



GUIDANCE NOTES
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CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR CONSTRUCTION MONITORING OF HULL STRUCTURES

2017

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CHAPTER 1 GENERAL

1.1 General provisions

1.1.1 The Guidelines are applied in addition to the requirements for survey of the critical locations within the ship structure, for the purpose of controls on alignment, fit-up, groove preparation and workmanship to the critical locations of the relevant hull structures, to ensure that the critical locations are built to both an acceptable quality standard and approved construction procedures.

1.1.2 The Construction Monitoring Plan (CMP) described in the Guidelines is also used for all parties concerned to focus the attention of knowledge of the critical locations during the service life of the ship.

1.1.3 Ships to which 1.2 of this Chapter applies and which have effectively implemented the procedural requirements described in 1.5.1 are to be assigned with CM notation.

1.2 Scope of application

1.2.1 The Guidelines apply to membrane LNG carriers as well as oil tankers, bulk carriers and container ships of 150 m or over in length applying for the assignment of CM notation.

1.2.2 New constructed ships other than those mentioned in 1.2.1 may be referred to the Guidelines.

1.3 Definitions

1.3.1 *Critical Areas* are those areas of the ship structure that have been shown by rules requirements, structural analysis and service experience to have a higher probability of failure than the surrounding ship structure.

1.3.2 *Critical Locations* are locations identified within the critical areas that experience high levels of stress or are prone to structural damages such as cracking, buckling and distortion.

1.3.3 *A Construction Monitoring Plan for hull structures* (hereinafter referred to as CMP) is a supplement to the Construction Quality Plan, which provides a specific quality standards and control procedures for the critical locations that have been identified.

1.4 General requirements

1.4.1 Critical locations of the hull structure of a ship are to be determined according to the requirements of 2.1.1 and 2.1.2 at the design stage. Appropriate measures for improvement, such as weld bead appearance, grinding and preheating, etc., are to be taken as necessary in order to reduce the probability of structural damage at the locations.

1.4.2 The following are to be completed by the shipyard during the process of design and construction:

(1) establishment of requirements for critical location construction tolerances control for a specific ship in accordance with Construction Monitoring Standard (hereinafter referred to as CMS) for hull structures described in Appendix B (which may also be completed by the designer);

- (2) development of a CMP and submitting it to CCS for approval according to the requirements of 2.3.1 (which may also be completed by the designer);
- (3) establishment of quality assurance procedures to ensure effective implementation of the CMP;
- (4) inspection and recording of critical locations and timely notifying the CCS site Surveyor(s) to confirm that the critical locations are constructed in compliance with the CMP; and
- (5) remedial measures as specified by the CMS against locations not constructed in compliance with the CMS.

1.4.3 During the service life of the ship, the shipowner is responsible for regular inspection and maintenance of the determined critical locations in accordance with the approved CMP.

1.5 Basic procedure

1.5.1 A basic construction monitoring procedure for hull structures and the flow chart thereof (given in Figure 1.5.1) include:

- (1) identification and confirmation of critical locations;
- (2) development and approval of CMP;
- (3) survey during construction;
- (4) assignment of CM notation; and
- (5) survey after construction.

1.6 Construction Monitoring Standard (CMS) for hull structures

1.6.1 A CMS for hull structures is a standard to ensure that the critical locations of hull structures meet relevant quality standards, which covers the following three aspects:

- (1) fit-up and alignment of structural components;
- (2) welding of structural components; and
- (3) remedial measures for inappropriate fit-up, misalignment or poor welding.

1.6.2 Requirements for alignment of critical locations and remedial measures for misalignment are specified in Appendix B of the Guidelines. The construction standards and tolerances not indicated in Appendix B are to be at least equivalent to the industrial, national or international standards or the approved yard's ship construction standards.

