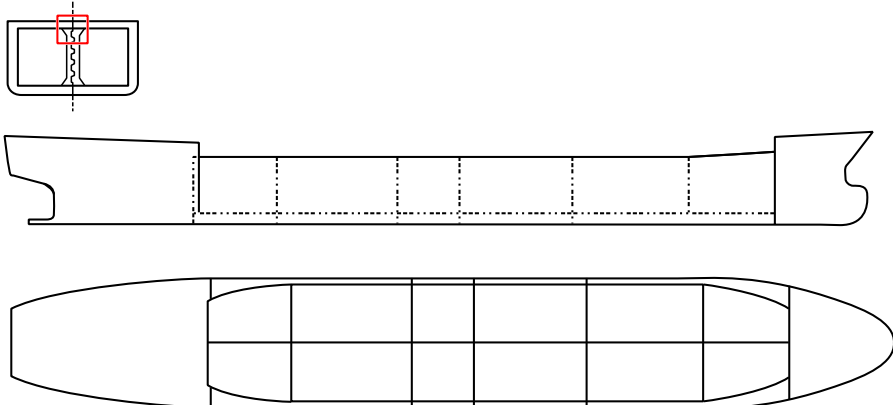
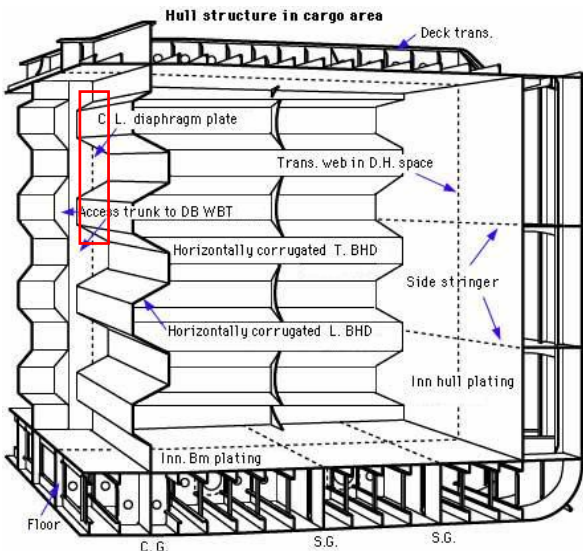
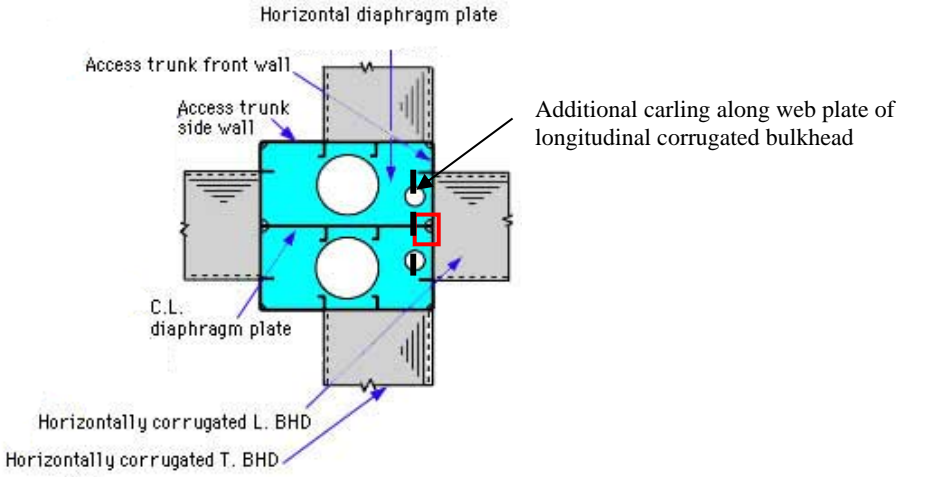
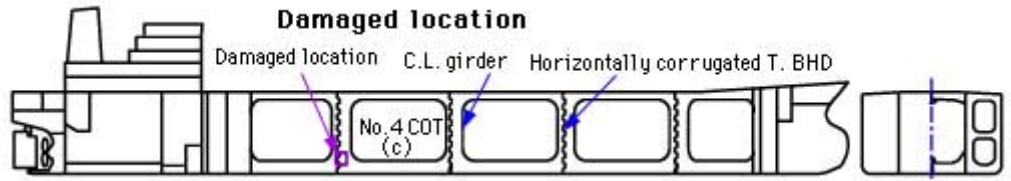
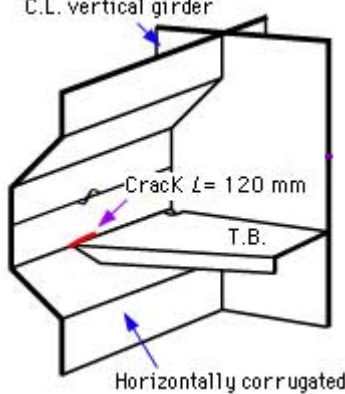
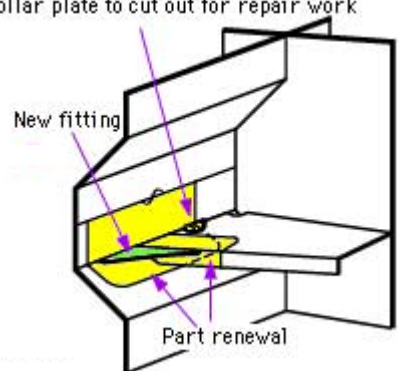


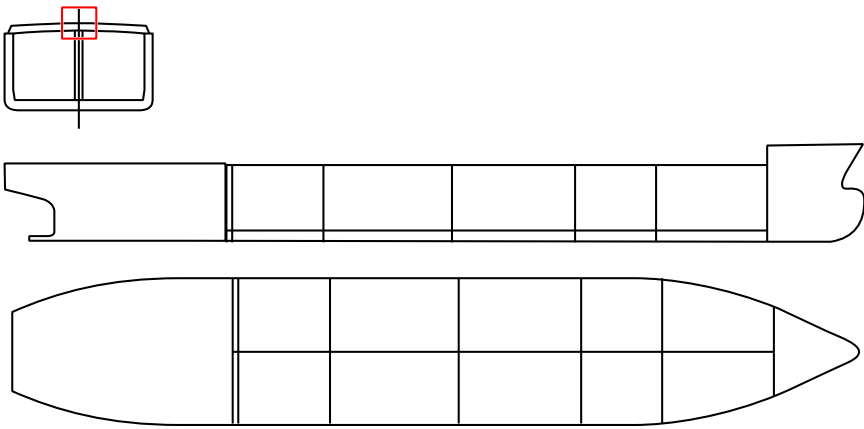

Table A.1 Overview of corrugated bulkhead damages

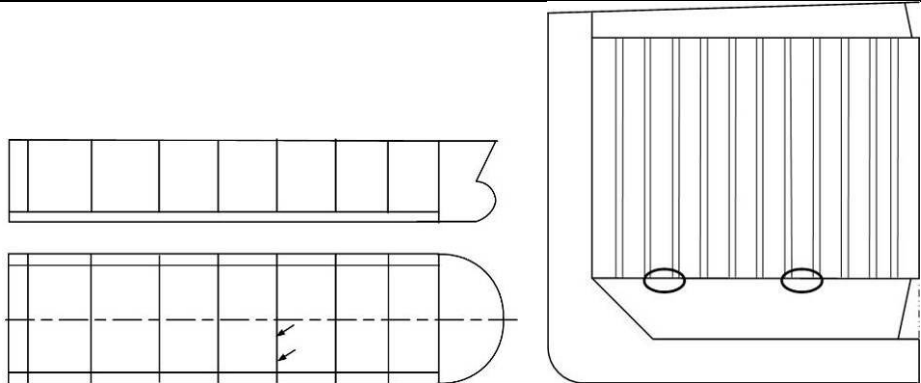
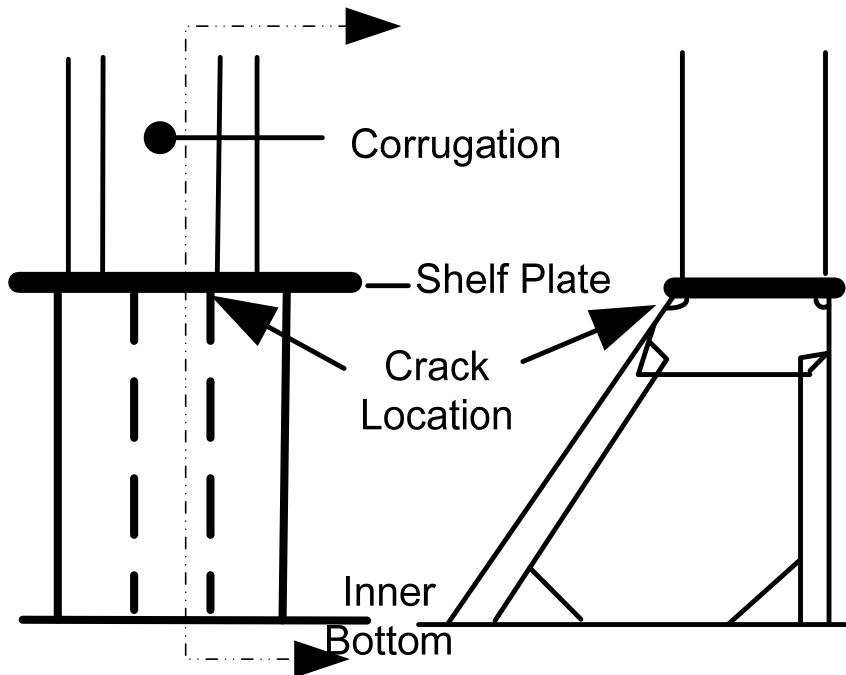
Case	Ship Type	Damage Location
1.1	Chemical Tanker	Longitudinal corrugated bulkheads (horizontal type) in way of mid cargo area.
1.2	Product Tanker	Transverse corrugated bulkhead (horizontal type) in way of cargo tank area.
1.3	Chemical Tanker	Longitudinal corrugated bulkheads (vertical type) in way of crane post at mid cargo area.
1.4	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), lower stool, shelf plate.
1.5	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), upper stool, sloped plate.
1.6	Chemical tanker	Deck longitudinals.
1.7	Tanker for Oil & Chemicals	Transverse and longitudinal corrugated bulkhead (horizontal type), Lower part of bulkhead/access trunk in way of replaced temporary access opening.
1.8	Chemical Tanker	Corrugation corners in areas of intersection of longitudinal corrugated bulkheads (vertical type) and longitudinal deck girder.
1.9	Chemical Tanker	Inner bottom longitudinals which are provided additionally in line with face of longitudinal corrugated bulkheads (vertical type).
1.10	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), lower stool, shelf plate.
1.11	Oil Tanker	Transverse corrugated bulkhead (vertical type), lower stool, corner of corrugation.
1.12	Tanker for Chemicals	Lower aft end termination of the longitudinal corrugated bulkhead (horizontal type).
1.13	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), lower stool, corner of corrugation.
1.14	Chemical Tanker	Longitudinal corrugated bulkhead in entire cargo tank areas
1.15	Chemical Tanker	Longitudinal corrugated bulkhead (vertical type).
1.16	Chemical Tanker	Longitudinal bulkhead (vertical type) connection to transverse bulkhead (horizontal type).
1.17	Chemical Tanker	Transverse bulkhead (vertical type) connection of the bottom of the corrugated bulkhead to the sloping hopper plating.
1.18	Product Tanker	Transverse bulkhead (vertical type) connection to lower stool shelf plate.
1.19	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), lower stool, shelf plate.
1.20	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), lower stool, shedder plate.
1.21	Oil Product Tanker	Transverse corrugated bulkhead (vertical type), upper stool (box type), shelf plate
1.22	Chemical Tanker	Transverse corrugated bulkhead (vertical type), connection to inner longitudinal bulkhead
1.23	Chemical Tanker	Transverse corrugated bulkhead in way of lower slope of ballast tank

