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AMERICAN BUREAU OF SHIPPING & AFFILIATED COMPANIES

SAFEHULL SYSTEM FOR BULK CARRIERS

GUIDE ON IMPROVEMENT FOR STRUCTURAL CONNECTIONS AND SAMPLE STRUCTURAL DETAILS —SERVICE EXPERIENCE AND MODIFICATIONS— FOR BULK CARRIERS

OCTOBER 1995

THE ABS SAFEHULL™ SYSTEM

SAFETY OF SHIP STRUCTURES BY DYNAMIC BASED DESIGN AND EVALUATION

Guide on Improvement for Structural Connections and Sample Structural Details — Service Experience and Modifications — for Bulk Carriers

October 1995

American Bureau of Shipping
Incorporated by the Legislature of
the State of New York 1862

1.0 GENERAL

This Guide identifies the influential parameters and provides guidelines on improvement of structural connections. It also provides for reference illustrations of local structural failures experienced in some existing bulk carriers and the corrective measures as compiled by the IACS and from the American Bureau of Shipping's data files.

For structural details similar to those in tankers, reference illustrations are to be found in the "Guide on Improvement for Structural Connections and Sample Structural Details - Service Experience and Modifications - for Tankers".

2.0 INFLUENTIAL PARAMETERS

For design of structural details, due consideration is to be given to the following influential parameters.

2.1 Loading Patterns and Nominal Stresses

The load distribution among the connected structural members and the corresponding nominal stresses at the location considered should be examined for the combined load cases specified in 5/3A3.5.2. It is important to consider the combined effects of all the simultaneously imposed load components, rather than only one selected dominating load component. The stress distribution may be obtained from a 3D structural analysis as specified in 5/3A5.3 or by other equivalent means.

2.2 Stress Concentration

Due to load transmission and diffusion at a structural joint, it is inevitable that some form of stress concentration is going to occur in the loaded structure. Therefore, particular attention should be paid to structural notches, abrupt changes in structural properties and excessive distortions and deformations; such as locations at bracket toes, cut-outs, terminations of heavily loaded members, connection of flexible elements with much stiffer members, ends of unbalanced structural members, just to name a few. For ship structures

designed with relatively low working stresses and high safety margins, the detrimental effects of such stress concentrations may not readily be apparent. On the other hand, for structures designed with high working stresses and low safety margins, damaging effects of such stress concentrations could appear sooner than the anticipated period of time.

Appropriate stress concentration factors (SCF's) obtained from either experimental data or structural analyses are required to evaluate the design of structural details.

2.3 Weld Effects and Fatigue Strength

Another important factor to be considered is the effects of welding on the properties of material (heating effects) and on structural continuity (profile of the weld deposit and under-cuts). This factor which highly depends on the welding methods, processes and workmanship is vital for assessing fatigue strength of the joint. To date, the welding effects on fatigue strength are primarily determined by experimental data presented in the form of S-N curves and characteristics of the test specimens, as shown in Appendix 5/3AA of the Rules.

3.0 CONSIDERATIONS FOR DESIGN OF STRUCTURAL DETAILS

In light of the discussions given in 5/3A5.4, it is apparent that the necessary criterion for the design of structural details is simply to offer a well balanced joint which is "compatible" with the anticipated working stresses. To this end, the solution is to be tailored to a specific location of a specific design. In addition, there is no unique solution to the problem. Many alternatives may exist. The designers/builder would have to exercise their judgment based on their fabrication facilities, techniques and experience. The information offered below is provided for reference.

3.1 Hold Frames and End Brackets

When selecting and sizing brackets connecting hold frames, due consideration should be given to the load transmission and relative stiffness of the members to be connected. A

pattern of smooth load transmission is essential. The connecting bracket is to be of sufficient size to withstand the highly concentrated loads and to relocate the critical spots (bracket toes) to lower stressed regions. Sample illustrations are shown in Figures 1, 1a and 1b for damages experienced in existing bulk carriers with some recorded repairs.

3.2 Connection of Transverse Bulkhead Structures

To prevent local fractures and to minimize the magnifying effects of structural notches, and misalignment/discontinuities consideration should be given to local reinforcements at the critical areas. Sample illustrations are shown in Figures 2a thru 2f for local damages and some recorded repairs.

3.3 Connection of Double Bottom Structures

Sample damaged structural details and connections are illustrated in Figures 3a thru 3h for double bottom structures. Attention should be paid to the weld connections of the slope longitudinal bulkhead and the inner bottom plating.

3.4 Connections of Lower Wing Tank Structures

Sample damages experienced in the existing bulk carriers are shown in Figures 4a and 4b.

3.5 Structures and Connections Within the Upper Wing Tanks

Sample fractures and buckling of the transverse webs and brackets are shown in Figures 5a thru 5d.

3.6 Deck Structures

Illustrations are given for cracks at hatch corners, buckling of the cross deck structures and hatch coaming in Figures 6a thru 6d.

3.7 Forepeak Structures

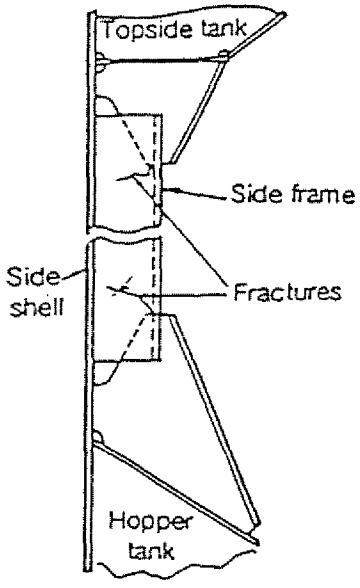
Some structural damages are shown in Figures 7a and 7b for the supporting structures in the forepeak region.

3.8 Transition Region in the Foremost Cargo Hold

Sample structural damages and repairs are shown in Figures 8a thru 8d for connections of the panting stringers and hold frames.

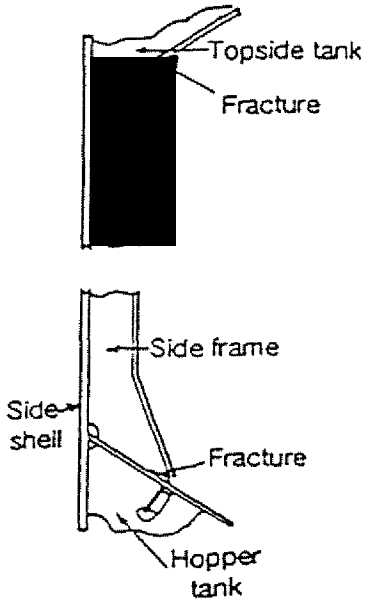
Side Frame Structure

Typical Damages to Hold Frames



Separate Bracket Configuration

(a)



Integral ■ Configuration

(b)

The type of bracket configuration used will to a large extent dictate the location and extend of fracture. Where separate brackets are employed, the fracture location is normally at the bracket toe position on the frames, whereas with integral brackets the fracture location is at the toe position on the hopper and topside tank.

Figure 1

Side Frame Structure

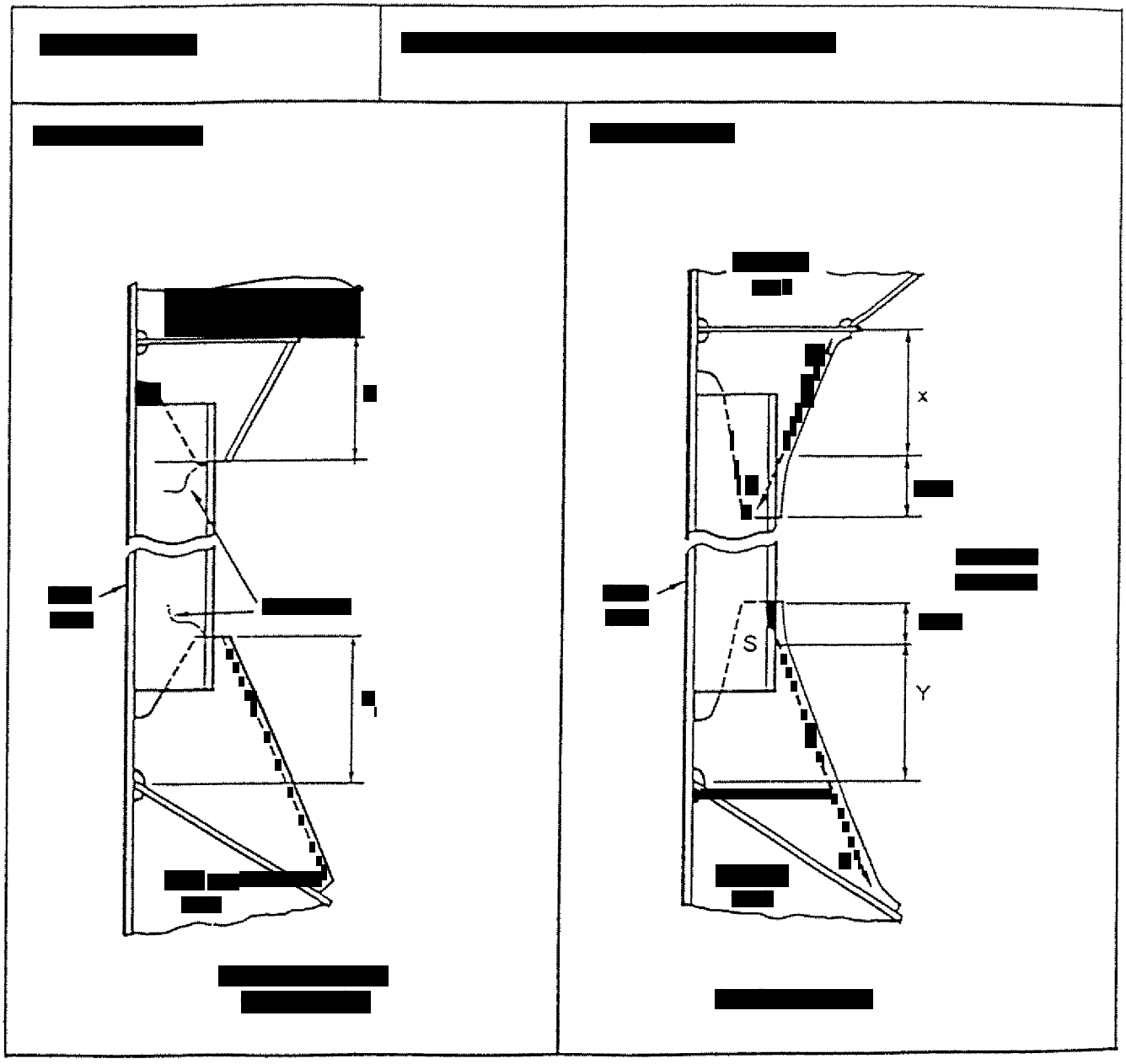
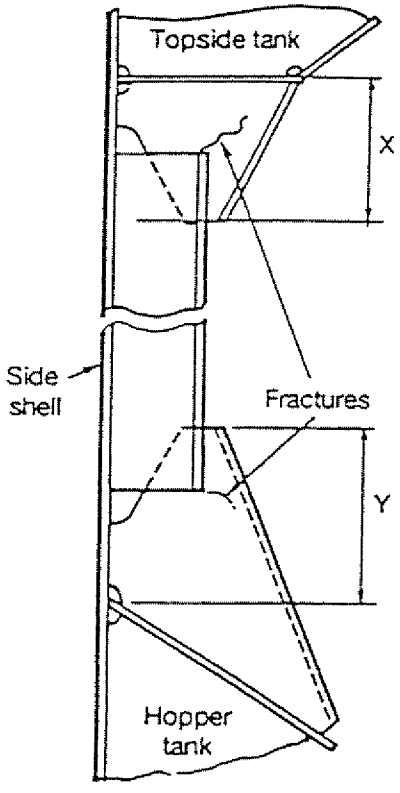


Figure 1a1

Side Frame Structure

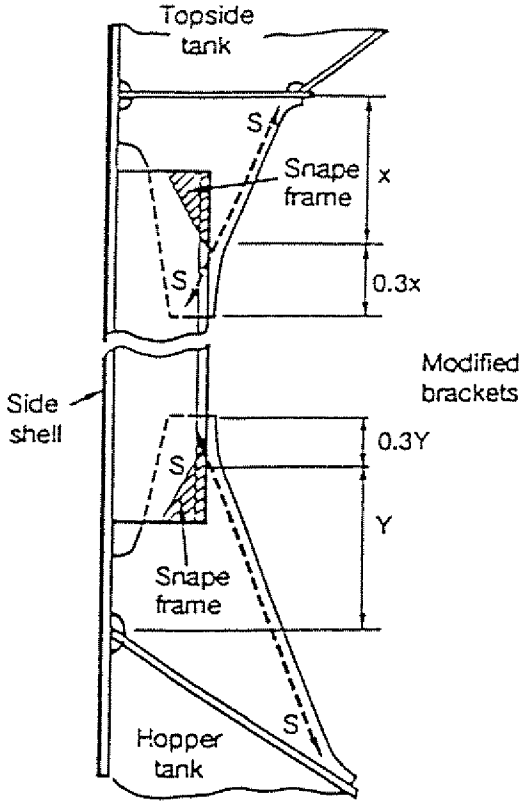
Detail of damage	Fractures on brackets at termination of frame