Construction monitoring procedure for hull structures-flowchart

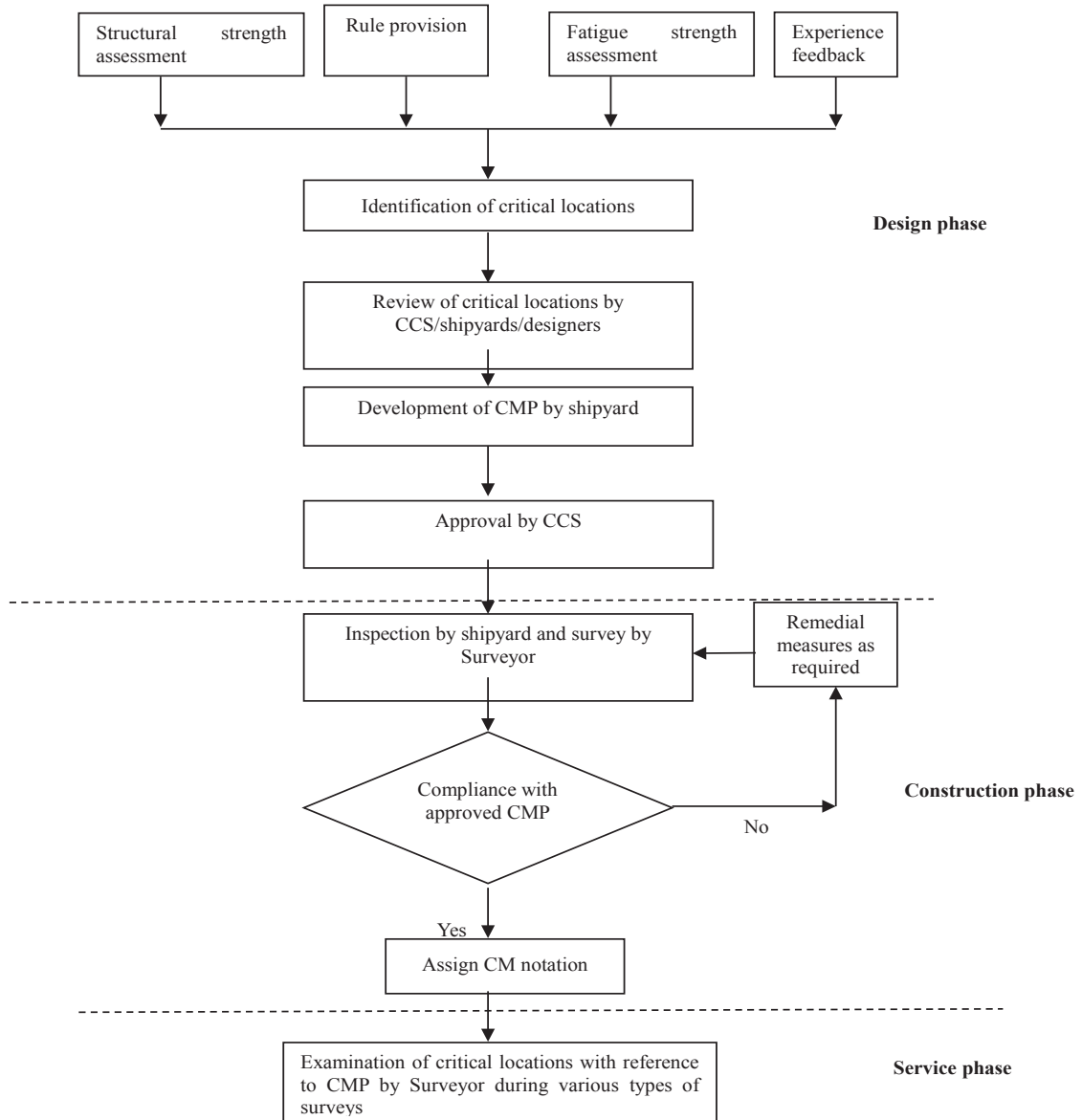


Figure 1.5.1

CHAPTER 2 MONITORING PRIOR TO CONSTRUCTION

2.1 Identification and labeling of critical locations

2.1.1 Critical locations of hull structures are to be identified on the basis of the following:

- (1) requirements of CCS Rules for Classification of Sea-going Steel Ships and relevant guidelines;
- (2) finite element structural strength assessment and fatigue strength assessment of hull structures; and
- (3) analysis of similar or sister ships for areas prone to cracking, buckling and distortion that will damage hull structural integrity.

2.1.2 Typical critical locations of hull structures for bulk carriers, oil tankers, container ships and membrane LNG carriers are indicated in Appendix A as guidance for identification of critical locations of the above ship types.

2.1.3 Critical locations are to be labelled in the CMP.

2.1.4 After confirmation of the review of critical locations, the plan approval Surveyor(s) is to contact the site Surveyor(s) to enable the latter to be fully aware of the information on critical locations. The site Surveyor(s) is to carry out control to avoid any steel cutting to relevant blocks of critical locations prior to the approval of CMP.

2.2 Development of CMP

2.2.1 The shipyard/designer is to develop the CMP on the basis of the critical locations of hull structures which have been confirmed. CCS may provide the format of CMP and relevant information where necessary.

2.2.2 A CMP is at least to contain the following information:

- (1) construction monitoring standard appropriate for the ship;
- (2) summary table (with typical diagrams) of all critical locations to be monitored, indicating alignment tolerances applied;
- (3) detailed structural drawing for each critical location, on which the following information is to be indicated:
 - ① alignment tolerances;
 - ② shapes and gaps of weld grooves;
 - ③ fatigue life improvement measures, if any, such as grinding of welds

unless the above information has been reflected in the relevant approved drawings or documents.

- (4) alignment verification methods used during fit-up, such as reference line marking; and
- (5) records and reports of construction monitoring inspection results (see the format in Annexes of Appendix C for reference).

2.2.3 A sample CMP of a large bulk carrier is shown in Appendix C of the Guidelines.

2.2.4 If necessary, a quality control plan for fit-up of structural components of all critical locations during pre-assembly, block assembly and gross assembly phases is to be developed.

2.3 Approval of CMP

2.3.1 The CMP is to be developed and submitted for approval at the earliest opportunity, the approval of which is to be completed prior to steel cutting to relevant blocks of identified critical locations at the latest, in order that the relevant issues found in practical construction, structural analysis and fatigue analysis as well as experience of similar ships in service are fully reflected in the plan.

2.3.2 Once approval is given, plan approval Surveyors are to inform site Surveyors of the technical principles and site Surveyors are to maintain efficient contact with all relevant parties to ensure that the requirements of the CMP are fully understood and effectively implemented by all interested parties.

2.3.3 A copy of the approved CMP and approved drawings and documents related to CMP are to be maintained on board either in electronic or hard copy format throughout the life of the ship for use during surveys after construction.

CHAPTER 3 MONITORING DURING CONSTRUCTION

3.1 Pre-assembly

3.1.1 The pre-assembly of each critical structural component is to be monitored in accordance with the approved CMP. The workmanship employed and material preparation during the pre-assembly stage is to conform to the relevant requirements defined in the CMP. Weld grooves and gaps of critical structural components required to be preassembled are to be inspected for compliance with CMS. Non-compliance, if any, is to be rectified.

3.1.2 In the process of assembly of critical structural components, appropriate methods are to be applied to ensure alignment of the components at joints. In general, two alignment verification methods may be used, i.e., profile gauge and offset marking. The method for inspection of alignment is to be to the satisfaction of the site Surveyor. The shipyard's quality personnel are to inspect the alignment of the critical structural components for compliance with CMS, using the method agreed by the site Surveyor. Non-compliance, if any, is to be rectified.

3.1.3 Upon completion of the above 3.1.1 and 3.1.2, the shipyard is to notify the site Surveyor to recheck.

3.2 Assembly of units and block assembly

3.2.1 During unit assembly, special attention is to be given to the alignment of critical structural components so as to ensure that each process is in compliance with the approved plan and construction tolerances. The plates and components are to be left loose as far as possible until such time that acceptable fit-up and alignment has been achieved so as to avoid great inner stress caused by forced assembly.

3.2.2 The shipyard's quality control personnel may use the method agreed by the site Surveyor as mentioned in 3.1.2 to inspect the alignment of critical structural components. If the alignment cannot comply with the specified tolerances, it is to be rectified and then re-inspected. For each critical structural component, the inspection of alignment, rectification of non-compliance and re-inspection are to be recorded.

3.2.3 After the positions of critical structural components have been fixed and satisfactorily inspected by the yard's quality control personnel and before welding is undertaken, the yard is to notify the site Surveyor. The Surveyor is to inspect the records of construction monitoring inspection results provided by the yard's quality control department and do sample recheck.

3.2.4 Welding sequences are to enable to reduce residual stress as far as possible, i.e., welding started from the middle to both ends or back-step welding.