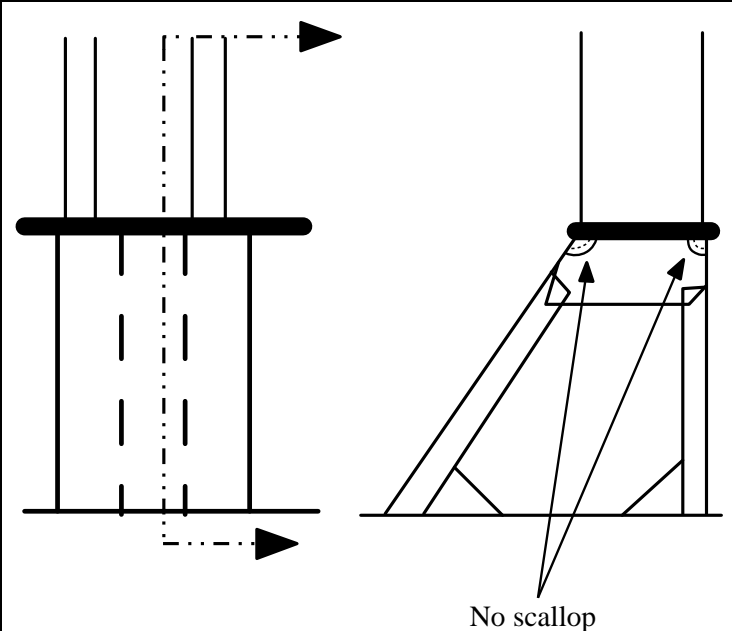
Case 1.1				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt. 17,000
Year of build	2000	Vessels age when damage found		7 years
Main dimensions	L	138 m	B	22 m
	T	-	D	11 m
Bulkhead	Horizontally corrugated		Longitudinal & transverse bulkhead	
Stool	None fitted			
Material	Stainless steel			
Overview of damage location	Longitudinal corrugated bulkheads (horizontal type) in way of mid cargo area.			
				
Description of damage	Cracks developed at longitudinal corrugated bulkhead (horizontal type) following fillet welding connection to access trunk wall. The crack initiated at crossing section with vertical stiffener of trunk wall on center line.			
				

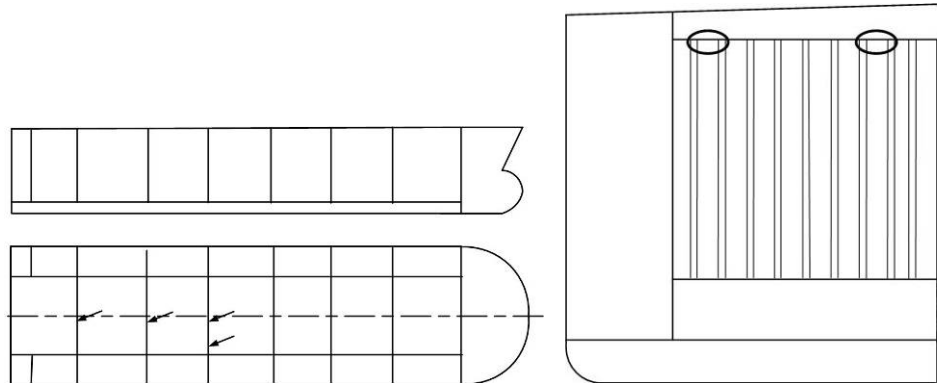
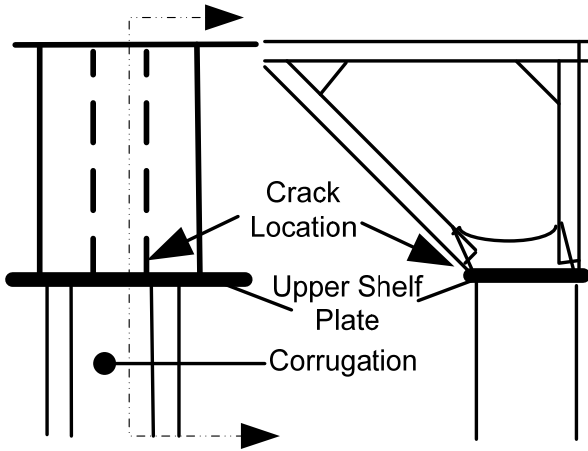
Description of Repair	
	<p>Cracks were gouged out and re-welded, and carling was additionally fitted along web plate of longitudinal corrugated bulkhead in access trunk.</p>
Probable cause of Damage	<p>Detail design</p>
Recommendation for design improvement	<p>In case of horizontally corrugated bulkheads, additional carlings to be fitted also along with web plate of bulkhead in order to reduce stress concentration caused by longitudinal moment. Any connection between the corrugation web and crossing stiffeners or other structure must be supported by brackets or carlings.</p>

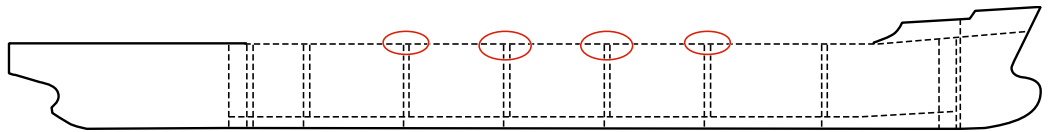
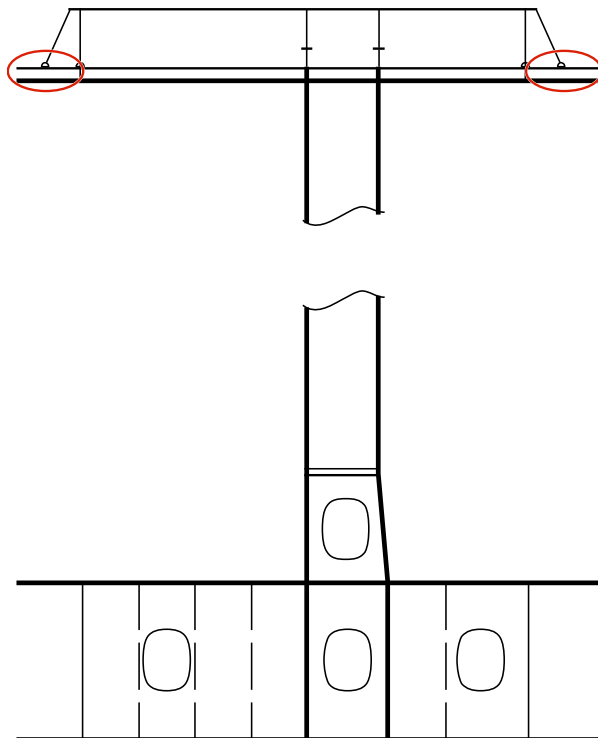
Case 1.2				
Ship-Type	Product Tanker		Capacity [dwt]	Abt. 30,000
Year of build	1990	Vessels age when damage found		11 years
Main dimensions	L	160 m	B	-
	T	-	D	-
Bulkhead	Horizontally corrugated		Transverse bulkhead	
Stool	None fitted			
Material	HT32			
Overview of Damage location	<p>Transverse corrugated bulkhead (horizontal type) in way of cargo tank area.</p> 			
Description of damage	<p>Crack developed on corrugated bulkhead. The crack was initiated from a toe end of tripping bracket to C.L. girder.</p> 			
Description of repair	<p>Cracked area of the bulkhead and the bracket were partly renewed. An additional small bracket was also fitted at toe end of the tripping bracket for reinforcement (reduce stress concentration).</p> 			
Probable cause of damage	Detail design			
Recommendation for design improvement	Soft end type bracket to be considered at such high stress area. Preferably the tripping brackets should be aligned with the inclined web of the corrugation.			


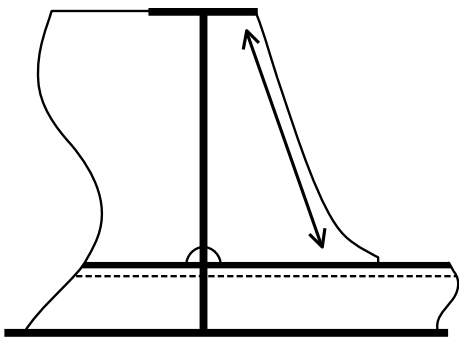
Case 1.3				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt. 9,000
Year of build	1998	Vessels age when damage found		9 years
Main dimensions	L	105 m	B	19 m
	T	-	D	10 m
Bulkhead	Vertically corrugated		Longitudinal bulkhead	
Stool	None fitted			
Material	Stainless steel			
Overview of damage location	Longitudinal corrugated bulkheads in way of crane post at mid cargo area.			
				
Description of damage	Crack developed on longitudinal corrugated bulkhead connection to upper deck. The crack initiated from fillet welding at the corrugation corner under a crane post.			
				
Description of repair	Cracks were gouged and re-welded by full penetration welding.			
Probable cause of damage	Detail design, insufficient welding			
Recommendation for design improvement	Sufficient reinforcement from upper deck side is preferable due to restriction for reinforcement from tank side. Full penetration welding should be generally preferred in way of supporting structures if the connection is exposed to high stresses.			

Case 1.4				
Ship-Type	Oil Product Tanker		Capacity [dwt]	Abt.36000
Year of build	1996	Vessels age when damage found		11 years
Main dimensions	L	175 m	B	30 m
	T	12 m	D	17 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade A			
Overview of damage location				
Description of damage	<p>Note Sloped Stool to shelf plate by full penetration welding</p>  <p>Two cracks approx. 50mm in welds between bottom stool shelf plate and sloping plate in way of corrugation corners</p>			
Description of repair	Affected welds gouged from both sides and rewelded. Additionally collar plates have been fitted to scallops in way.			
Probable cause of damage	Stress concentrations in-way of the corrugation corner due to lack of web support and scallops.			
Recommendation				

Case 1.4	
for design improvement	 <p>No scallop</p> <p>Close Scallops in way of brackets below corrugation corners Carlings/brackets aligned with the corrugation webs should also be considered.</p>

Case 1.5				
Ship-Type	Oil Product Tanker		Capacity [dwt]	Abt.107,000
Year of build	1986	Vessels age when damage found		10 years
Main dimensions	L	237 m	B	43 m
	T	15 m	D	21 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade A			
Overview of damage location				
Description of damage	 <p>Cracks in upper stool sloped plate near junction of upper stool sloped side plate and upper stool shelf plate.</p>			
Description of repair	<ol style="list-style-type: none">1) Upper stool shelf plating of void space cropped and part renewed with increased thickness2) Upper stool sloped side plating cropped and part renewed with increased thickness3) Longitudinal bracket at bottom of void space (11mm) connecting stool side stiffeners at bottom of void space modified4) Additional bracket fitted in line with corrugated bulkhead web underneath			
Probable cause of damage	Detail design			
Recommendation for design improvement	Scallops/openings to be avoided in way of connection of sloped stool plate to shelf plate			