Sketch of damage



Separate Bracket Configuration

Sketch of repair



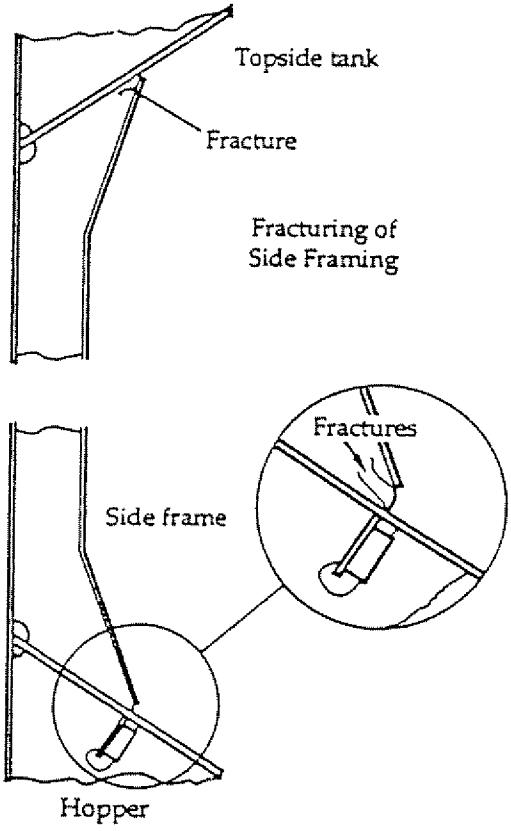
S = Snaped end

Figure 1a2

Side Frame Structure

Detail of damage	Fractures and the Toe Position on the Side Tank Sloping Plating

Sketch of damage



Integral Bracket Configuration

Sketch of repair

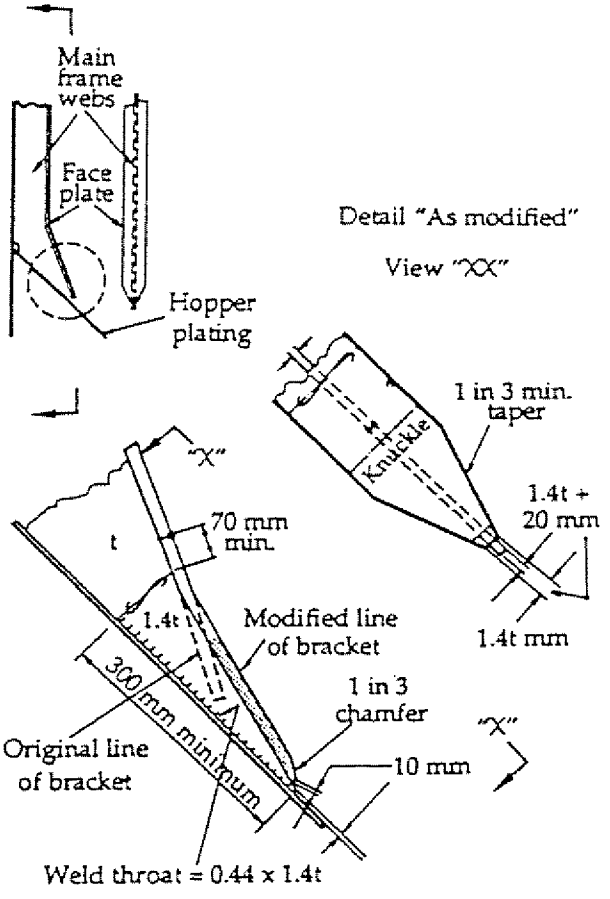
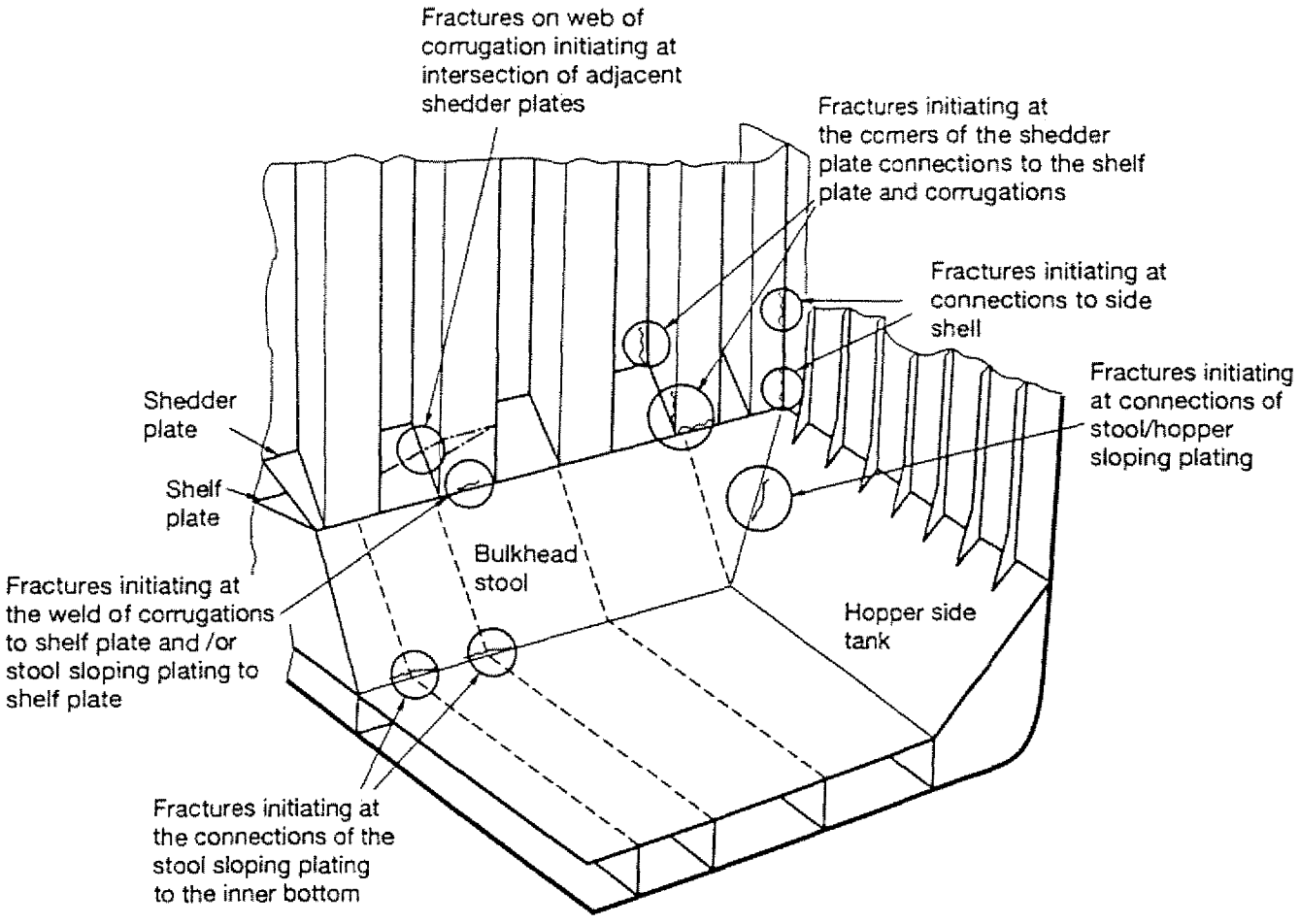


Figure 1b



(Similar damages may occur at the upper connections of the bulkhead to the deck structure)

Figure 2 Typical Fracturing at the Connection of Transverse Bulkhead Structure

Transverse Bulkhead Structure

Detail of damage	Fractures at weld connections to stool shelf plate

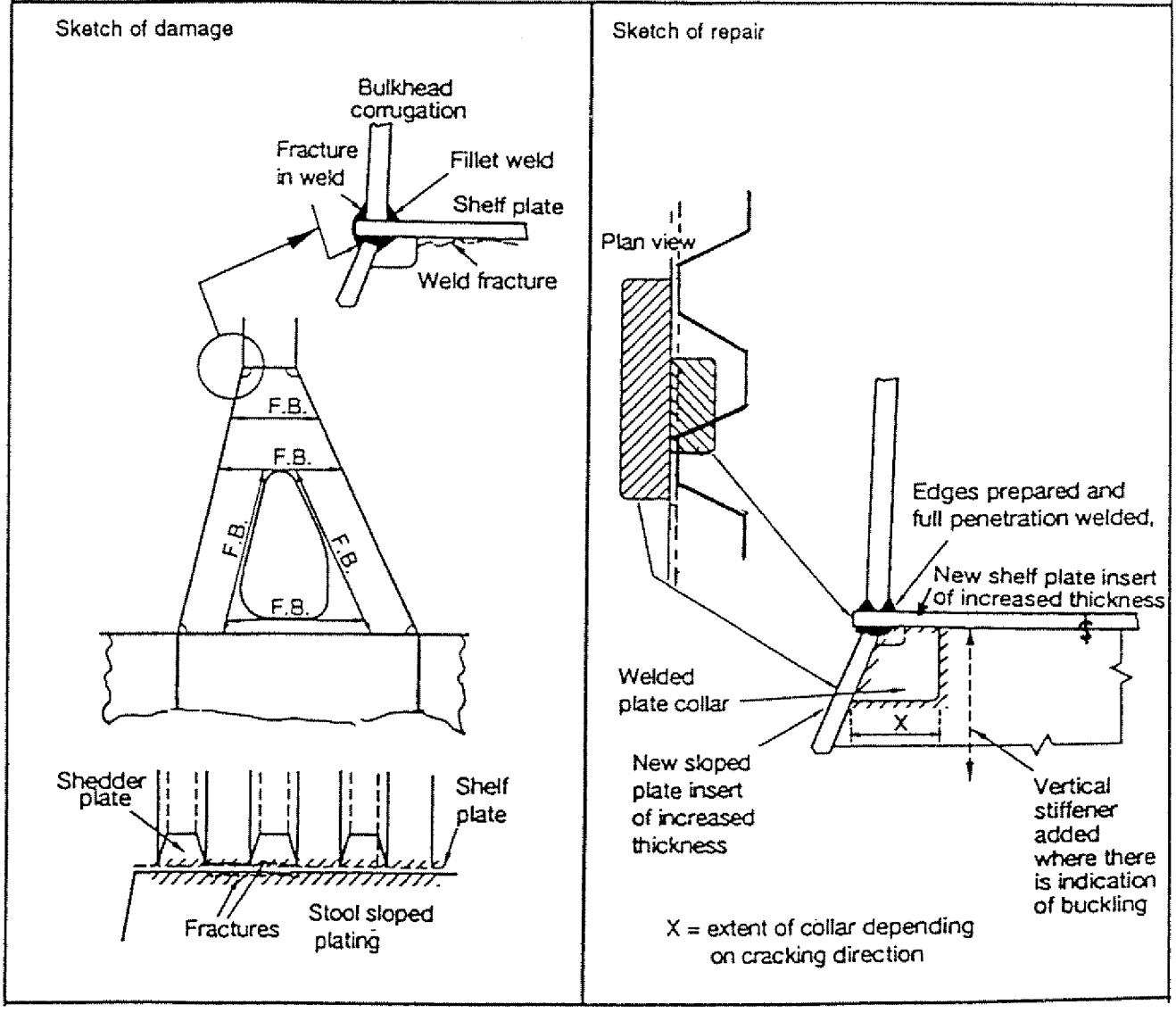
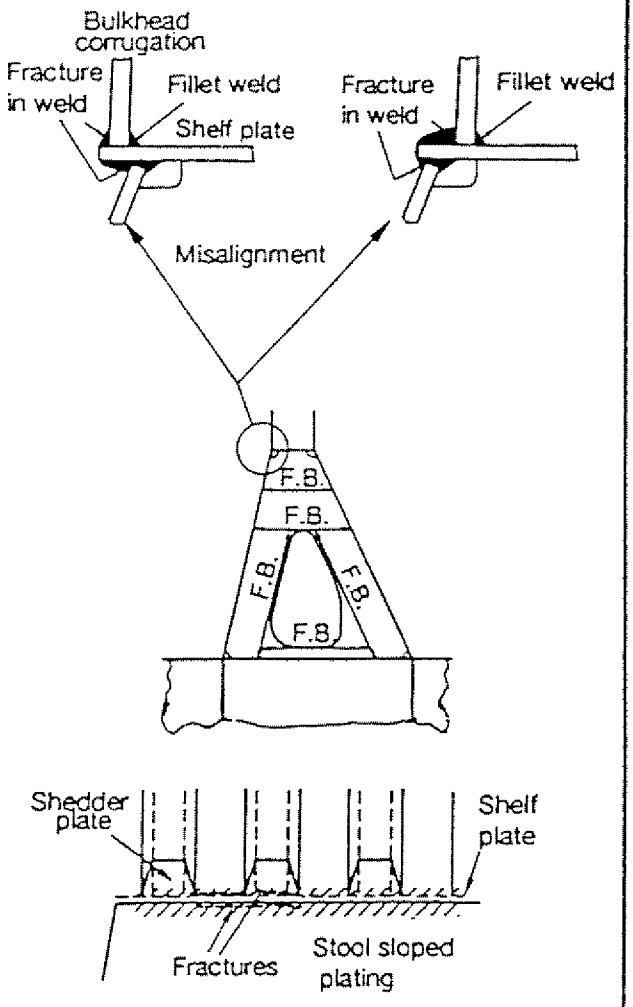


Figure 2a

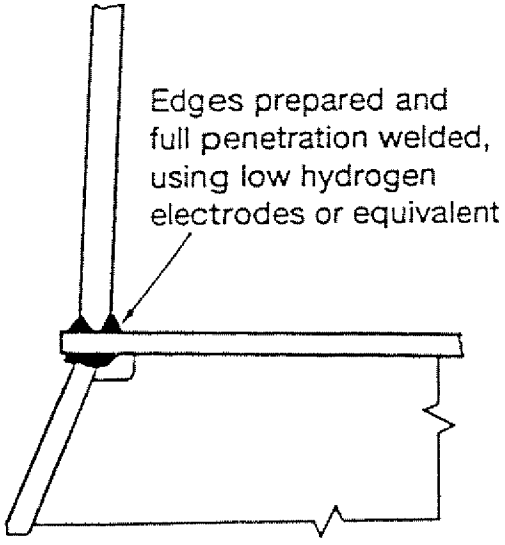
Transverse Bulkhead Structure

Detail of damage	Fractures at weld connections of stool plating and corrugation flange to the shelf plate

Sketch of damage



Sketch of repair



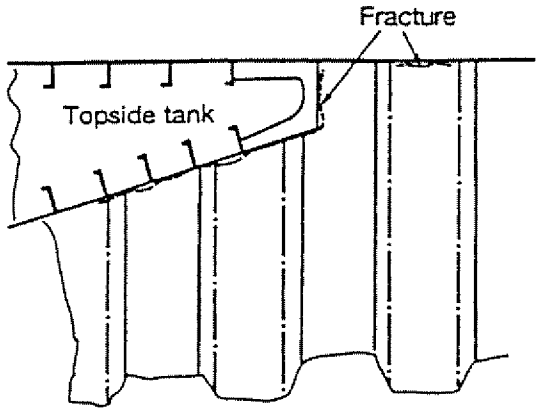
Structure to be released and misalignment rectified

