in Longitudinal Bulkhead

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Overall shear distortion of bulkhead.
2. Stress concentration at corner of opening.
3. Corrosion losses due to flume action.

Additional Notes

4. NEW CONSTRUCTION

4.1 Avoid excessive lightening holes to prevent stress concentrations in primary webs and bulkheads. In large openings provide as big a radius at corner as possible.

4.2 Properly stiffen flume and swash openings to account for sloshing forces. Consider increased thickness of scantling to offset accelerated corrosion losses.

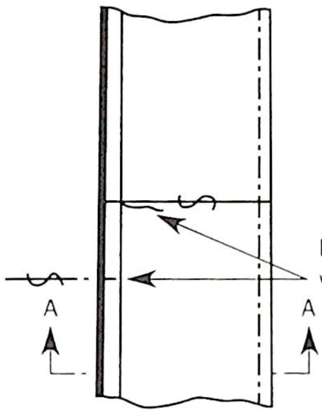
Figure 62:	*Catalogue of Structural Details*
5 of 5	

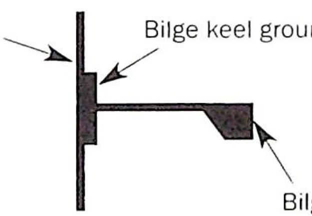
GROUP
No. 13
(Refer to index on Page 182)

Location: Bilge Keel

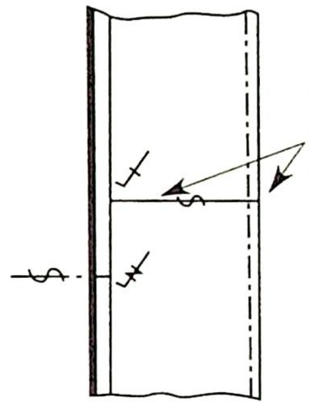
Example No. 1: Fracture in Continuous Bilge Keel and Ground Bar

Typical Damage	*Proposed Repair*





View A-A



 Butt weld to be confirmed by non-destructive testing. Butt weld is not to penetrate into the ground bar

 Welding of butts in ground bar not to penetrate into shell plating

FACTORS CONTRIBUTING TO DAMAGE

1. Defective butt welds.
2. Contact damage to bilge keel.

Additional Notes

1. REPAIR NOTES

1.1 Crack arresting holes may be drilled through the butt welds and should have a minimum diameter of 25 mm and extend beyond the fore and aft extent of the butt weld. These holes can be used to examine the butt weld penetration to confirm welds have full penetration.

1.2 Where fractured bilge keel butt welds are found, all the remaining butt welds to be checked by NDT.

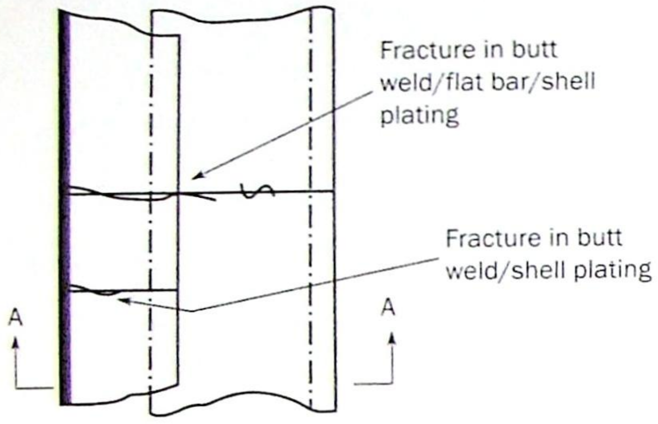
1.3 In carrying out butt welds in the bilge keel flat bar or ground bar adjacent to the shell, care should be taken to avoid direct connection between the shell and the butt weld, by means of a temporary backing strip of copper, asbestos etc.

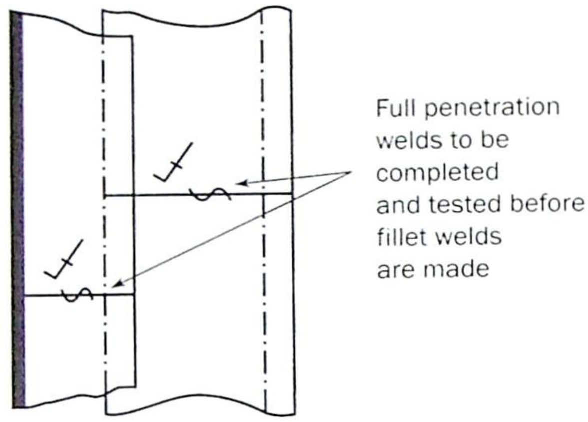
Figure 63: *Catalogue of Structural Details*

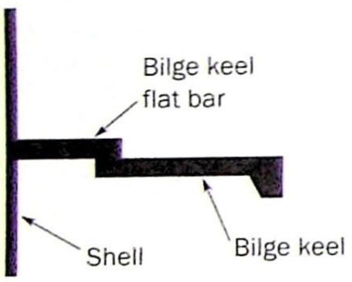
1 of 3

GROUP No. 13 (Refer to index on Page 182)	*Location: Bilge Keel*
	Example No. 2: Fracture in Continuous Bilge Keel and Flat Bar

Typical Damage	*Proposed Repair*







View A-A

Butts to be confirmed by non-destructive testing.
Butt weld of butt in flat bar is not to penetrate into shell plating

Butt weld in flat bar or bilge keel not to penetrate into bilge keel or flat bar respectively

FACTORS CONTRIBUTING TO DAMAGE

1. Defective butt welds.
2. Contact damage to bilge keel.

Additional Notes

2. ALTERNATIVE REPAIRS

2.1 Refer to Example No. 3, make bilge keel continuous.

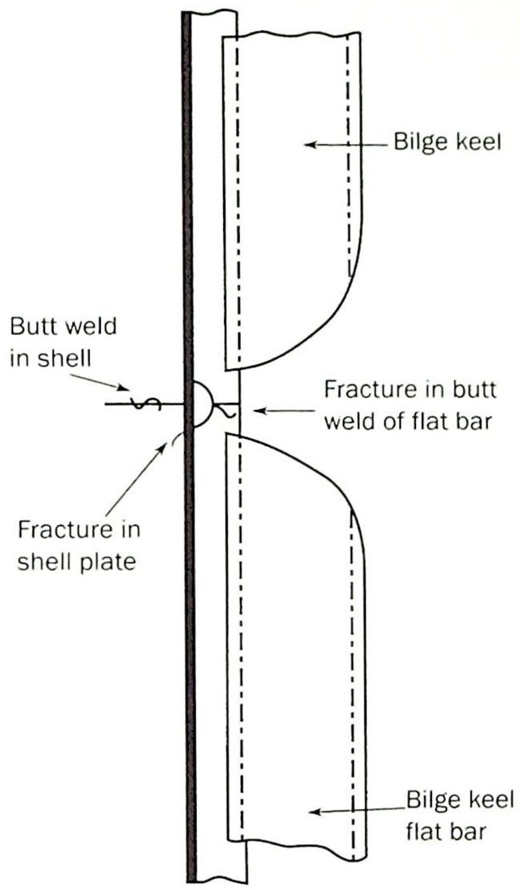
3. UNSUCCESSFUL REPAIRS

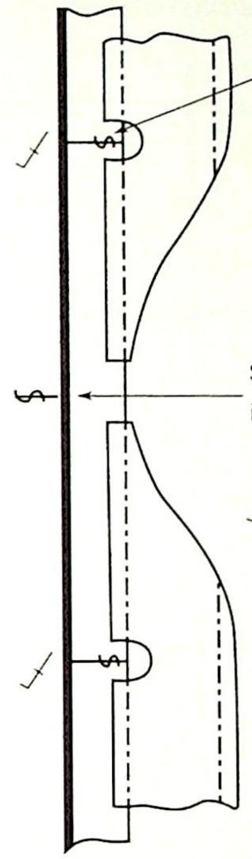
3.1 Introduction of scallops adjacent to the shell when repairing butt welds leads to fractures due to stress concentrations.

Figure 64:	*Catalogue of Structural Details*
2 of 3	

GROUP No. 13 *(Refer to index on Page 182)*	*Location: Bilge Keel*
	Example No. 3: Fracture in Continuous Scalloped Flat Bar for Intermittent Bilge Keel

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Defective butt welds.
2. Defective fillet weld in flat bar at notch.
3. Stress concentration associated with notch in flat bar.
4. Contact damage to bilge keel.

Additional Notes

4. NEW CONSTRUCTION

4.1 Fit where possible a bilge keel arrangement incorporating a ground bar as shown in Example No. 1.

4.2 Ensure all butt welds in ground bars and bilge welds are full penetration.

4.3 Confirm all butt welds by NDT.

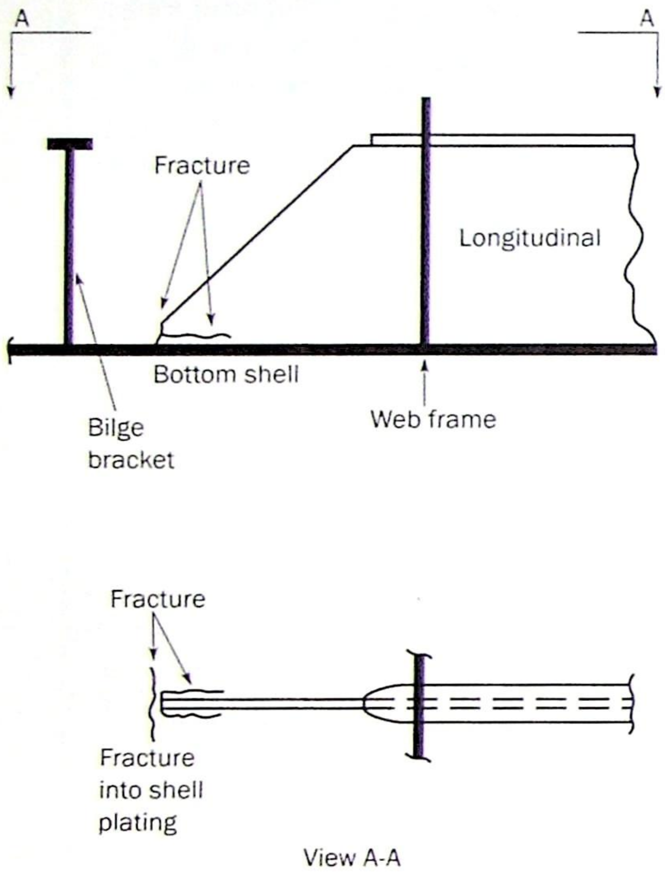
4.4 The use of scallops adjacent to the shell or shell ground bar should be avoided.

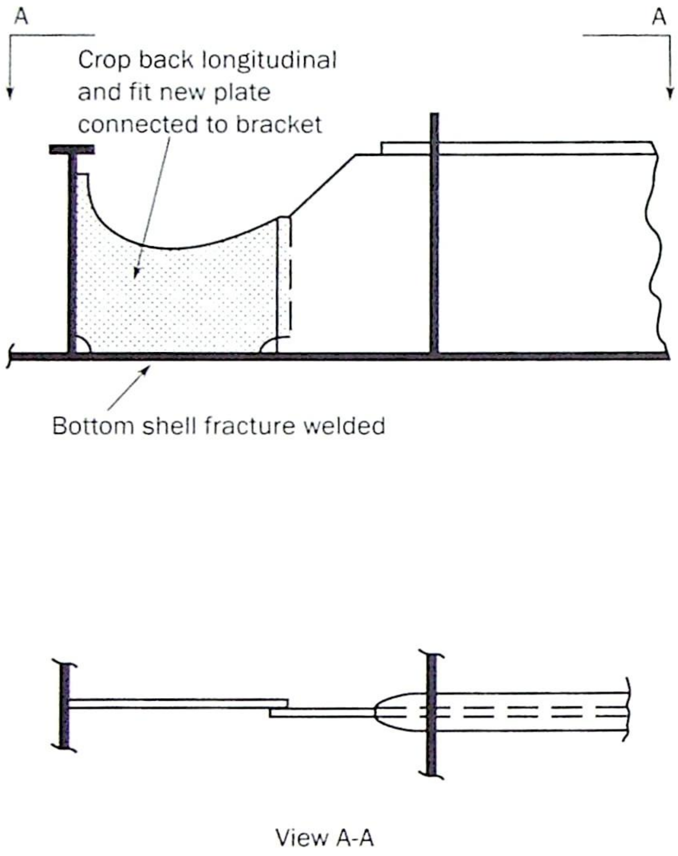
4.5 Where bilge keels are discontinued in way of erection butts keep the tapered ends clear of shell butts. Support all tapered ends of bilge keels by stiffening inside the tank.

