

**PRESENTATION OF THE 1997 TSCF GUIDANCE
MANUAL FOR TANKER STRUCTURES**

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**AT
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ABSTRACT

In 1986 the Forum published the "Guidance Manual for the Inspection and Condition Assessment of Tanker Structures", which contains the accumulated experience of the Forum's members with tanker structures. This manual quickly became an indispensable handbook and standard setter for all parties involved in building, operating and inspecting tankers. Technological developments made it necessary to update the Guidance Manual in the early nineties and the Forum concentrated its efforts on a revision of the 1986 Guidance Manual. The Guidance Manual was combined with the booklet "Condition Evaluation and Maintenance of Tanker Structures" published in 1992 into one publication with the new title "Guidance Manual for Tanker Structures". This extensive work was done in close co-operation with the International Association of Classification Societies (IACS). The new Guidance Manual is available since the end of 1997.

The Guidance Manual is divided into four chapters which contain guidelines for the preparation and execution of surveys, the analysis of survey data as well as chapters for maintenance and repair. Comprehensive appendices contain inter alia applicable IACS rules and regulations and - which is most important - a catalogue of typical failures of structural details in tankers. The paper gives an overview of the Guidance Manual and highlights its most important parts.

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1. INTRODUCTION

In 1986 the Forum published the “Guidance Manual for the Inspection and Condition Assessment of Tanker Structures“, which contains the accumulated experience of the Forum’s members with tanker structures. This manual very quickly became an indispensable handbook and standard setter for all parties involved in building, operating and inspecting tankers, i.e. owners, classification societies and shipyards.

Technological development made it necessary to update the Guidance Manual in the early nineties. Since 1993 the Forum therefore concentrated its efforts on a revision and update of the 1986 Guidance Manual. It was decided to combine the Guidance Manual and the 1992 published booklet “Condition Evaluation and Maintenance of Tanker Structures“ into one publication with the new title “Guidance Manual for Tanker Structures“. This extensive work was done in close co-operation with the International Association of Classification Societies (IACS). The new Guidance Manual is available since the end of 1997 [1].

The Guidance Manual is divided into four main chapters which contain guidelines for:

1. Survey Preparation
2. Survey Execution
3. Survey Data Analysis
4. Maintenance and Repair.

Comprehensive appendices contain inter alia applicable IACS rules and regulations, parts of the International Safety Guide for Oil Tankers and Terminals (ISGOTT) and, which is most important, a catalogue of typical failures of structural details in tankers. Furthermore, these appendices contain in-service corrosion studies and guidelines for structural inspections, for the assessment of existing surface coating systems and for the on board documentation.

In the following an overview of the above chapters is given. When figures are shown in this paper to illustrate the text, their original numbers in the Guidance Manual are used for easy reference.

2. REVIEW OF THE CHAPTERS OF THE GUIDANCE MANUAL

2.1 Survey Preparation Guidelines

2.1.1 Survey requirements

This chapter starts with an overview of the two basic survey requirements i.e. class and statutory requirements as well as owner’s requirements. Statutory surveys for fulfilling Convention requirements are very similar to class requirements and are therefore mostly carried out together by the class surveyors acting on behalf of the Flag Administration. While the class survey intends to ensure compliance with the standards of the Classification Society for hull strength and integrity, the owner may also require information on the ship’s structural condition which may affect the operating costs of his vessel.

2.1.2 Safety measures

Due to the importance of safety measures for survey execution, a special section of this chapter is devoted to safety and access aspects. For basic tank entry it is recommended to follow the ISGOTT-Guide. The main safety aspects discussed are:

- Gas testing for tank entry,
- tank preparation,

- safety watch and safety equipment,
- tank cleaning,
- use of electrical and electronic equipment in cargo tanks,
- lighting in the tanks,
- safety aspects of rafting surveys.

2.1.3 Means of access

The various means for access to structure are discussed such as permanent arrangements, temporary staging, mobile platforms, rafting, remotely operated devices, use of divers and in-tank cameras. Here, at the meeting with shipbuilders the importance of permanent arrangements shall be highlighted, because much can be achieved, when at the early design stage of the vessel consideration is given to a proper access to structure for survey purposes, which is of specific importance for the close-up survey.

2.1.4 Ultrasonic thickness determination

Determination of the remaining thickness of the structure is essential in most surveys. The following items are discussed:

- Survey team qualification,
- basic equipment types,
- measurement accuracy,
- measurement procedures.

2.1.5 Technical background for surveys

Important for a successful survey is the understanding of some basic principles on how the tanker structures are loaded and how they respond to the loads in terms of stresses or even failures such as fractures or buckling. The Forum therefore decided to include into the new Guidance Manual an extra section on these subjects. Emphasis is put on the fatigue phenomenon such as the description of typical locations sensitive to fatigue failure and the effect of higher tensile steel on the fatigue behaviour of structures exposed to cyclic loads.

This section further deals with corrosion phenomena such as typical corrosion patterns, factors influencing corrosion, corrosion trends in cargo and ballast tanks, in-service corrosion rates and corrosion control systems (hard coatings, soft coatings, cathodic protection).

For reasons of clarity it is recommended to use in reports standard nomenclature for structural elements as shown in Figures 1.1 and 1.2. Figure 1.3 shows typical locations and distribution of fatigue damage. Figure 1.10 shows corrosion rates of a transverse web frame in an uncoated segregated ballast tank where due to high shear stresses in the vertical girders and the horizontal cross ties higher corrosion rates have been observed.

2.2 Survey Execution Guidelines

In this chapter some basic principles are suggested how to conduct the various types of surveys mentioned in 2.1.1. Apart from the main surveys associated with class and statutory requirements, more emphasis is now being placed on oil tanker owners to be fully aware of the structural condition of their vessels at any stage of their service life and to take necessary action to maintain their structural integrity. Therefore, also the owner's surveys are addressed.

One section addresses the general planning requirements applicable to all types of survey. The scope, detailed planning, data collection and reporting associated with these structural inspections are discussed. It should be pointed out that the major difficulty in adequately surveying tankers is the physical size of the task. For example a 250,000 tdw double hull tanker has a total tank area to inspect of approximately 350,000 m² and a coated ballast tank area of over 200,000m².

2.2.1 Data collection and reporting

With the increasing requirement for analysing corrosion data of older vessels a means of computerised storage and retrieval for these data (database) became more and more important. The need for such database has been heightened by the enhanced survey requirement of IACS and the requirement to keep survey records on board.

2.2.2 Structural aspects and risk categories

In these sections the critical areas of main structural elements are described and what kind of wastage or failure from corrosion, fracture or buckling may be expected in these areas. Risky areas of structures that are more prone to corrosion are identified, see Table 2.1. Areas at higher risk from defects due to corrosion, buckling or cracks are also identified, see Table 2.2. Figure 2.1 shows local areas of high stresses in transverse web frames, and Figure 2.2 shows typical wastage of bottom structures.

2.2.3 Class and owner's surveys

A comprehensive section is devoted to the IACS Unified Requirements for Hull Surveys of Oil Tankers (U.R. Z 10.1), which became also a statutory requirement by virtue of IMO-Resolution A.744("Guidelines on the Enhanced Programme of Inspections During Survey of Oil Tankers and Bulk Carriers").

Another section deals with the specific features of the owner's survey, which is mainly intended to determine the vessel's condition, corrosion rates and, where applicable, the repair specification. When conducted under the guidance of the appropriate classification society, a detailed condition survey can also be planned so as to satisfy the enhanced survey requirements according to the IACS UR. Z 10.1.

2.3 Survey Data Analysis Guidelines

This chapter gives guidance how to analyse the collected survey data and findings with the aim to assess the residual strength of the ship and to consider maintenance need for a further operation period. The basic objectives are the determination of corrosion trends and the identification of potential risk areas for corrosion, cracking, buckling and leakage.

Annex VII of the Guidance Manual provides considerable material to assist the surveyor in the assessment of the coating condition. Examples are given in Figures VII.3 and VII.13.

Although it is difficult to define generally applicable acceptance criteria because the ships are built according to different rules at different times, the Guidance Manual provides some guidance on wastage data to assess the local and buckling strength of structural components, see Table 3.1. Table 3.2 gives guidance on the minimum remaining plate thickness in pits for pitting intensity of less than 20%. With regard to the residual longitudinal strength the rules of the relevant Classification Society apply. The IACS U.R. S 7 requires that due to corrosion and wastage the minimum longitudinal strength standard shall not fall below 90% of the standard required for the newbuild ship. In a presentation at the 1992 TSCF Shipbuilders Meeting the problem of the residual strength of corroded structures has been discussed [2].

2.4 Maintenance And Repair Guidelines

This chapter gives guidance for the maintenance and repair strategy. Two basic types of repair are mentioned:

- Mandatory repair, which is carried out to comply with the mandatory requirement of the Flag Administration and / or Classification Society.
- Voluntary repair, and maintenance, which are carried out to minimise the total maintenance cost for the intended service life.