Figure 2b

Transverse Bulkhead Structure

Detail of damage	Fractures at the upper boundaries to topside tanks

Sketch 0f damage



Sketch of repair

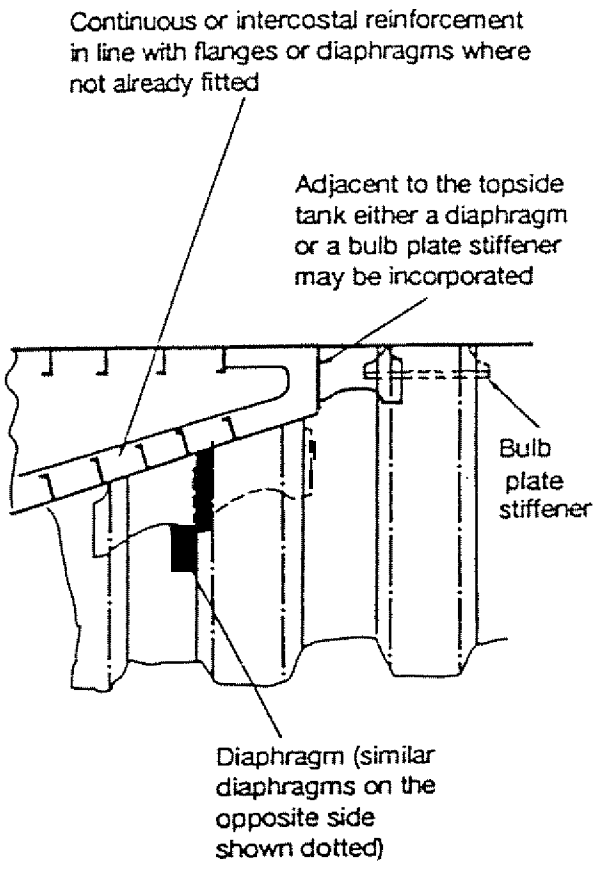


Figure 2c

Transverse Bulkhead Structure

Detail of damage	Fractures on the web of corrugation initiating at intersection of adjacent shedder plates

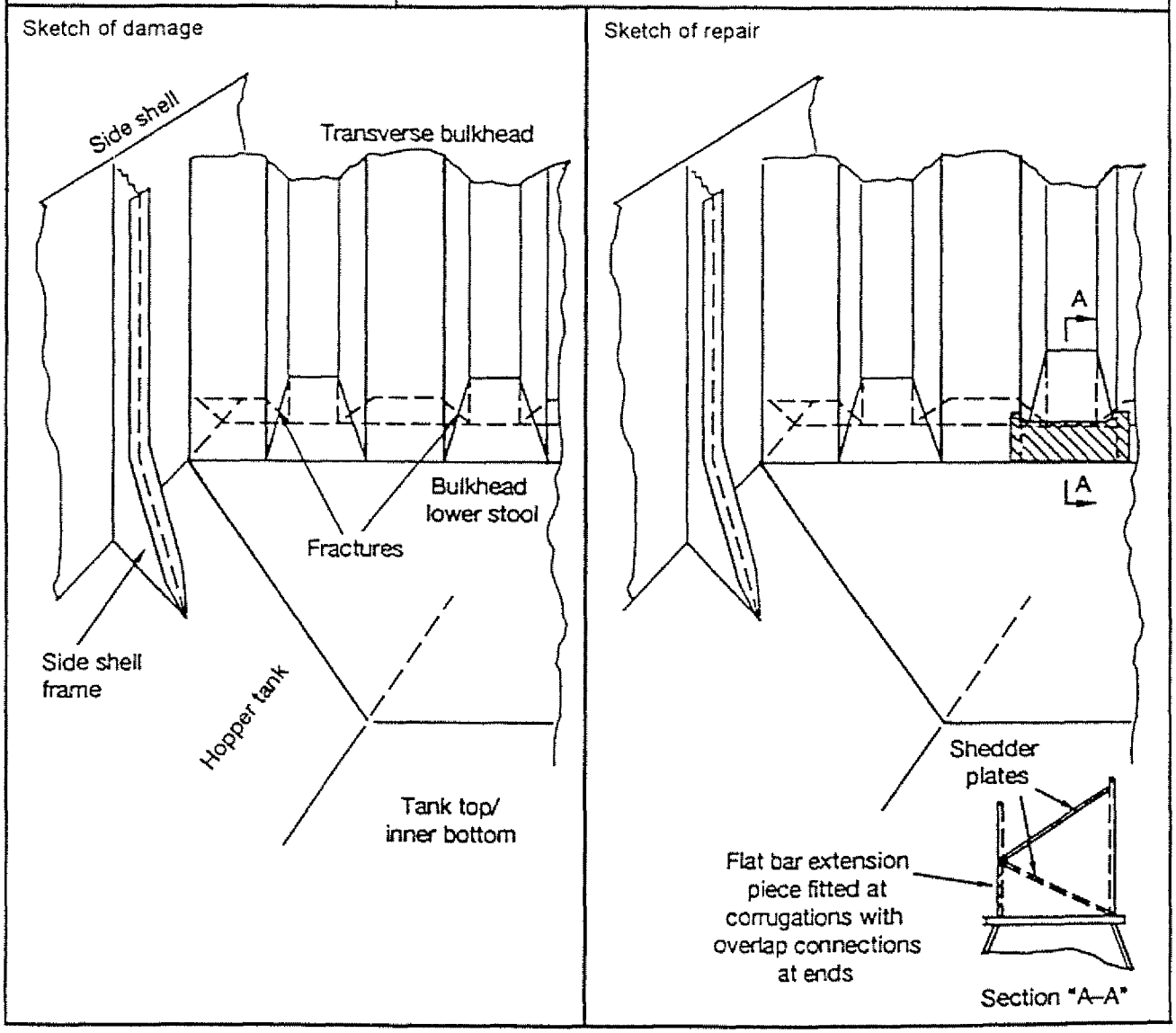


Figure 2d

Transverse Bulkhead Structure

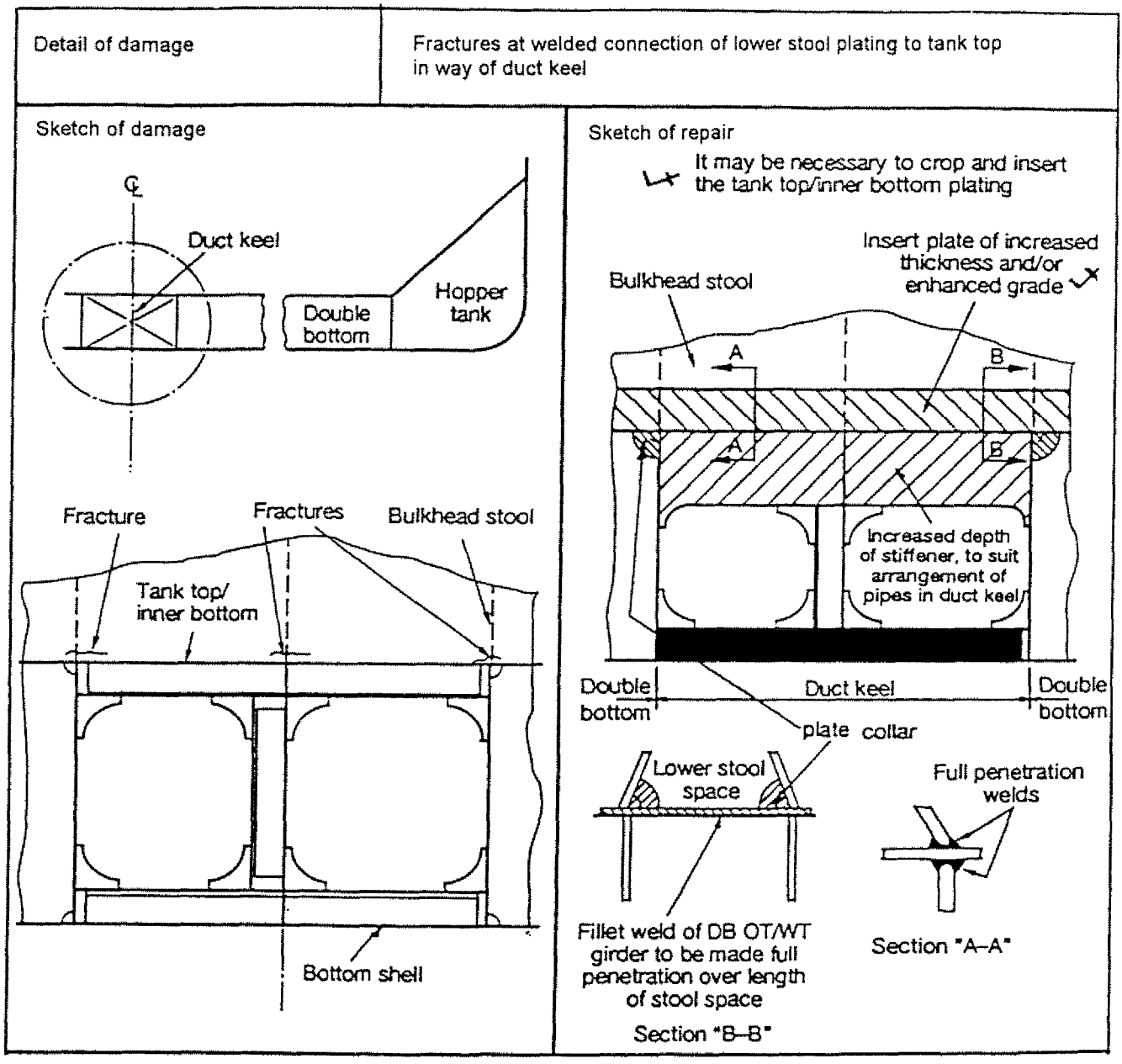


Figure 2e

Transverse Bulkhead Structure

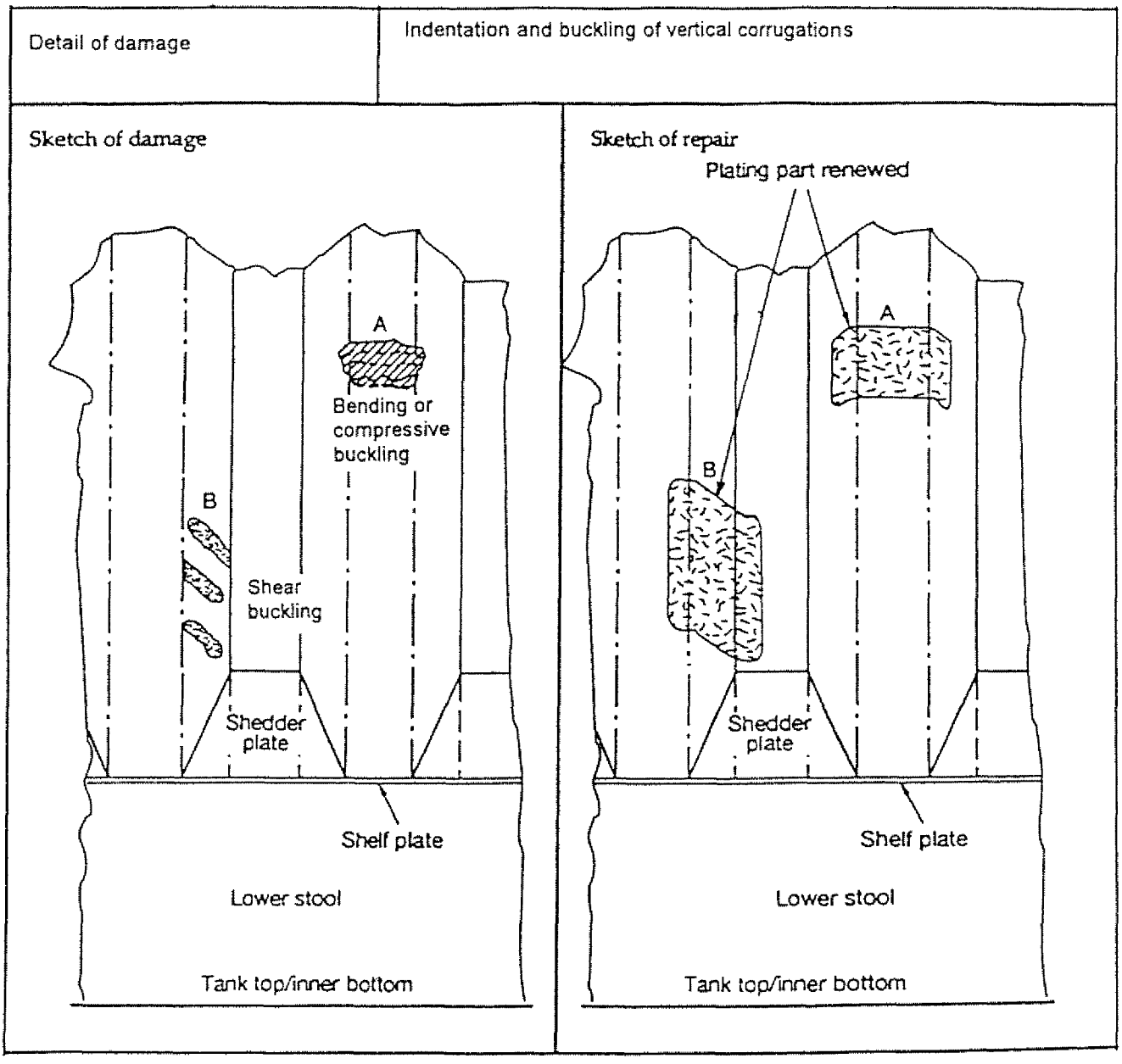


Figure 2f

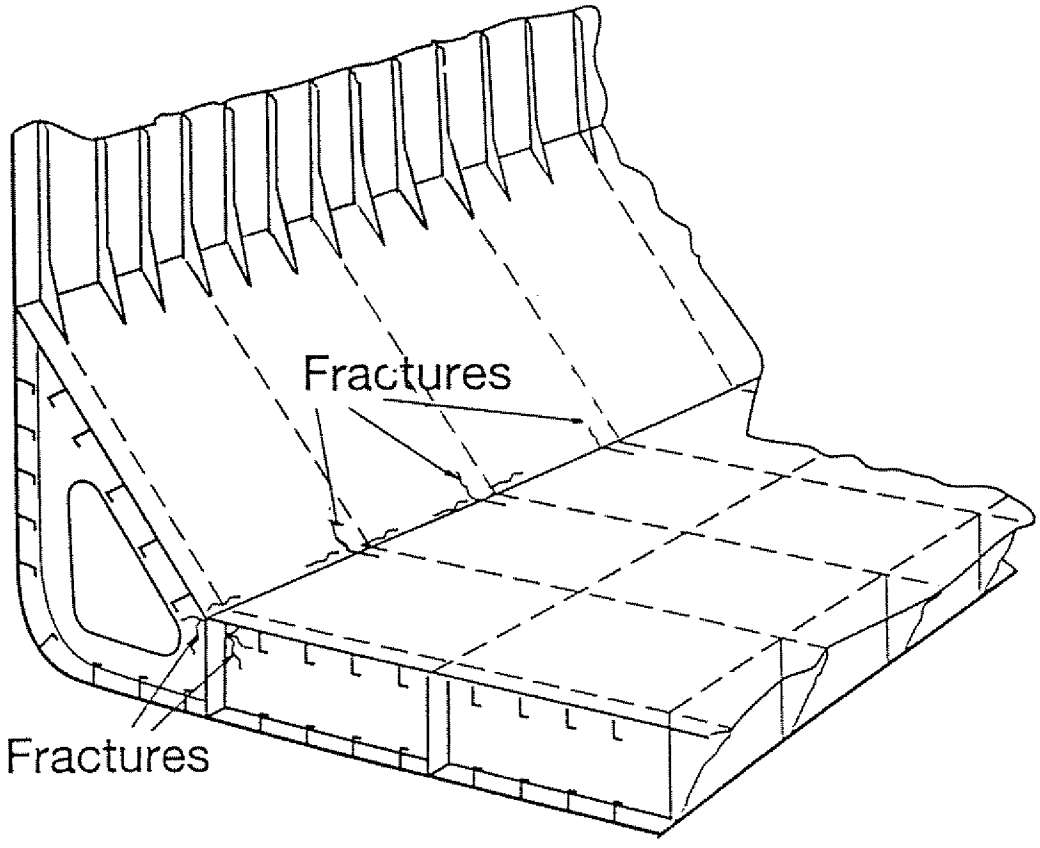
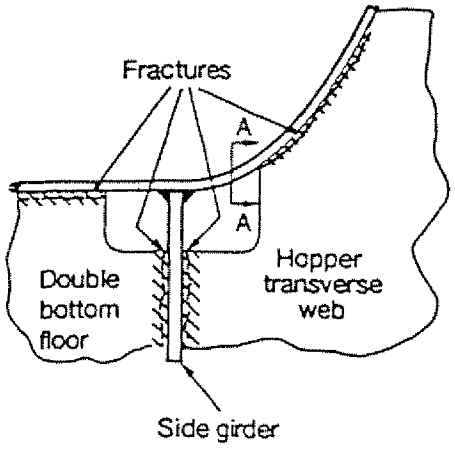