3.2.5 Surfaces intended to be welded are to be clean and dry. Measures of pre-heating and heat preservation for the weld areas are to be taken as necessary, with the aim to prevent cracks and other defects due to rapid cooling of welds. For any given welding method, the welding processes are to be in compliance with the welding procedures approved by CCS. All welders involved are to have qualifications approved by CCS.

3.2.6 Temporary components are normally not allowed at critical locations. Where such components as lifting lugs have to be welded at critical locations, the temporary components and their adjacent structures are to be inspected to ensure that no cracks or defects are present. When temporary components are removed, the Surveyor may request inspection of the surface for possible cracks, in order to eliminate defects and potential damage.

3.3 Inspection after welding

3.3.1 Upon completion of the welding of critical structural components, a visual inspection is to be carried out. Prior to the inspection, all rust, weld slag and coatings that may impair the inspection are to be removed. The inspection is to ensure that:

- (1) all welds are in good shape, homogeneous and reasonably smooth, which are to comply with class B of ISO 5817, and grinding is applied when necessary;
- (2) all weld sizes meet the design requirements over their entire length;
- (3) double continuous round welding is applied at the ends of structural components (e.g. brackets) or openings in way of their ends. The round welds are not less than 75 mm in length and the size of the weld leg may be increased as appropriate, thus avoiding cracks at points of stress concentration; and
- (4) if repair welding has been undertaken, the repair welds are not to be less than 50 mm in length.

3.3.2 Welds may be examined using Ultrasonic, Magnetic Particle, Radiographic, Dye Penetrant or other approved NDT methods. The quality of a weld is often affected by factors such as heat input and the welding process, therefore, when specifying an NDT procedure, full consideration is to be given to the weld process employed to ensure that the method of NDT is suitable for the type of weld under consideration. At critical locations where full or deep penetration welding is employed, generally at least one NDT is to be carried out at every 10 locations.

3.3.3 Where defects of welds are observed and are tended to be progressive, examination is to be expanded. Unacceptable weld defects detected by NDT are to be removed and re-welded using approved procedures.

3.3.4 At critical locations where repairs or re-welds have been undertaken, appropriate measures are to be taken to avoid distortion and stress concentration due to excessive welding. Re-inspection using the appropriate method of NDT is to be carried out for repairs where necessary, until no defects are discovered.

3.3.5 Additional welding inspection or NDT may be carried out if the site Surveyor considers necessary.

3.3.6 The site Surveyor is to recheck the inspection and repair records of welding of critical structural components made by the yard's quality control department.

3.4 Departure from the Approved Hull Structure

3.4.1 Where a ship has undergone departure from the approved hull structure, any location subsequently identified as being critical is to be constructed to the CMP.

3.4.2 The CMP involved in an alteration is to be developed and submitted for approval at the earliest opportunity, the approval of which is to be completed prior to steel cutting to relevant blocks of identified critical locations at the latest.

3.4.3 Locations not previously identified but subsequently found to be critical due to the structural alteration are to be examined in detail to ensure that no severe misalignment and weld imperfections exist.

CHAPTER 4 MONITORING AFTER CONSTRUCTION

4.1 Monitoring after construction

4.1.1 The Surveyor undertaking various surveys (such as annual, intermediate and special surveys) for ships in service is to, according to the extent of close-up surveys specified in Chapter 5, PART ONE of CCS Rules for Classification of Sea-going Steel Ships, identify those critical structural locations from the CMP.

4.1.2 During surveys, the Surveyor is to pay attention to possible defects of critical structural locations identified in 4.1.1 such as cracking, corrosion, local damage, severe distortion and local coating breakdown.

4.1.3 Repairs undertaken at the critical locations of ships with CM notation are also to be undertaken in accordance with CMP.

4.1.4 When finding the defects of critical structural locations not included in the CMP during the surveys for sister ships or series of ships, the Surveyor is to analyze, study and report the defects to the plan approval unit in accordance with CCS procedures, so as to determine whether the CMP needs to be revised.

4.2 Structural conversion of ships in service

4.2.1 If a ship with CM notation in service is intended to undergo major conversion of its hull structure, the shipowner is to re-assess structural strength and fatigue strength of the hull structure, subsequently identify critical locations of the hull structure, and update the CMP. The revised drawings and updated CMP are to be submitted to CCS for re-approval in accordance with 3.4.2. During the conversion, alignment and welding of the subsequently identified critical structural components is to comply with the revised CMP approved.

4.2.2 The structures at new critical locations not previously identified but subsequently found due to the conversion are to be examined closely to ensure that relevant structures meet the tolerances and welding quality required.

Appendix A

CRITICAL LOCATIONS OF HULL STRUCTURES

Critical Locations of Typical Bulk Carriers

Table A.1

Structure	No.	Critical location	Figure
Deck	1	Hatch end beam toe in way of topside tank transverse web frames	Fig. A.1(1), Position 1
	2	Connection of deck longitudinal to transverse bulkhead	Fig. A.1(10), Position 1
	3	Scallops in way of block connections joints at cargo hold deck within $0.4L$ amidships	Fig. A.1(8), Positions 1 and 2
Hatch coaming	1	Hatch coaming longitudinal end bracket toe	Fig. A.1(2), Position 1
Hold main frame	1	Toe connection of hold main frame to topside tank sloping plating (in way of web frames)	Fig. A.1(1), Position 2
	2	Toe connection of hold main frame to hopper tank sloping plating (in way of web frames)	Fig. A.1(1), Position 3
Double side skin	1	Connection of topside tank sloping plating to inner hull longitudinal bulkhead plating	Fig. A.1(3), Position 1
	2	Connection of hopper tank sloping plating to inner hull longitudinal bulkhead plating	Fig. A.1(3), Position 2
Hopper tank	1	Connection of hopper tank sloping plating to inner bottom plating	Fig. A.1(1), Position 4
Transverse bulkhead	1	Connection of lower stool side plating to inner bottom plating and hopper tank sloping plating in way of double bottom girders	Fig. A.1(4), Position 1
	2	Connection of lower stool top plating to corrugated bulkhead in way of lower stool diaphragm	Fig. A.1(4), Position 2
	3	Connection of upper stool to corrugated bulkhead and topside tank sloping plating	Fig. A.1(6), Position 1
	4	Connection of transverse bulkhead to inner bottom plating in way of double bottom girders (if no lower stool is fitted)	Fig. A.1(7), Position 1
Hatchway	1	Hatch corners of strength deck	Fig. A.1(5), Position 1
Webs of primary members	1	Cut out for longitudinal stiffeners in web-frame without web stiffener connection	Fig. A.1(9), Positions 1, 2 and 3
Double bottom	1	Connection of inner bottom longitudinal stiffener to transverse bulkhead	Fig. A.1(10), Position 2
	2	Connection of bottom longitudinal stiffener to transverse bulkhead	Fig. A.1(10), Position 2