Figure 65:	*Catalogue of Structural Details*
3 of 3	

GROUP No. 14 (Refer to index on Page 182)	*Location: Miscellaneous*
	Example No. 1: Shell Fracture at Sniped Ends of Bilge Longitudinals

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Longitudinal stopped too short of bilge bracket in unstiffened panel.
2. Stress concentration at longitudinal toe.

Figure 66:	*Catalogue of Structural Details*
1 of 5	

GROUP No. 14 (Refer to index on Page 182)	Location: Miscellaneous
	Example No. 1: Shell Fracture at Sniped Ends of Bilge Longitudinals

Additional Notes

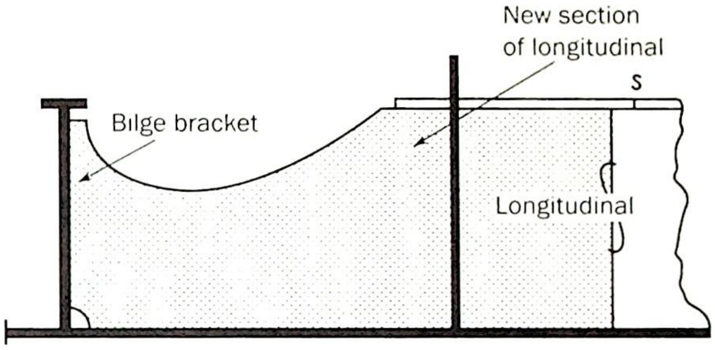
1. REPAIR NOTES

1.1 Fractured weld should be gouged and welded and confirmed by NDT.

1.2 Snipe of longitudinal should be cropped back and extended by a lapped plate to connect to the bilge bracket.

2. ALTERNATIVE REPAIRS

2.1 Longitudinal may be cropped back and new piece fitted extending longitudinal to next bilge bracket or transverse member.



3. UNSUCCESSFUL REPAIRS

3.1 Rewelding fractures without extension of longitudinal.

4. NEW CONSTRUCTION

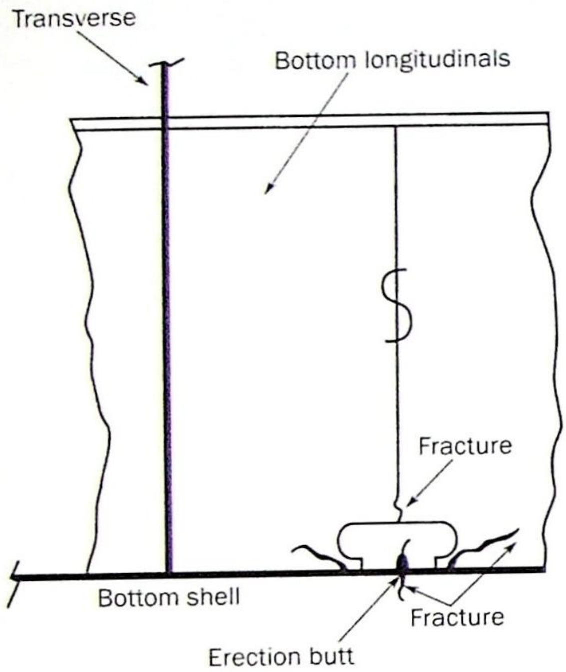
4.1 Design details at ends of longitudinals with special attention to taper.

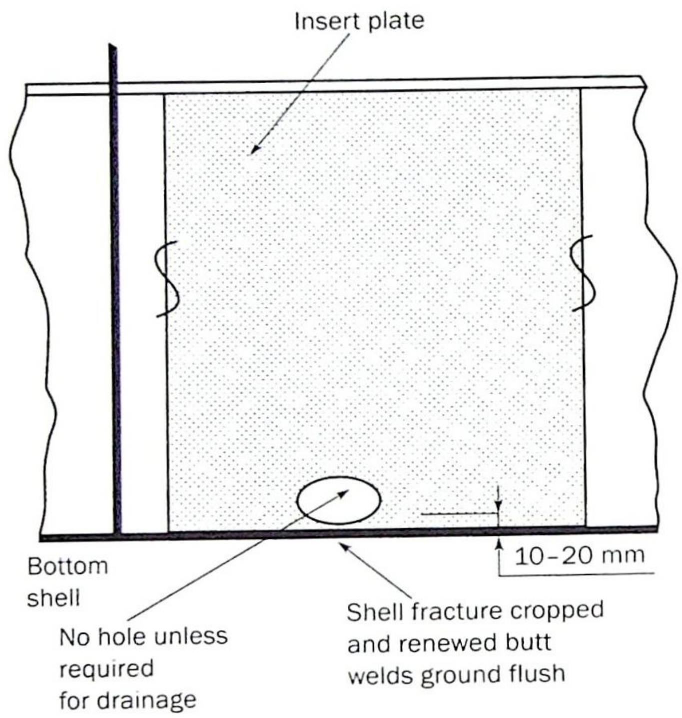
4.2 Keep sniped ends to within approximately 25 mm of transverse member. Alternatively, connect ends of longitudinal to adjacent bilge bracket.

Figure 67: 2 of 5	Catalogue of Structural Details

GROUP No. 14 (Refer to index on Page 182)	*Location: Miscellaneous*
	Example No. 2: Fractured Butt Welds in Shell and Bottom Longitudinals

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Defective return weld at butt of longitudinal.
2. Defective weld due to wide gap at erection butt prior to welding.

Additional Notes

1. REPAIR NOTES

1.1 Fractured longitudinals should be cropped and insert fitted. Butt of new insert should not coincide with shell butt.

1.2 Fractured shell butt should be gouged, welded and checked by NDT. Where the fracture is extensive or has propagated into the plate, the shell plating in way should be cropped and part renewed.

1.3 Where slots in longitudinal are not required for drainage they should be omitted.

2. ALTERNATIVE REPAIRS

3. UNSUCCESSFUL REPAIRS

3.1 Welding of fractures in longitudinal may lead to re-occurrence of fracture.

4. NEW CONSTRUCTION

4.1 Return welds should be completed.

4.2 Run-off plates should be used where appropriate.

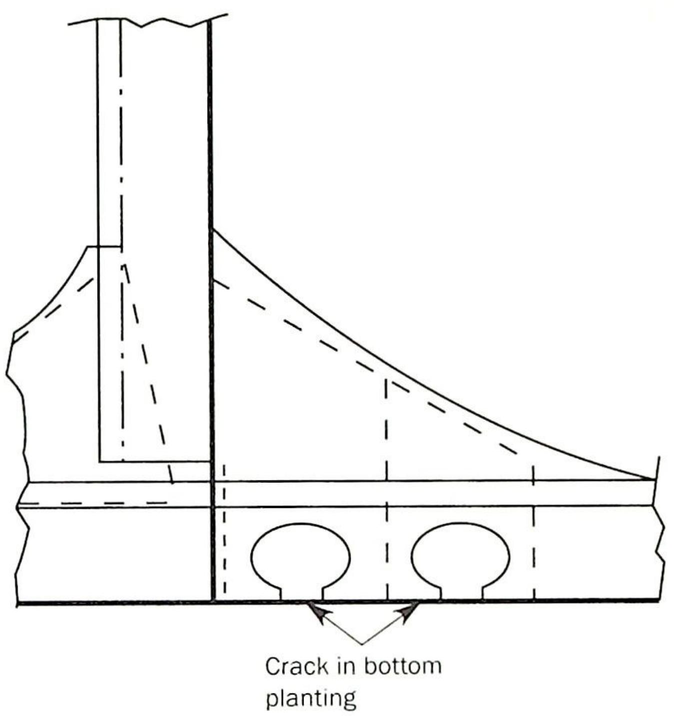
4.3 Erection butt of longitudinal and shell plate should be staggered if practical.

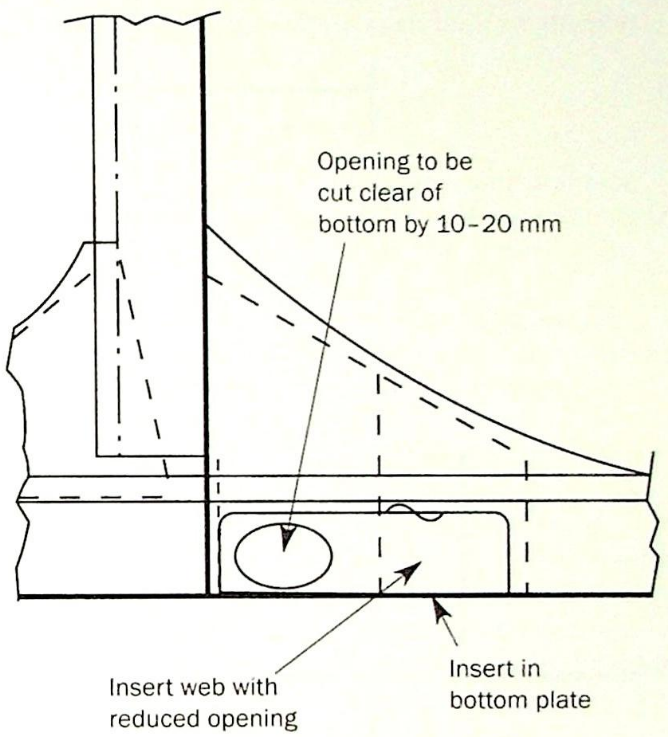
4.4 Drainage openings should be kept clear of the bottom plating by approximately 10–20 mm.