Case 1.6				
Ship-Type	Chemical tanker		Capacity [dwt]	Abt.29,000
Year of build	2005	Vessels age when damage found		3 years
Main dimensions	Length	167 m	Breadth mld.	29m
	Draft mld.	9.5 m	Depth mld.	14 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	No upper stool		Height lower stool	1400 mm
Material	Bulkhead Grade A		Damaged Area AH36	
Overview of damage location				
Description of damage	 <p>Crack is developing in the deck longitudinals in way of the bracket toe at the forward or aft end of the partial girder supporting the top of the corrugated bulkhead. There are six such partial girders across the deck in way of each transverse bulkhead.</p>			

Case 1.6	
	<p>Photo of crack:</p>  <p>Note: On above picture the deck longitudinal is cracked through to the deck plating. The majority of the other cracks found were less than 10 mm deep. On above picture a pipe support is landing adjacent to the bracket nose on the same deck longitudinal. This might have contributed to the problem at this position. However cracks are also appearing where there are no pipe supports.</p>
Description of repair	<p>Cracks in bracket toe welding and/or bulb:</p> <ul style="list-style-type: none"> • Determine extent of crack by dye penetration • Gouge out existing fillet welding 200 mm away from bracket toe. • Re-weld with full penetration. • Open crack in bulb by gouging and re-welding. • All welding to be ground smooth by means of pencil grinder (not disc grinder). <p>See also sketch below.</p> 

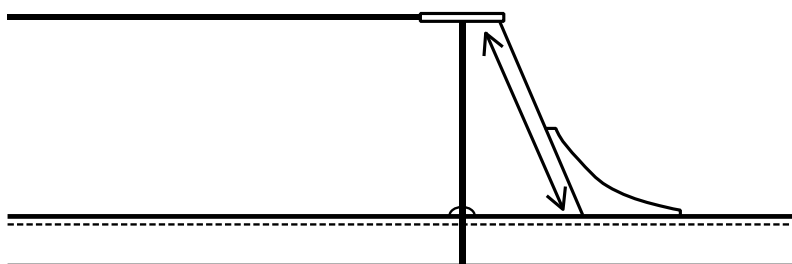
Case 1.6

Cracks in profile up to 50% of profile height:

- Determine extent of crack by dye penetration
- Stop drill crack at the crack tip by hole of diameter 50% higher than the profile thickness.
- Open crack in bulb by gouging and re-welding.
- Apply bracket as shown on above sketch of temporary repair
- All welding to be ground smooth by means of pencil grinder (not disc grinder).
- Drain holes within 200 mm from bracket nose to be closed by doubling plate.

Cracks in profile deeper than 50% of profile height:

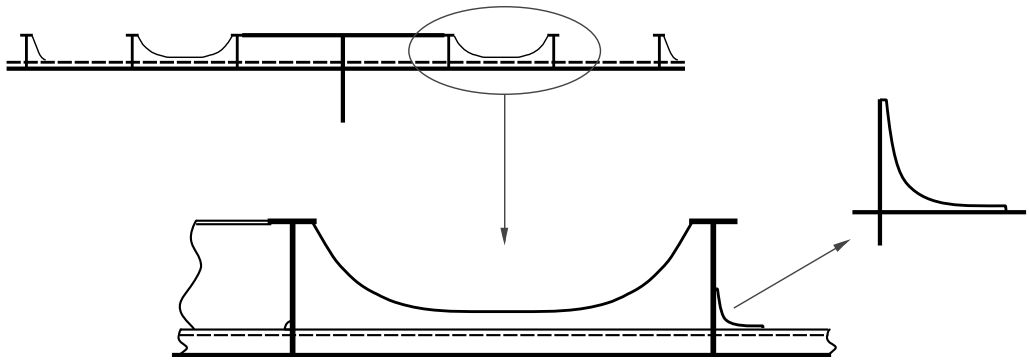
- Determine extent of crack by dye penetration
- Crop and renew cracked profile by insert. (Minimum distance from insert to any existing profile lightening hole shall be minimum 500 mm)
- Apply bracket as shown on below sketch.
- All welding to be ground smooth by means of pencil grinder (not disc grinder).
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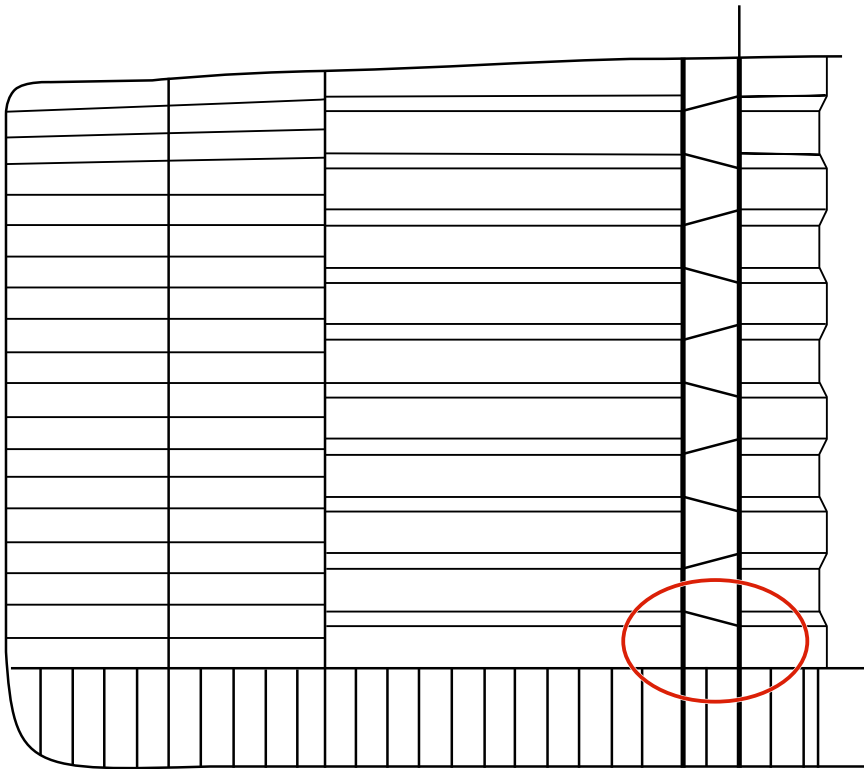





The development of the crack problem on the vessel series to be closely monitored on a continuous basis, i.e. minimum bi-monthly inspections of all bracket noses.

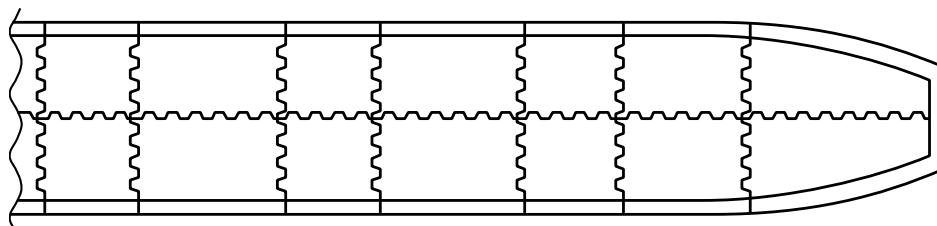
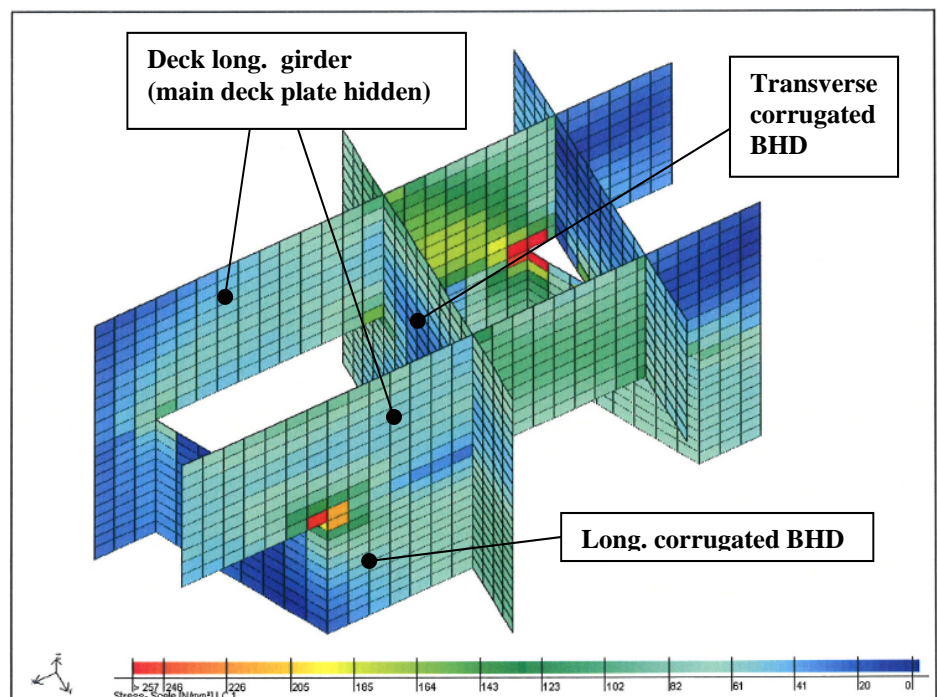
In case the problem accelerates significantly, the following permanent reinforcement will be carried out:

- Fit U-shape brackets to each end of the partial girder (see sketch below):

Case 1.6	
	
Probable cause of damage	<ul style="list-style-type: none"> • Poor detail design • No fatigue assessment at design stage • Support for deck piping close to the bracket nose has in some cases contributed to the problem.
Recommendation for design improvement	<p>For the vessels in question: See above</p> <p>For future newbuildings:</p> <p>The fatigue life of the structural interface between bulkhead and deck structure to be examined during design stage in order to obtain a design with sufficient structural redundancy.</p> <p>Pipe supports adjacent to the bracket nose shall be avoided.</p>

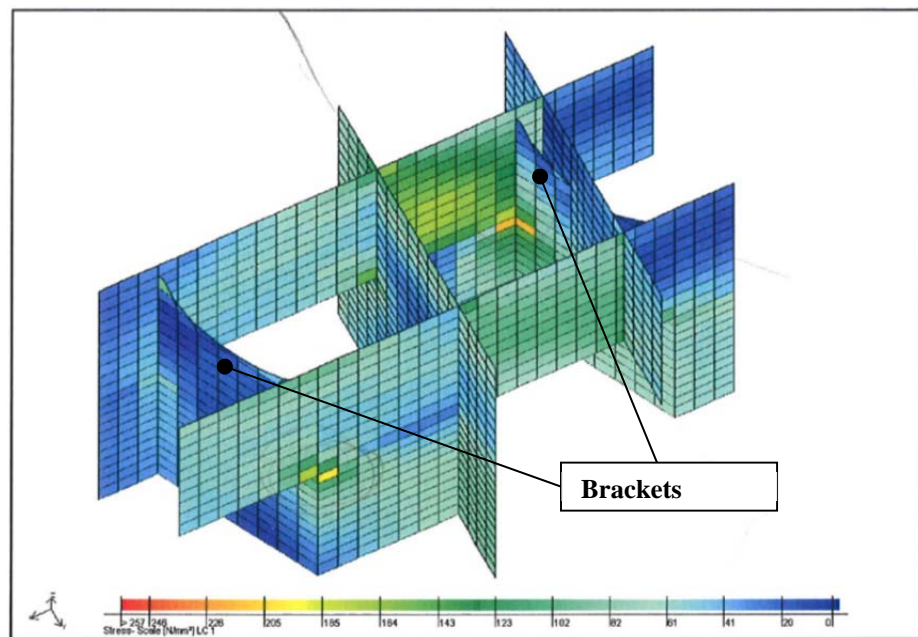
Case 1.7				
Ship-Type	Tanker for Oil & Chemicals		Capacity [dwt]	Abt.40,000
Year of build	1988	Vessels age when damage found		19 years, reoccurrence
Main dimensions	L	163 m	B	32 m
	T	11 m	D	15 m
Bulkhead	Horizontally corrugated		Longitudinal & transverse bulkhead In centre section.	
	Height from tank top to deck		13.4 m	
Stool	None fitted			
Material	MS and HT36			
Description of damage				
	<p>1. Cracks found in CL in lower part of bulkhead/access trunk in way of replaced temporary access opening. Cracks have been found before in same location.</p> <div></div>			

Case 1.7	
	<p>2. Cracks in the corner where transverse and longitudinal corrugations meet, lower corrugation.</p> 
Description of repair	Gouging and rewelding, full pen, two sided.
Probable cause of damage	Detailed design
Recommendation for design improvement	<p>No. 1: Relocate such openings to lower stressed areas. Increase the width of the opening to reduce welding stresses.</p> <p>No. 2: Fit brackets inside trunk, aligned with corrugation webs.</p>

Case 1.8				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt.20,000
Year of build	2002	Vessels age when damage found		5 years
Main dimensions	L	155 m	B	23 m
	T	9.5 m	D	13 m
Bulkhead	Vertically corrugated		Longitudinal bulkhead	
	Height from tank top to deck		11.6	
Stool	None fitted			
Material	Duplex stainless steel			
Overview of damage location				
Drawing/Sketch of original structure				
Description of damage	Cracks developed at corrugation corners in areas of intersection of longitudinal bulkheads and longitudinal deck girder.			