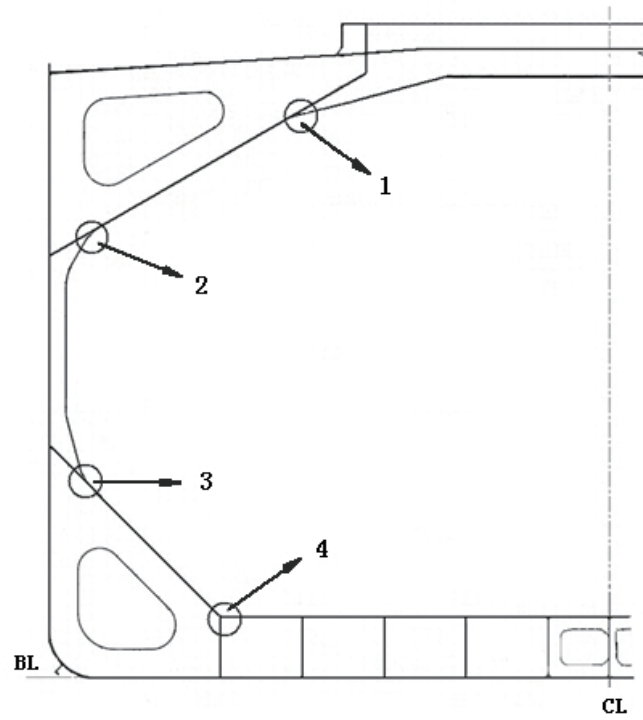


Figure A.1(1)

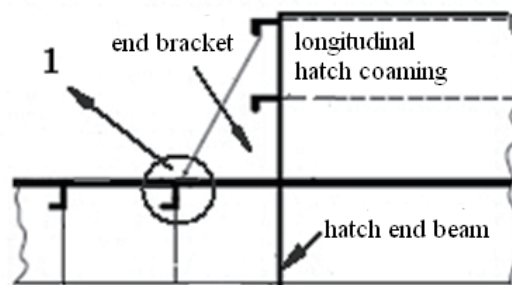


Figure A.1(2)

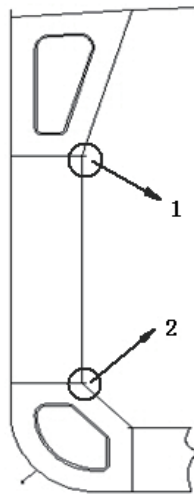


Figure A.1(3)

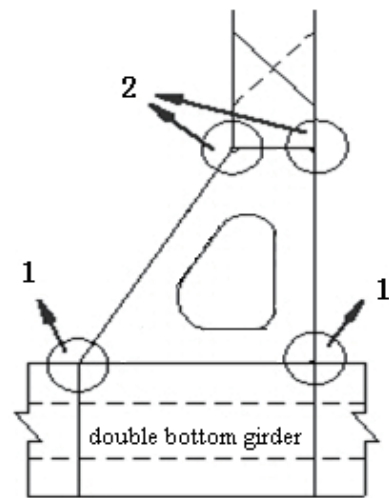


Figure A.1(4)

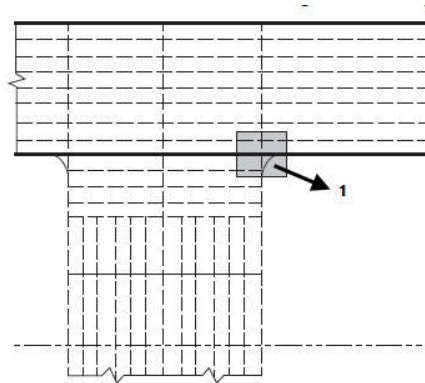


Figure A.1(5)

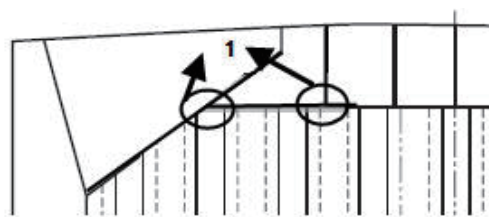


Figure A.1(6)

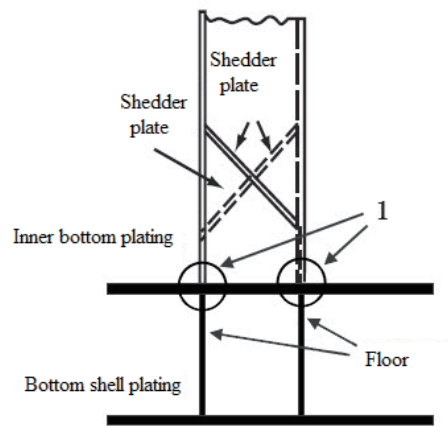


Figure A.1(7)

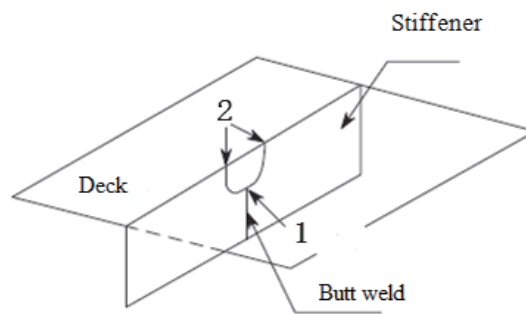


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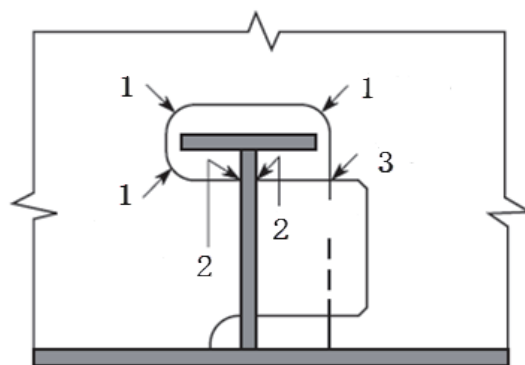