Furthermore the different maintenance and repair methods are discussed such as:

- Repair of existing coated areas in segregated ballast tanks,
- repair of uncoated areas in cargo tanks,
- pitting and grooving repair,
- repair and renewal of steel structures.

Repair and renewal of steel structures is of utmost importance. Based on the experience of its members the Forum has elaborated a comprehensive catalogue of structural detail failures. Such catalogue was already contained in the 1986 edition of the Manual, but has been further expanded and updated in the 1997 edition. The catalogue of the 1986 edition was presented at the 1987 TSCF Meeting with Shipbuilders [3]. The new catalogue, which contains a large number of typical structural failures, is divided into 14 structural groups. The factors contributing to damage are listed and suitable repair methods are proposed. In a special group, called “group 0”, recommended designs for bracket connections are given because a large number of defects have their origin in unsuitable bracket design. It is suggested that shipyards study specifically this part of the Guidance Manual in order to avoid repetition of the constructional defects made in the past. The following examples of the catalogue are shown here for illustration purposes: Figure B and Figures 7,10,15,20,39,52,77. It can be seen that constructional defects which repeatedly occur are :Hard points causing stress concentrations, insufficient end connections, insufficient stiffening. Finally, measures for an optimum maintenance and repair strategy are discussed.

3. CONCLUSIONS

The Tanker Structure Co-operative Forum is a unique panel of the tanker industry which discusses in an open minded manner experiences and problems with tanker structures. The collected experiences of the Forum’s members with tanker structures and the conclusions from structural defects have, inter alia, been summarised in the Guidance Manual, the second edition of which has been published in 1997. It is the intent of this presentation to draw the attention of the shipbuilding industry to this publication with the aim to improve tanker construction by avoiding constructional defects made in the past.

REFERENCES

- [1] Tanker Structure Co-operative Forum: Guidance Manual for Tanker Structures, published by Witherby & Co. 199 ISBN 1 85609 093 0.
- [2] Tanker Structure Co-operative Forum: Proceedings of the 1992 Meeting with Shipbuilders, Paper: “Corrosion Allowances for Newbuild Tankers“.
- [3] Tanker Structure Co-operative Forum: Proceedings of the 1987 Meeting with Shipbuilders, Paper: “Structural Details, Previous Failures and Their Implications for New Designs“.