Case 1.8

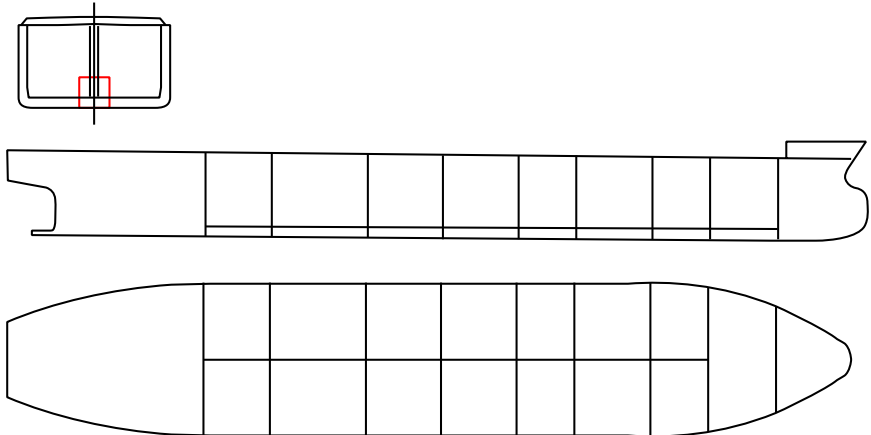

Cracks were re-welded. Brackets were installed above upper deck along web plate of longitudinal corrugated bulkhead between the longitudinal deck girders.

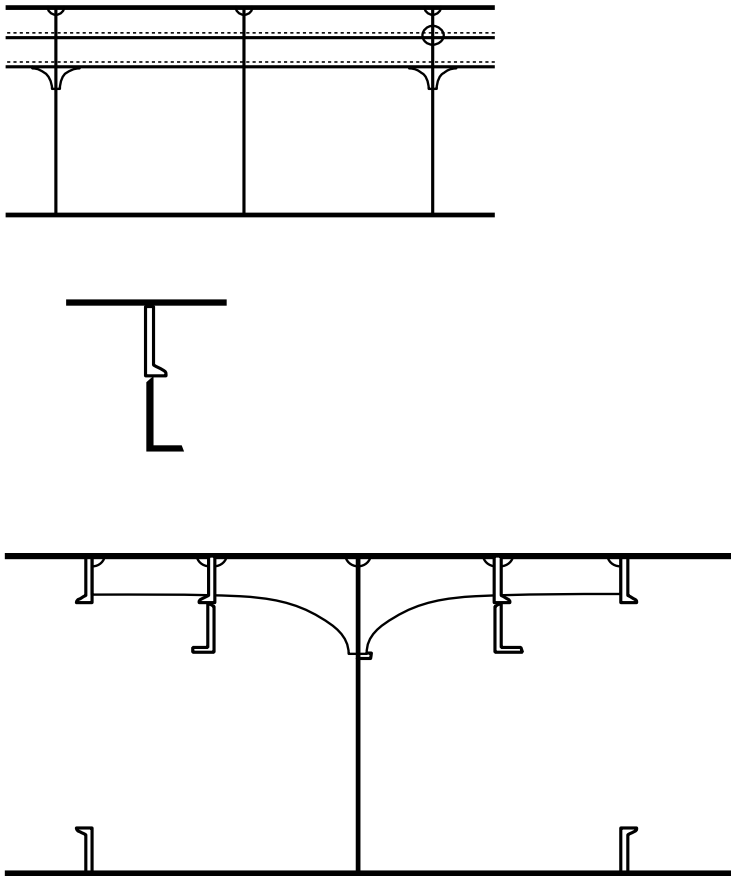
Description of repair**Probable cause of damage**

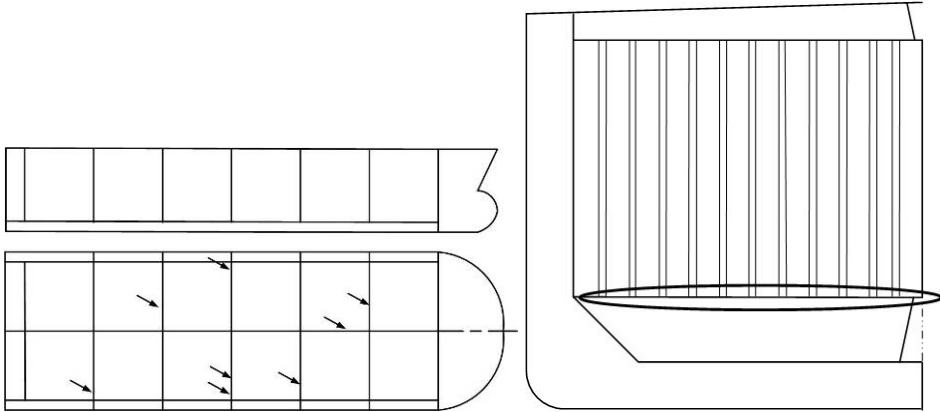
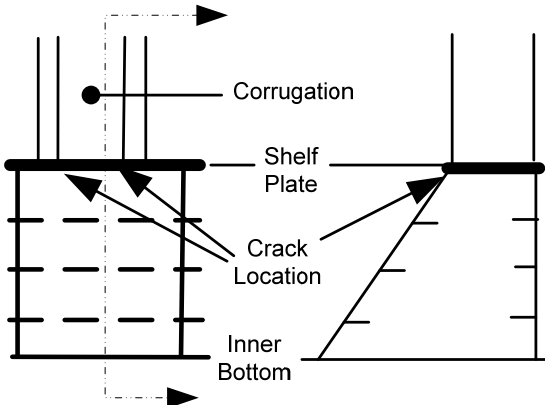
Insufficient support


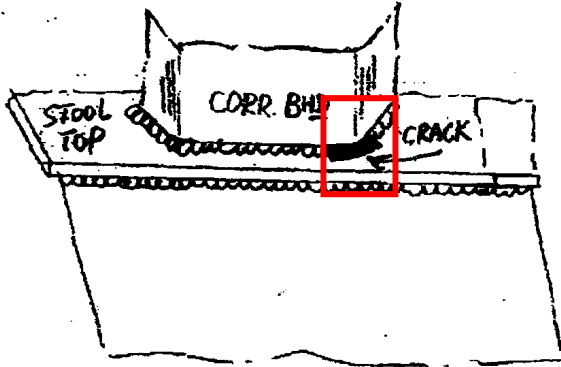
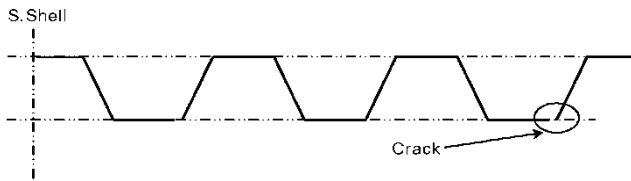
Recommendation for design improvement

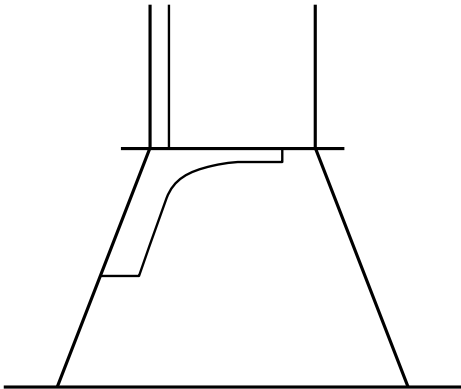
Continuous support of the web plate of the corrugated bulkhead to be provided on upper deck.

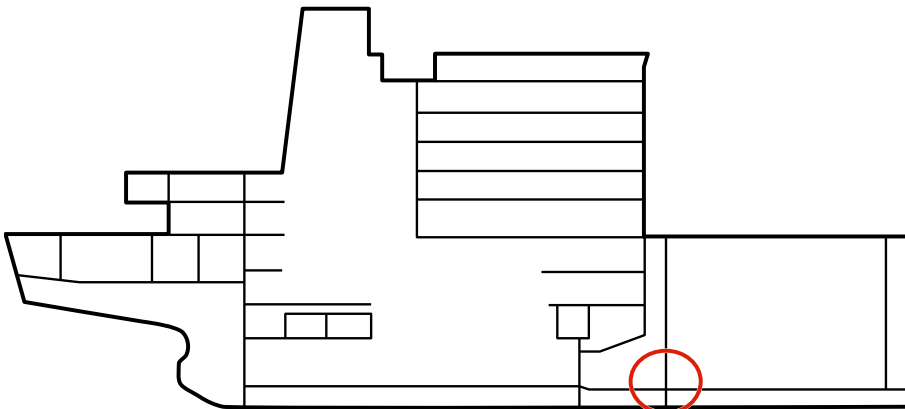
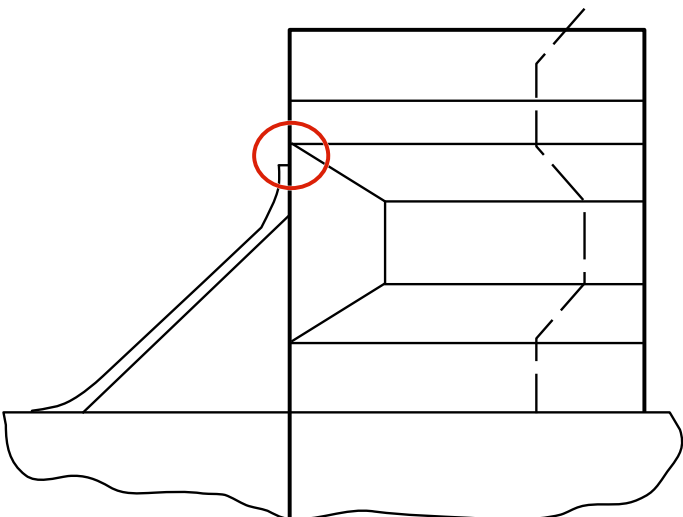
Case 1.9				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt. 11,000
Year of build	1998	Vessels age when damage found		5 years
Main dimensions	L	110 m	B	20 m
	T	-	D	11 m
Bulkhead	Vertically corrugated		Longitudinal bulkhead	
Stool	None fitted			
Material	Stainless steel			
Overview of damage location	Inner bottom longitudinals in line with face of longitudinal corrugated bulkheads in cargo areas.			
				