Figure 3 Typical Fractures in the Connection of Hopper Plating and Tanktop/Inner bottom

Double Bottom Structure

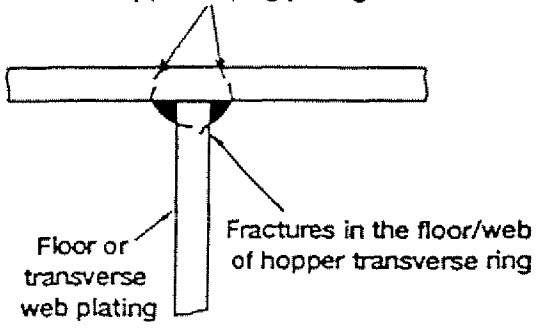
Detail of damage	Fracture at weld connection of floors in way of hopper/ tank top interface

Sketch of damage

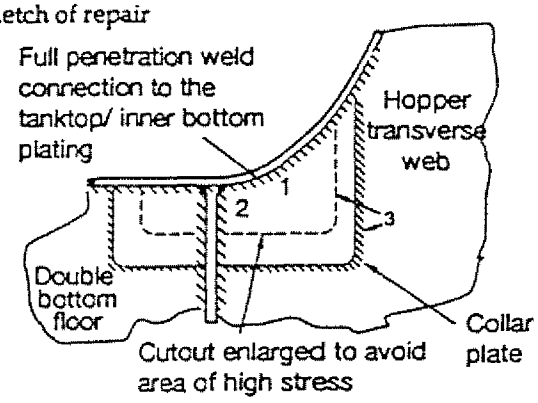


View "A-A"

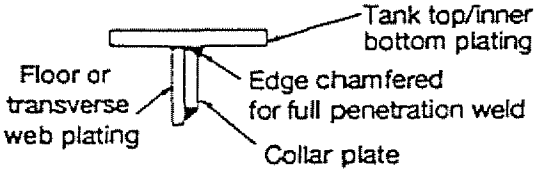
Transverse fractures in hopper web plating and possibly extending into the hopper sloping plating



Sketch of repair



1,2,3 represents sequence of welding



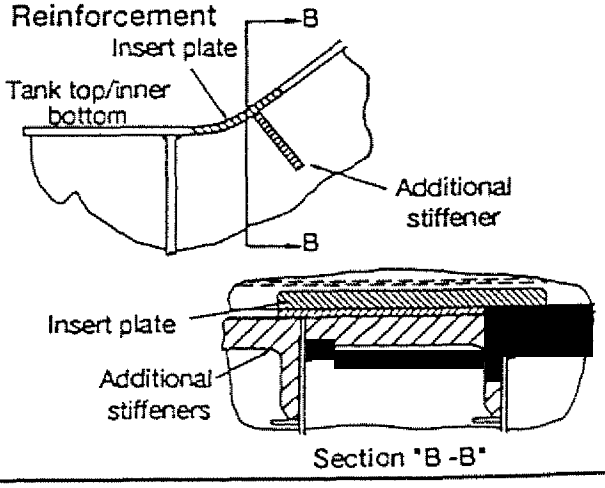


Figure 3a

Double Bottom Structure

Detail of damage	Fracturing at weld connection of floors in way of hopper tank and tanktop/inner bottom interface

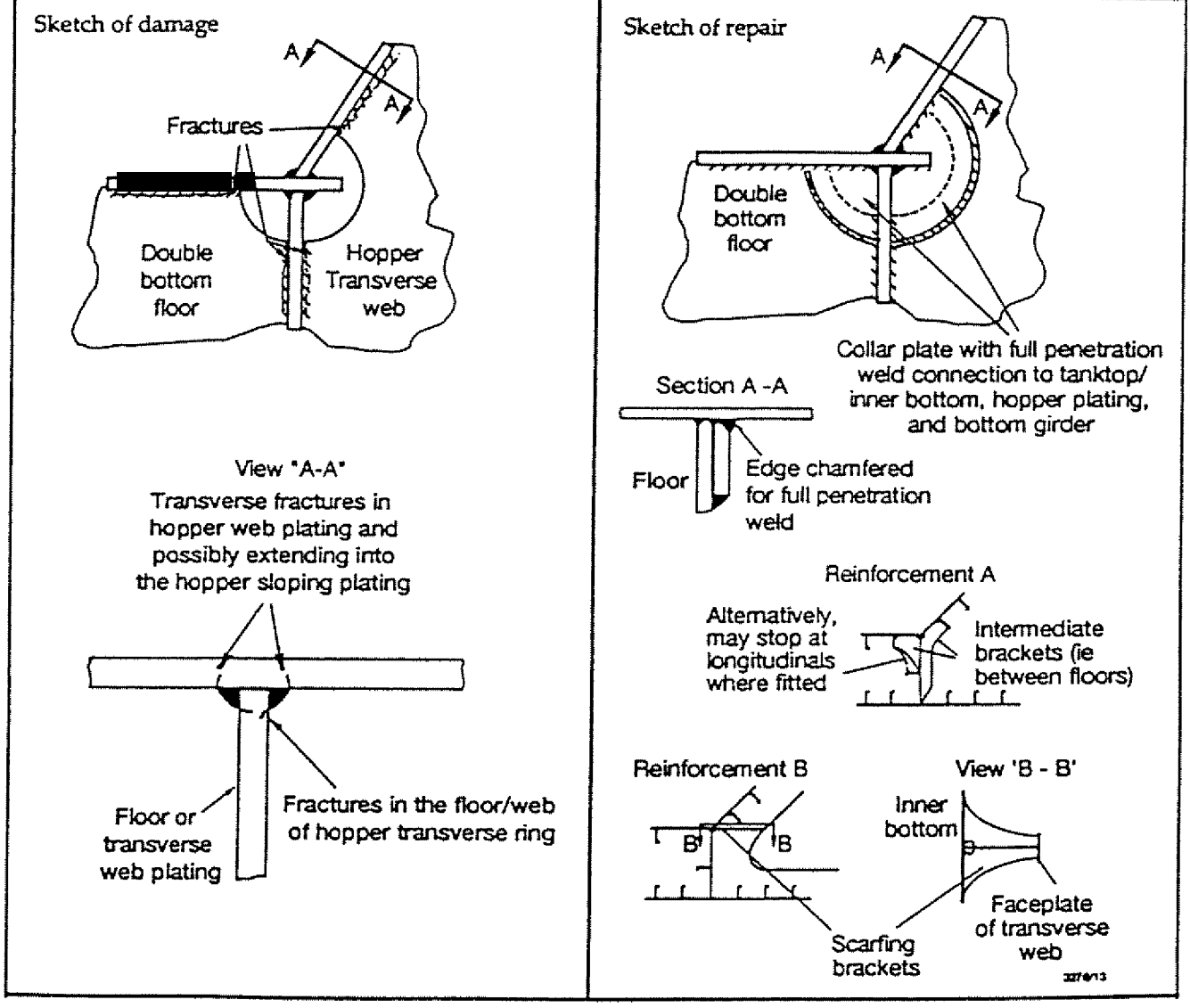
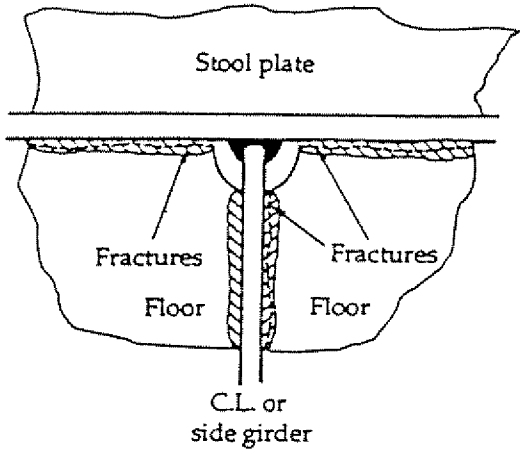


Figure 3b

Double Bottom Structure

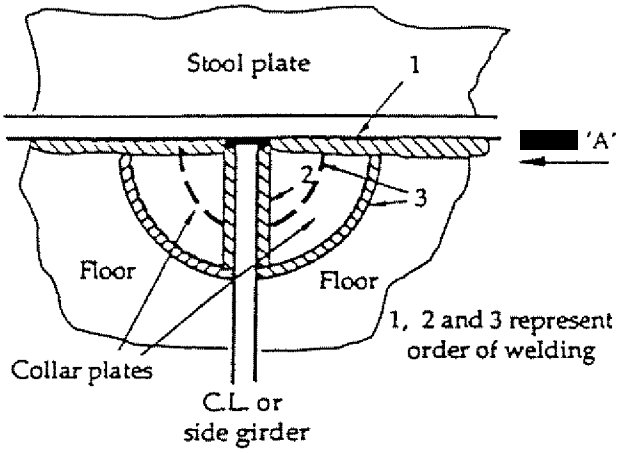
Detail of damage	Fractures at Weld Connections of Floors in Way of Tank Top/inner bottom and side girder in Way of Stool plates