Figure 68:	*Catalogue of Structural Details*
3 of 5	

GROUP No. 14 (Refer to index on Page 182)	Location: Miscellaneous
	Example No. 3: Fractures in Bottom Plating in Way of Drainage Openings

Typical Damage	*Proposed Repair*





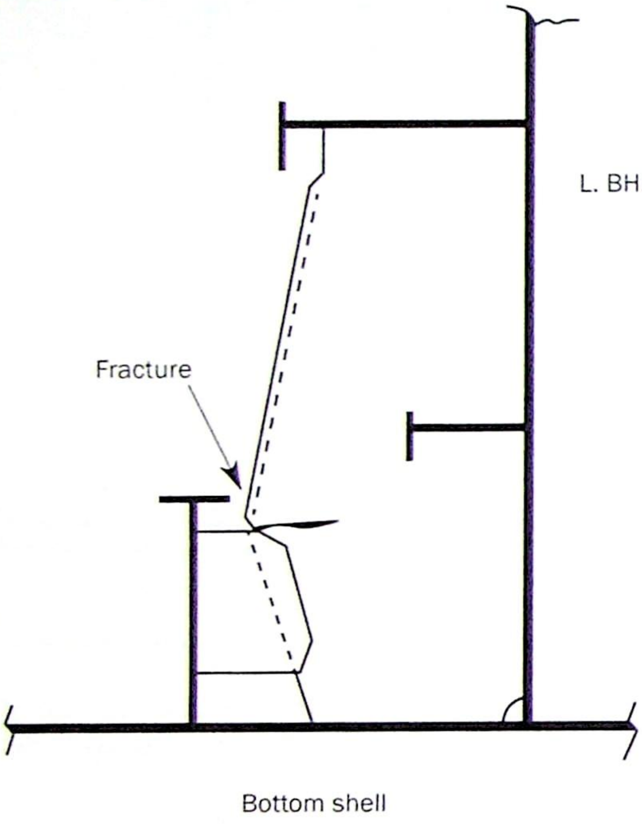
FACTORS CONTRIBUTING TO DAMAGE

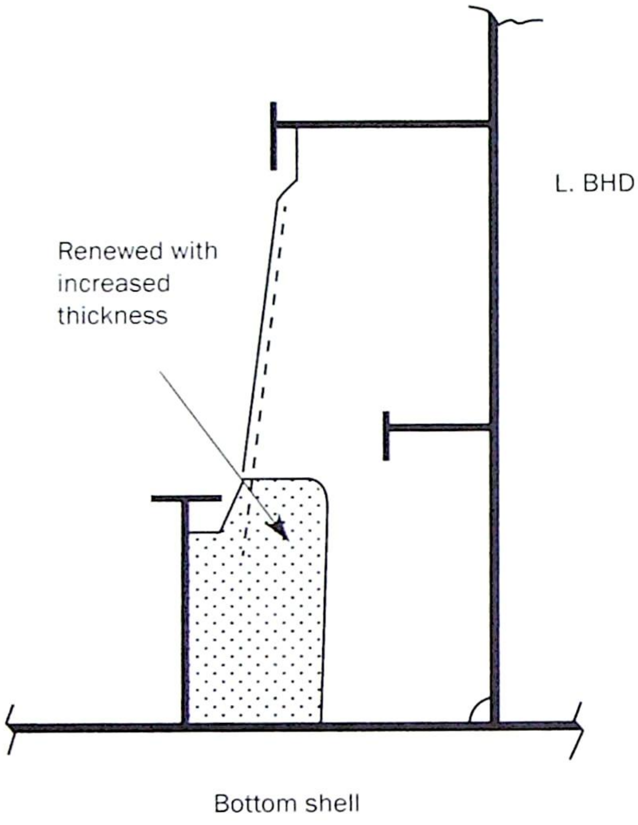
1. Large opening area compared with longitudinal height, not compensated by bracket.
2. High stress concentration.
3. Localized corrosion/erosion at area of stress concentration.

Figure 69:	*Catalogue of Structural Details*
4 of 5	

GROUP No. 14 (Refer to index on Page 182)	Location: Miscellaneous
	Example No. 4: Fractures in Docking Brackets

Typical Damage	*Proposed Repair*





FACTORS CONTRIBUTING TO DAMAGE

1. Excessive stress concentration led to fatigue cracks.
2. Increased additional stress due to large sheer deflection of transverse webs led to fatigue cracks.

NOTE FOR NEW CONSTRUCTION

3. Stiffener/flange should continue close to the bottom.

Figure 70:	*Catalogue of Structural Details*
5 of 5	

Appendix V

In-Service Corrosion Rate Studies

There are considerable amounts of general corrosion data published, which is accessible to the industry, this has been found not always to be applicable in the case of tanker structures. The Forum therefore initiated a program in 1988 to study 'in-service' corrosion rates. The aim of this study was to determine the corrosion rate of various components of internal structure and to provide a better understanding of corrosion problems the industry had experienced in the past and still has to deal with continuously.

For this purpose, corrosion data was collected from the Forum members, representing the empirical information that their tankers had experienced in real environments in the past three decades.

In 1988 an in-service corrosion rate survey questionnaire was distributed to all Forum members and responses cover data from a total of 32 tankers: 21 VLCCs, 10 non-VLCCs and one 23,000 dwt chemical tanker. The data was updated in 1991, 1994 and 1995 to include additional corrosion rate data accumulated.

In this study, tanks are separated into 5 types:

1. Segregated ballast	Carrying permanent water ballast only.
2. Cargo/arrival ballast	Cargo tank also carrying arrival clean water ballast.
3. Cargo/departure ballast	Cargo tank also carrying departure dirty water ballast.
4. Cargo/heavy ballast	Cargo tank also carrying dirty water ballast in heavy weather only.
5. Cargo only	Carrying cargo oil only.

The structural components in each tank are divided into 4 groups.

1. Longitudinal elements:

(a) Deck	Plating, web and face plate of longitudinals and vertical girder.
(b) Side shell	Plating, web and face plate of longitudinals and horizontal girder.
(c) Bottom shell	Plating, web and face plate of longitudinals, vertical girder and bottom centreline girder.
(d) Longitudinal bulkhead	Plating, web and face plate of longitudinals and horizontal girder.
(e) Centreline bulkhead	Plating, web and face plate of longitudinals and horizontal girder.
(f) Inner bottom	Plating, web and face plate of longitudinals.

2. Transverse web frames:

(a) Deck transverse	Web plating, stiffener and bracket and ring face plate.
(b) Horizontal tie beam	Web plating, stiffener and bracket and ring face plate.
(c) Bottom transverse	Web plating, stiffener and bracket and ring face plate.
(d) Side shell transverse	Web plating, stiffener and bracket and ring face plate.

(e)	Longitudinal bulkhead	Web plating stiffener and bracket and face plate. transverse.
(f)	Centreline bulkhead	Web plating stiffener and bracket and face plate. transverse.

3. Transverse bulkheads:

(a)	Plating	Web and face plate of stiffener and bracket.
(b)	Horizontal stringer	Web plating, stiffener and bracket and face plate.
(c)	Vertical girder	Web plating, stiffener and bracket and face plate.

4. Swash bulkheads:

(a)	Plating	Web and face plate of stiffener and bracket and ring face plate.
(b)	Horizontal stringer	Web plating, stiffener and bracket and face plate.
(c)	Vertical girder	Web plating, stiffener and bracket and face plate.

The influence factors contributing to corrosion as listed in 1.4.6 of the Guidance Manual are clearly demonstrated in the scattered data that has been collected. In most of the cases, a 'range' of corrosion rates can be established for each structural component. An empirical in-service 'representative' corrosion wastage curve and corrosion rate can be established as a comparative baseline for each structural component where data is available.

Tables 1 to 4 are the corrosion rates for each individual structural component in each different type of tank. Limited corrosion rate data is available for the cargo/heavy ballast tank and normally this tank is carrying cargo oil only. The most accurate approach is to base corrosion rates on cargo departure ballast and cargo only tank corrosion rates proportional to time in each service.

Location	Side	General	Pit/Groove (5)	Remark
1. Longitudinal Elements:				
a. Deck Plating	1	0.10–0.50(1)		Uncoated
Deck Longitudinals (Web)	2	0.25–1.00(1)	0.05–2.00 (2)	Uncoated
Deck Longitudinals (Face Plate)	2			
b. Side Shell Plating	1	0.06–0.10(1)	Uncoated	
Side Shell Longitudinals (Web)	2	0.20–1.00(1)	Uncoated	
Side Shell Longitudinals (Face Plate)	2			
c. Bottom Shell Plating	1	0.05–0.25 (1)	0.50–1.50	Uncoated
			4.00–6.00 (4)	Coated (3)
Bottom Shell Longitudinals (Web)	2			
Bottom Shell Longs (Face Plate)	2			
d. Longitudinal Bulkhead Plating	1	0.10–0.30(1)	1.00–3.00 (2)	Uncoated
			1.00–3.00 (2)	Coated (3)
Longitudinal Bulkhead Longs (Web)	2	0.20–1.20(1)	1.00–3.00 (2)	Uncoated
Longitudinal Bulkhead Longs (Face Plate)	2	0.20–0.60 (1)		
2. Transverse Web Frames:				
a. Deck Transverse Web Plating	2	0.30–0.70(1)	0.50–2.00(2)	Uncoated
Deck Transverse Ring Face Plate	2			
b. Horizontal Tie Beam Web Plating	2	0.20–0.35(1)		Uncoated
Horizontal Tie Beam Ring Face Plate	2			
c. Bottom Transverse Web Plating	2	0.10–0.20(1)		Uncoated
Bottom Transverse Ring Face Plate	2			
d. Side Shell Transverse Web Plating	2	0.15–0.25(1)		Uncoated
Side Shell Transverse Ring Face Plate	2			
e. Longitudinal Bhd. Transverse Web Plating	2	0.20–0.65 (1)	1.00–3.00(2)	Uncoated
Longitudinal Bhd. Transverse Ring Face Plate	2			
3. Transverse Bulkheads:				
a. Transverse Bhd. Plating	1	0.30–0.50 (1)		Uncoated
Transverse Bhd. Vertical Stiffener (Web)	2	0.20–0.60 (1)		Uncoated
Transverse Bhd. Vertical Stiffener (Face Plate)	2			
b. Transverse Bhd. Hor. Str. Web Plating	2	0.10–0.80 (1)		Uncoated
c. Transverse Bhd. Vert. Girder Web Plating	2			
4. Swash Bulkheads:				
a. Swash Bhd. Web Plating	2	0.15–0.25 (1)		Uncoated
b. Swash Bhd. Hor. Stringer Web Plating	2	0.15–0.25 (1)		Uncoated
c. Swash Bhd. Vert. Girder Web Plating	2	0.15–0.25 (1)		Uncoated

NOTES

1. Age effect.
2. Necking effect.
3. In coating breakdown area.
4. Microbial influenced corrosion.
5. The corrosion rate is based on the mixed data of tanks with or without anode installation. The lower figures generally correspond to tanks with anode installation.

Table V1: Segregated Ballast Tank Corrosion Rate (MM/YR)

Location		Side	General	Pit/Groove (3)	Remark
1. Longitudinal Elements:					
a.	Deck Plating	1	0.05–0.30		Uncoated
	Deck Longitudinals (Web)	2	0.05–0.30	0.10–1.00(1)	Uncoated
	Deck Longitudinals (Face Plate)	2			
b.	Side Shell Plating	1	0.05–0.10	0.20–1.50	Uncoated
	Side Shell Longitudinals (Web)	1	0.05–0.10	0.20–1.50	Uncoated
	Side Shell Longitudinals (Face Plate)	2			
c.	Bottom Shell Plating	1	0.05–0.25	1.00–2.00	Uncoated
				1.00–3.00	Coated (2)
	Bottom Shell Longitudinals (Web)	2	0.05–0.10		Uncoated
	Bottom Shell Longitudinals (Face Plate)	2			
d.	Longitudinal Bulkhead Plate	1	0.03–0.50	0.20–1.50	Uncoated
	Longitudinal Bulkhead Longitudinals (Web)	1	0.03–0.50	0.20–1.50	Uncoated
	Longitudinal Bulkhead Longs (Face Plate)	2			
2. Transverse Web Frames:					
a.	Deck Transverse Web Plating	2	0.05–0.30		Uncoated
	Deck Transverse Ring Face Plate	2			
b.	Horizontal. Tie Beam Web Plate	2			
	Horizontal. Tie Beam Ring Face Plate	2			
c.	Bottom Transverse Web Plate	2	0.03–0.30	1.00–2.00	Uncoated
	Bottom Transverse Ring Face Plate	2			
d.	Side Shell Transverse. Web Plate	2	0.03–0.30	1.00–2.00	Uncoated
	Side Shell Transverse. Ring Face Plate	2			
e.	Longitudinal Bhd. Transverse Web Plate	2	0.03–0.30	1.00–2.00	Uncoated
	Longitudinal Bhd. Transverse Ring Face Plate	2			
3. Transverse Bulkheads:					
a.	Transverse Bhd. Plating	1	0.02–0.10	0.20–1.50	Uncoated
	Transverse Bhd. Vertical Stiffener (Web)	2	0.03–0.10		
	Transverse Bhd. Vertical Stiffener (F. Pl.)	2			
b.	Transverse Bhd. Horizontal Stringer (Web)	1	0.05–0.70	1.00–2.00	Uncoated
c.	Transverse Bhd. Vertical Girder (Web)	2	0.05–0.10		
4. Swash Bulkheads:					
a.	Swash Bhd. Web Plating	2	0.05–0.50	1.00–2.00	Uncoated
b.	Swash Bhd. Horizontal Stringer Web Plating	1	0.05–0.70	1.00–2.00	Uncoated
c.	Swash Bhd. Vertical Girder Web Plating	2	0.03–0.50		Uncoated

NOTES

1. Necking effect.
2. In coating breakdown area.
3. The corrosion rate is based on the mixed data of tanks with or without anode installation. The lower figures generally correspond to tanks with anode installation.