Description of damage	Cracks developed at penetrations of the inner bottom longitudinals through floors.			
				
Description of repair	To increase rigidity of the longitudinals, additional stiffeners were fitted on original longitudinals with end brackets. In addition, transverse carlings were fitted at the mid area in floor spaces.			

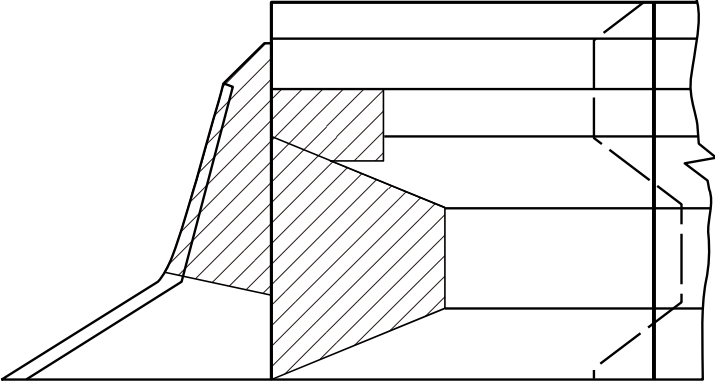
Case 1.9	
	
Probable cause of damage	Detail design Insufficient support
Recommendation for design improvement	Additional longitudinal stiffeners in line with face plate of corrugated bulkhead shall be arranged to support the load induced.

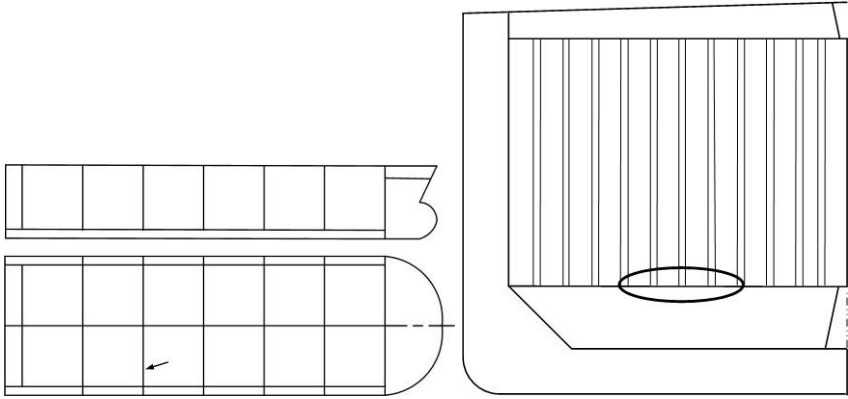
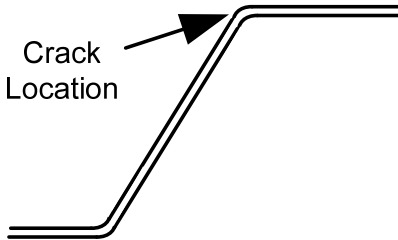
Case 1.10				
Ship-Type	Oil Product Tanker		Capacity [dwt]	Abt.47,000
Year of build	2005	Vessels age when damage found		3 years
Main dimensions	L	174 m	B	32 m
	T	12 m	D	19 m
Bulkhead	Vertically corrugated		Longitudinal and transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade AH			
Overview of damage location				
Description of damage	<p>Note: Welding of stool side to shelf plate by deep penetration</p> <p>Note: Partial backing structure for webs of corrugation is provided in some locations</p>  <p>Cracks at intersection of lower transverse bulkhead stool side plate connection to shelf plate in way of corners of corrugation flanges at locations where no backing structure for corrugation web</p>			
Description of repair	Backing brackets below web plate of corrugated bulkhead extended			
Probable cause of damage	Lack of Continuity			
Recommendation for design improvement	For corrugations of high tensile steel, backing brackets to be fitted below corrugation webs			

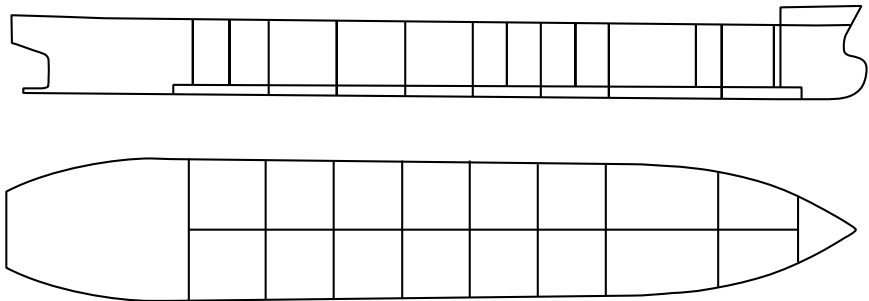
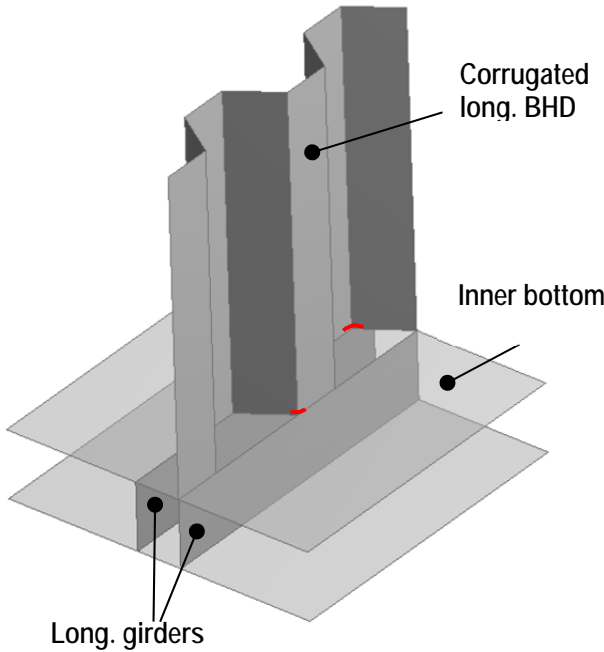
Case 1.11				
Ship-Type	Oil Tanker		Capacity [dwt]	Abt. 46,000
Year of build	2003	Vessels age when damage found		4 years
Main dimensions	L	172 m	B	32 m
	T	-	D	18 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower stool only			
Material	HT36			
Overview of damage location	Transverse corrugated bulkheads in cargo tank area.			
				
Description of damage	Cracks developed around transverse corrugated bulkhead connection to stool structure. Cracks were initiated mainly from corner area of corrugated bulkhead but also from stool slant plate connection to top plate just under the corner area.			
	 			
Description of repair	Cracks were gouged and re-welded. As a reinforcement, an additional bracket was installed below web plate of corrugated bulkhead in lower stool.			

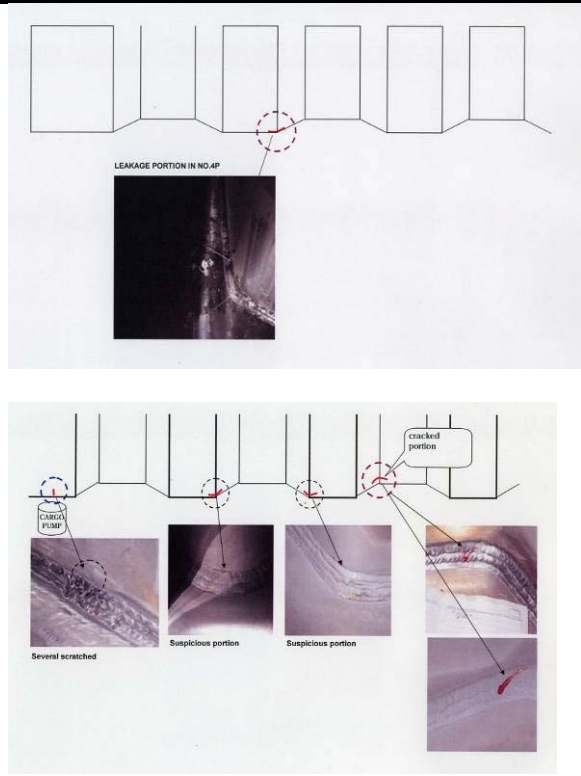
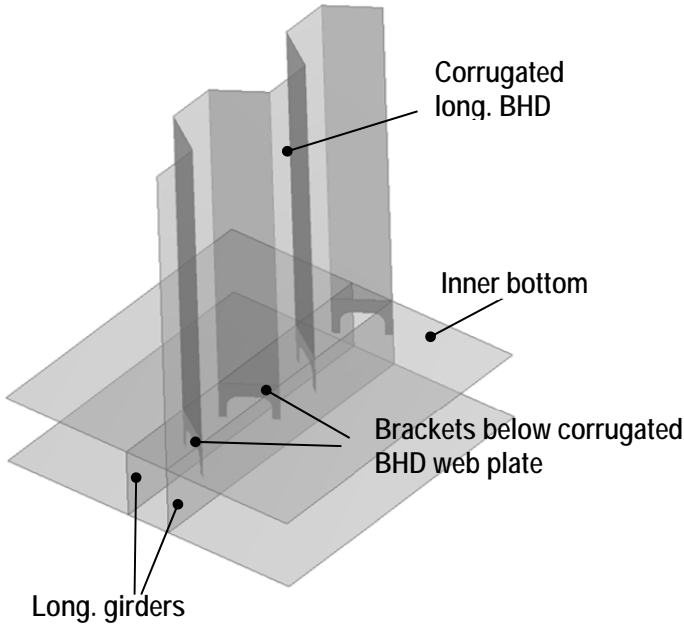
Case 1.11	
	
Probable cause of Damage	Lack of continuity
Recommendation for design improvement	Same as above structural modification or increase scantling of corrugated bulkhead / stool structure.