Sketch of damage



Sketch of repair

Sequence of welding is important



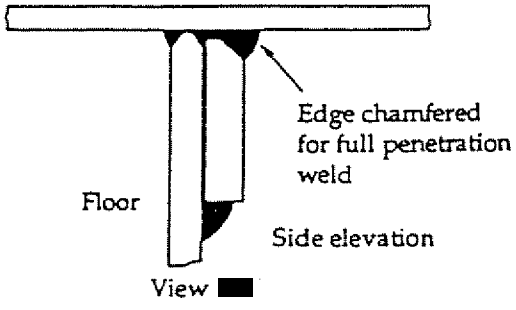


Figure 3c

Double Bottom Structure

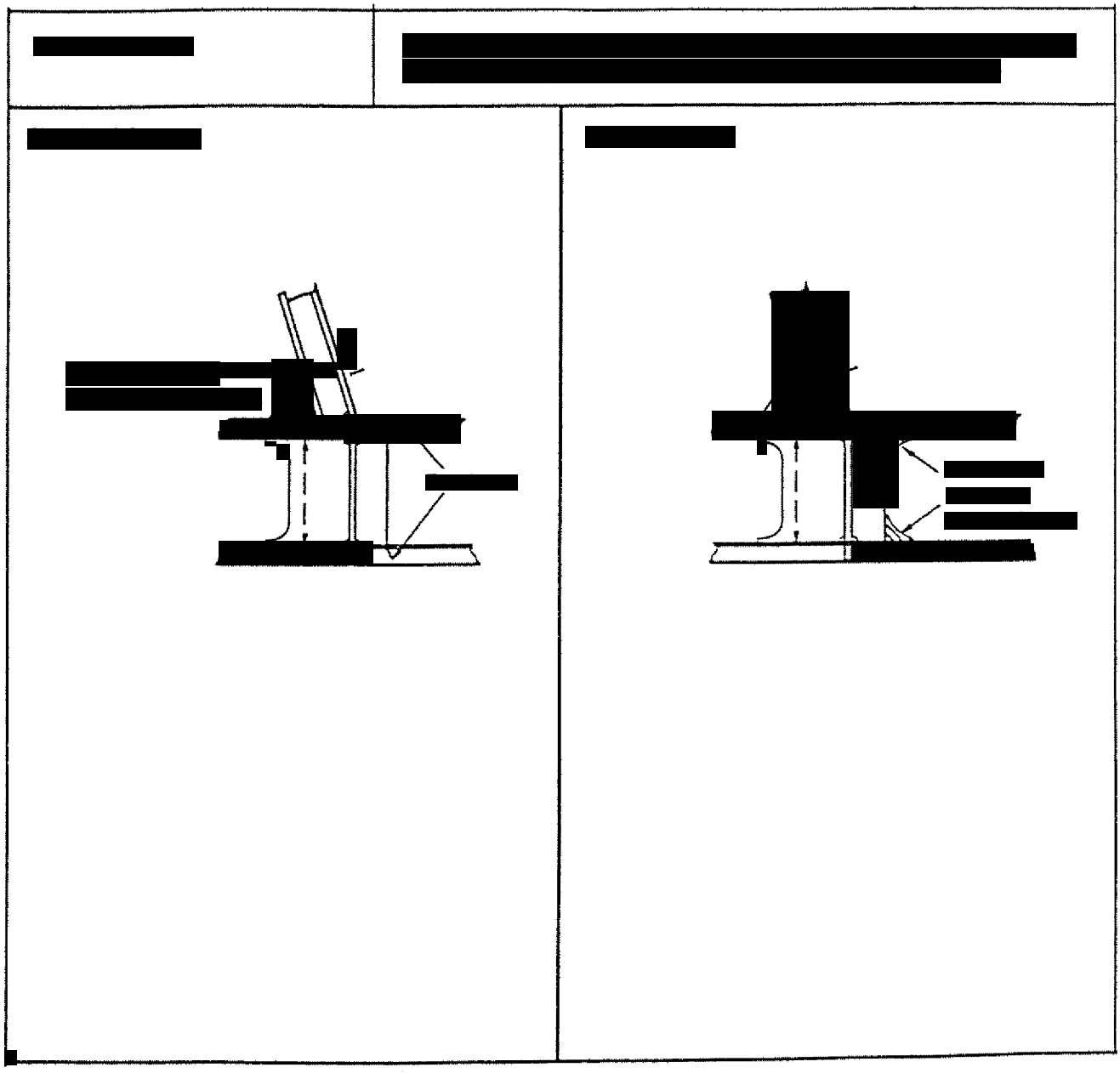


Figure 3d

Double Bottom Structure

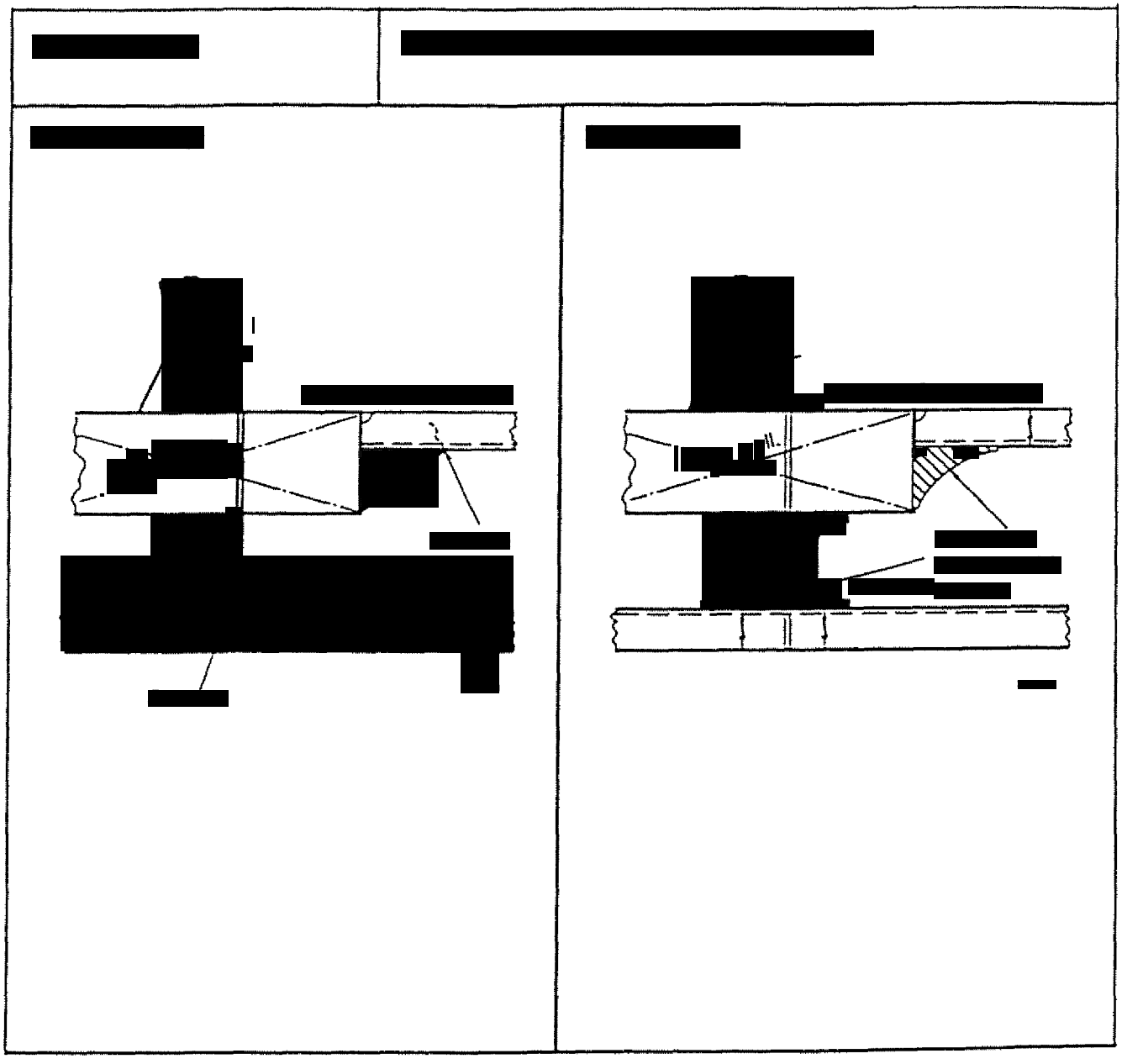
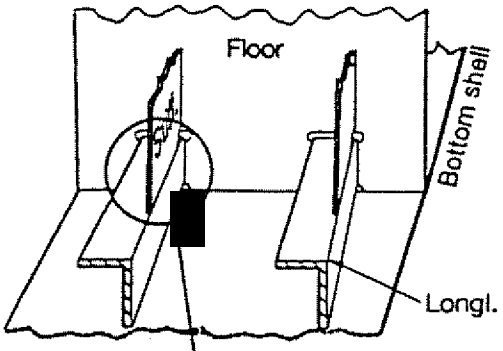


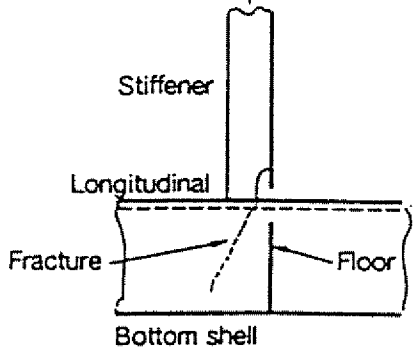
Figure 3e

Double Bottom Structure

Detail of damage	Fractures at welded boundaries of the floor stiffener (heel) to both bottom shell and tank top longitudinals

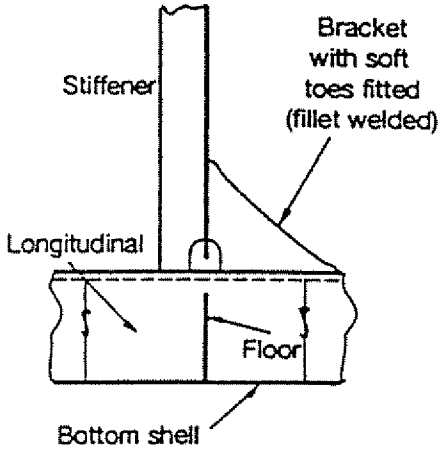
Sketch of damage





Note : same damage may occur at similar connections on tank top

Sketch of repair



It is recommended that the cutout for the purpose of fabrication (rathole) in the stiffener is designed as shown

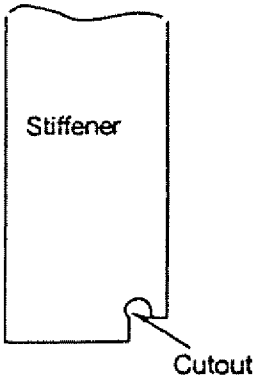
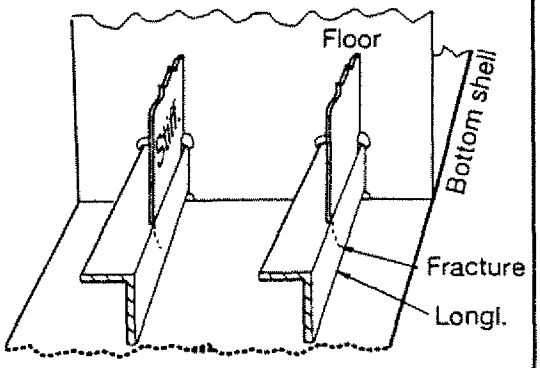


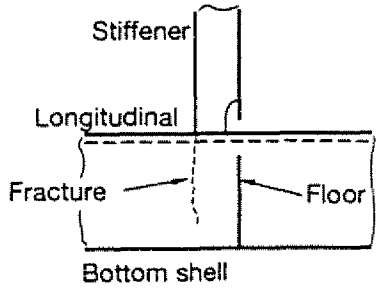
Figure 3f

Double Bottom Structure

Detail of damage	Fractures at welded boundaries (toe) of the floor stiffener to both bottom shell and inner bottom longitudinals

Sketch of damage

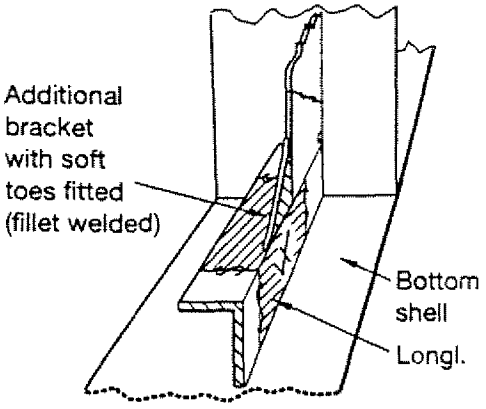




Note : same damage may occur at similar connections to inner bottom

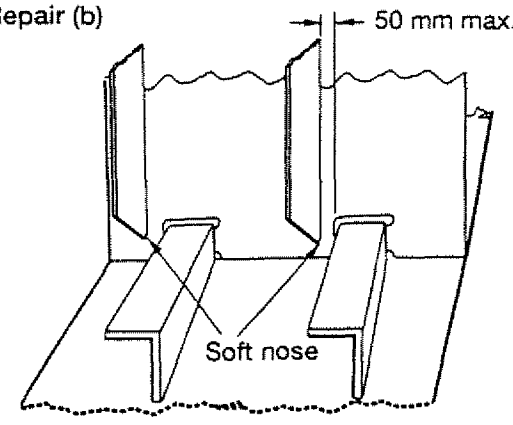
Sketch of repair

Repair (a)



✓ Where required the longitudinal to be cropped and part renewed

Repair (b)



Notes on repairs

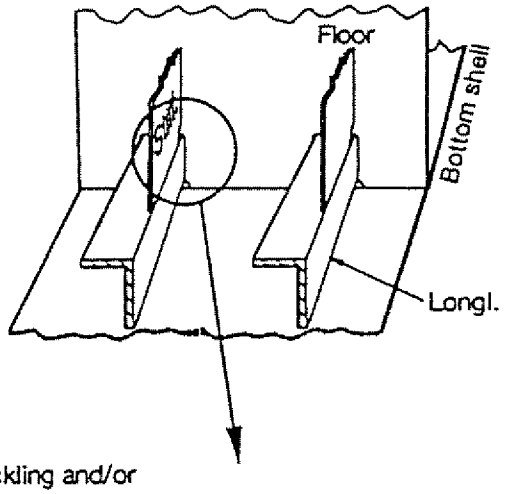
Repair (b), where the stiffeners are unconnected to the longitudinals and offset from them, is to be incorporated after approval by the classification Society concerned. Lugs and/or collars may be necessary at the cutouts in the floor for passage of longitudinals.

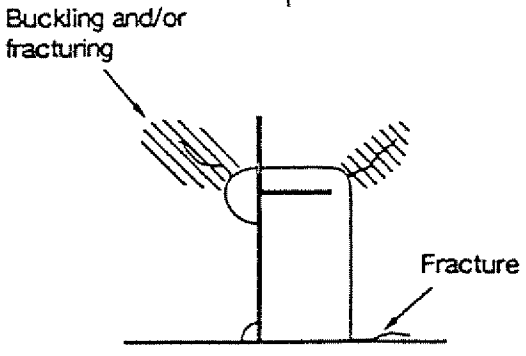
Figure 3g

Double Bottom Structure

Detail of damage	Fractures and buckling in way of a cutout for the passage of a longitudinal through a transverse primary member

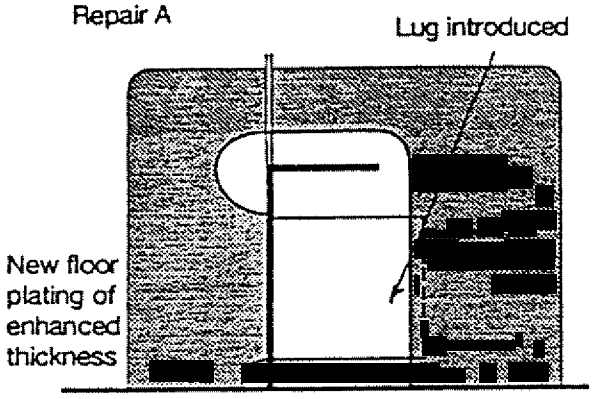
Sketch of damage





Note : same damage may occur at similar connections on tank top

Sketch of repair



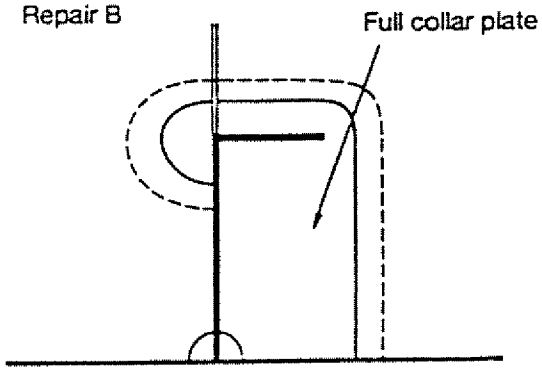
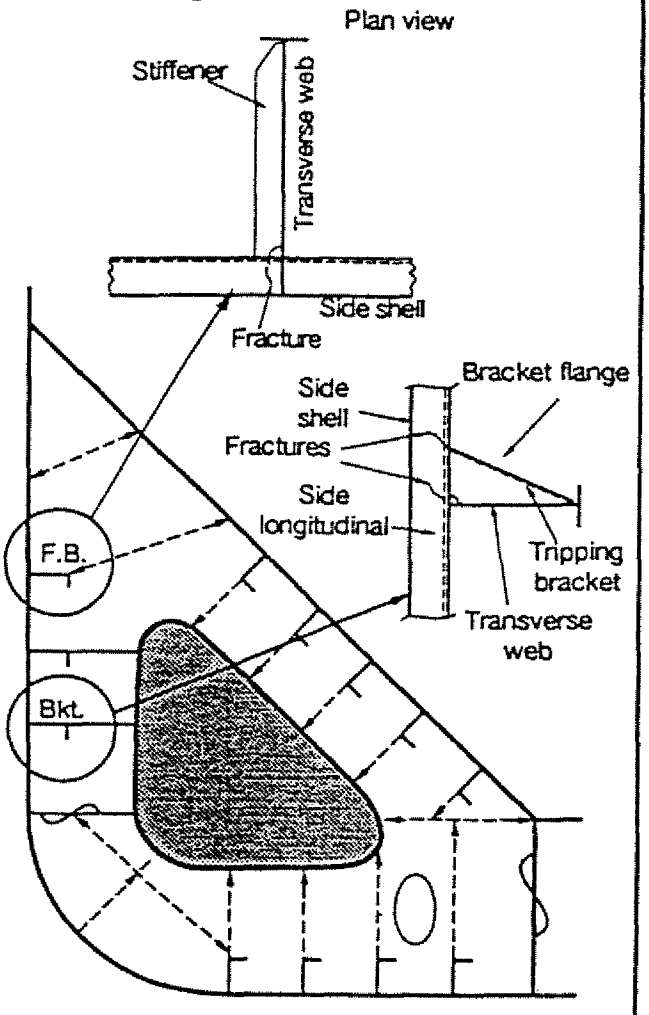