Table V2: Cargo/Arrival Ballast Tank Corrosion Rate (MM/YR)

Location		Side	General	Pit/Groove (3)	Remark
1. Longitudinal Elements:					
a.	Deck Plating	1	0.03–0.10		Uncoated
	Deck Longitudinals (Web)	2	0.03–0.10	0.10–1.00 (1)	Uncoated
	Deck Longitudinals (Face Plate)	2			
b.	Side Shell Plating	1	0.03–0.10	0.20–1.50	Uncoated
	Side Shell Longitudinals (Web)	1	0.03–0.10	0.20–1.50	Uncoated
	Side Shell Longitudinals (Face Plate)	2			
c.	Bottom Shell Plating	1	0.05–0.25	1.00–2.00	Uncoated
				1.00–3.00	Coated (2)
	Bottom Shell Longitudinals (Web)	2	0.05–0.10		Uncoated
	Bottom Shell Longitudinals (Face Plate)	2			
d.	Longitudinal Bulkhead Plating	1			
	Longitudinal Bulkhead Longitudinals (Web)	1	0.03–0.10	0.20–1.50	Uncoated
	Longitudinal Bulkhead Longs. (Face Plate)	2	0.03–0.10	0.20–1.50	Uncoated
2. Transverse Web Frames:					
a.	Deck Transverse Web Plating	2	0.04–0.10		Uncoated
	Deck Transverse Ring Face Plate	2			
b.	Horizontal Tie Beam Web Plating	2			
	Horizontal Tie Beam Ring Face Plate	2			
c.	Bottom Transverse Web Plating	2	0.03–0.10	0.10–0.50	Uncoated
	Bottom Transverse Ring Face Plate	2			
d.	Side Shell Transverse Web Plating	2	0.03–0.10	0.10–0.50	Uncoated
	Side Shell Transverse Ring Face Plate	2			
e.	Longitudinal Bhd. Transverse Web Plating	2	0.03–0.10	0.10–0.50	Uncoated
	Longitudinal Bhd. Transverse Ring Face Plate	2			
3. Transverse Bulkheads:					
a.	Transverse. Bhd. Plating	1	0.03–0.10	0.20–1.50	Uncoated
	Transverse. Bhd. Vertical Stiffener (Web)	2	0.03–0.10		Uncoated
	Transverse. Bhd. Vertical Stiffener (F. Pl.)	2			
b.	Transverse. Bhd. Horizontal Stringer Web Pl.	1	0.05–0.50	0.50–1.50	Uncoated
c.	Transverse. Bhd. Vertical Girder Web Plating	2	0.03–0.10		Uncoated
4. Swash Bulkheads:					
a.	Swash Bhd. Web Plating	2	0.04–0.10	0.20–1.50	Uncoated
b.	Swash Bhd. Horizontal. Stringer Web Pl.	1	0.05–0.50	0.50–1.50	Uncoated
c.	Swash Bhd. Vertical Girder Web Pl.	2	0.04–0.10		Uncoated

NOTES

1. Necking effect.
2. In coating breakdown area.
3. The corrosion rate is based on the mixed data of tanks with or without anode installation. The lower figures generally correspond to tanks with anode installation.

Table V3: Cargo/Departure Ballast Tank Corrosion Rate (MM/YR)

Location		Side	General	Pit/Groove	Remark
1. Longitudinal Elements:					
a.	Deck Plating	1	0.03–0.10		Uncoated
	Deck Longitudinals (Web)	2	0.03–0.10	0.10–1.00 (1)	Uncoated
	Deck Longitudinals (Face Plate)	2			
b.	Side Shell Plating	1	0.03		Uncoated
	Side Shell Longitudinals (Web)	1	0.03		Uncoated
	Side Shell Longitudinals (Face Plate)	2			
c.	Bottom Shell Plating	1	0.04–0.30 (3)	0.05–1.00 (3)	Uncoated
				1.00–2.00	Coated (2)
	Bottom Shell Longitudinals (Web)	2	0.03–0.10		Uncoated
	Bottom Shell Longitudinals (Face Plate)	2			
d.	Longitudinal Bulkhead Plating	1	0.03–0.10		Uncoated
	Longitudinal Bulkhead Longs (Web)	1	0.03–0.10		Uncoated
	Longitudinal Bulkhead Longs (Face Plate)	2			
2. Transverse Web Frames:					
a.	Deck Transverse Web Plating	2	0.04–0.10		Uncoated
	Deck Transverse Ring Face Plate	2			
b.	Horizontal Tie Beam Web Plating	2			
	Horizontal Tie Beam Ring Face Plate	2			
c.	Bottom Transverse Web Plating	2	0.03		Uncoated
	Bottom Transverse Ring Face Plate	2			
d.	Side Shell Transverse Web Plating	2	0.03		Uncoated
	Side Shell Transverse Ring Face Plate	2			
e.	Longitudinal Bhd. Transverse Web Plating	2	0.03		Uncoated
	Longitudinal Bhd. Transverse Ring Face Plate	2			
3. Transverse Bulkheads:					
a.	Transverse Bhd. Plating	1	0.03–0.10		Uncoated
	Transverse Bhd. Vertical Stiffener (Web)	2	0.03–0.10		Uncoated
	Transverse Bhd. Vertical Stiffener (Face Plate)	2			
b.	Transverse Bhd. Horizontal Stringer Web Pl.	1	0.06–0.10	0.50–1.00	Uncoated
c.	Transverse Bhd. Vertical Girder Web Plating	2	0.03		Uncoated
4. Swash Bulkheads:					
a.	Swash Bhd. Web Plating	2	0.03		Uncoated
b.	Swash Bhd. Horizontal Stringer Web Pl.	1	0.06–0.10	0.50–1.00	Uncoated
c.	Swash Bhd. Vertical Girder Web Plating	2	0.03		Uncoated

NOTES

1. Necking effect.
2. In coating breakdown area.
3. Microbial influenced corrosion.

Table V4: Cargo Oil Tank Corrosion Rate (MM/YR)

Appendix VI

Structural Inspection Guidelines

GENERAL

The following summary highlights the principal guidelines to be followed in the planning, preparation, and execution of a particular structural inspection. The referred forms and examples of forms are given at the end of the Appendix.

PLANNING

Identify the purpose of the inspection, either for:

(a) Classification Societies' statutory requirements

(i) Special survey

(ii) Intermediate survey

(iii) Annual survey

(iv) Damage condition survey

(b) Owner inspection requirements

(i) Corrosion trends survey

(ii) Pre-periodic overhaul planning

(iii) Pre-purchasing condition appraisal

(iv) Life continuance planning

(v) Structural defects/fractures detection.

Collection of background information (see Forms VI.1, VI.2 and VI.3), relative to:

(a) General: dimensions, deadweight, classification status, age and tank arrangement, etc.

(b) As built structural drawings and details

(c) Corrosion control systems: extent of coating, type of coating, age of coating, condition of coating, layout of sacrificial anodes and condition of anodes, impressed current cathodic protection systems etc.

(d) Operation history: trading route, type of cargo oil, loading conditions, etc.

(e) Repair and maintenance history

(f) Previous inspection records.

Analysis of structure at 'risk' by:

(a) Review of background information as suggested in Table 2.1

(b) Corrosion evaluation as identified in Table 2.2

(c) Structural design evaluation as highlighted in Section 2.4.

PREPARATION

Inspection goal, scope and plan.

The ultimate goal is to collect as much as possible of the necessary information useful for future analysis.

From the results of risk analysis in 2.5.5 and the minimum gauging requirements as specified by IACS in Appendix II, the extent of critical areas which need to be inspected can be identified:

(a) Specific tanks and areas to be inspected (ref. Form VI.4)

(b) Specific structural components to be inspected (ref. Forms VI.5 and VI.6)

(c) Specific gauging pattern to be used Guidance Manual

(d) Specific inspection priority for high risk areas (ref. Forms VI.5 and VI.6)

(e) Specific adhesion test for hard coating if required.

INSPECTION SCHEDULE

To find the availability of vessel schedule 'window' for inspection:

(a) Voyage inspection

(b) In port

(c) In shipyard.

EXECUTION

Effective communication and co-ordination between the vessel personnel and inspection team is very important to the success of the inspection.

(a) Notification to the vessel on:

(i) Inspection purpose

(ii) Inspection goal, scope and plan

(iii) Tank washing requirements

(iv) Safety precautions, tank venting and access

(v) Additional outside support requirement

(vi) Attending inspection team personnel

(b) Be attentive to the inspection goal

(i) Alter the inspection plan to suit the tank washing schedule

(ii) Do not over inspect (or gauge) in certain areas and tanks nor under inspect (or gauge)

(c) Be attentive to safety

(d) Be attentive to the inspection method and gauging pattern as recommended in 1.3

(e) Monitor the inspection progress and simultaneously analyse the inspection result.

INSPECTION REPORT

The report should contain:

(a) Corrosion control systems

(i) Coating conditions: percentage of breakdowns, peeling, flaking blistering, brittleness, breakdown at free edges and adhesion tests for hard coating, if any

(ii) Pitting corrosion

(iii) Sacrificial anode conditions

(iv) Condition of impressed current cathodic protection systems

(b) Structural defects and fractures

(c) Structural damages

(d) Thickness gauging data.

This inspection report may be generated either manually on typical forms or by using computerised report system, ref. 2.2.2.