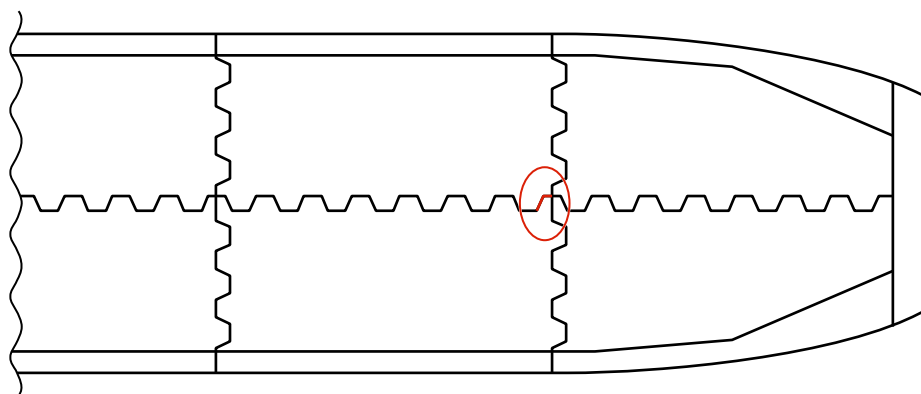

Case 1.12				
Ship-Type	Tanker for Chemicals		Capacity [dwt]	Abt.28000
Year of build	1989	Vessels age when damage found		13 years
Main dimensions	L	180 m	B	25 m
	T	-	D	15 m
Bulkhead	Horizontally corrugated		Longitudinal Bulkhead	
Stool	None fitted			
Material	Grade A			
Overview of damage location				
Description of damage	 <p>Damage shown on sketch of original structure. Damage located in lower aft end termination of the longitudinal bulkhead.</p>			

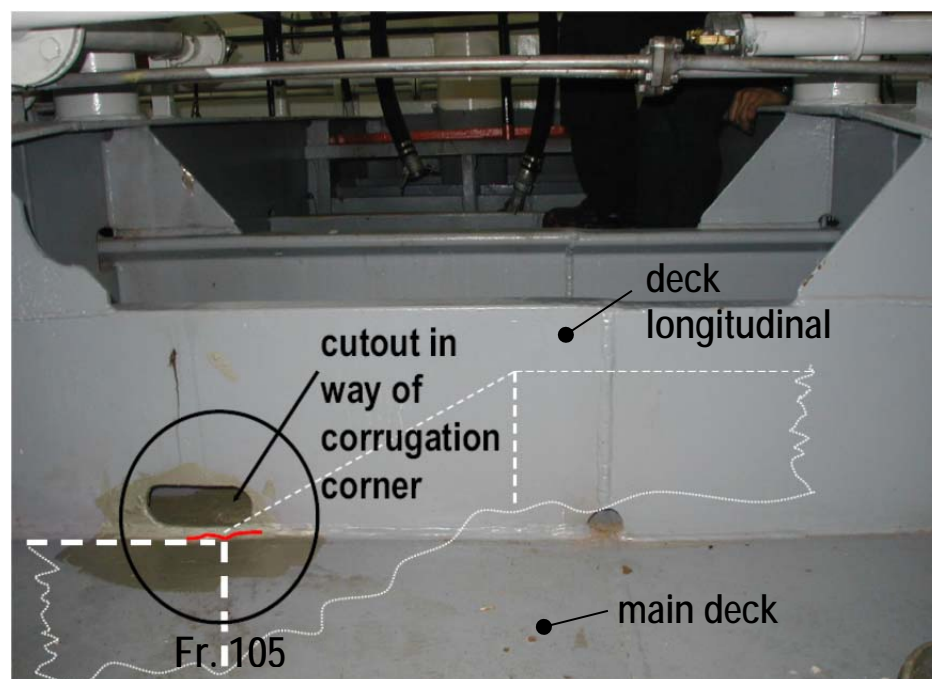
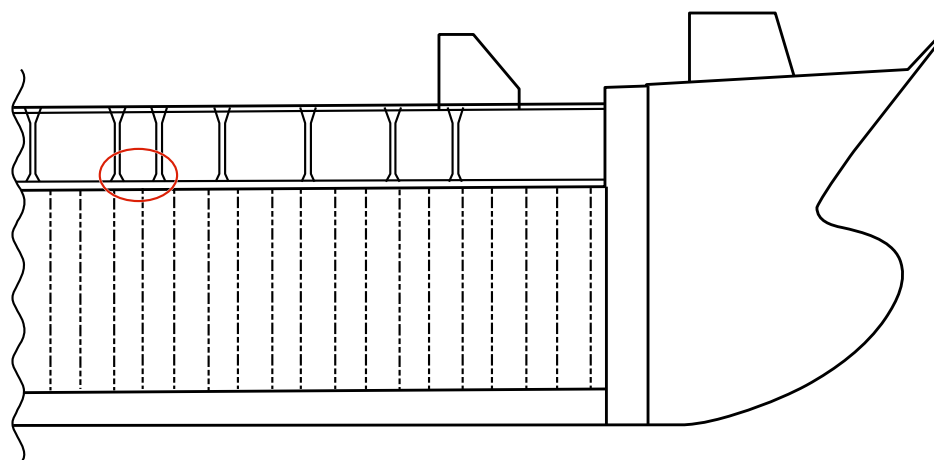
Case 1.12	
Description of repair	
Probable cause of damage	<ul style="list-style-type: none"> • Detail design • Lack of continuity • Generally, the scarfing brackets are undersized.
Recommendation for design improvement	<ul style="list-style-type: none"> • See Sketch • For further improvement a bigger and softer bracket.

Case 1.13				
Ship-Type	Oil Product Tanker		Capacity [dwt]	Abt.64,000
Year of build	2000	Vessels age when damage found		1 year
Main dimensions	L	219 m	B	32 m
	T	13 m	D	22 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade A			
Overview of damage location				
Description of damage	<p>Note Connection of sloped plating to shelf plate by penetration welding</p>  <p>Fillet welding between the shelf plate and sloped plating of lower stool cracked approx. 500 mm in the middle No.4 Cargo Tank (P) and No.4 Ballast Water Tank (P) and oil leaked into the bottom stool in No.4 B.W.T.(P). Cracks and paint cracks were found at the round end corners of transverse corrugated bulkhead inside of bottom stool in No.4 Cargo Oil Tank(P)/No.4 Ballast Water tank(P).</p>			
Description of repair	Brackets fitted side of bulkhead at frame 55,63,71 & 79 corrugation in way of shelf plate bottom connection and gauging out stool plate to self plate connection and welding back after examination with MPI. The above repair carried out at builder suggestion based on history of crack of sister vessel and on this vessel which found and gauged out during above repairs.			
Probable cause of damage	Lack of continuity Insufficient throat thickness of fillet weld			
Recommendation for design improvement	Continuous support of corrugated bulkhead inside of bottom stool to be provided Full penetration welding			

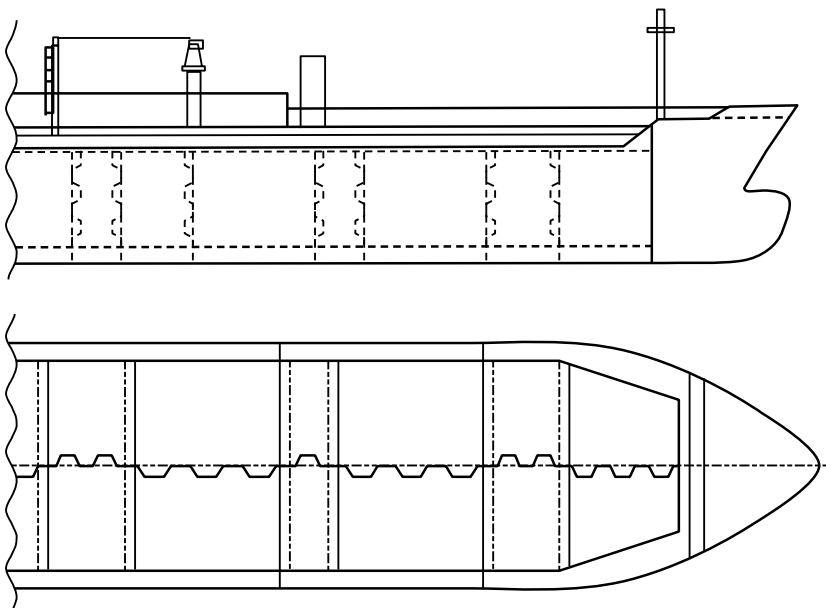
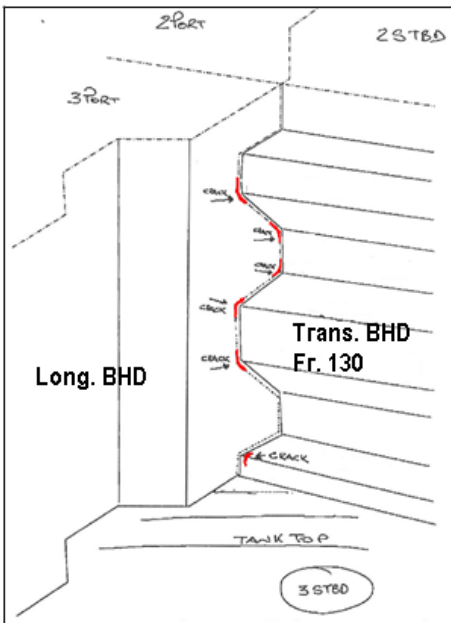
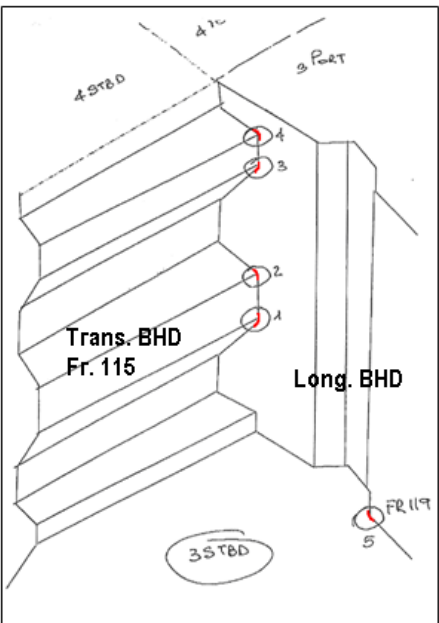
Case 1.14				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt. 20,000
Year of build	2002	Vessels age when damage found		5 years
Main dimensions	L	141 m	B	24 m
	T	-	D	12 m
Bulkhead	Vertically corrugated		Longitudinal bulkhead	
Stool	None fitted			
Material	Stainless steel			
Overview of damage location	Longitudinal corrugated bulkheads in entire cargo tank areas.			
				
Description of damage	Cracks developed around corners of corrugated bulkhead connection to inner bottom plates.			
				

	
Description of repair	Cracks were gouged and re-welded by full penetration welding.
Probable cause of damage	Detail design (insufficient support of corrugated bulkhead). Insufficient throat thickness of fillet weld.
Recommendation for design improvement	<p>Full penetration welding with grinding to smooth up welding bead or increase scantling of corrugated bulkheads.</p> <p>Continuous support along web plate of longitudinal corrugated bulkhead below inner bottom plate between the longitudinal girders to be provided as sketched below.</p> 

Case 1.15				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt.6,000
Year of build	2002	Vessels age when damage found		2 years
Main dimensions	L	97 m	B	15 m
	T	7 m	D	7.5 m
Bulkhead	Vertically corrugated		Longitudinal bulkhead	
	Height from tank top to deck		6.7	
Stool	None fitted			
Material	Grade A			
Overview of damage location				
Drawing/Sketch of original structure				

Case 1.15

Description of damage	<ol style="list-style-type: none"> 1. Indent of longitudinal bulkhead occurred at half height of tank at frame 105. 2. Crack occurred between longitudinal bulkhead and main deck in way of corrugation corner below cutout in deck longitudinal at frame 105.
Description of repair	<ol style="list-style-type: none"> 1. Renewal of longitudinal bulkhead in way of frames 105-106. 2. Deck longitudinal was supported by HP200×11.5 in way of frames 105-106. Cutout in deck longitudinal was closed by insert.
Probable cause of damage	<ol style="list-style-type: none"> 1. Unknown 2. Poor detail design
Recommendation for design improvement	Discontinuities of supporting structure (e.g. cutouts in deck longitudinal girders) in way of corrugation corners are to be avoided.