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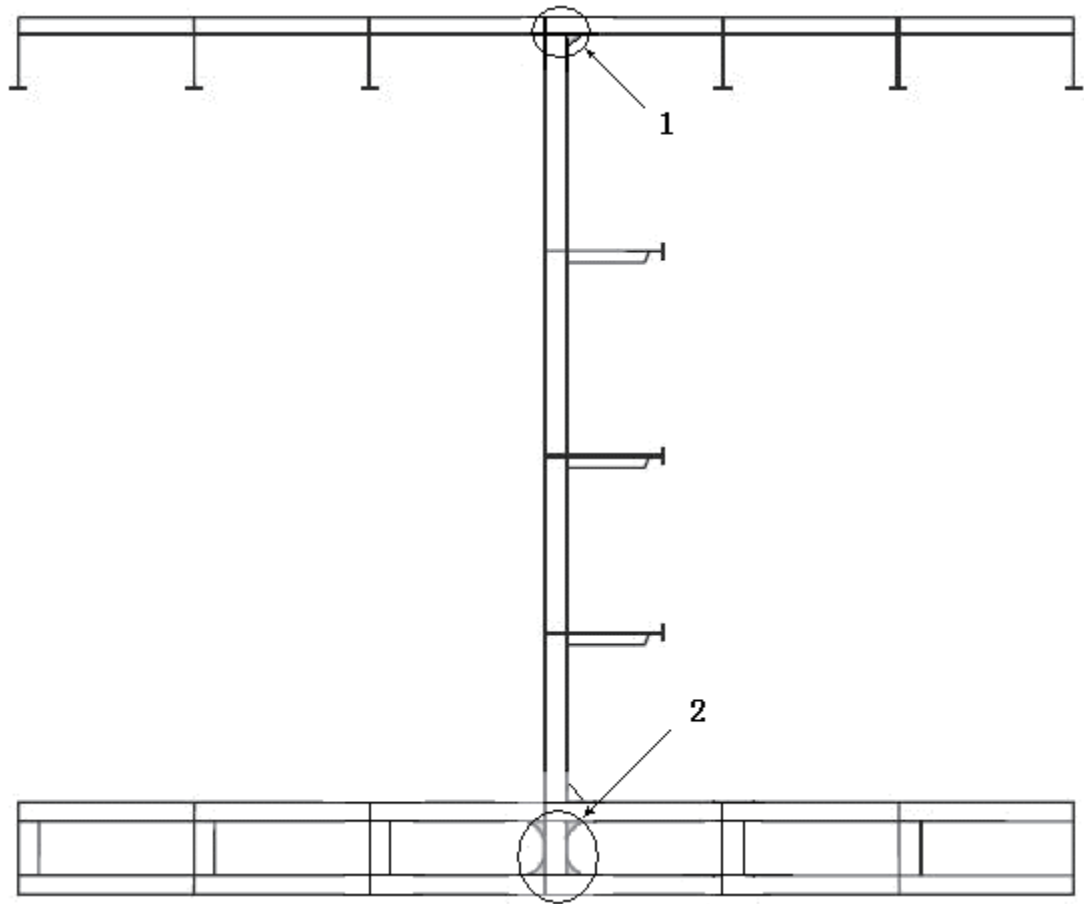


Figure A.1(10)

Critical Locations of Oil Tankers

Table A.2

Structure	No.	Critical location	Figure
Inner hull	1	Intersection of inner hull longitudinal bulkhead, hopper tank sloping plating and side stringer in double side tank	Fig. A.2(1) Position 1
	2	Intersection of hopper tank sloping plating, inner bottom plating and double bottom girder	Fig. A.2(1) Position 2
	3	Intersection of inner hull longitudinal bulkhead, topside tank sloping plating and side stringer in double side tank	Fig. A.2(2) Position1
Bulkhead	1	Intersection of longitudinal and transverse vertical corrugated bulkheads in way of lower stool	Fig. A.2(2) Position 2
	2	Intersection of longitudinal and transverse vertical corrugated bulkheads in way of upper stool	Fig. A.2(2) Position 3
	3	Intersection of lower stool side plating, inner bottom plating and floor	Fig. A.2(3) Position 1
	4	Connection of lower stool top plating to corrugated bulkhead in way of lower stool diaphragm	Fig. A.2(3) Position 2
Deck	1	Connection of transverse end bracket to inner hull longitudinal bulkhead	Fig. A.2(1) Position 3
	2	Deck transverse end bracket toe in way of topside tank transverse web	Fig. A.2(4) Position 1
	3	Connection of transverse end bracket to longitudinal bulkhead	Fig. A.2(1) Position 4
	4	Connection of deck longitudinal stiffener to transverse bulkhead	Fig. A.2(7) Position 1
	5	Scallops in way of block connections joints at cargo hold deck within 0.4L amidships	Fig. A.2(8) Positions 1 and 2
Longitudinal bulkhead	1	Connection of vertical web lower end bracket to inner bottom	Fig. A.2(1) Position 5
Transverse bulkhead	1	Connection of horizontal girder to longitudinal bulkhead	Fig. A.2(5) Position 1
	2	Connection of horizontal girder to inner hull longitudinal bulkhead	Fig. A.2(5) Position 2
	3	End of horizontal girder, including bracket toe (where back bracket is fitted)	Fig. A.2(5) Position 3
Inner bottom	1	Toe of big bracket connecting inner bottom and longitudinal bulkhead	Fig. A.2(1) Position 6
Swash bulkhead (cargo oil tank)	1	Bracket connecting swash bulkhead and inner hull longitudinal bulkhead	Fig. A.2(6) Position 1
Wing cargo oil tank	1	Toe connection of cross-tie to inner hull longitudinal bulkhead	Fig. A.2(1) Position 7
Double bottom	1	Connection of inner bottom longitudinals to transverse bulkhead	Fig. A.2(7) Position 2
	2	Connection of bottom longitudinals to transverse bulkhead	Fig. A.2(7) Position 2
Webs of primary members	1	Cut out for longitudinal stiffeners in web-frame without web stiffener connection	Fig. A.2(9) Positions 1, 2 and 3

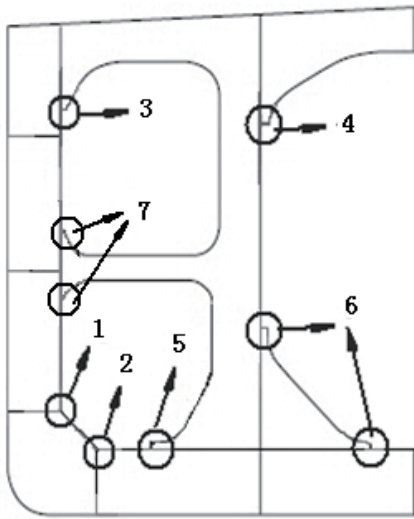


Figure A.2(1)