Summary of Vessel Information Data

Name: *Class:*
Builder: *Hull N°:*
Delivered:

LOA: *LBP:* *Beam:*
Depth: *Draft:* *DWT:*

SYSTEMS FITTED

IGS:
COW:

HULL MATERIALS

Deck:
Bottom:
Side:
Long. Bhd:
Trv. Bhd:

STRUCTURAL CONFIGURATION

Web Frame Spacing:
N° of Cross Ties in Web Frame:
N°of Tanks in Cargo Area:
N° of Long. Girders in CT:
N° of Long. Girders in WT:

Normal Types of Cargo:
Segregated Ballast Tanks:
Combined/Cargo Ballast Tanks:

Minimum Thicknesses Available From Class:

Form VI.1: Summary of Vessel Information Data

Experience Data – Trading History

BALLAST

Normal Ballast Pattern:

Tank N°	*Clean or Dirty*	*Average Ballast Time (Days)*	*Ballast Factor%*

CARGO

Normal Type of Cargo:
Typical Routes:

TRADING OCCURRENCES (Ref: also Structural Condition Form):

Heavy Weather (with Risk of overstressing):
Dates/Load condition/Exposed Areas:

Contact Damage (collision/grounding):
Dates/Load condition/Exposed Areas:

Form VI.2: Experience Data – Trading Ship

Experience Data – Structural Condition

Tank:

ACTUAL MATERIALS

Deck: *Side:*
Bottom: *Long. Bhd:*

Elements	*Cracks*	*Buckles*	*Corr.*	*Coat. con.*	*Pitting*	*Mod./Rep.*	*Other*
Deck:							
Bottom:							
Side:							
Longitudinal Bulkheads:							
Transverse Bulkheads:							

REPAIRS CARRIED OUT DUE TO:

THICKNESS MEASUREMENTS CARRIED OUT:
RESULTS IN GENERAL:

OVERDUE SURVEYS:

OUTSTANDING CONDITIONS OF CLASS:

COMMENTS

Form VI.3: Experience Data – Structural Condition

Combined Risk Evaluation – Longitudinal Material

		Extent of Coating:			Other Protection:			
Tank N°	Type of Tank	Fully Coated	Upper Part Coated	Lower Part Coated	Anodes	Other	Risk of Corr in Tank	Location of Risk

Risk of Corrosion

H = *High*   *M* = *Medium*   *L* = *Low*

p = *Pitting*

Type of Tank

C = *Cargo*   *AB* = *Arrival Ballast*   *DB* = *Departure Ballast*

HB = *Heavy Ballast*   *SBT* = *Segregated Ballast*   *S* = *Slop*

Locations:

U = *Upper Part*   *M* = *Middle Part*   *L* = *Lower Part*

C = *Complete Tk*

Additional Information, If available:

– Recoating   *– Steel renewals*   *– Other*

Form VI.4: Risk of Corrosion in Cargo and Ballast Tanks

Combined Risk Evaluation – Longitudinal Material

Tank:

ACTUAL MATERIALS

Deck:	*Side:*
Bottom:	*Long. Bhd:*

Component	*Original Dimension*	*Act. S/t*	*Manual S/t*	*Risk of Buckling*	*Risk of Corrosion*	*Risk of Pitting*	*Risk of Cracks*
Plate:							
Deck:							
Bottom:							
Side:							
L. Bhd:							
Longs:							
Deck:							
Bottom:							
Side:							
L. Bhd:							

H = High Risk	*M = Medium Risk*	*L = Low Risk*
+ = Increased Risk	*– = Decreased Risk*	

Form VI.5: Combined Risk Evaluation – Longitudinal Material

Combined Risk Evaluation – Transverse Material

Tank:

ACTUAL MATERIALS

Web frames:
Transverse Bhd Stiffeners:
Transverse Bhd Plate:
Transverse Bhd Girders:

Component	*Original t*	*Act. S/t*	*Risk of Buckling*	*Risk of Corrosion*	*Risk of Pitting*	*Risk of Cracks*
Web Frame:						
Bottom:						
Side:						
Deck:						
Long. Bhd:						
Transverse Bulkhead:						
Girders:						
Plates:						
Long, penetr. in Web Frame (ship side):						
Long, attachment to bulkhead:						

H = High Risk *M = Medium Risk* *L = Low Risk*
+ = Increased Risk *– = Decreased Risk*

Form VI.6: Combined Risk Evaluation – Transverse Material

Summary of Vessel Information Data

Name:	Example	*Class:*	ABSBVDnVGLLRNK		
Builder:	Yard	*Hull N°:*	12345		
Delivered:	6/1974				
LOA:	189.0 m	*LBP:*	180.0 m	*Beam:*	27.0 m
Depth:	14.95 m	*Draft:*	11.0 m	*DWT:*	36,500 t

SYSTEMS FITTED

IGS:	Yes
COW:	Yes

HULL MATERIALS

Deck:	MS
Bottom:	MS
Side:	MS
Long. Bhd:	MS
Trv. Bhd:	MS

STRUCTURAL CONFIGURATION

Web Freinte Spacing:	3.600 m
N" of Cross lies in Web Frame:	1
N" of Tanks in Cargo Area:	N° 3 WT (incl. slops) p + s
N° of Long. Girders in CT:	1
N° of Long. Girders in WT:	0
Normal Types of Cargo:	Arabian Crudes
Segregated Ballast Tanks:	N° 3 WT p+s, APT, FPT
Combined/Cargo Ballast tanks.	4 WT p+s, 5 CT

Minimum Thicknesses Available From Class: Yes

Example Form 1: Summary of Vessel Information Data

Experience Data – Trading History

BALLAST

Normal Ballast Pattern:

Tank N°	*Clean or Dirty*	*Average Ballast Time (Days)*	*Ballast Factor%*
N°3	Clean	21	40

CARGO

Normal Type of Cargo: Arabian Crudes
Typical Routes: Arabian Gulf to Far East/Europe

TRADING OCCURRENCES (Ref. also Structural Condition Form):

Heavy Weather (with Risk of overstressing):
Dates/Load condition/Exposed areas: Not known

Contact Damage (collision/grounding):
Dates/Load condition/Exposed areas: Not known

Example Form 2: Experience Data – Trading Ship

Experience Data – Structural Condition

Tank: N° 3 p+s (Perm. Ballast)

ACTUAL MATERIALS

Deck:	*MS*	*Side:*	*MS*
Bottom:	*MS*	*Long. Bhd:*	*MS*

Elements	*Cracks*	*Buckles*	*Corr.*	*Coat. con.*	*Pitting*	*Mod/Rep.*	*Other*
Deck:							
Panels	*No*	*No*	*Yes*	*POOR*	—	*No*	*1)*
Web frame	*No*	*No*	*Yes*	*POOR*	—	*No*	*1)*
Bottom:							
Plating	*No*	*No*	*No*	*GOOD*	*Yes*	*Yes*	
Longs	*No*	*No*	*No*	*GOOD*	*Yes/flanges*	*No*	
Web frame	*Yes*	*No*	*No*	*GOOD*	*Yes/flanges*	*No*	
Side:							
Panels	*No*	*No*	*No*	*GOOD*	*No*	*No*	
Web frame	*Yes*	*No*	*No*	*GOOD*	—	*Yes*	*2)*
Longitudinal Bulkheads:							
Plating	*No*	*No*	*Yes*	*Medium*	—	*No*	
Longs	*No*	*No*	*No*	*Medium*	*Grooving*	*No*	*3)*
Web Frame	*No*	*No*	*No*	*GOOD*	—	*No*	
Transverse Bulkheads:							
Panels	*No*	*No*	*No*	*Medium*	—	*No*	
Stringers	*No*	*No*	*Yes*	*Medium*	*Yes*	*No*	*4*

REPAIRS CARRIED OUT DUE TO:
Cracks in scallops of ship side web frames, repaired by fitting additional lugs (Ref. 2).

THICKNESS MEASUREMENTS CARRIED OUT. 9/90
RESULTS IN GENERAL:
Except for the main deck and upper part of the longitudinal bulkhead the measurements show good results.

OVERDUE SURVEYS:
None

OUTSTANDING CONDITIONS OF CLASS:
Deck longs, web frame flanges of upper part, stiffeners/brackets at upper part of web frames and long. bhd longs. N° 1+2 from top in ballast wing tanks N°s 3 p+s to be renewed.

COMMENTS:
Corrosion of upper deck structure reported and coating poor, however deck plating is still within acceptable limits.
Deck longitudinals are below acceptable limits.
Upper longs of longitudinal bhd. have almost vanished.

Example Form 3: Experience Data – Structural Condition

Combined Risk Evaluation – Longitudinal Material

Tank N°	Type of Tank	Extent of Coating: Fully Coated	Upper Part Coated	Lower Part Coated	Other Protection: Anodes	Other	Risk of Corr. in Tank	Location of Risk
1 p+s	C							
2 c	C							
2 p+s	DB/C							
3 c	C							L(p)
4 c	C							
4 p+s	CI AB							L(p)
5 c	C/HB							L(p)
5 p+s	C							L(p)
6 p+s	S							L(p)

Risk of Corrosion

H	= High	M	= Medium	L	= Low
p	= Pitting				

Type of Tank

C	= Cargo	AB	= Arrival Ballast	DB	= Departure Ballast
HB	= Heavy Ballast	S BT	= Segregated Ballast	S	= Slop

Locations:

U	= Upper fan	M	= Middle Part	L	= Lower Part
C	= Complete Tk				

Additional Information, If available:

– Recoating – Steel renewals – Other

Example Form 4: Risk of Corrosion in Cargo and Ballast Tanks

Combined Risk Evaluation – Longitudinal Material

Tank: N° 3 p+s

ACTUAL MATERIALS

Deck:	*MS*	*Side:*	*MS*
Bottom:	*MS*	*Long. Bhd.*	*MS*

Component	*Original Dimension*	*Act. S/t*	*Manual S/t*	*Risk of Buckling*	*Risk of Corrosion*	*Risk of Pitting*	*Risk of Cracks*
Plate:							
Deck	*20*	*42.5*	*55-60*	*L*	*M*	--	*L*
Bottom	*21.5*	*39.5*	*55-60*	*L*	*L*	*M*	*L*
Side	*18.5*	*43*	--	*L*	*L*	--	*M*
L. Bhd:							
– u.str	*14.0*	*57*	*70-75*	*L*	*M*	--	*L*
– next 2.str.	*11.0*	*73*	*70-75*	*M*	*M*	--	*L*
	12.0	*66.5*	*70-75*	*L*	*M*	--	*L*
	13.0	*61.5*	*70-75*	*L*	*L*	--	*L*
	15.5	*51.5*	*70-75*	*L*	*L*	--	*L*
– l.str	*20.0*	*40*	*70-75*	*L*	*L*	--	*L*
Longs:							
Deck	*250x22*	*11.5*	*15.20*	*L*	*M*	--	*L*
Bottom							
– web	*500x13.5*	*37*	*50-65*	*L*	*L*	--	*M*
– flange	*200x16.0*	*6*	*10*	*L*	*L*	*M*	*M*
Side from top (web only):							
	250x90x10/15	*15.5-31*	---	*L*	*L*	*L*	*M*
	250x90x12/16	" "	"	"	"	"	"
	300x90x11/16	" "	"	"	"	"	"
	300x90x13/17	" "	"	"	"	"	"
	350x100x12/17	" "	"	"	"	"	"
	400x100x13/18	" "	"	"	"	"	"
L. Bhd from top (web only):							
	200x90x9/14	*21-31*	---	*L*	*L*	*L*	*M*
	250x90x10/15	" "	"	"	"	"	"
	250x90x12/16	" "	"	"	"	"	"
	300x90x11/16	" "	"	"	"	"	"
	300x90x13/17	" "	"	"	"	"	"
	350x100x12/17	" "	"	"	"	"	"
	400x100x13/18	" "	"	"	"	"	"

H = High Risk *M = Median Risk* *L = Low Risk*
+ = Increase Risk *– = Decreased Risk*

Example Form 5: Combined Risk Evaluation – Longitudinal Material

Combined Risk Evaluation – Transverse Material

Tank: N° 3 p+s

ACTUAL MATERIALS

Web frames:	*MS*	*Transverse Bhd Plate:*	*MS*
Transverse Bhd Stiffeners:	*MS*	*Transverse Bhd Girders:*	*MS*