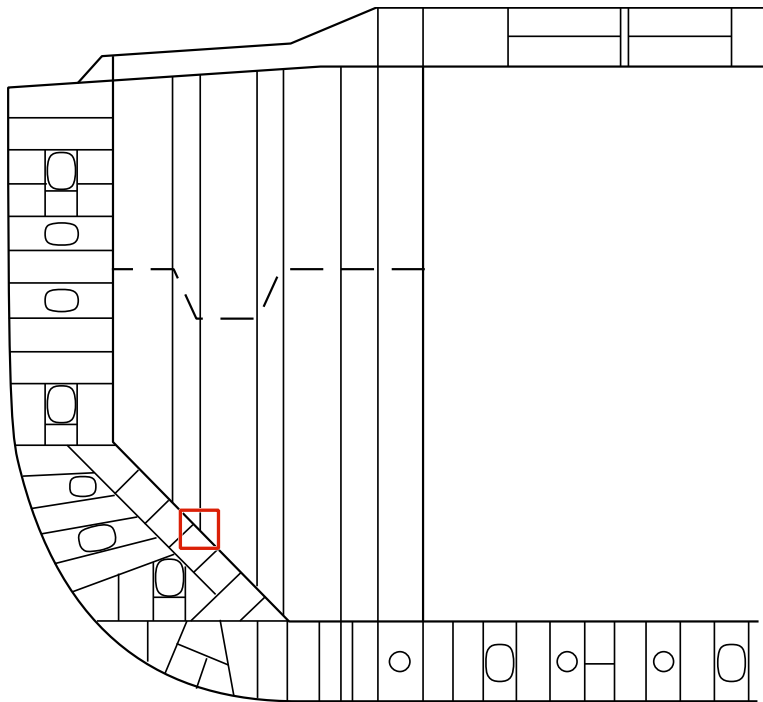
Case 1.16				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt.15,000
Year of build	1999	Vessels age when damage found		7 years
Main dimensions	L	127m	B	20 m
	T	9 m	D	11m
Bulkhead	Vertically corrugated		Longitudinal bulkhead	
	Height from tank top to deck		11.0 m	
Stool	None fitted			
Material	Grade A			
Overview of damage location				
Description of damage	<div><div><p>Frame 130</p></div><div><p>Frame 115,119</p></div></div>			

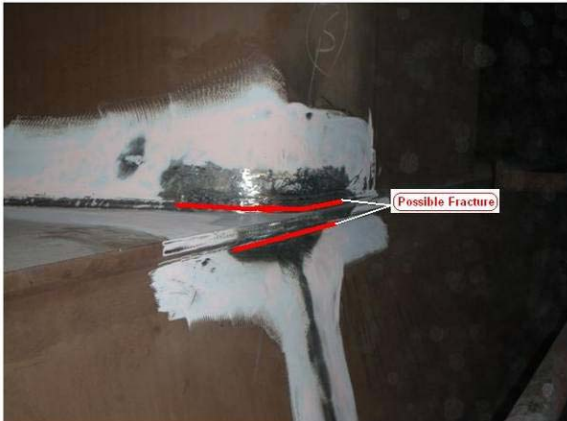
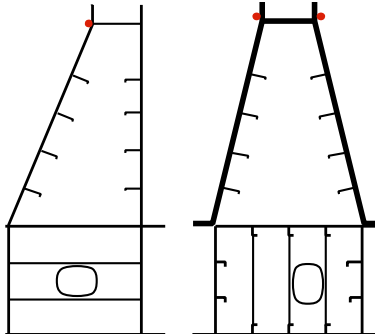

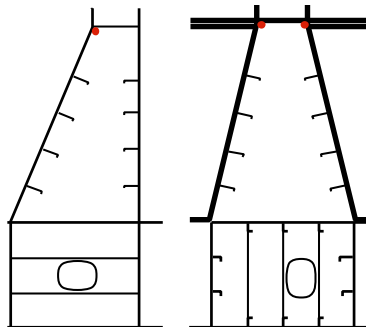
Case 1.16

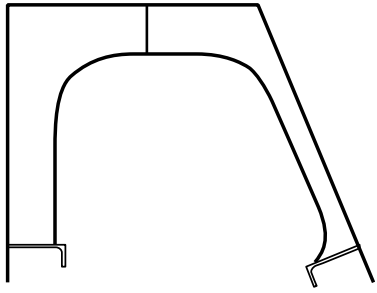
Cracks of 60mm to 250mm developed in longitudinal bulkhead at corrugation corners at frames 115 and 130 (connection to transverse bulkheads), and frame 119 (connection to tank top plate). One crack (250mm) developed in transverse bulkhead at corrugation corner at frame 130 (connection to longitudinal bulkheads).

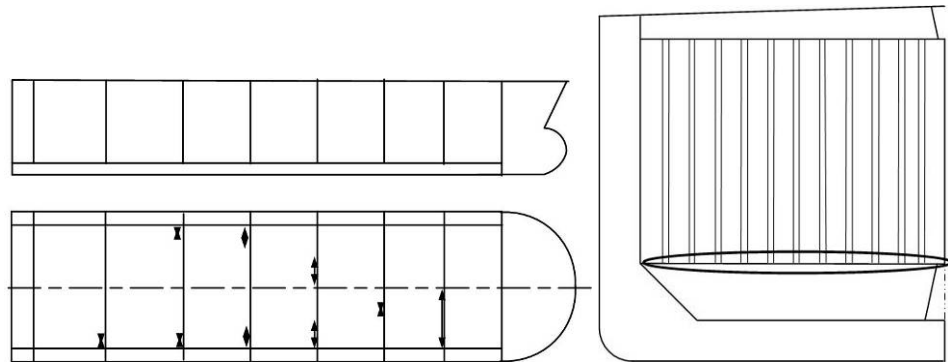
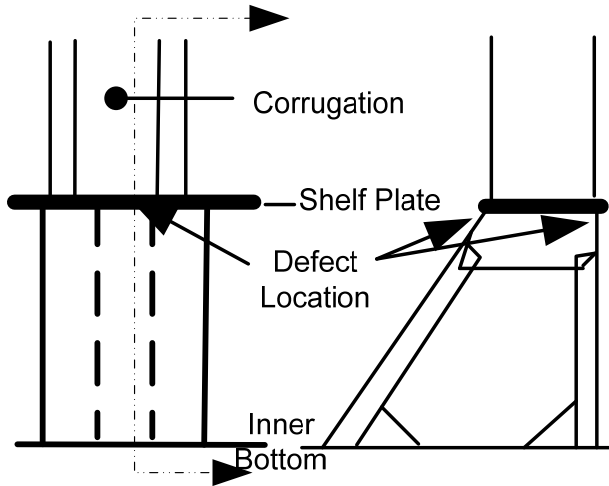


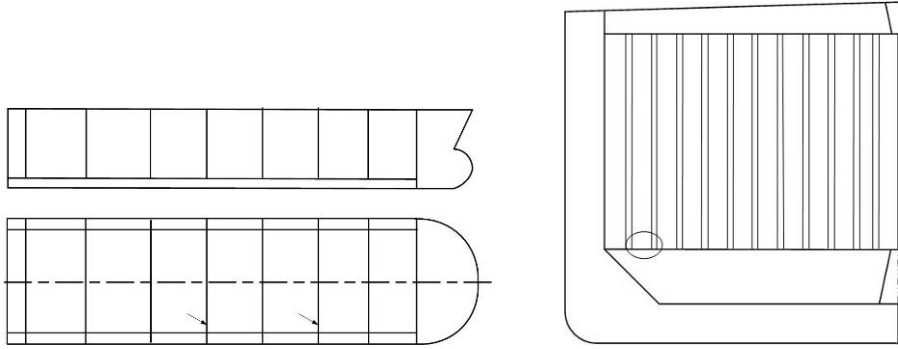
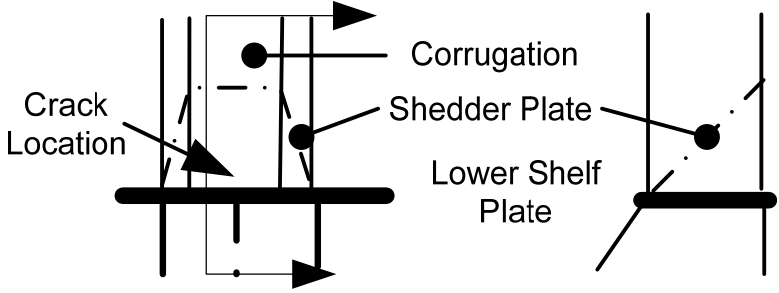
Description of repair	All cracks were gouged and re-welded.
Probable cause of damage	Misalignment Insufficient throat thickness of fillet weld
Recommendation for design improvement	Full penetration welding.

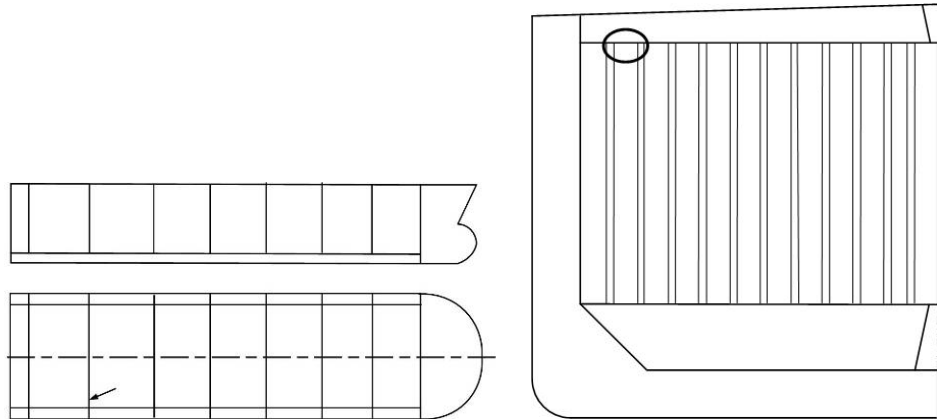
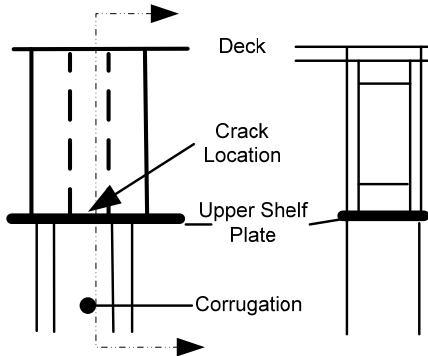
Case 1.17				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt.20,000
Year of build	1996	Vessels age when damage found:		7 years
Main dimensions	L	144 m	B	25 m
	T	-	D	12 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	None fitted			
Material	Stainless steel			
Overview of damage location	The damage was located at the connection of the bottom of the corrugated bulkhead to the sloping hopper plating outside the parallel part of the cargo area.			
Description of damage	A crack developed at the connection between the transverse corrugated bulkhead and the hopper plate. The hopper plate angle to the horizontal changes along ship length (fore and aft) and this produces difficulties in alignment and welding of the corrugated bulkhead.			
				
Description of repair	The cracks were gouged and re-welded.			
Probable cause of damage	<ul style="list-style-type: none">• Misalignment and poor fit up• Welding			
Recommendation for design improvement	Special consideration should be given at the design and construction stages to ensuring accuracy of alignment & fitting as well as a good weld connection (type of edge preparation, full penetration, toe grinding, etc.) and proper support of the flanges and webs of the corrugations.			