FIGURES AND TABLES

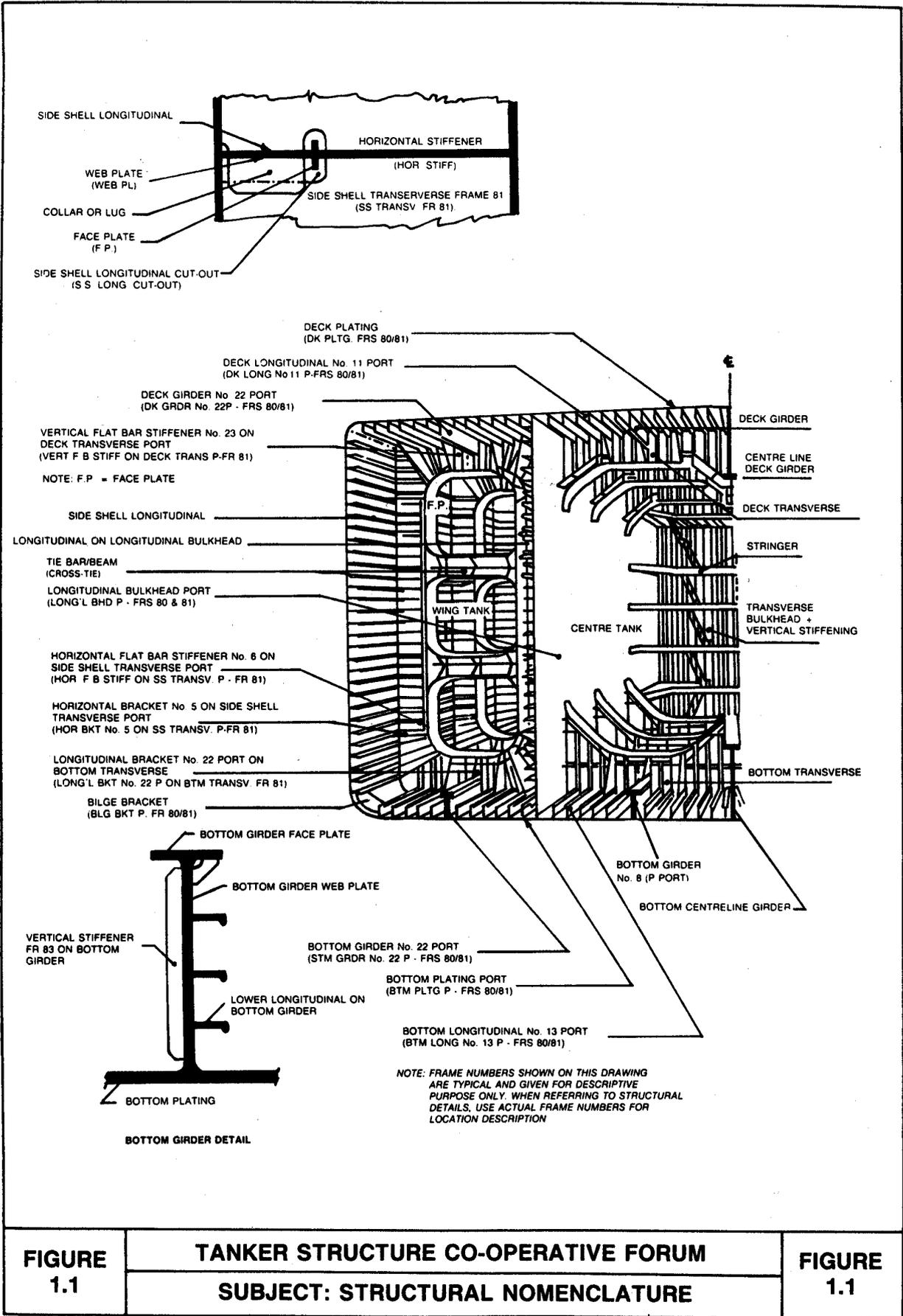


FIGURE 1.1

TANKER STRUCTURE CO-OPERATIVE FORUM
SUBJECT: STRUCTURAL NOMENCLATURE

FIGURE 1.1

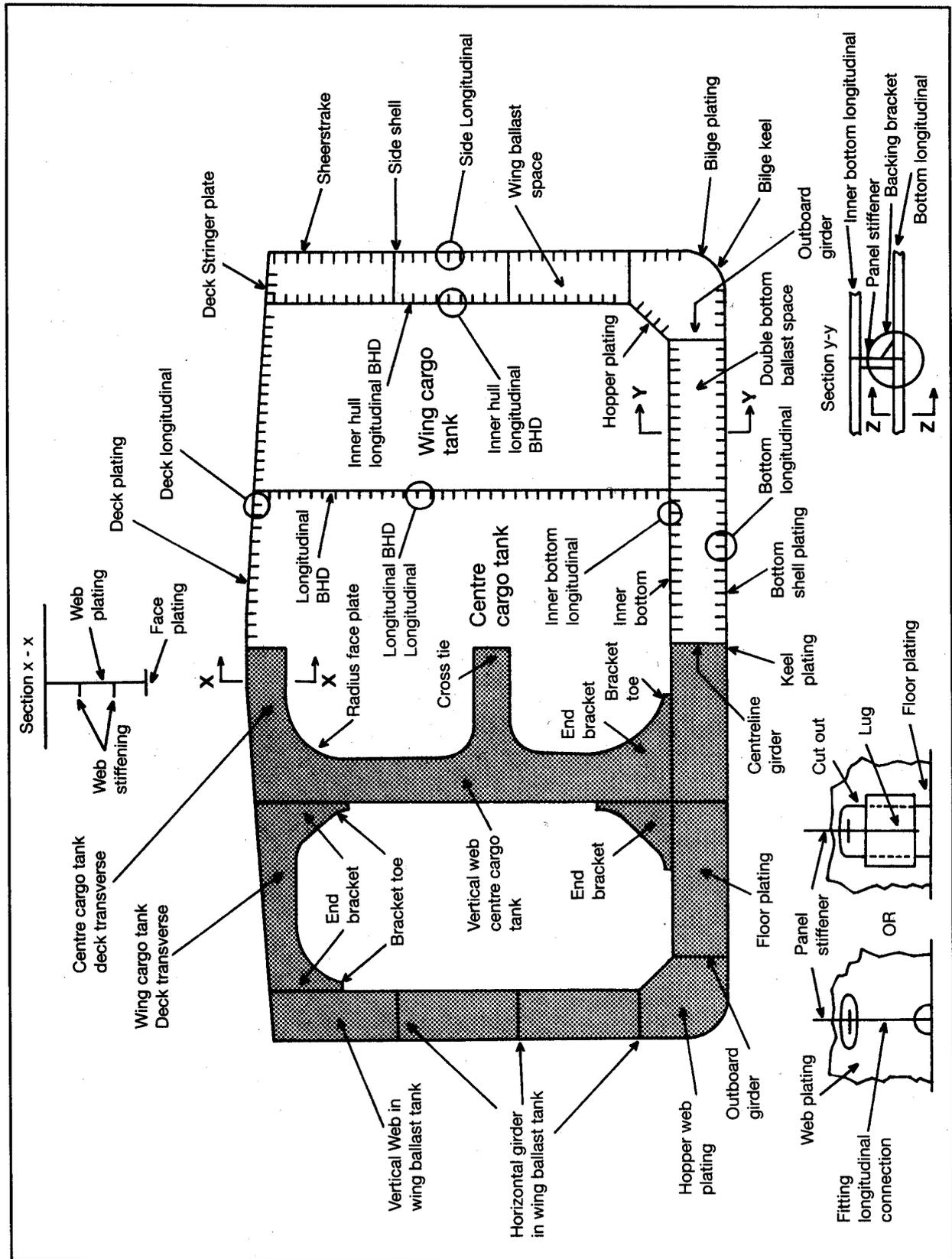
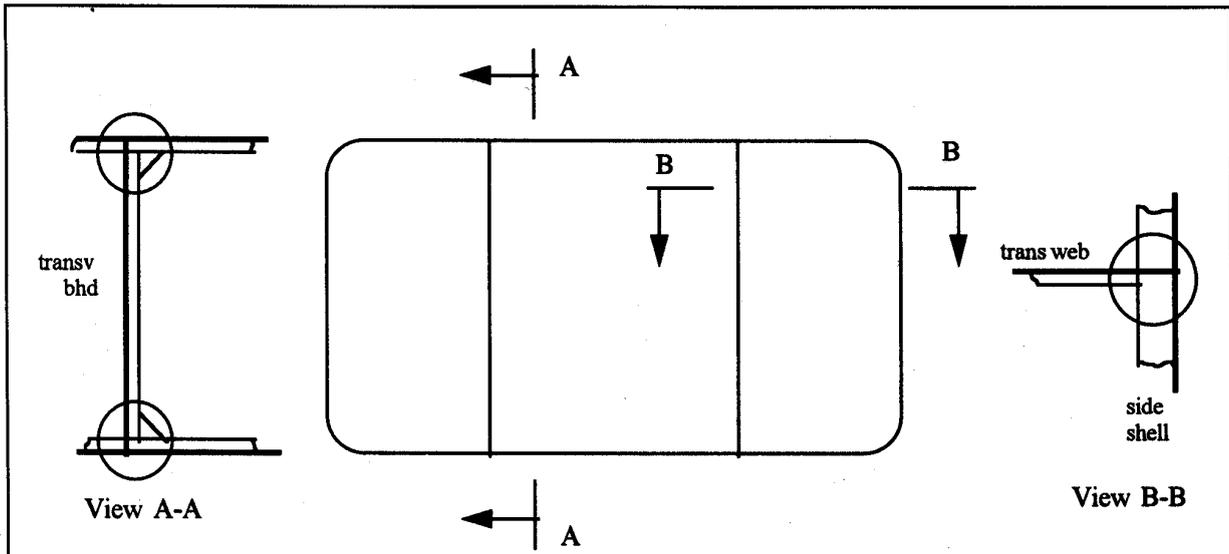
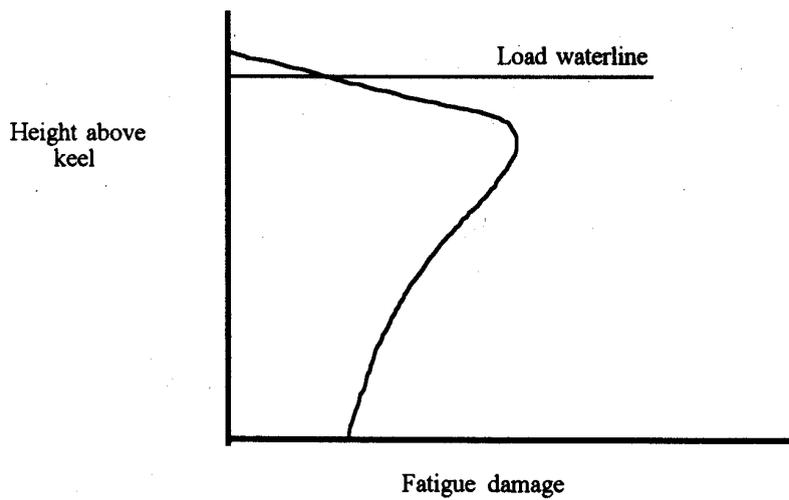


FIGURE 1.2	TANKER STRUCTURE CO-OPERATIVE FORUM SUBJECT: TYPICAL DOUBLE HULL MIDSHIP SECTION NOMENCLATURE	FIGURE 1.2
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Typical Connections Between Longitudinals and Transverse Web or Bulkhead



Distribution of Fatigue Damage From Wave Loading Over Depth of Vessel

FIGURE 1.3	TANKER STRUCTURE CO-OPERATIVE FORUM	FIGURE 1.3
	TYPICAL FATIGUE DAMAGE LOCATIONS AND DISTRIBUTION	

TRANSVERSE WEB FRAME PLATING

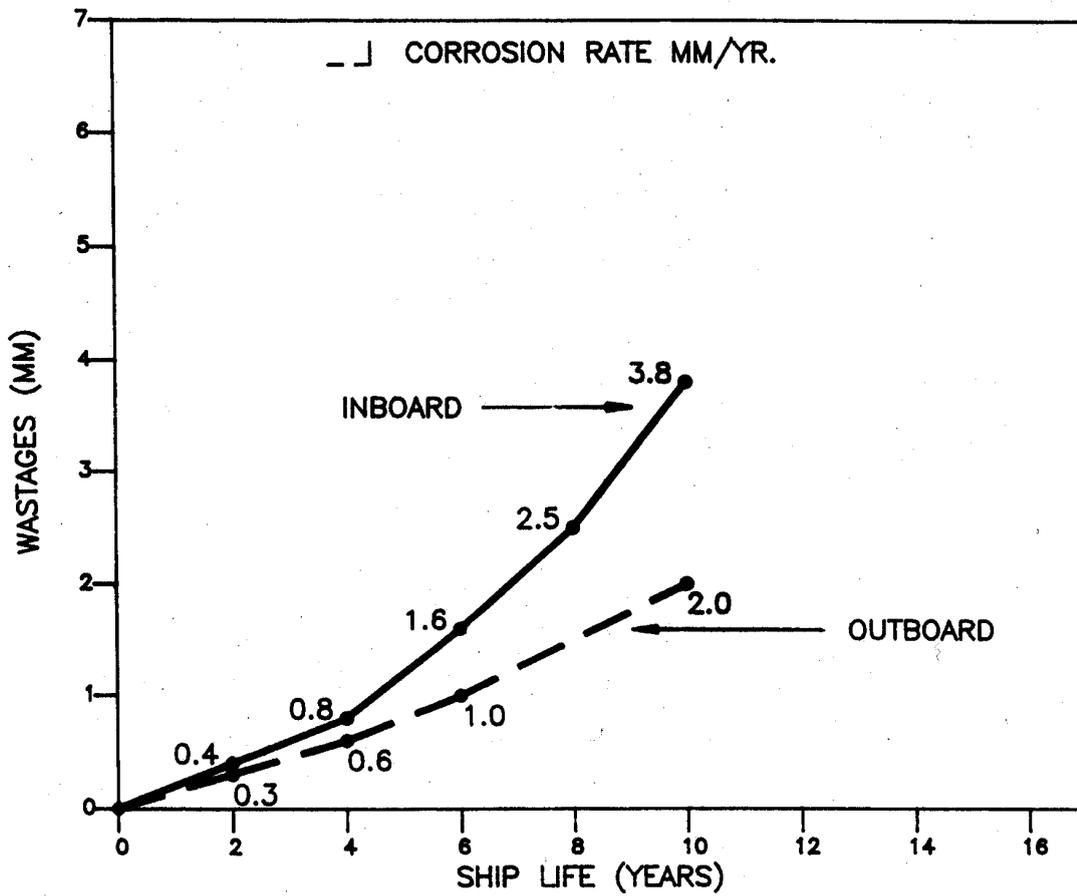
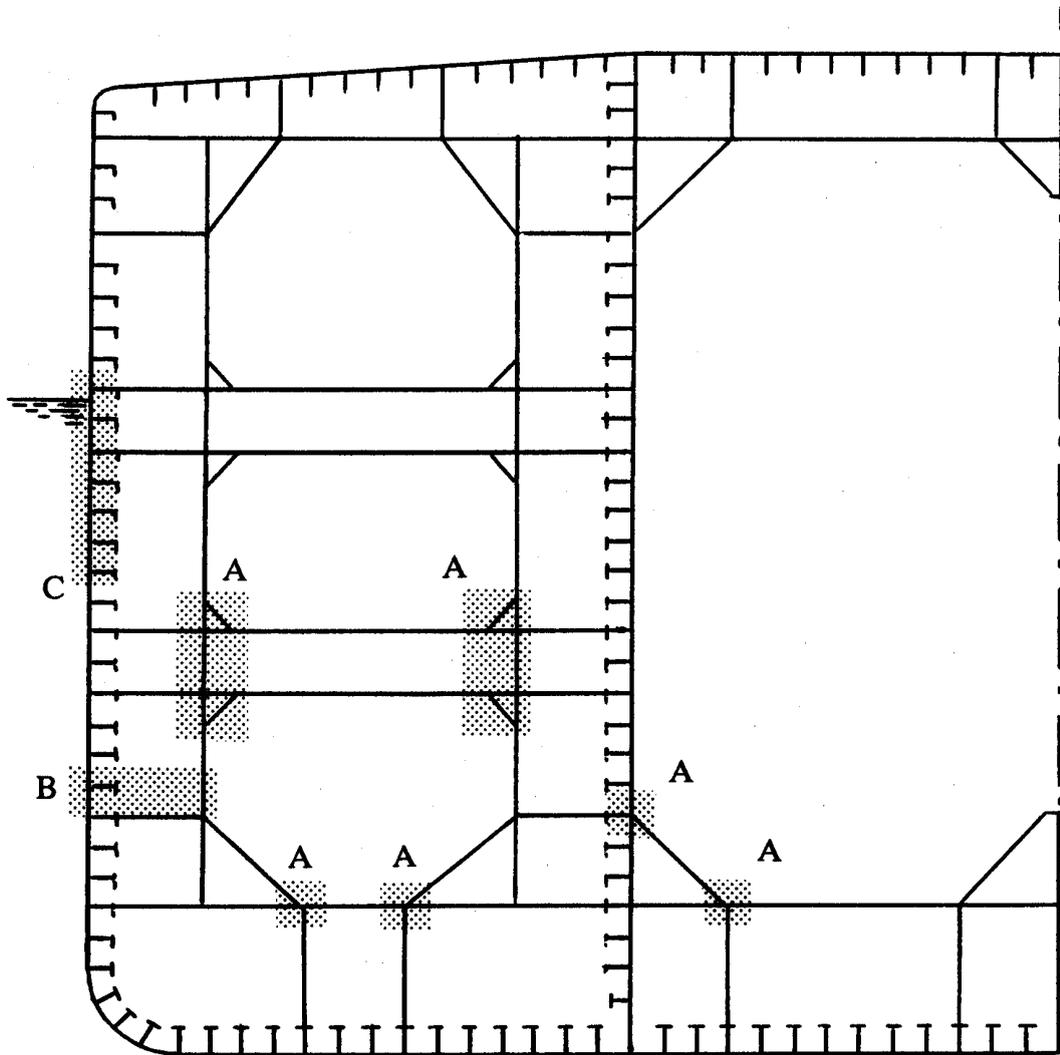