Figure 3h

Hopper Tank Structure

Detail of damage	Fracturing of hopper longitudinal at boundary with transverse web

Sketch of damage



Sketch of repair

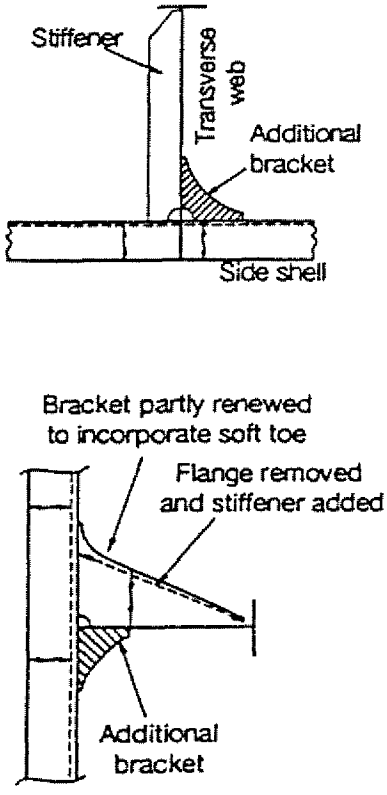
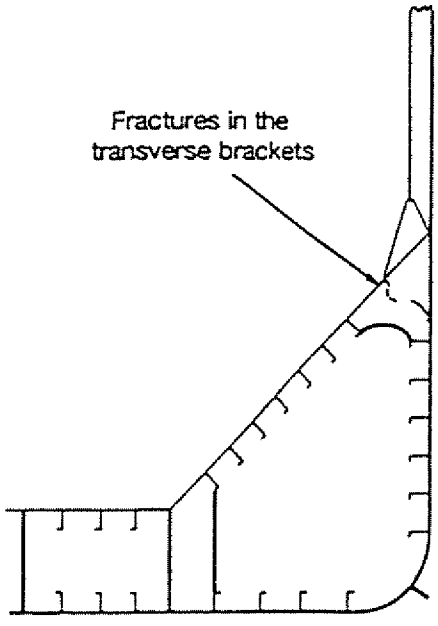


Figure 4a

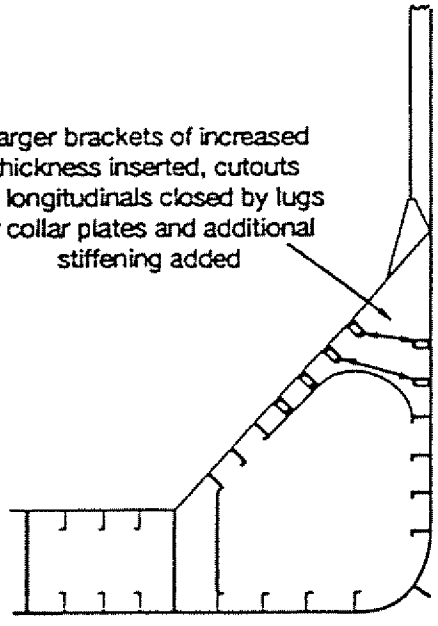
Hopper Tank Structure

Detail of damage	Fractures at weld connection of the transverse brackets

Sketch of damage



Sketch of repair



Note :

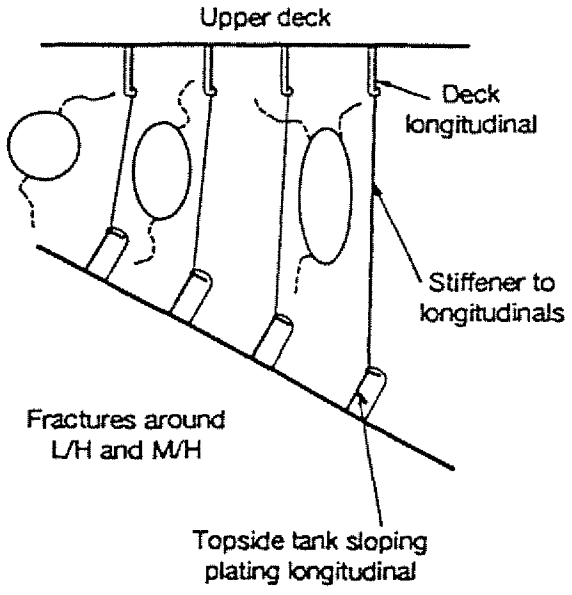
If the damage is caused by misalignment with the frame bracket above, the misalignment is to be rectified and the replacement by a bigger bracket incorporated only if felt necessary.

Figure 4b

Structure Within Topside Tanks

Detail of damage	Fractures around unstiffened L/H and M/H in wash bulkhead

Sketch of damage



Sketch of repair

Repair (a)

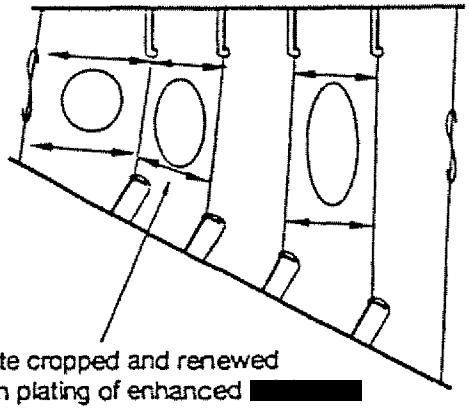


Plate cropped and renewed with plating of enhanced [redacted] and horizontal stiffeners [redacted]

Repair [redacted]

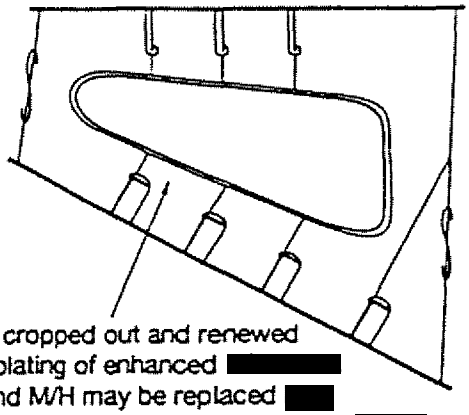


Plate cropped out and renewed with plating of enhanced [redacted] L/Hand M/H may be replaced [redacted] cut-out as shown and incorporating [redacted] plate to form a transverse [redacted] in accordance with the relevant [redacted] Society Rules

Figure 5a

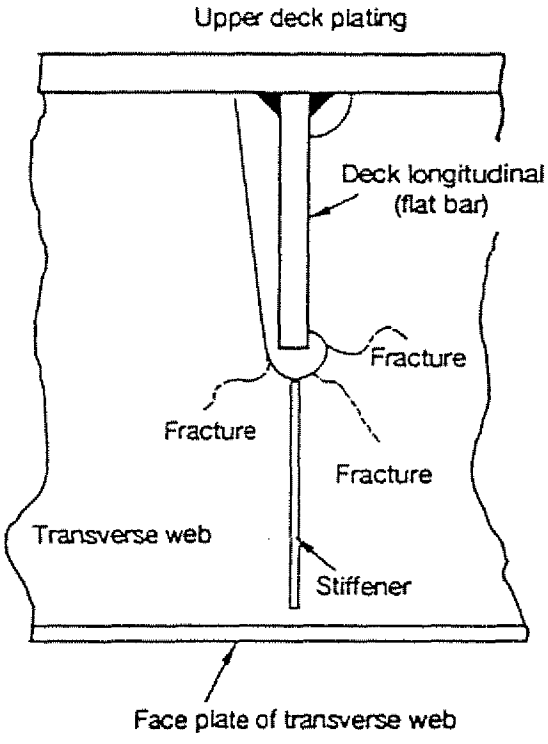
Structure Within Topside Tanks

Figure 5b

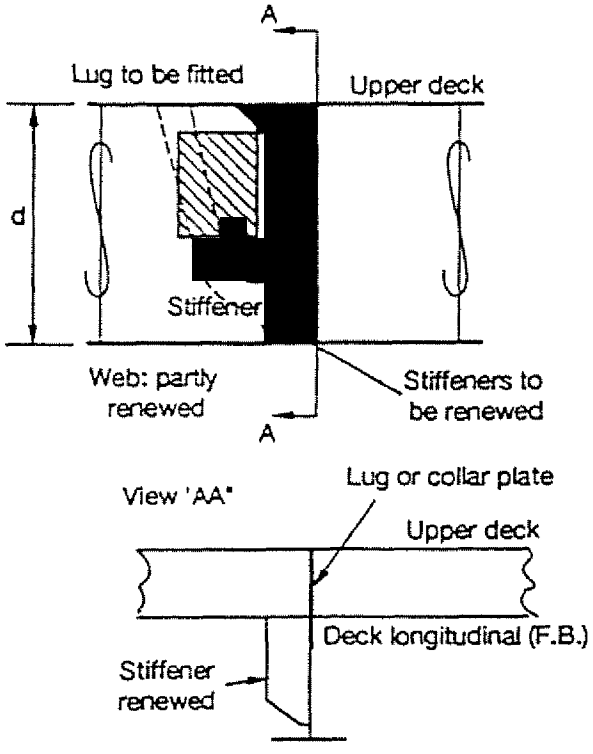
Structure Within Topside Tanks

Detail of damage	Fractures at slots in way of transverse webs

Sketch of damage



Sketch of repair



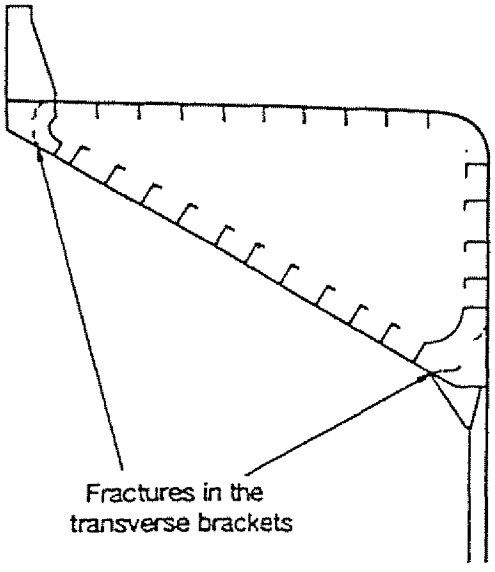
✓ Full collar plate where bottom of cutout ≤ 0.4d and in areas of high shear stress

Figure 5c

Structure Within Topside Tanks

Detail of damage	Fractures at weld connections of the transverse brackets.

Sketch of damage



Sketch of repair

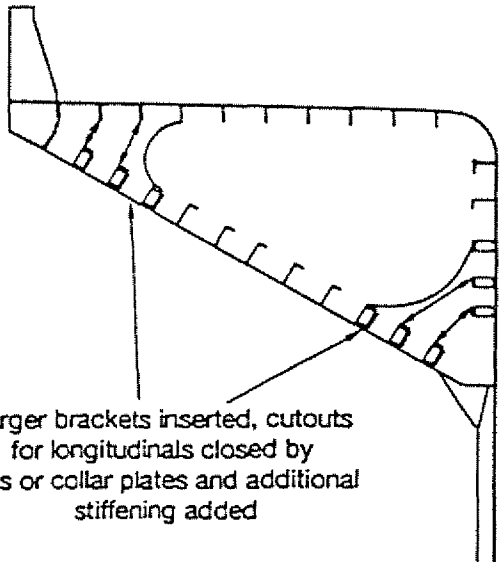
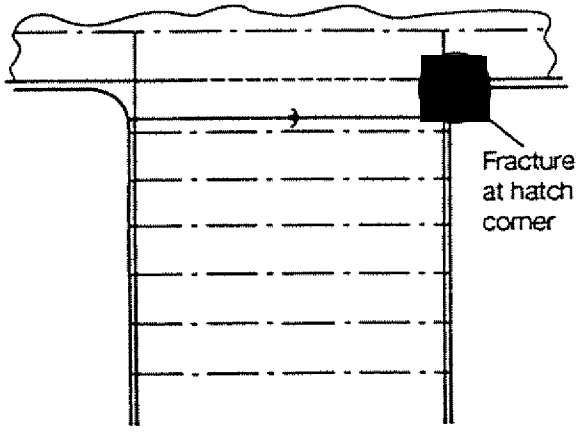


Figure 5d

Deck Structure

Detail of damage	Fractures at the hatch corners

Sketch of damage



Sketch of repair

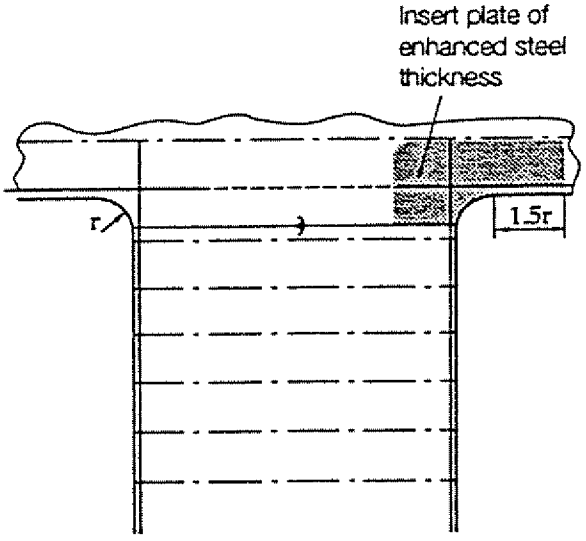
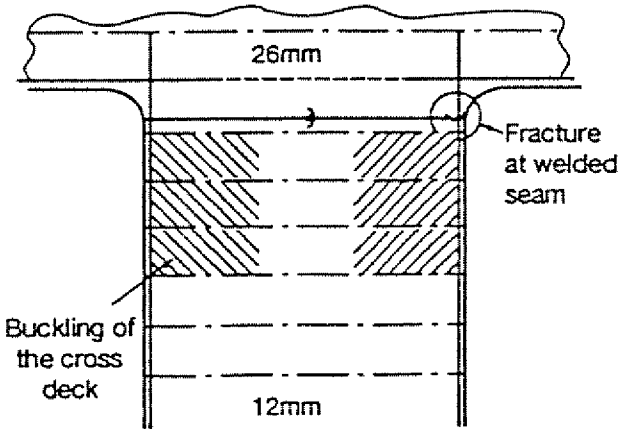