Component	*Original t*	*Act. S/t*	*Risk of Buckling*	*Risk of Corrosion*	*Risk of Pitting*	*Risk of Cracks*
Web Frame:						
Bottom:						
Web plate	*14*	*61*	*L*	*L*	*M*	---
	18	*47*	*L*	*L*	*M*	---
Flange	*22*	*4.5*	*L*	*L*	*M*	*M*
Side:						
Web plate	*18*	*44.5*	*L*	*L*	*M*	---
	11	*73*	*M*	*L*	*M*	---
	14.5	*55*	*L*	*M*	*M*	---
Fhmge	*12*	*8.5*	*L*	*M*	*l.*	---
Deck:						
Web plate	*14.5*	*55*	*L*	*M*	*L*	---
Flange	*12*	*8.5*	*L*	*M*	*L*	---
Long. Bhd:						
Web plate loe end	*14*	*57*	*L*	*M*	*M*	---
	11	*73*	*M*	*M*	*M*	---
Flange	*22*	*4.5*	*L*	*L*	*M*	---
Transverse Bulkhead:						
Girders:						
Upper stringer web	*11*	*77*	*M*	*M*	*M*	*H*
Upper stringer flange	*12*	*8.5*	*L*	*M*	*M*	---
Middle stringer	*11*	*77*	*M*	*M*	*M*	*H*
Middle flange	*16*	*6.5*	*M*	*M*	*M*	---
Lower stringer	*12*	*71*	*M*	*M*	*M*	*H*
Lower stringer flange	*18*	*7*	*M*	*M*	*M*	---
Plates:						
Upper strake	*14.5*	--	*L*	*M*	*L*	---
Next 2 strokes	*11.0*	--	*L*	*M*	*L*	---
	12.5	--	*L*	*M*	*L*	---
	13.5	--	*L*	*L*	*L*	---
Lower strake	*14.5*	--	*L*	*L*	*L*	---
Long. penetr. in Web Frame (ship side)						
All fitted with lugs and bkt. or flat bar on top			---	---	*L*	---
Long. attachment to bulkhead						
All fitted with lugs and bkt. or flat bar on top			---	---	*L*	---

H = High Risk *M = Medium Risk* *L = Low Risk*
+ = Increased Risk *– = Decreased Risk*

Example Form 6: Combined Risk Evaluation – Transverse Material

Appendix VII

Assessment of Existing Surface Coating Systems

For the purpose of consistent assessments of the 'degree of effectiveness' of an existing surface coating system, it is suggested that a convenient 'rating' be used, together with guidance standards if possible, such as the IACS/IMO standard:

1. GOOD condition, with only minor spot rusting.
2. 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.
3. POOR condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration.

Above definitions are expanded in the following table:

Rating → Condition ↓	GOOD	FAIR	POOR
Spot Rust Light Rust	Minor Minor	 > 20%	
Edges and Welds	< 20%	> 20%	
Hard Scale	Minor	< 10%	> 10%
General Breakdown	Minor	< 20%	> 20%
Other References:			
ISO 4628/3-1982	RI3	RI4	RI5
European Rust Scale *)	RE3	RE5	RE7

*) Published by the European Committee of Paint, Printing Ink and Artists' Colours Manufacturers' Association, Brussels, Belgium.

The lowest rating within any category shall govern the final rating.

An 'Assessment Scale for Breakdown' of coatings is shown in Figure VII.1. Examples of coating system condition categorised under the above rating system are shown in the following paragraphs (Figures VII.2 to VII.15).

The coating condition should normally be judged over larger areas. For classification purposes it is normal to judge the complete tank. However, if the conditions vary to a great extent between the various main parts (bottom, deck, longitudinal bulkheads, and transverse bulkheads) of the tank, for instance due to partly re-coating, then an evaluation of the various parts may be advantageous.

Some of the pictures shown in this appendix are not from tankers but from ballast tanks of dry cargo ships. However, since the coating condition is in focus here it was decided to use them in this context.

Assessment Scale for Breakdown

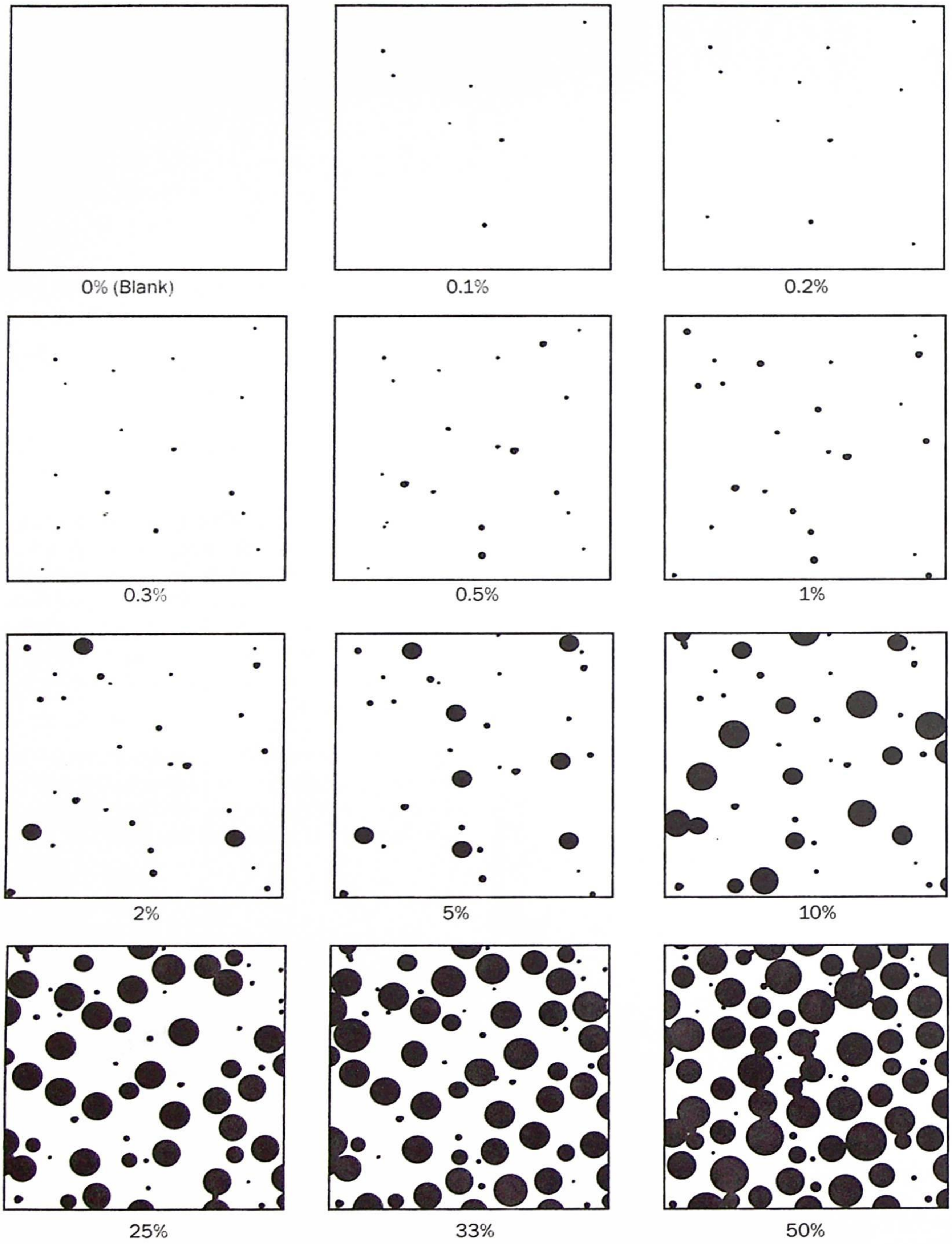
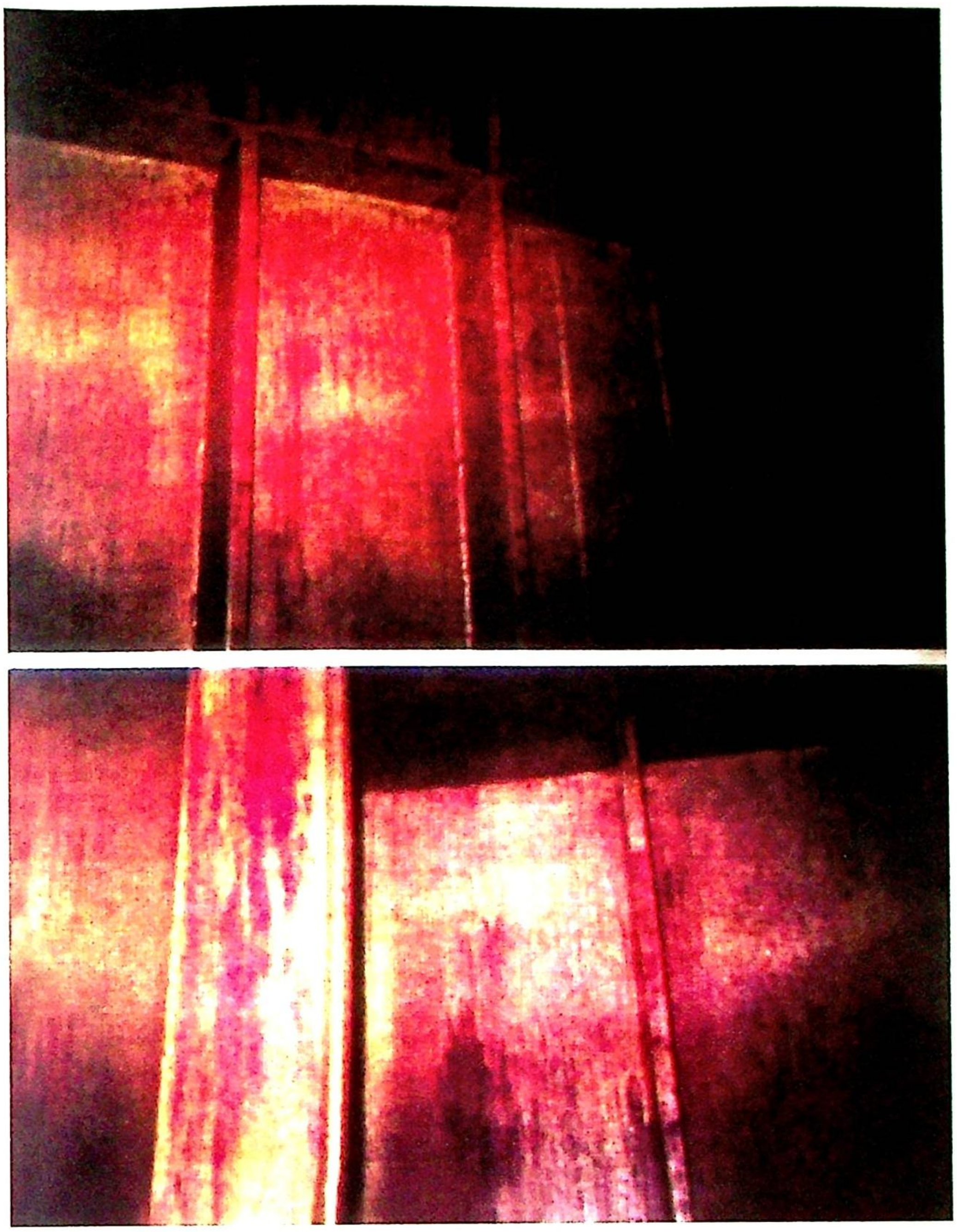