FIGURE	TANKER STRUCTURE CO-OPERATIVE FORUM	FIGURE
1.10	ACCELERATED CORROSION UNCOATED SEGREGATED BALLAST TANK	1.10



- 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	TANKER STRUCTURE CO-OPERATIVE FORUM	FIGURE
2.1	LOCAL AREAS OF HIGH STRESS IN TRANSVERSE WEB FRAMES	2.1

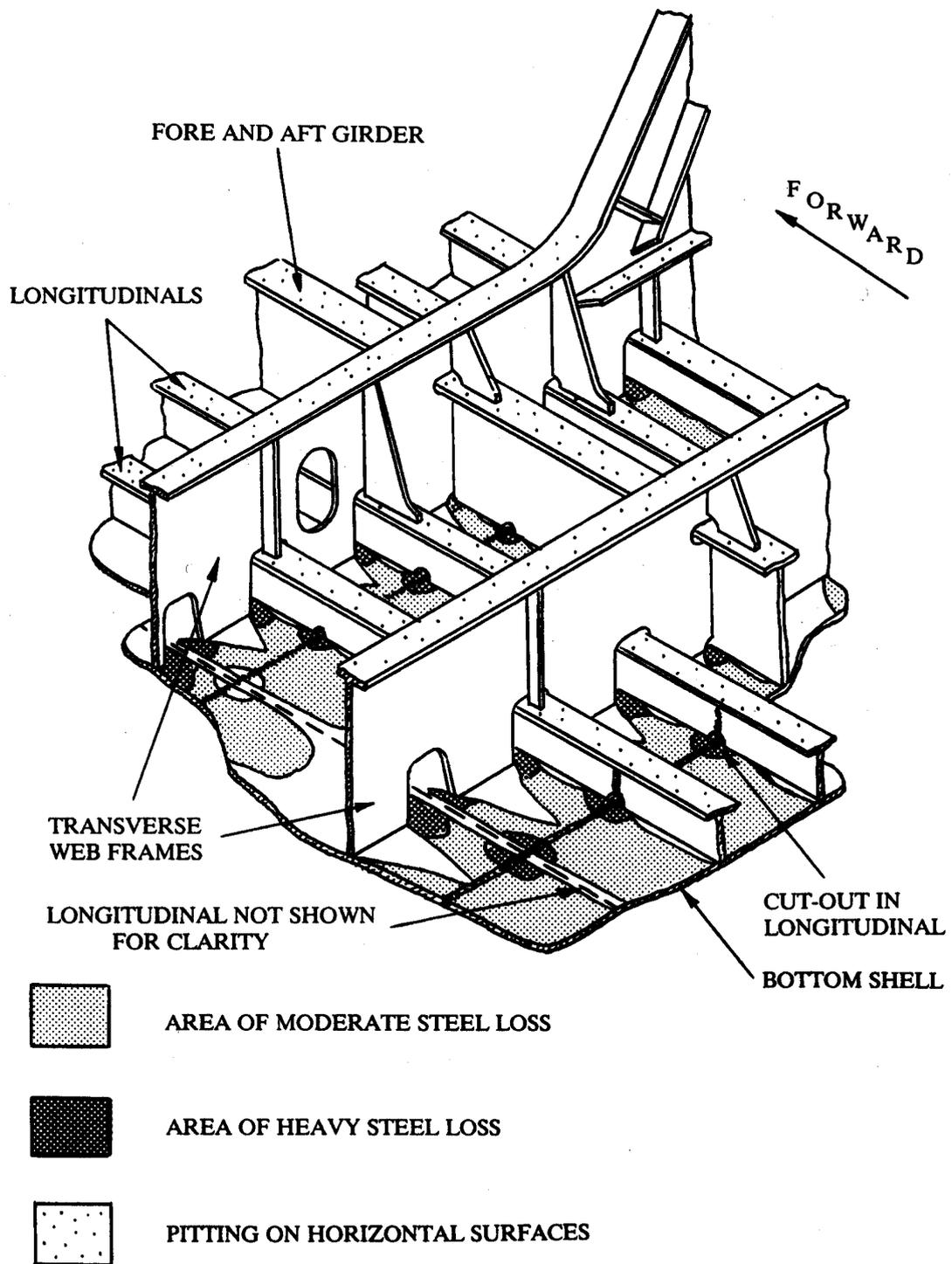


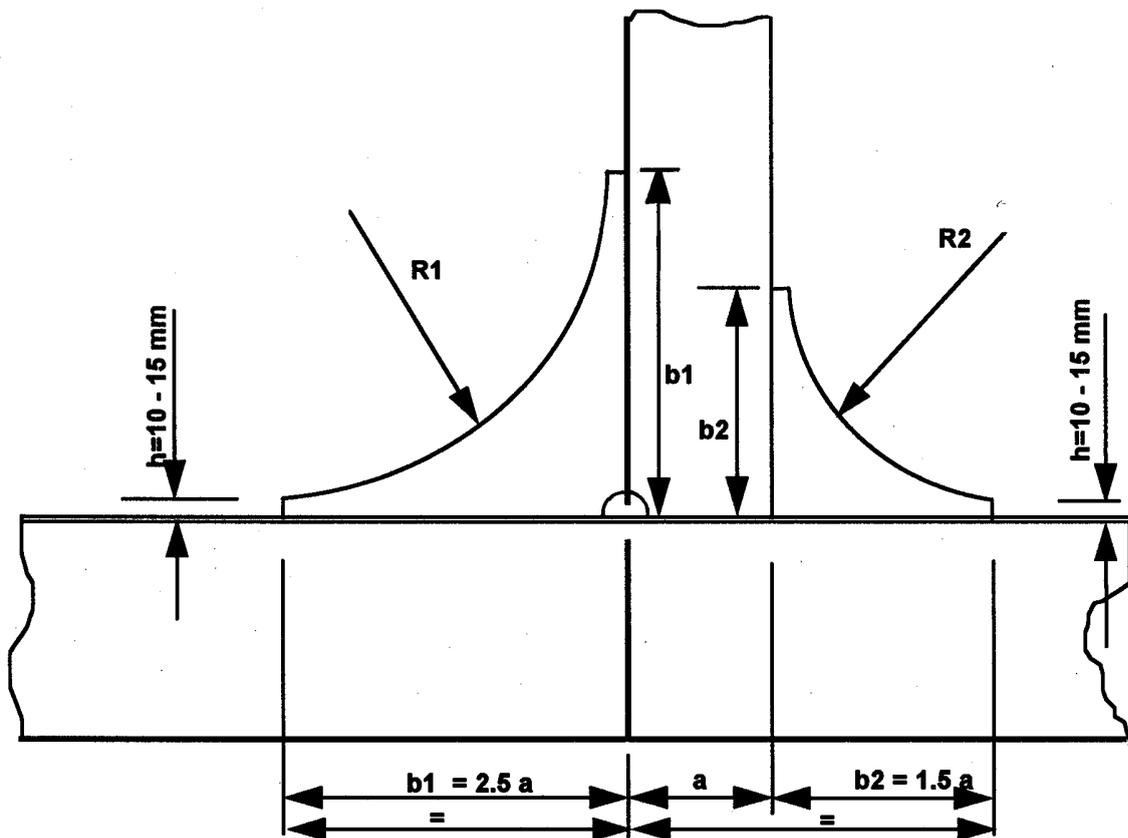
FIGURE 2.2	TANKER STRUCTURE CO-OPERATIVE FORUM	FIGURE 2.2
	TYPICAL WASTAGE OF BOTTOM STRUCTURE	