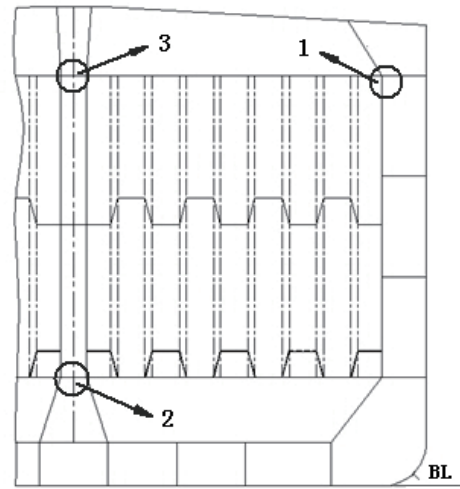


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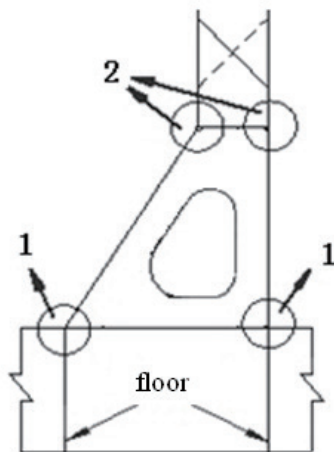


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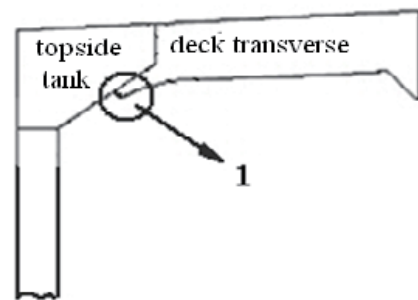


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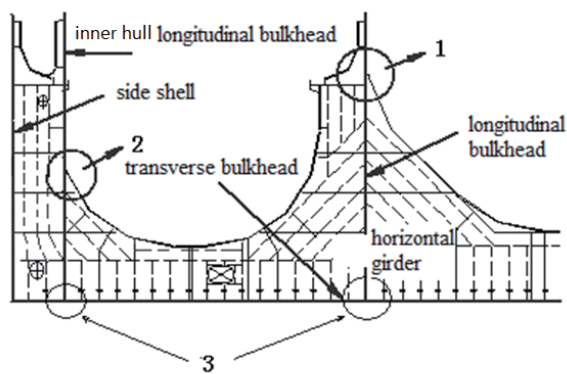


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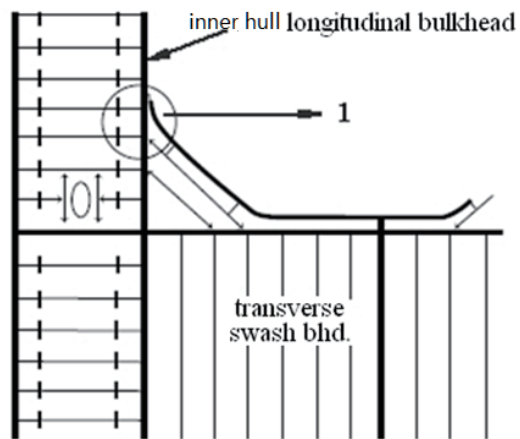


Figure A.2(6)

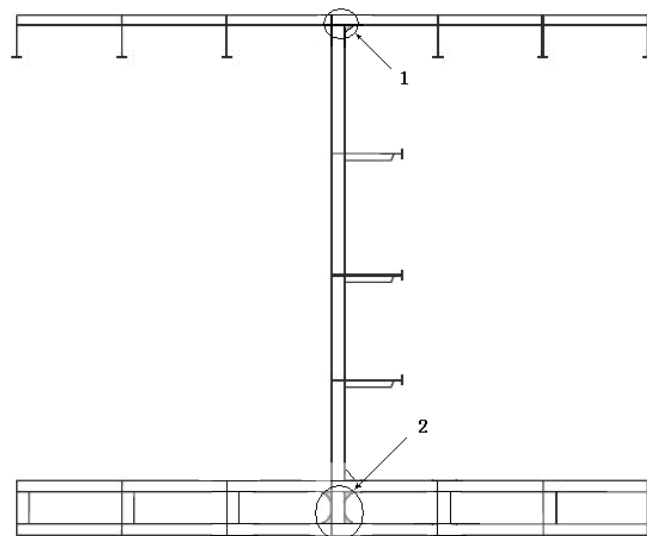


Figure A.2(7)

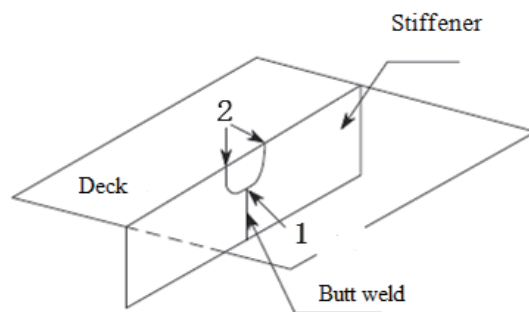


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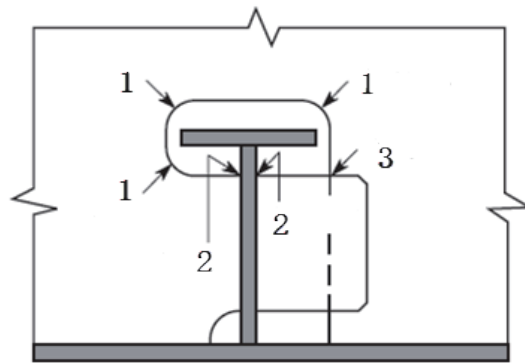


Figure A.2(9)