Figure 6a

Deck Structure

Detail of damage	Fracture of welded seam and probable plate buckling at cross deck

Sketch of damage



Sketch of repair

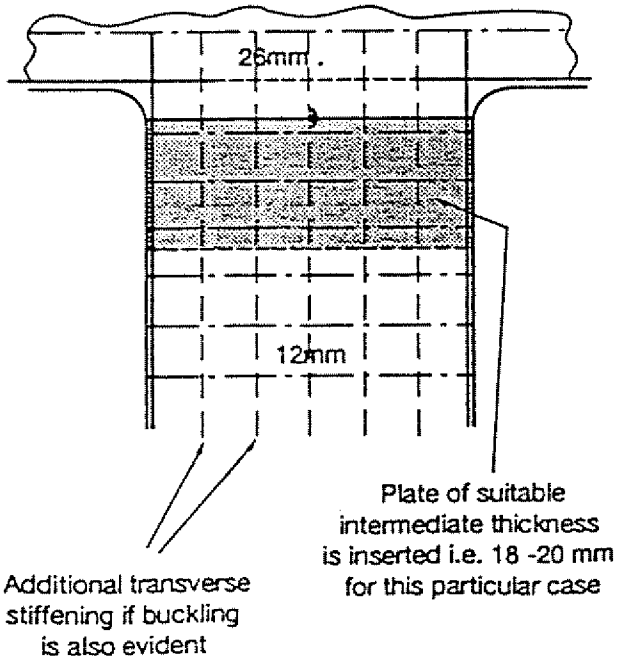


Figure 6b

Deck Structure

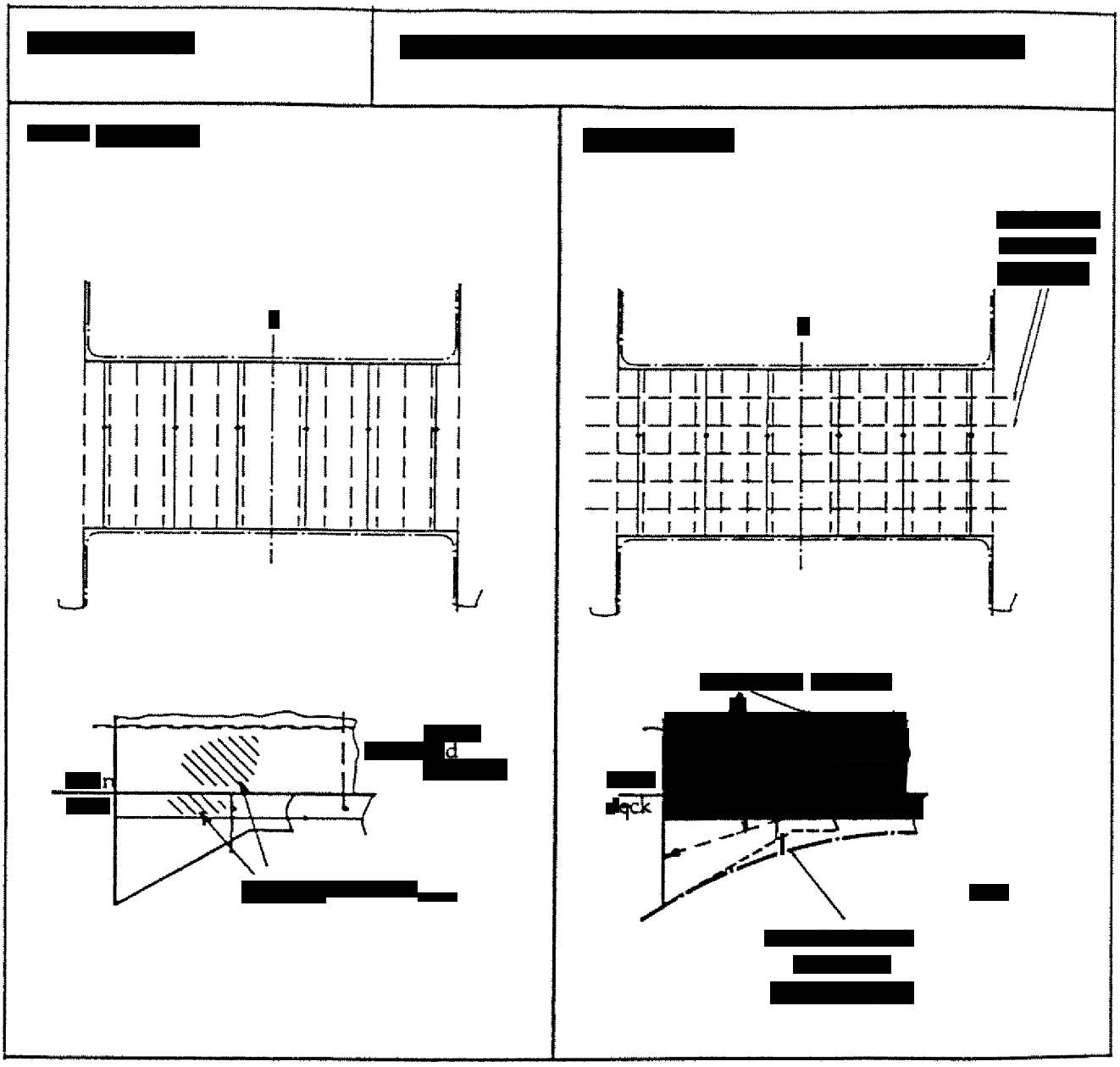


Figure 6c

Deck Structure

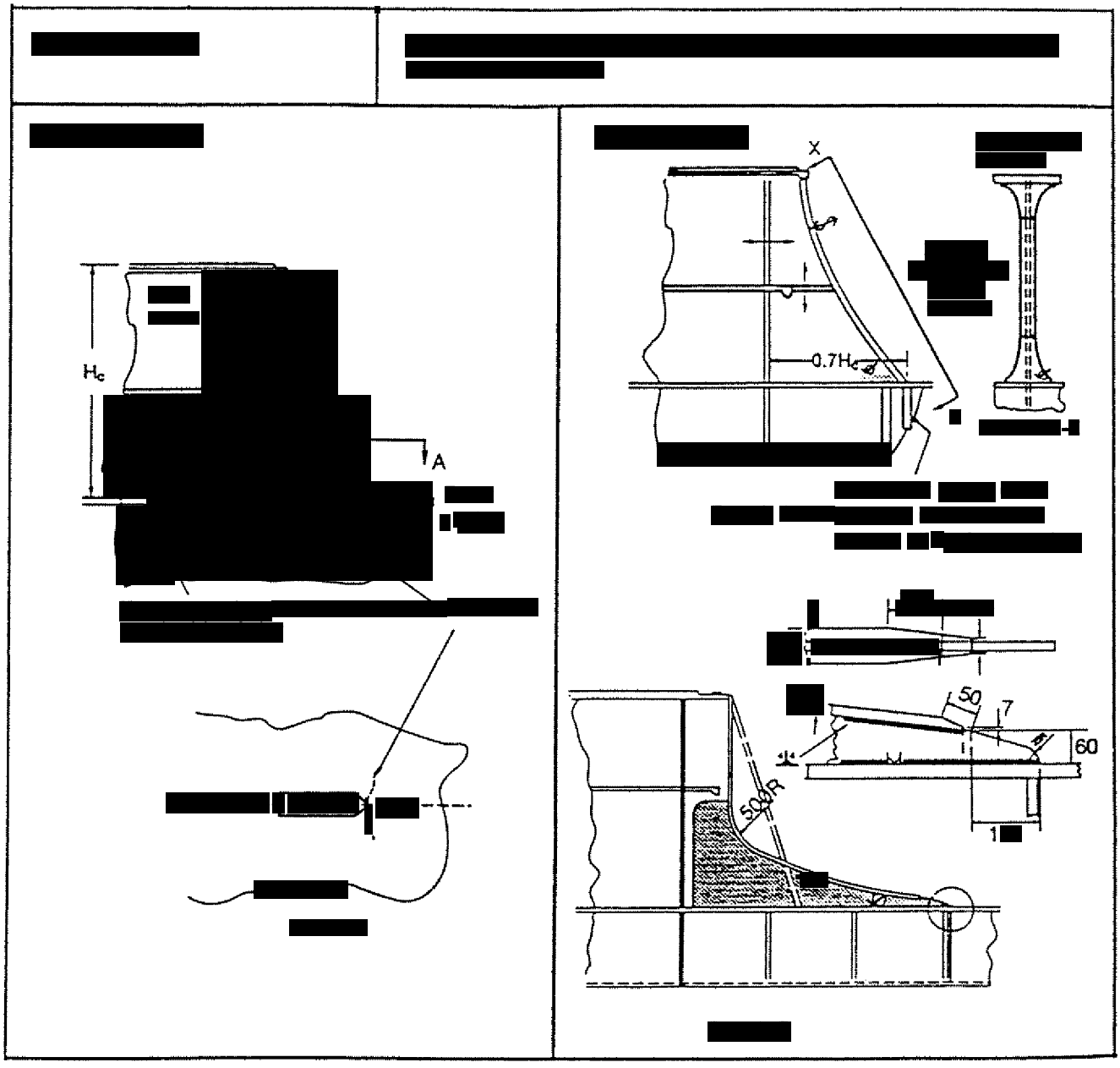


Figure 6d

Forepeak Structure

Figure 7a

Forepeak Structure

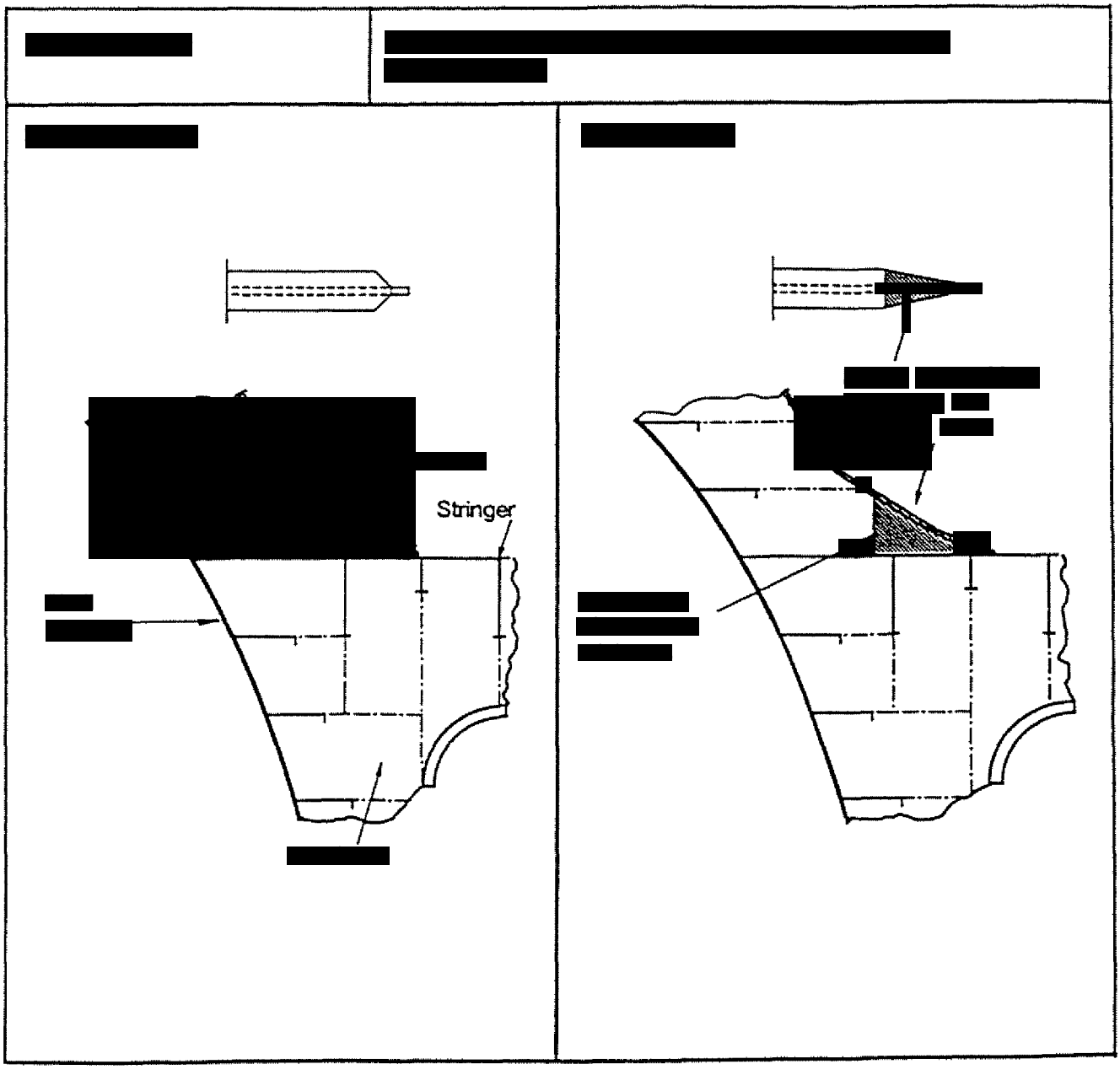


Figure 7b

Transition Regions in Cargo Spaces, Fore and Aft

Detail of damage	Fractures at the supporting brackets in way of the collision bulkhead, where side shell panting stringers fitted