TYPICAL LOCATION: Web Frame / Side Longitudinal

GROUP
No.
0

DETAIL TYPE: Connection Brackets

RECOMMENDED DESIGN



NOTES:

- 1 - For a slope at toes max. 1:3, $R1 = (b_1 - h) \times 1.6$ and $R2 = (b_2 - h) \times 1.6$
- 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

TANKER STRUCTURE CO-OPERATIVE FORUM

SUBJECT: CATALOGUE OF STRUCTURAL DETAILS

FIGURE
B



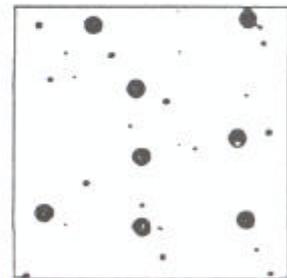
NOTES:

CONDITION: 1. GOOD

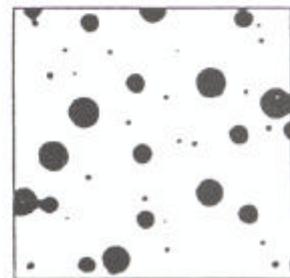
BREAKDOWN
 PERCENTAGE: 5 - 10 % in general
 < 20 % on edges

REMARKS: Lower end of GOOD

ASSESSMENT SCALE:



5%



10%

FIGURE
VII.3

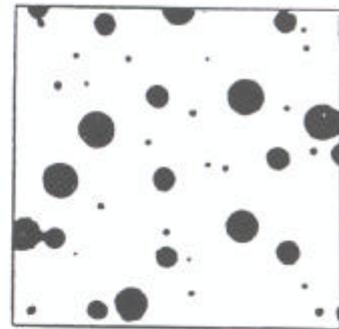
TANKER STRUCTURE CO-OPERATIVE FORUM

FIGURE
VII.3

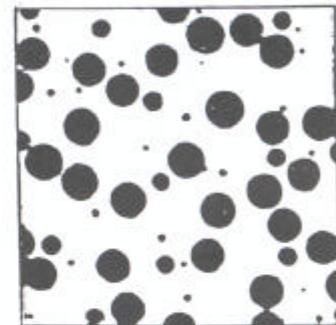
COATING CONDITION EVALUATION



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.

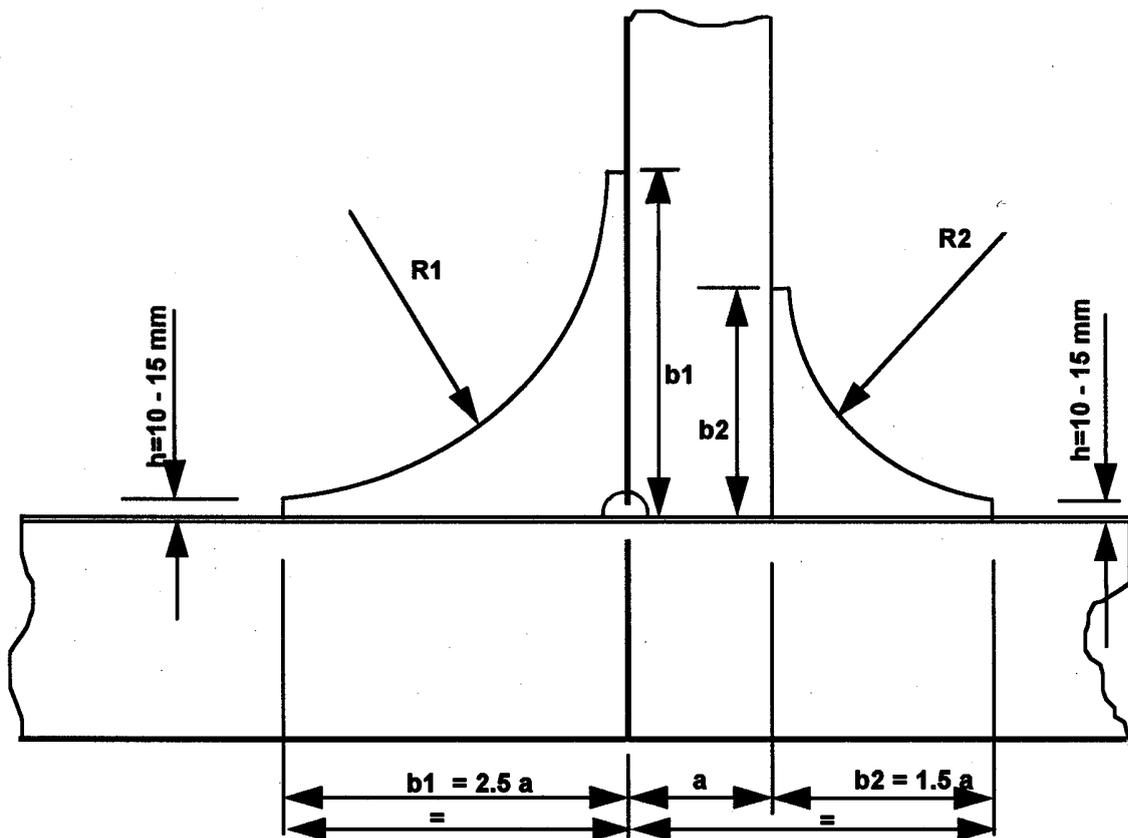
FIGURE VII.13	TANKER STRUCTURE CO-OPERATIVE FORUM	FIGURE VII.13
	COATING CONDITION EVALUATION	

TYPICAL LOCATION: Web Frame / Side Longitudinal

GROUP
No.
0

DETAIL TYPE: Connection Brackets

RECOMMENDED DESIGN



NOTES:

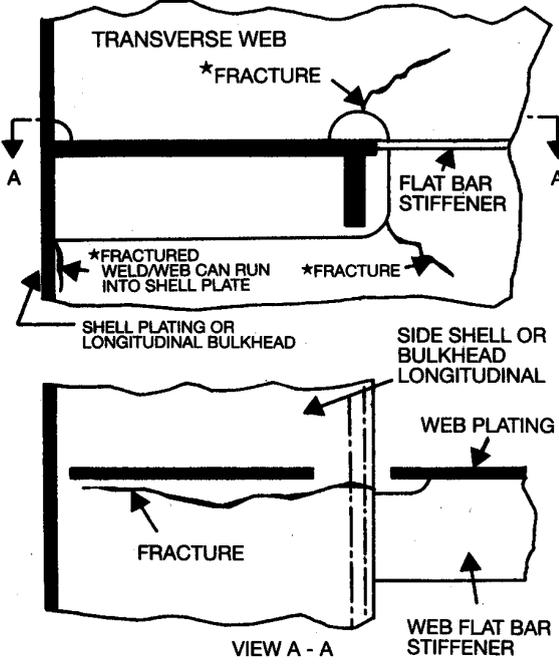
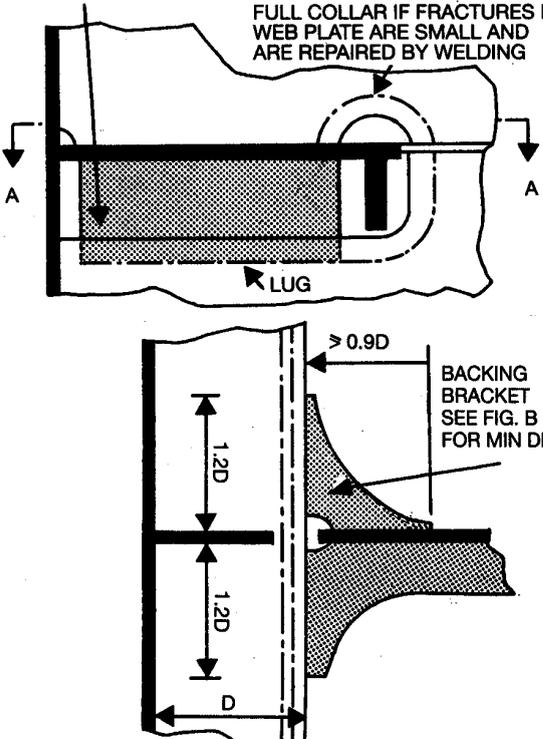
- 1 - For a slope at toes max. 1:3, $R1 = (b1 - h) \times 1.6$ and $R2 = (b2 - h) \times 1.6$
- 2 - Soft toe bracket to be welded first to longitudinal
- 3 - Scallop in bracket to be as small as possible, recommended max. 35 mm
- 4 - If toes of brackets are ground smooth, full penetration welds in way 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