Critical Locations of Container Ships

Table A.3

Structure	No.	Critical location	Figure
Deck	1	Deck plating in way of hatch corner of cargo hold	Fig A.3(1) Position 1
Hatch coaming	1	Connection of longitudinal hatch coaming with superstructure	Fig A.3(2) Position 1
	2	Toe connection of longitudinal hatch coaming transverse stay bracket to deck plating	Fig A.3(2) Position 2
	3	Connection between transverse and longitudinal top plating of hatch coamings	Fig A.3(3) Position 1
	4	Longitudinal hatch coaming end bracket toe	Fig A.3(4) Position 1
Double side hold	1	Intersection of inner hull longitudinal bulkhead, inner bottom plating and double bottom side girder in way of floor	Fig A.3(5) Position 1
	2	Intersection of inner hull longitudinal bulkhead with bilge tank top plating in way of transverse web	Fig A.3(2) Position 3
Bilge tank	1	Intersection of bilge tank longitudinal bulkhead, inner bottom plating and double bottom side girder in way of floor	Fig A.3(2) Position 4
	2	Connections in way of bilge tank stepped longitudinal bulkhead	Fig A.3(6) Position 1
Watertight & non-watertight bulkheads	1	Connection of cargo hold hatch end beam to inner hull longitudinal bulkhead (including 2 nd deck)	Fig A.3(2) Position 5
	2	Toe connection of vertical web to inner bottom plating	Fig A.3(2) Position 6
	3	Intersection of transverse bulkhead plating or bulkhead bottom box side plating, floor, inner bottom plating and double bottom longitudinal girder	Fig A.3(7) Position 1

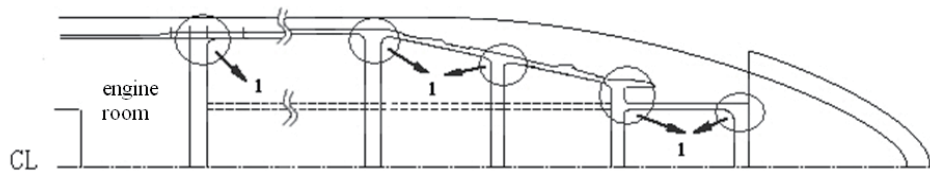


Figure A.3(1)

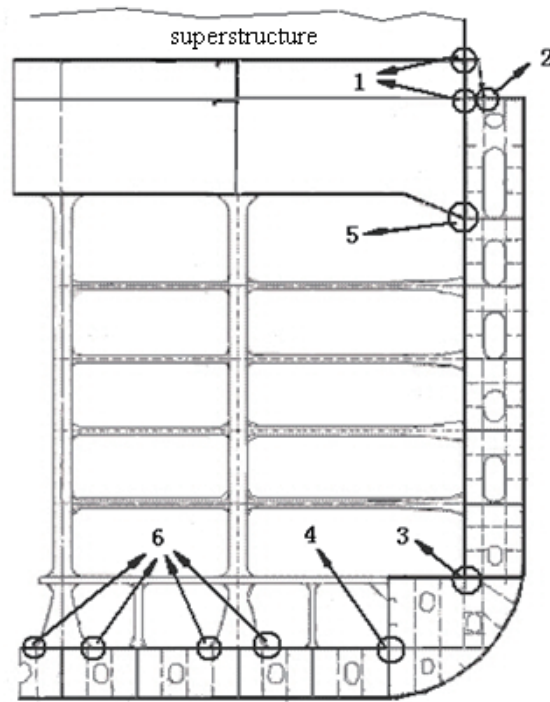


Figure A.3(2)

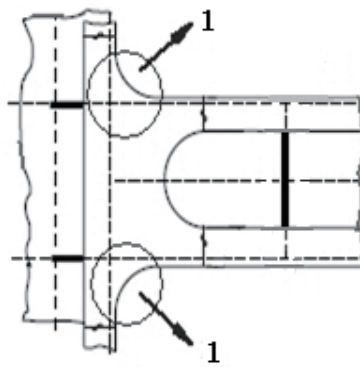


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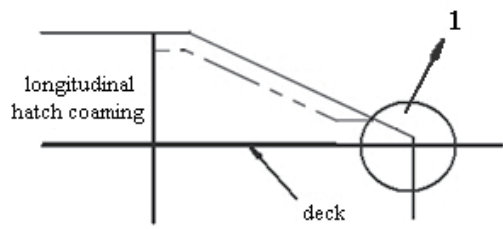
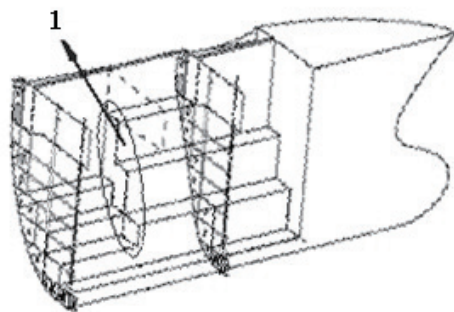


Figure A.3(4)



Figure A.3(5)



FigureA.3(6)

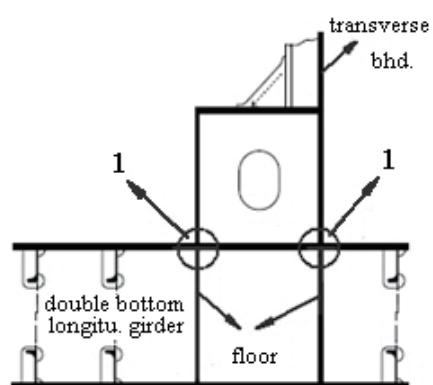


Figure A.3(7)