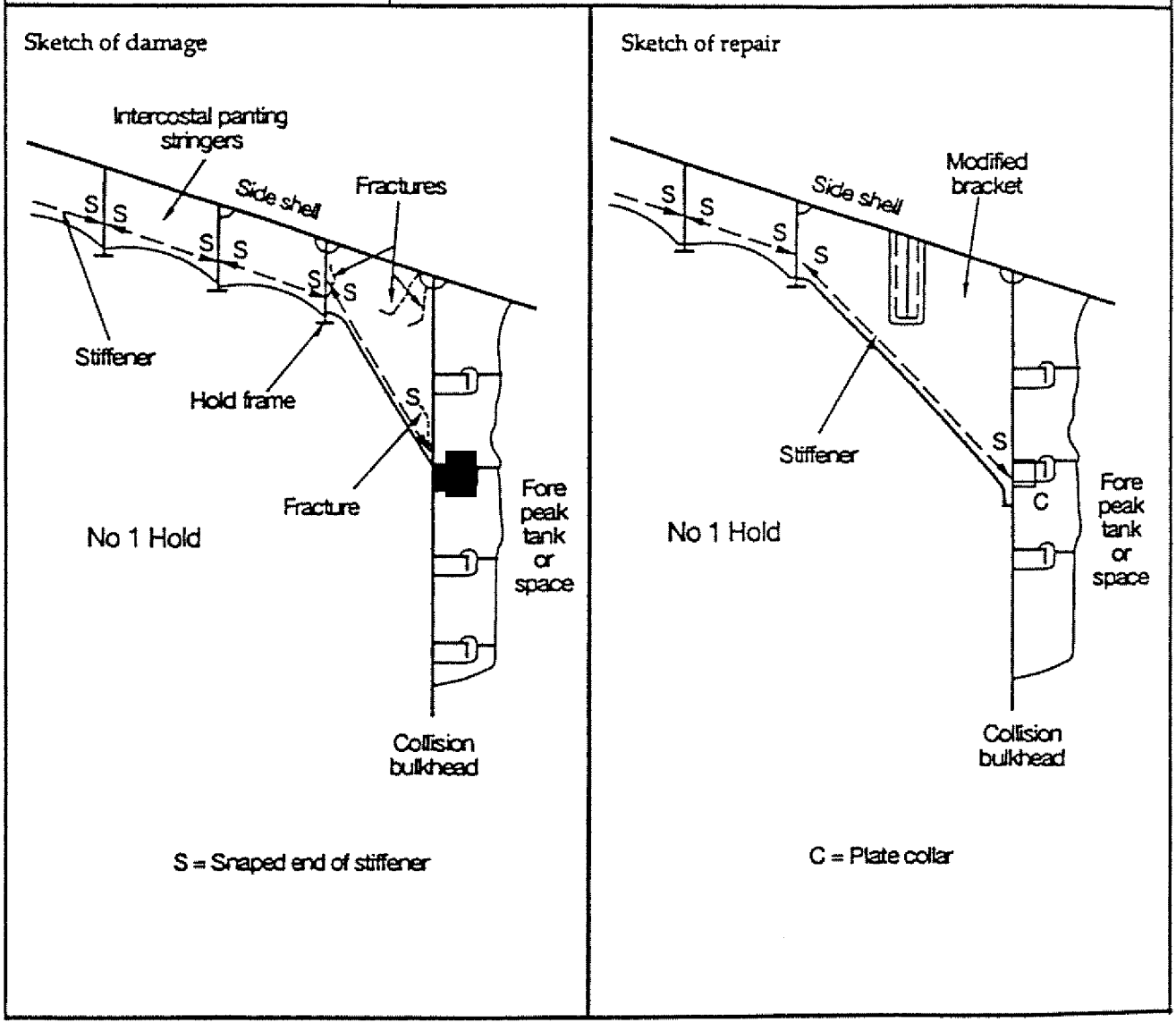


Figure 8a

Transition Regions in Cargo Spaces, Fore and Aft

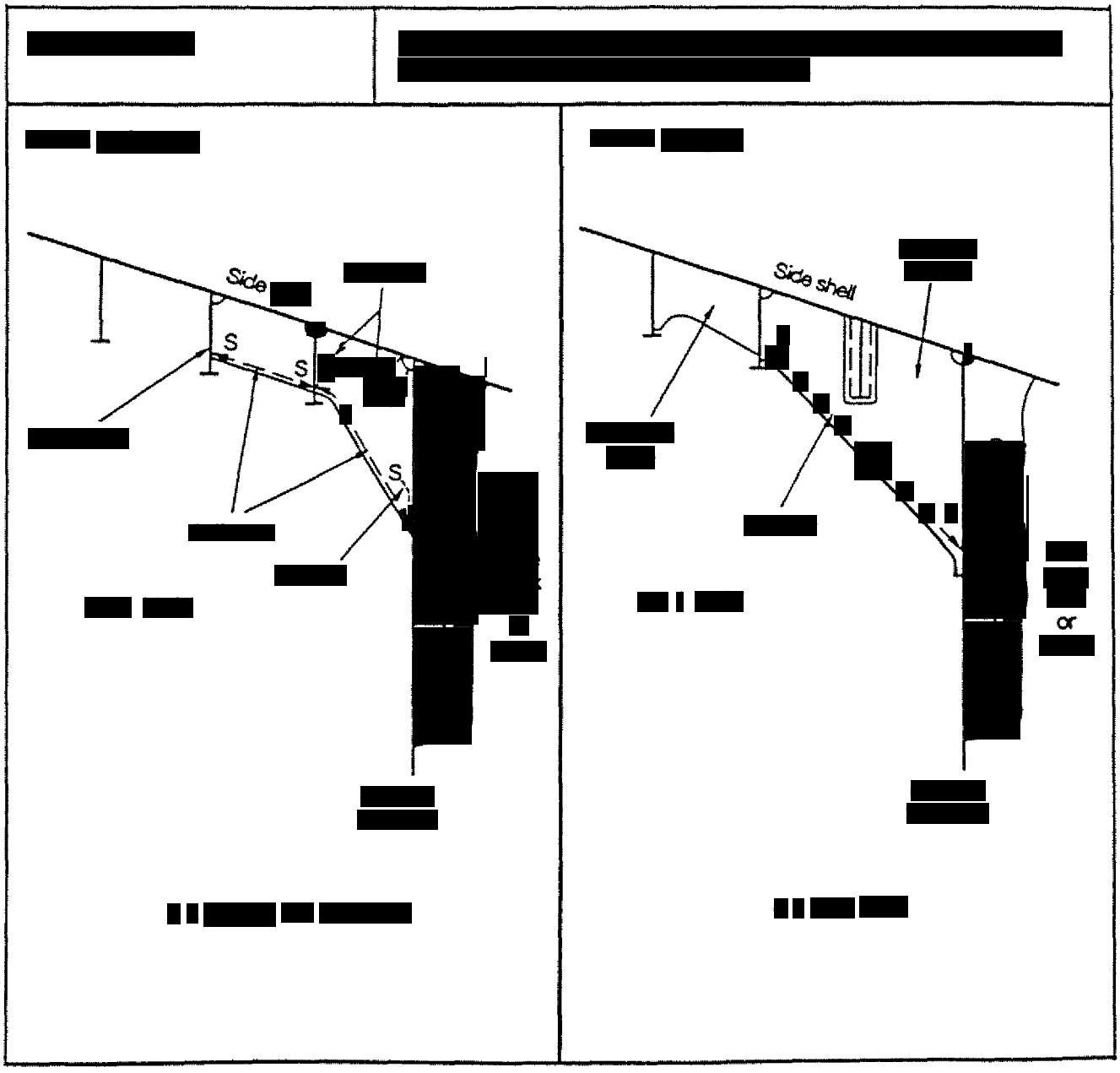


Figure 8b

Transition Regions In Cargo Spaces, Fore and Aft

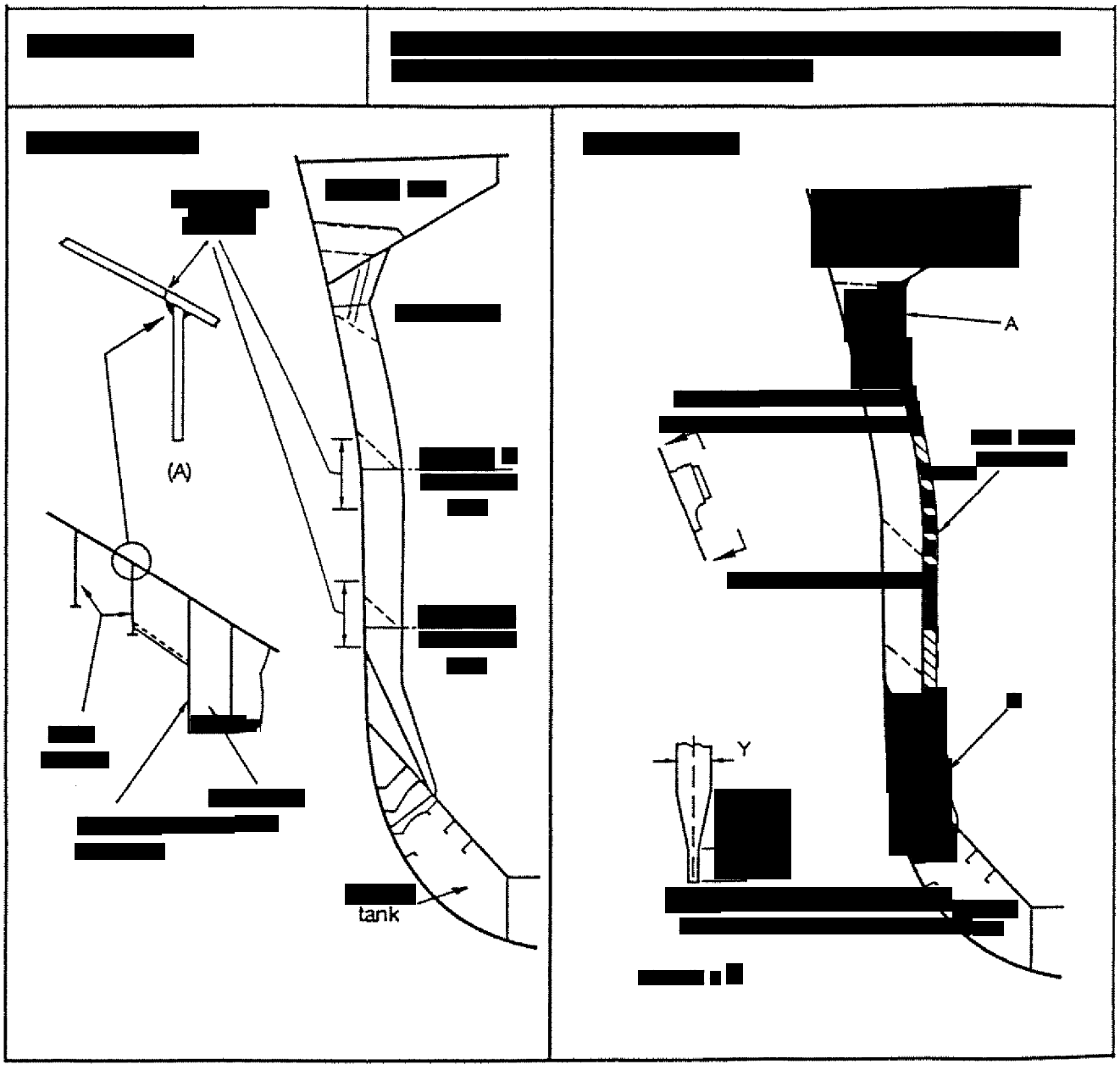


Figure 8c

Transition Regions in Cargo Spaces, Fore and Aft

Detail of damage	Fractures in way of horizontal diaphragms in the connecting trunk between topside tank and hopper double bottom tank on after side of collision bulkhead in No 1 Hold.

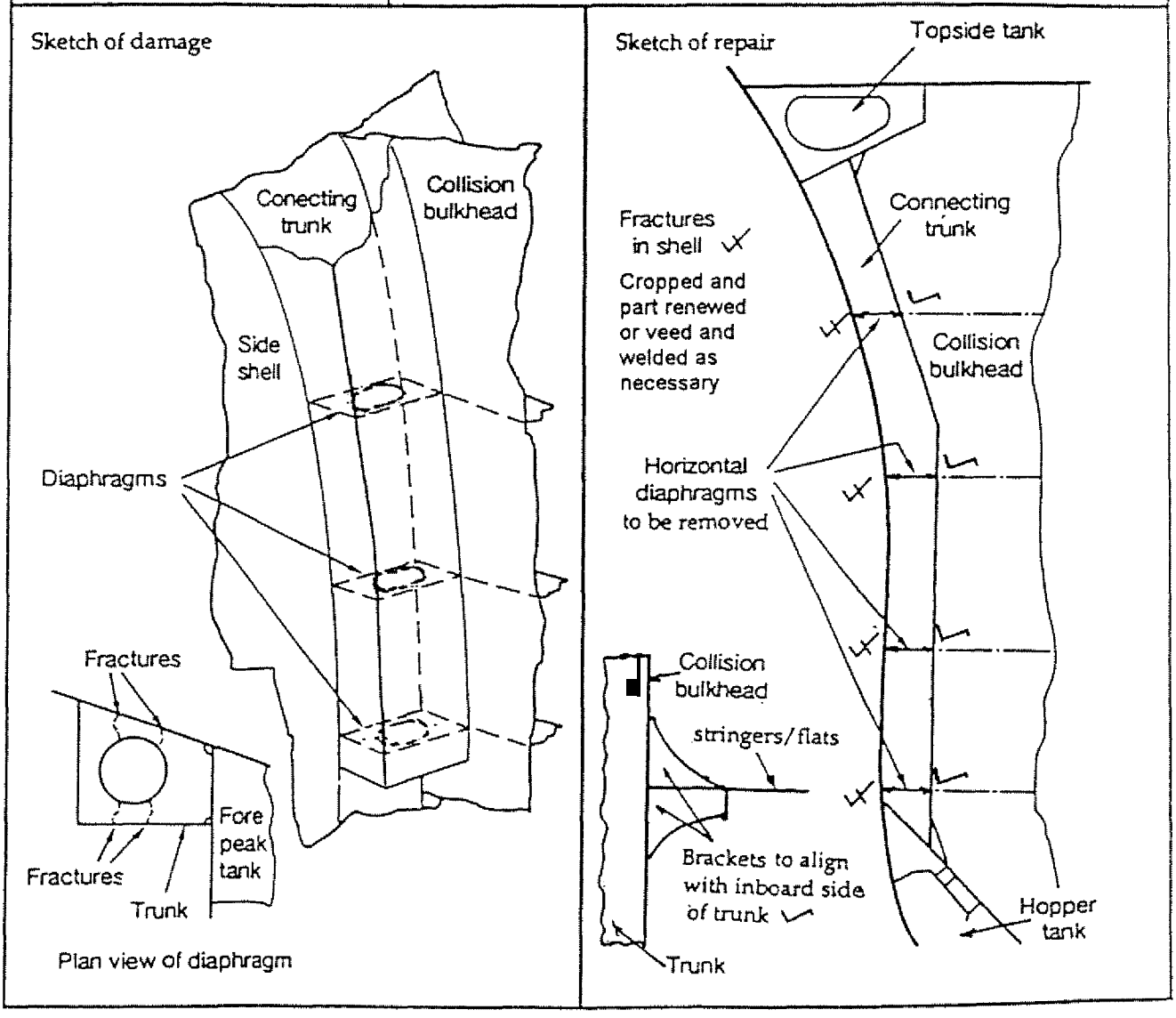


Figure 8d