TANKER STRUCTURE CO-OPERATIVE FORUM

SUBJECT: CATALOGUE OF STRUCTURAL DETAILS

FIGURE
B

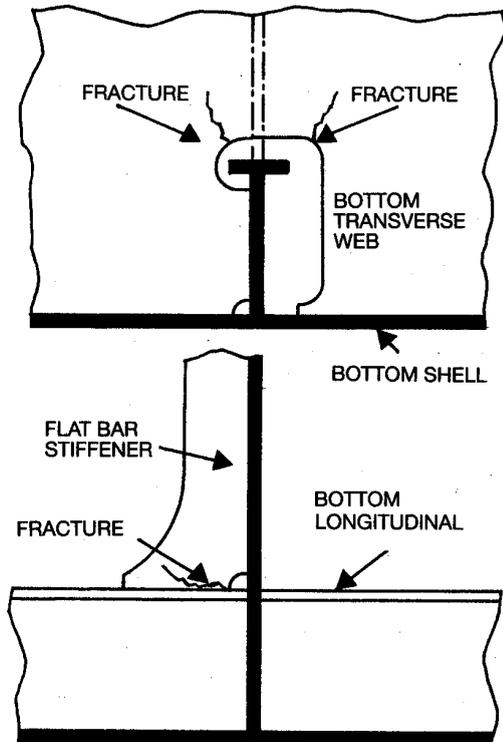
LOCATION:	Connection of longitudinals to transverse webs.	GROUP No. 1
EXAMPLE No. 7:	Web and longitudinal fractures. Face plate attached to underside of web. Flat bar butt welded.	
TYPICAL DAMAGE		PROPOSED REPAIR
 <p>NOTE: *ONE OR MORE FRACTURES MAY OCCUR</p>		<p>RECOMMENDED TO BE CONNECTED TO SHELL IF CONNECTION WEB/SHELL HAS CRACKED.</p> <p>FULL COLLAR IF FRACTURES IN WEB PLATE ARE SMALL AND ARE REPAIRED BY WELDING</p>  <p>BACKING BRACKET SEE FIG. B FOR MIN DIM.</p>
FACTORS CONTRIBUTING TO DAMAGE		
<ol style="list-style-type: none"> 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	TANKER STRUCTURE CO-OPERATIVE FORUM SUBJECT: CATALOGUE OF STRUCTURAL DETAILS	FIGURE 7

LOCATION: Connection of longitudinals to transverse webs.

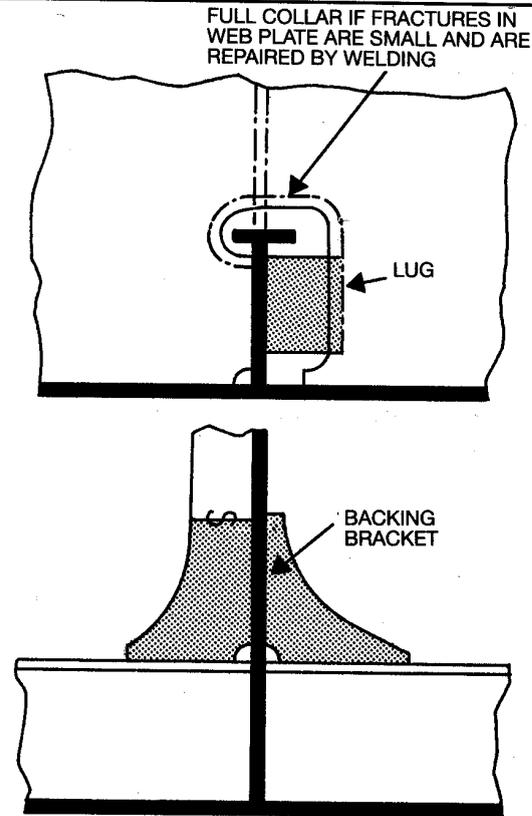
**GROUP
No.
1**

EXAMPLE No. 8: Bottom web and flat bar fractures at the cut-out for the longitudinal connections.

TYPICAL DAMAGE



PROPOSED REPAIR



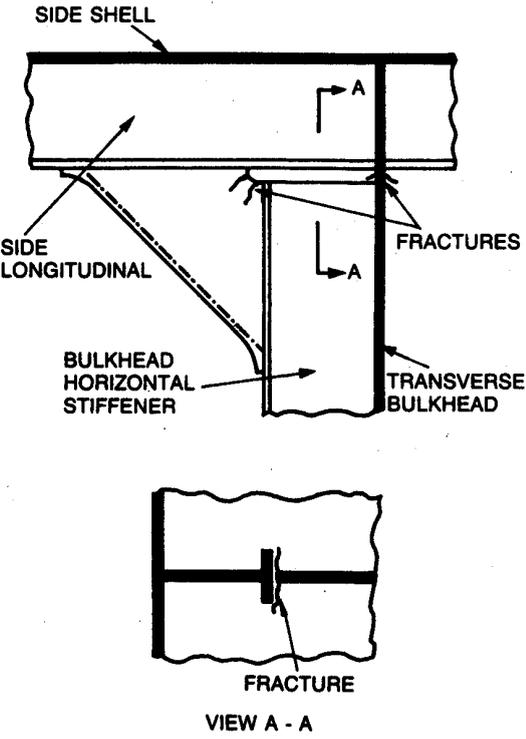
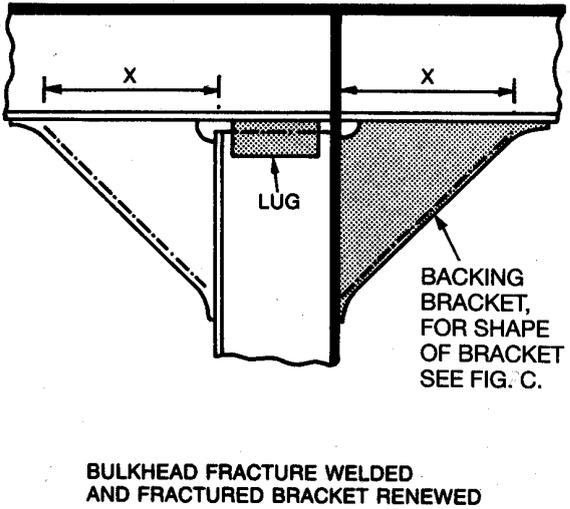
FACTORS CONTRIBUTING TO DAMAGE

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.