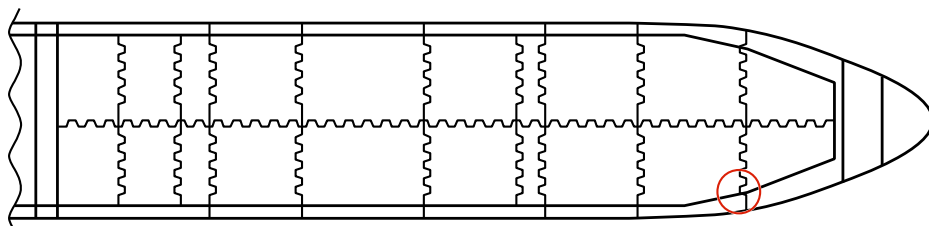
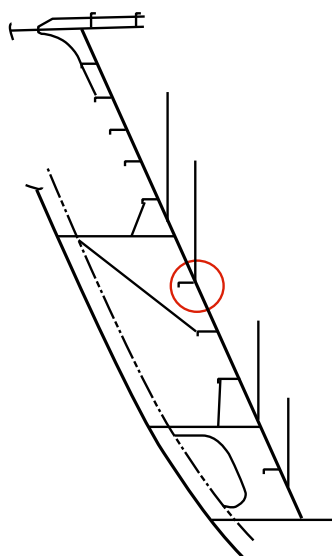
Case 1.18				
Ship-Type	Product Tanker		Capacity [dwt]	Abt.46,000
Year of build	2005	Vessels age when damage found		4 years
Main dimensions	L	174 m	B	32 m
	T	11	D	19 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
	Height from tank top to deck		16.6	
Stool	Lower and upper stool			
Material	Grade A			
Description of damage	Cracks found at connection of corrugated bulkhead to lower stool shelf plate and lower stool shelf plate to sloping plate.			
	<div></div> <div></div> <p>Inside stool space:</p> <div></div> <div></div> <p>Cracks were found in the welds connecting the corrugated bulkhead to the shelf plate and the shelf plate to the sloping plate. The cracks were found in way of the radius of the corrugated bulkhead and at the toe of the bracket within the stool (water ballast tank).</p>			
Description of repair	<ul style="list-style-type: none">Welds gouged out, replaced with full penetration welds and groundBrackets modified as below to remove the toe of the bracket within the stool from the shelf plate/sloping plate weld			

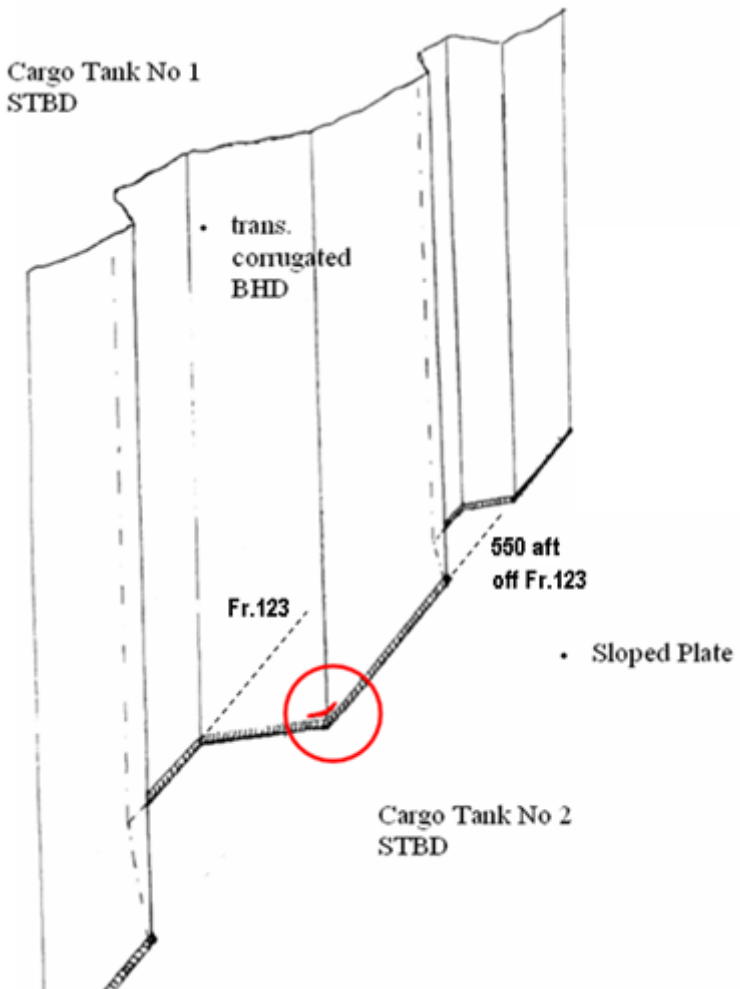
Case 1.18	
	
Probable cause of damage	Poor detail design and lack of full penetration welding, creating hotspot at toe of stool bracket in way of highly stressed corrugated bulkhead radius.
Recommendation for design improvement	Brackets in stools, backing up corrugated bulkhead webs, should preferably be continuous and extend down the sloping plate. If in conflict with the normal brackets inside the stool, the brackets should be terminated close to the middle of the shelf plate.

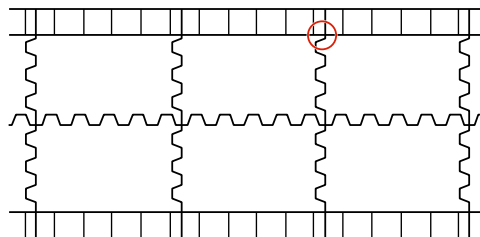
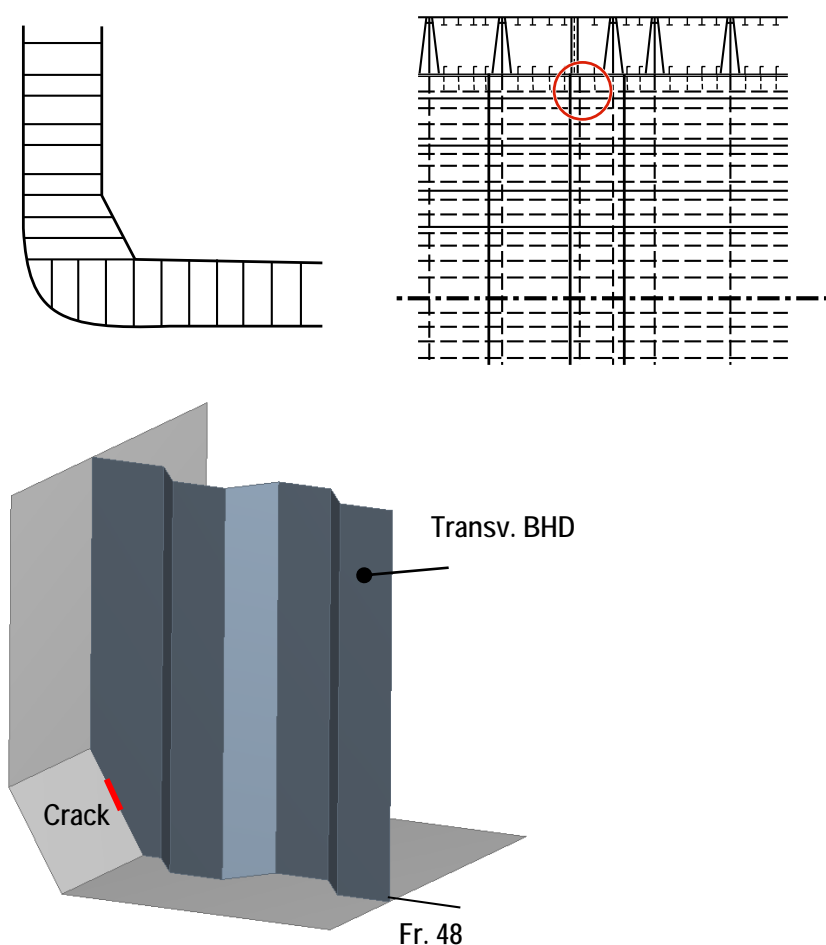
Case 1.19				
Ship-Type	Oil Product Tanker		Capacity [dwt]	Abt.36,000
Year of build	1992	Vessels age when damage found		15 years
Main dimensions	L	174 m	B	30 m
	T	12 m	D	17 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade A			
Overview of damage location				
Description of damage	 <p>Magnetic Particle Inspection of forward and aft corrugated bulkhead weld seams at the connection with the lower stools revealed porosities and lack of penetration.</p>			
Description of repair	Above affected weld seams were gouged and full penetration welded. Existing scallops in way of the water ballast tank internals (stool spaces) were closed with welded collar plates.			
Probable cause of damage	Poor welding control.			
Recommendation for design improvement	Scallops/openings to be avoided in way of connection of sloped stool plate to shelf plate. Weld connection between bulkhead and stool to be full penetration and to be confirmed with ultrasonic testing.			

Case 1.20				
Ship-Type	Oil Product Tanker		Capacity [dwt]	Abt.36,000
Year of build	1992	Vessels age when damage found		5 years
Main dimensions	L	174 m	B	30 m
	T	12 m	D	17 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade A			
Overview of damage location				
Description of damage	 <p>Note: Shedder plate to lower stool connected by full penetration welding</p> <p>Aft bulkhead of Cargo Oil tank numbers 2 and 4 cracked at connection of outermost corrugation shedder plate lower edge to lower shelf plate on starboard side.</p>			
Description of repair	Cracked areas of plating cropped and part renewed as found necessary. On completion repairs examined and found satisfactory, tested tight.			
Probable cause of damage	Poor welding control, poor alignment between shedder plate and stool sloping plate.			
Recommendation for design improvement	Ensure weld between shedder plate and shelf plate is full penetration through ultrasonic testing. Ensure good alignment between shedder plate lower edge and stool sloping plating.			

Case 1.21				
Ship-Type	Oil Product Tanker		Capacity [dwt]	72,000
Year of build	2004	Vessels age when damage found		11 years
Main dimensions	L	219 m	B	32 m
	T	14 m	D	20 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
Stool	Lower and upper stool			
Material	Grade A			
Overview of damage location				
Description of damage	<p>Note: Welding of stool side to shelf plate by full penetration</p>  <p>Welding cracked at intersection of upper transverse bulkhead stool side plate connection to shelf plate.</p>			
Description of repair	Weld gouged and re-welded.			
Probable cause of damage	Welding defects			
Recommendation for design improvement	None			

Case 1.22				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt.6,000
Year of build	1996	Vessels age when damage found		5 years
Main dimensions	L	95 m	B	16.5m
	T	6 m	D	8 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
	Height from tank top to deck		6.6 m	
Stool	None fitted			
Material	Duplex stainless steel			
Overview of damage location				
				

<p>Description of damage</p>	 <p>Cargo Tank No 1 STBD</p> <ul style="list-style-type: none"> trans. corrugated BHD Fr.123 550 aft off Fr.123 Sloped Plate Cargo Tank No 2 STBD <p>Crack of approx. 70mm developed in transverse corrugated bulkhead 550mm aft of Fr.123 running parallel to weld seam between the transverse bulkhead and ballast tank at a height of about 3.5m above the bottom of the cargo tank.</p>
<p>Description of repair</p>	<p>Crack was gouged and re-welded.</p>
<p>Probable cause of damage</p>	<p>Insufficient throat thickness of fillet weld. Misalignment between transverse corrugated bulkhead and supporting bracket in ballast tank.</p>
<p>Recommendation for design improvement</p>	<p>Full penetration welding and good alignment.</p>

Case 1.23				
Ship-Type	Chemical Tanker		Capacity [dwt]	Abt.33,500
Year of build	1997	Vessels age when damage found		9 years
Main dimensions	L	166 m	B	25 m
	T	12 m	D	15 m
Bulkhead	Vertically corrugated		Transverse bulkhead	
	Height from tank top to deck		--	
Stool	None fitted			
Material	Steel grade EH32			
Overview of damage locationnn				
Description of damage	<div><p>Crack developed at weld seam of transverse corrugated bulkhead (Fr. 47 3/5) in way of lower slope of ballast tank.</p></div>			

Case 1.23	
Description of repair	Insert plate in the transverse corrugated bulkhead and the slope of double bottom tank
Probable cause of damage	Insufficient throat thickness of fillet weld. Misalignment between transverse corrugated bulkhead and wing web frame.
Recommendation for design improvement	Full penetration welding and good alignment.