Figure VII.1: Assessment Scale for Breakdown



NOTES

CONDITION: 1.GOOD

BREAKDOWN
PERCENTAGE: 5–10%

REMARK: Light rusting, no edge breakdown

Assessment Scale

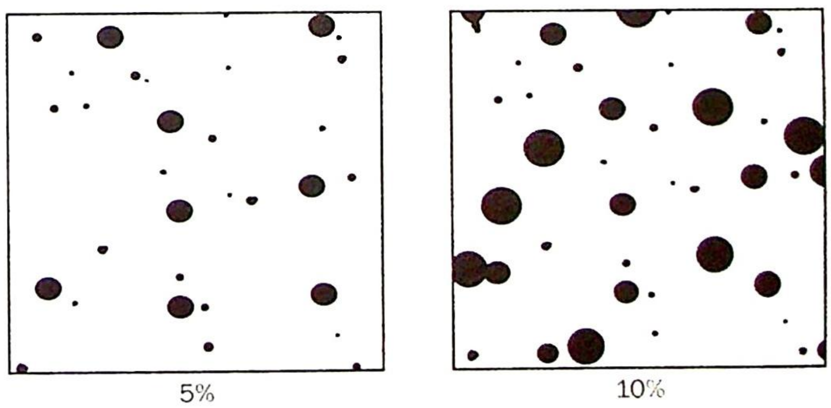


Figure VII.2: Coating Condition Evaluation

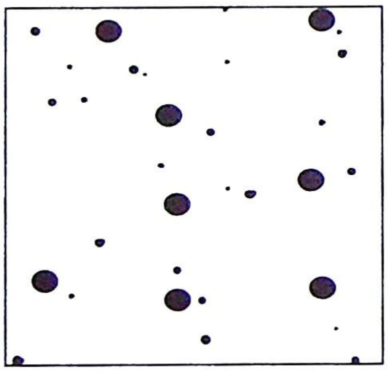
NOTES

CONDITION: 1. GOOD

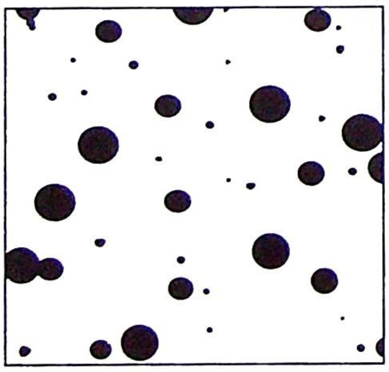
BREAKDOWN
PERCENTAGE: 5–10% in general
< 20% on edges

REMARKS: Lower end of GOOD

Assessment Scale



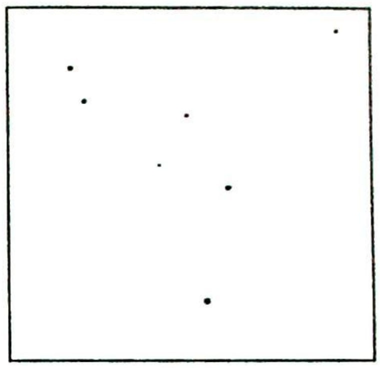
5%



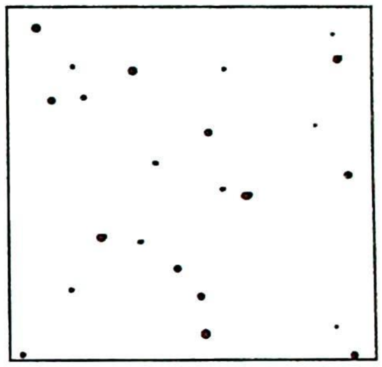
10%

Figure VII.3: Coating Condition Evaluation

Assessment Scale



0.1%



1%

NOTES

CONDITION: 1. GOOD

BREAKDOWN
PERCENTAGE: Minor

REMARKS: Local corrosion problem which must be dealt with, however, considered not to reflect the general coating condition

Figure VII.4: Coating Condition Evaluation

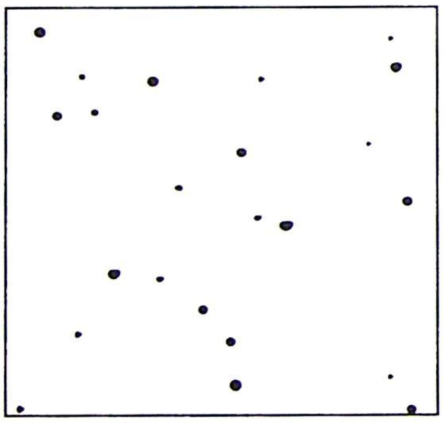
NOTES

CONDITION: 2. FAIR

BREAKDOWN
PERCENTAGE: Minor Spot Corrosion
Approx. 20% Edge Breakdown

REMARKS: Upper end of FAIR

Assessment Scale



1%

Figure VII.5: Coating Condition Evaluation

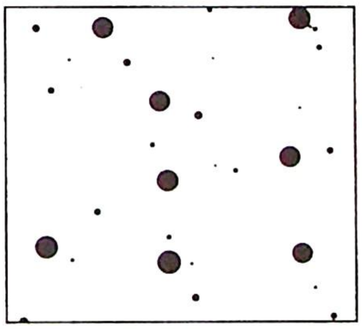
NOTES

CONDITION: 2. FAIR

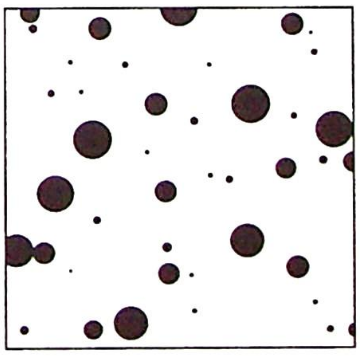
BREAKDOWN
PERCENTAGE: General Breakdown 5–10%
Edge Breakdown > 20%

REMARKS: Typical FAIR Condition

Assessment Scale



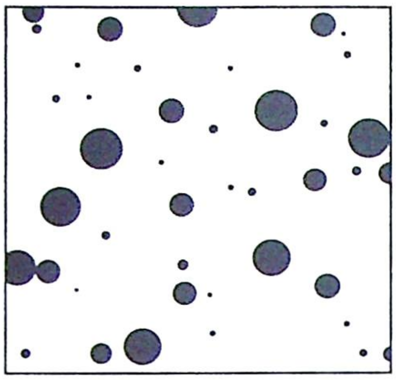
5%



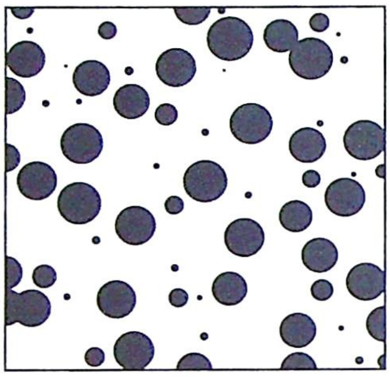
10%

Figure VII.6: Coating Condition Evaluation

Assessment Scale



10%



25%

NOTES

CONDITION: 2. FAIR

BREAKDOWN
PERCENTAGE: General Breakdown 10–20%
Edge Breakdown > 20%

REMARKS: Lower end of FAIR. Condition of upper side of horizontal surface should be included in the evaluation before final condition is determined.

Figure VII.7: Coating Condition Evaluation

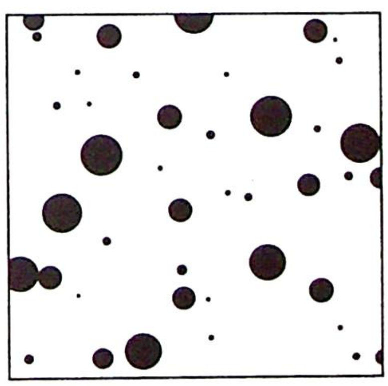
NOTES

CONDITION: 2. FAIR

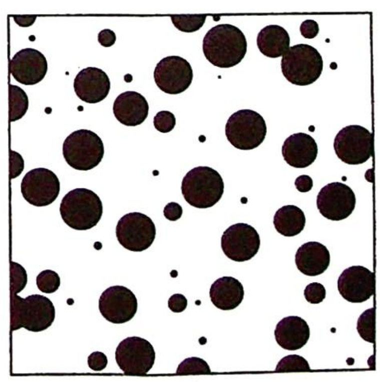
BREAKDOWN
PERCENTAGE: General Breakdown 10–20%
Edge Breakdown > 10%

REMARKS: - Lower end of FAIR
- Condition shown after descaling

Assessment Scale



10%



25%

Figure VII.8: Coating Condition Evaluation

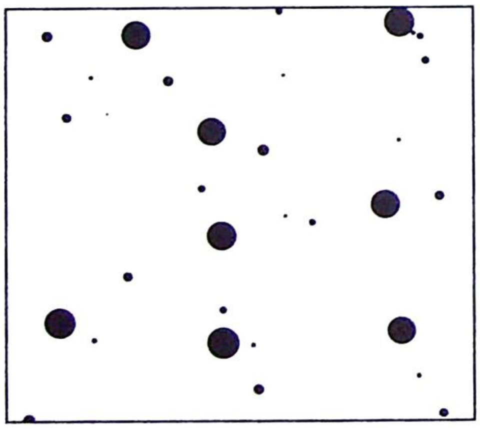
NOTES

CONDITION: 2. FAIR

BREAKDOWN
PERCENTAGE: Light rusting over 5% of area

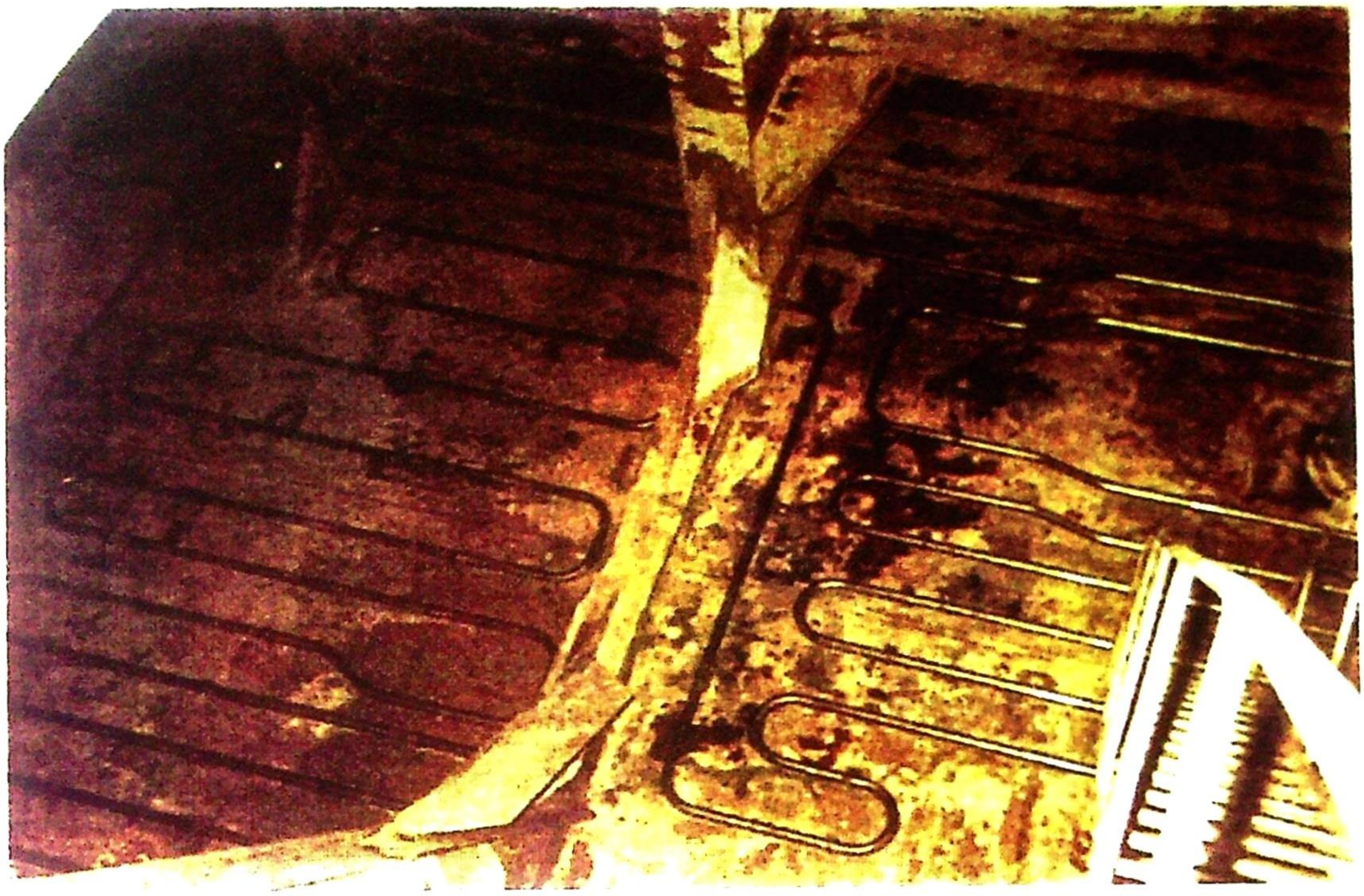
REMARKS:

Assessment Scale



5%

Figure VII.9: Coating Condition Evaluation



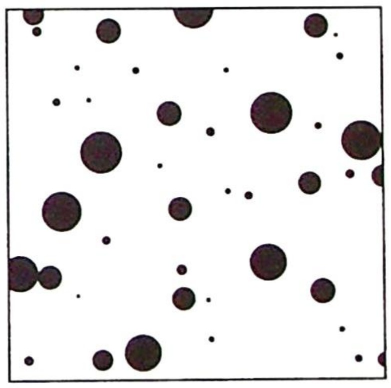
NOTES

CONDITION: 2. FAIR

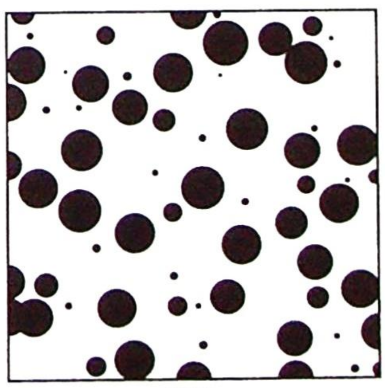
BREAKDOWN
PERCENTAGE: Light rusting over 20% of area

REMARKS:

Assessment Scale



10%



25%

Figure VII.10: Coating Condition Evaluation

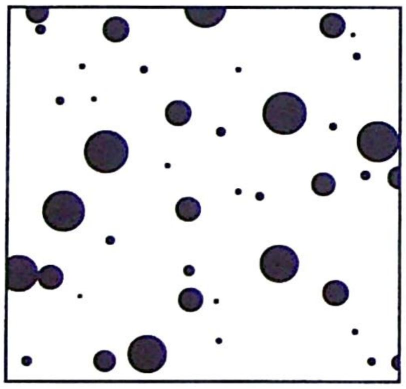
NOTES

CONDITION: 3. GOOD

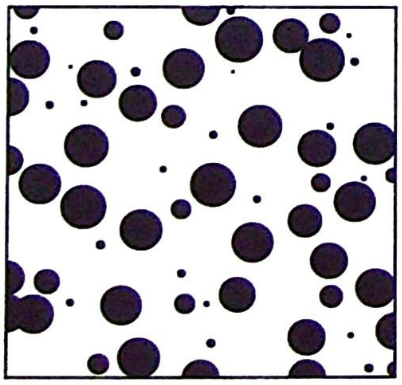
BREAKDOWN
PERCENTAGE: Hard Scale > 10%
General Breakdown < 20%

REMARKS:

Assessment Scale



10%



25%

Figure VII.11: Coating Condition Evaluation

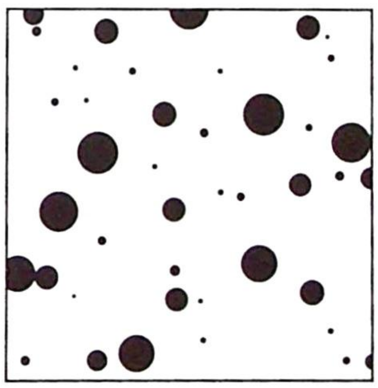
NOTES

CONDITION: 3. POOR

BREAKDOWN
PERCENTAGE: Light rusting over 20% of area

REMARKS:

Assessment Scale



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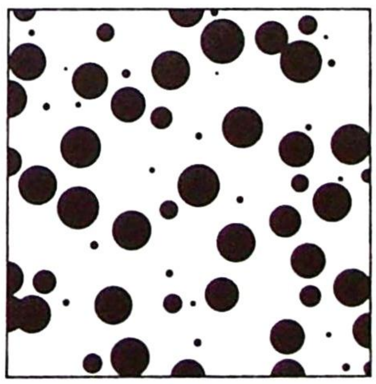
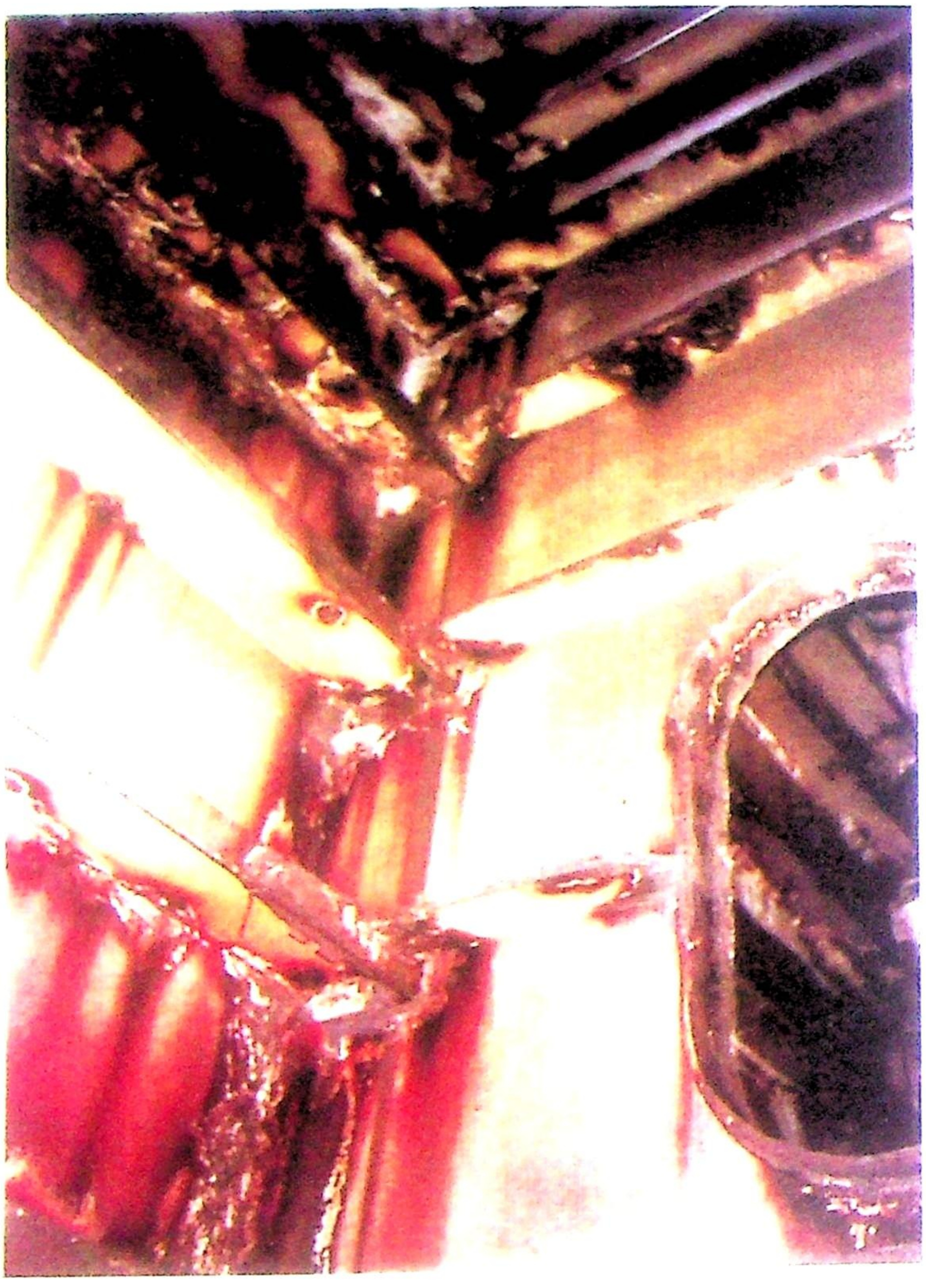
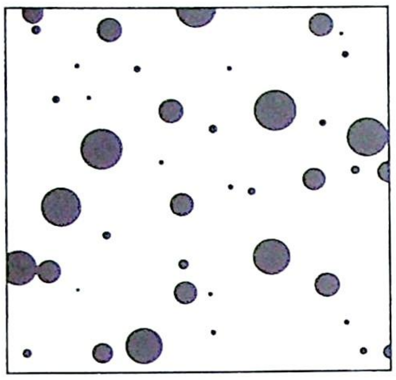


25%

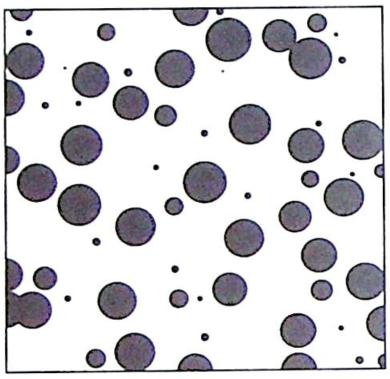
Figure VII.12: Coating Condition Evaluation



Assessment Scale



10%



25%

NOTES

CONDITION: 3. POOR

BREAKDOWN
PERCENTAGE: Hard Scale > 10%

REMARKS: Upper part POOR. Lower part may be considered closer to FAIR.

Figure VII.13: Coating Condition Evaluation

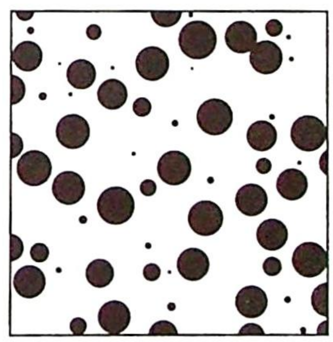
NOTES

CONDITION: 3. POOR

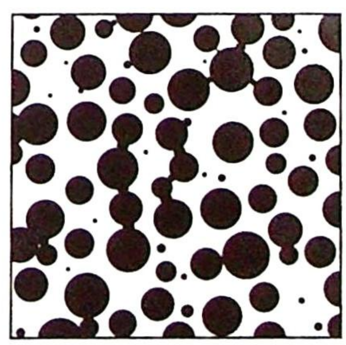
BREAKDOWN
PERCENTAGE: General Breakdown 25–50%

REMARKS: POOR Condition of Coating.
(Picture taken after cleaning.)

Assessment Scale



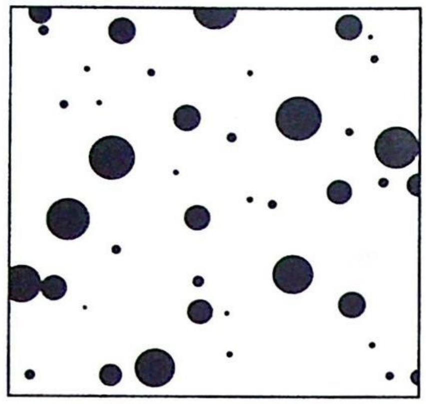
25%



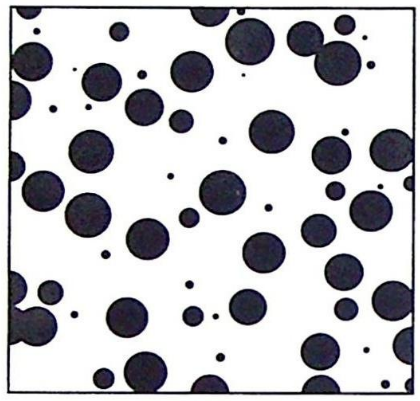
50%

Figure VII.14: Coating Condition Evaluation

Assessment Scale



10%



25%

NOTES

CONDITION: 3. POOR

BREAKDOWN
PERCENTAGE: More than 10% Hard Scale

REMARKS:

Figure VII.15: Coating Condition Evaluation