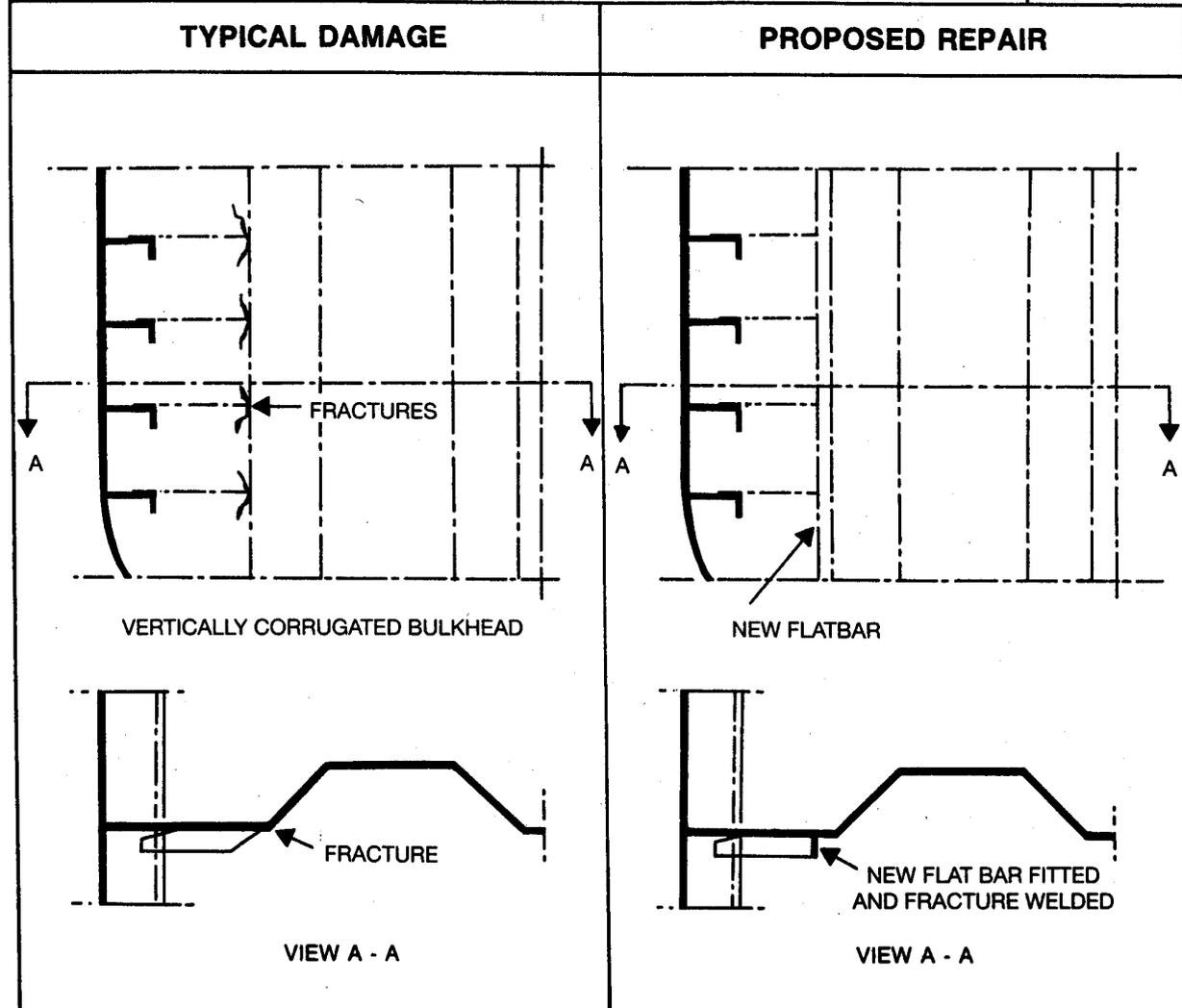
**FIGURE
10**

**TANKER STRUCTURE CO-OPERATIVE FORUM
SUBJECT: CATALOGUE OF STRUCTURAL DETAILS**

**FIGURE
10**

<p>LOCATION: Connection of longitudinals to plane transverse bulkheads</p> <p>EXAMPLE No. 2: Fractured bulkhead end bracket at side shell. Bulkhead horizontally stiffened.</p>	<p>GROUP No. 2</p>	
<p style="text-align: center;">PROPOSED REPAIR</p>		
	 <p style="text-align: center;">BULKHEAD FRACTURE WELDED AND FRACTURED BRACKET RENEWED</p>	
<p>FACTORS CONTRIBUTING TO DAMAGE</p> <ol style="list-style-type: none"> 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. 		
<p>FIGURE 15</p>	<p style="text-align: center;">TANKER STRUCTURE CO-OPERATIVE FORUM</p> <p style="text-align: center;">SUBJECT: CATALOGUE OF STRUCTURAL DETAILS</p>	<p>FIGURE 15</p>

LOCATION:	Connection of longitudinals to corrugated transverse bulkheads	GROUP No. 3
EXAMPLE No. 1:	Bulkhead fracture at toe of horizontal flatbar stiffener. Vertically corrugated bulkhead.	

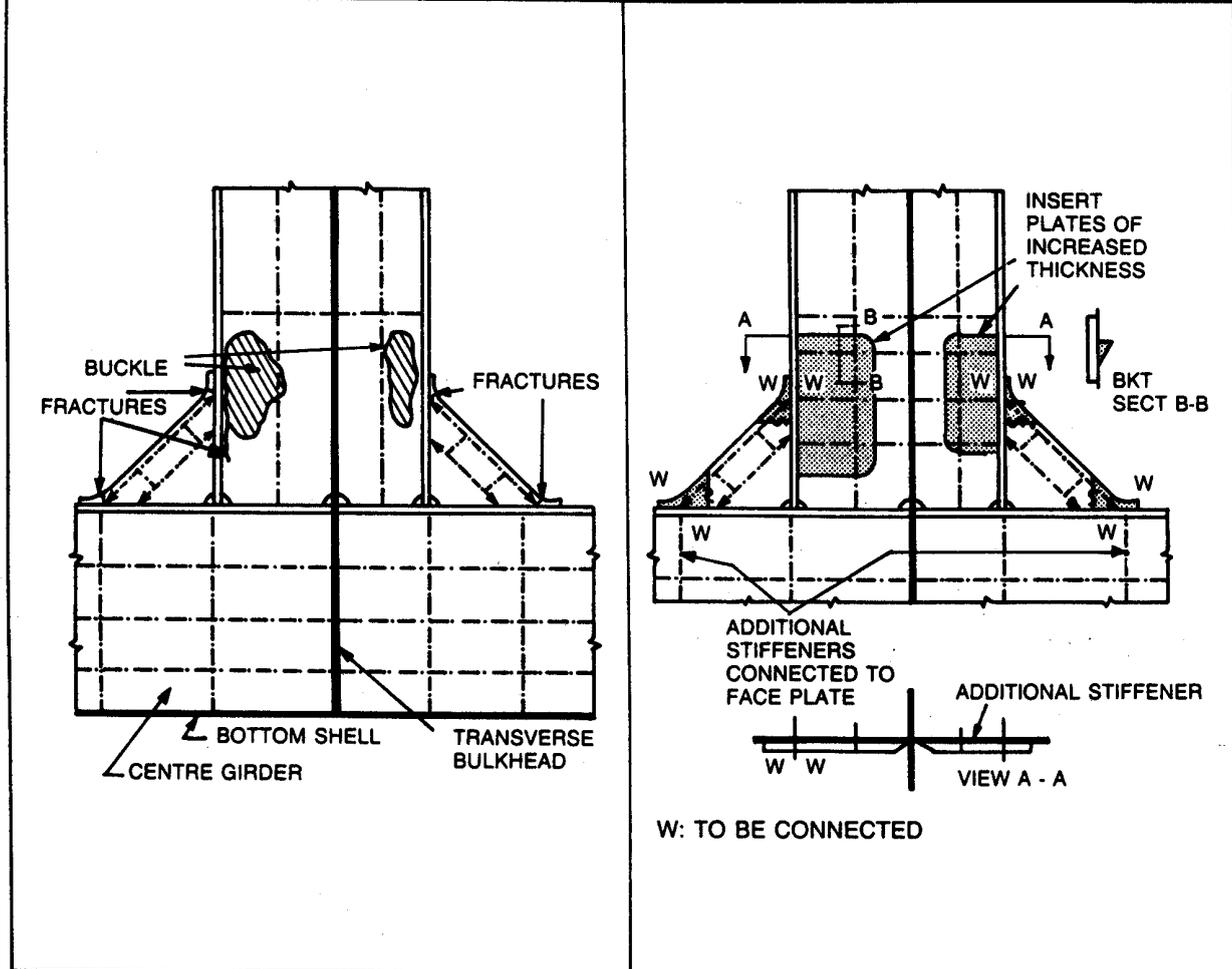


FACTORS CONTRIBUTING TO DAMAGE

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.

LOCATION:	Longitudinal girder end brackets	GROUP No. 6
EXAMPLE No. 4:	Buckled and fractured vertical web and bottom centreline girder bracket connection	

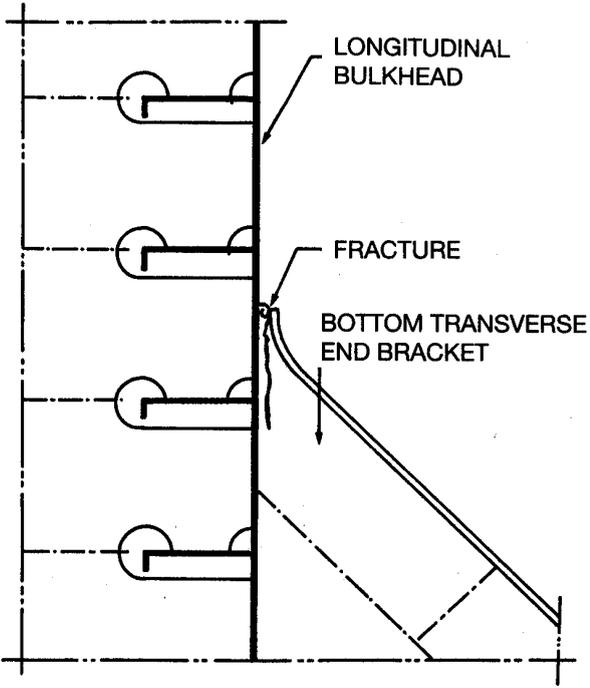
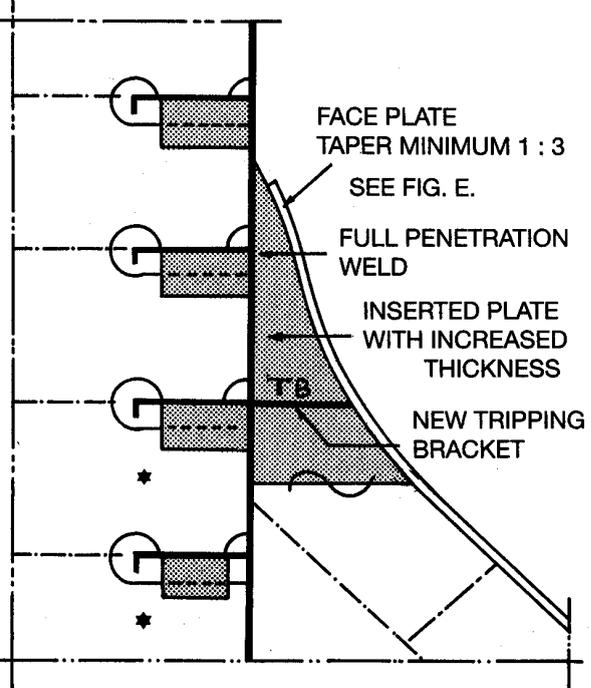
TYPICAL DAMAGE	PROPOSED REPAIR
-----------------------	------------------------



FACTORS CONTRIBUTING TO DAMAGE

1. Insufficient panel stiffening on vertical web.
2. Stress concentration at bracket toes with sniped face plate.

FIGURE 39	TANKER STRUCTURE CO-OPERATIVE FORUM	FIGURE 39
	SUBJECT: CATALOGUE OF STRUCTURAL DETAILS	

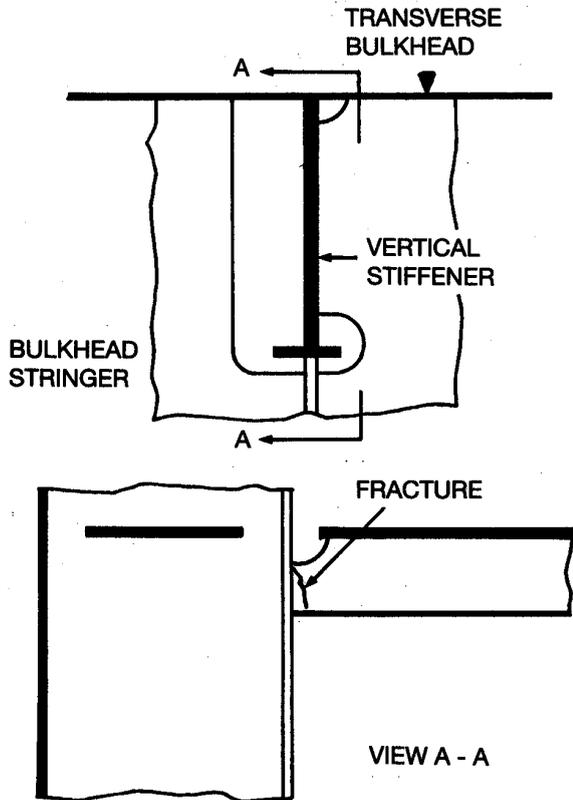
LOCATION: Transverse web frame end brackets EXAMPLE No. 4: Fractured centre tank bottom transverse end bracket. Symmetrical face plate.	GROUP No. 7	
TYPICAL DAMAGE	PROPOSED REPAIR	
	 <p style="text-align: center;">★ NEW LUGS RECOMMENDED</p>	
FACTORS CONTRIBUTING TO DAMAGE <ol style="list-style-type: none"> 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. 		
FIGURE 52	TANKER STRUCTURE CO-OPERATIVE FORUM SUBJECT: CATALOGUE OF STRUCTURAL DETAILS	FIGURE 52

LOCATION: Transverse bulkhead stiffener/primary web intersection.

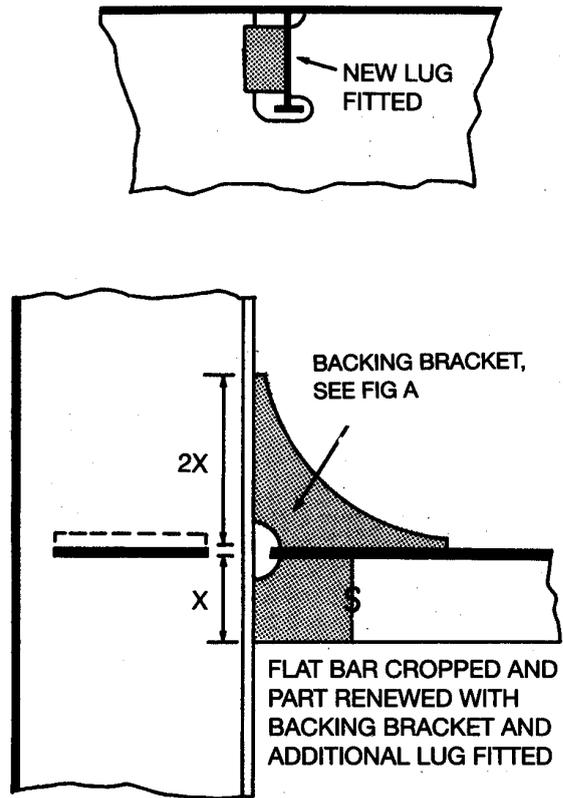
**GROUP
No.
11**

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.

**FIGURE
77**

TANKER STRUCTURE CO-OPERATIVE FORUM
SUBJECT: CATALOGUE OF STRUCTURAL DETAILS

**FIGURE
77**

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 *H+ = Higher Risk* *X = Not Considered*
M = Medium Risk
L = Low Risk *L- = Lower Risk* *() = Negligible*
p = Risk of Pittings

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 2.1).*
 - *Areas with high flow rate, i.e. around openings, notches etc (see Figure 2.2).*
 - *Drip locations of cleaning guns.*

TABLE 2.1	TANKER STRUCTURE CO-OPERATIVE FORUM	TABLE 2.1
	RISK OF CORROSION AND PITTING	

TYPICAL DEFECTS TYPES

Item	Corrosion	Buckling	Cracks
Longitudinal Material	<ul style="list-style-type: none"> - 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 suction. - Longitudinal bulkhead plating (Rel. thin). 	<ul style="list-style-type: none"> - Upper deck plating. - Upper deck longitudinals. - Bottom plating. - Bottom longitudinals. - Longitudinal Bulkhead plating middle and upper part. - Deck and bottom girders. 	<ul style="list-style-type: none"> - At discontinuities. - At openings, notches. - At connections with transverse elements.
Transverse Web Frames	<ul style="list-style-type: none"> - Upper part, connection to deck. - Just below top coating. - Flanges of bottom transverses. 	<ul style="list-style-type: none"> - Web plate (Shear). - Brackets. - Flanges. - Cross ties 	<ul style="list-style-type: none"> - Connections with longitudinal elements. - Scallops in connection with longitudinals. - Bracket toes. - Holes and openings. - Crossing face flats.
Transverse Bulkheads	<ul style="list-style-type: none"> - Upper part, connection to deck. - Stringer webs. - Close to openings in stringers. - High stress locations, i.e. around bracket toes etc. 	<ul style="list-style-type: none"> - Horizontal stringers, web plate (Shear). - Girder/stringer brackets. - Vertical girders, web plate (Shear). - Corrugated bulkhead plate. 	<ul style="list-style-type: none"> - Connections with longitudinal elements. - Connection between girder systems. - Bracket toes.
Swash Bulkheads	<ul style="list-style-type: none"> - Upper part, connection to deck. - Stringer webs. - Close to openings in bulkhead plating. - High stress locations, i.e. around bracket toes. 	<ul style="list-style-type: none"> - Horizontal stringers, web plate (Shear). - Vertical girders, web plate (Shear). - Girder/stringer brackets. - Bulkhead plating around openings. 	<ul style="list-style-type: none"> - Connections with longitudinal elements. - Connections between girder systems. - Bracket toes. - At openings in bulkhead plating.

TABLE

2.2

TANKER STRUCTURE CO-OPERATIVE FORUM

TYPICAL DEFECTS TYPES

TABLE

2.2

The following Table 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/t = 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	TANKER STRUCTURE CO-OPERATIVE FORUM	TABLE 3.1
	GUIDELINES FOR CORROSION WASTAGE	

The following Table 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	$t_{\min} = \sim 2/3 * t_0$ (2) (3)
Webs of horizontal members (Stringers, longitudinals etc.)	$t_{\min} = \sim 1/2 * t_0$ (4)

Notes

- (1) For pitting intensity refer to Appendix VIII, Fig. VIII.5.2 and 3. 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 pitfilling is to be carried out in accordance with the filler manufacturers 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	TANKER STRUCTURE CO-OPERATIVE FORUM	TABLE
3.2	GUIDELINES FOR PITTING REPAIR	3.2