Critical locations of membrane LNG carriers

Table A.4

Structure	No.	Critical Location	Figure
Inner hull	1	Hopper sloping plating connection to inner bottom plating	Fig. A.4(1), Position 1
	2	Hopper sloping plating intersection to side longitudinal bulkhead plating	Fig. A.4(1), Position 2
	3	Chamfer sloping plating connection to side longitudinal bulkhead plating	Fig. A.4(1), Position 3
	4	Chamfer sloping plating connection to inner deck plating	Fig. A.4(1), Position 4
Double bottom	1	Longitudinal girder plating connection to inner bottom plating in way of transverse BHD	Fig. A.4(2), Position 1
	2	Longitudinal girder plating connection to lower hopper knuckle	Fig. A.4(1), Position 1
	3	Double bottom longitudinals connection to partial girder plating	Fig. A.4(3), Position 1
Double Side	1	Longitudinal stringer plating connection to side longitudinal bulkhead plating	Fig. A.4(4), Position 1
	2	Longitudinal stringer plating connection to upper hopper knuckle	Fig. A.4(1), Position 2
	3	Longitudinal stringer plating connection to lower chamfer knuckle	Fig. A.4(1), Position 3
Double Deck	1	Trunk deck plating connection to upper deck plating	Fig. A.4(1), Position 5
	2	Longitudinal deck girder plating connection to inner deck plating	Fig. A.4(2), Position 2
	3	Longitudinal deck girder plating connection to upper chamfer knuckle	Fig. A.4(1), Position 4
	4	Double deck longitudinals connection to partial deck girder plating	Fig. A.4(3), Position 2
	5	Inner deck plating connection to coaming of liquid dome opening	Fig. A.4(7), Position 1
	6	Trunk deck plating connection to coaming of liquid dome opening	Fig. A.4(7), Position 2
	7	Corners of rectangular liquid dome opening on the trunk deck	Fig. A.4(8), Position 1
	8	End bracket of trunk deck sloping plating	Fig. A.4(9), Position 1
	9	End bracket of chamfer sloping plating	Fig. A.4(9), Position 2
Transverse Bulkhead	1	Transverse bulkhead plating connection to inner bottom plating and double bottom floor	Fig. A.4(6), Position 1
	2	Transverse bulkhead plating connection to side longitudinal bulkhead plating and double side web	Fig. A.4(6), Position 2
	3	Vertical diaphragm plating connection to double bottom longitudinal girder plating	Fig. A.4(2), Position 1
	4	Vertical diaphragm plating connection to double deck longitudinal girder plating	Fig. A.4(2), Position 2
	5	Horizontal stringer plating connection to double side longitudinal stringer	Fig. A.4(4), Position 1
	6	Partial horizontal stringer plating connection to double side longitudinal stringer	Fig. A.4(5), Position 1

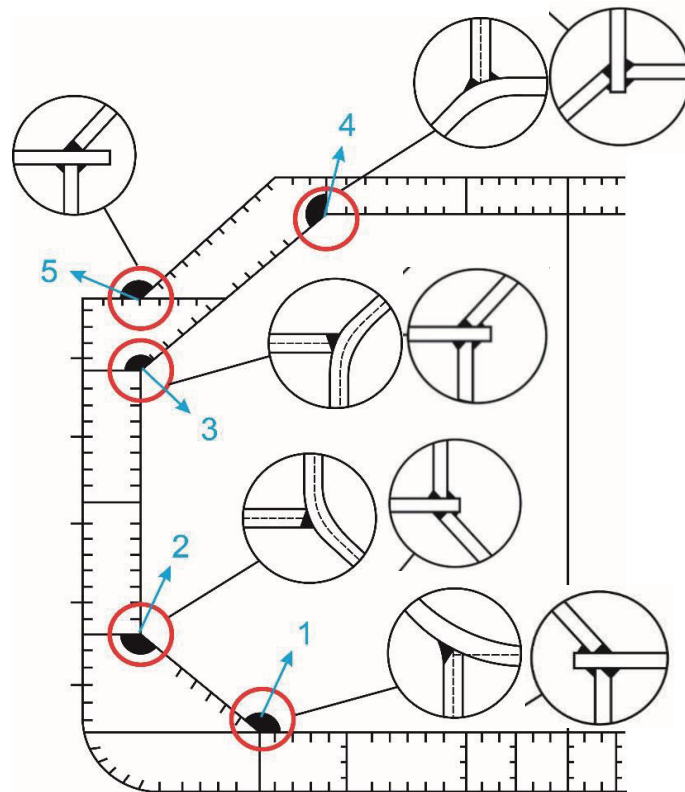


Figure A.4(1)

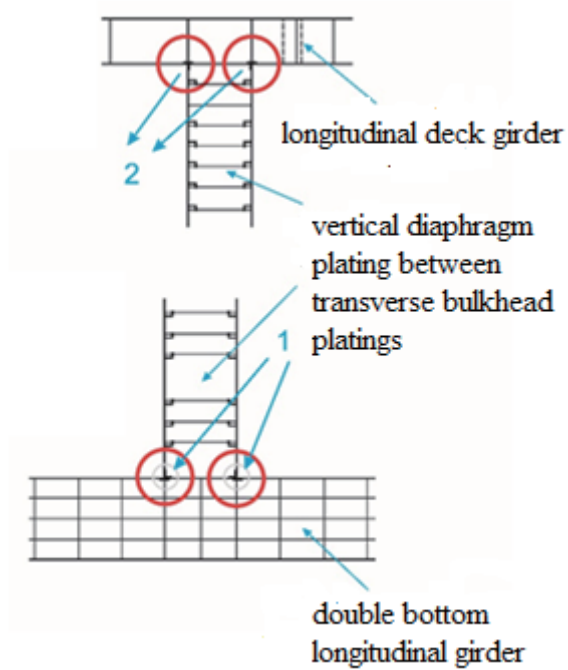


Figure A.4(2)

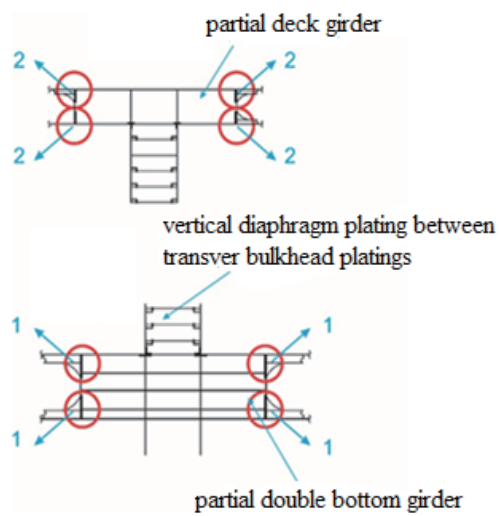


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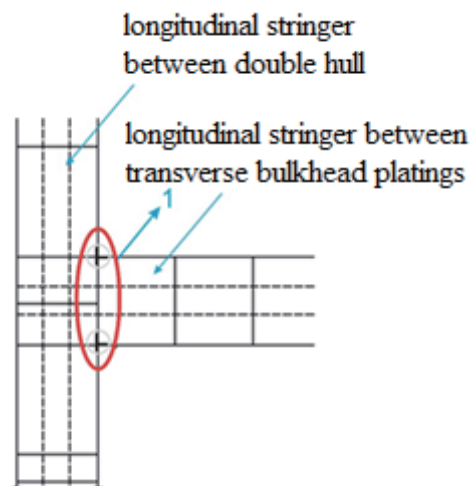


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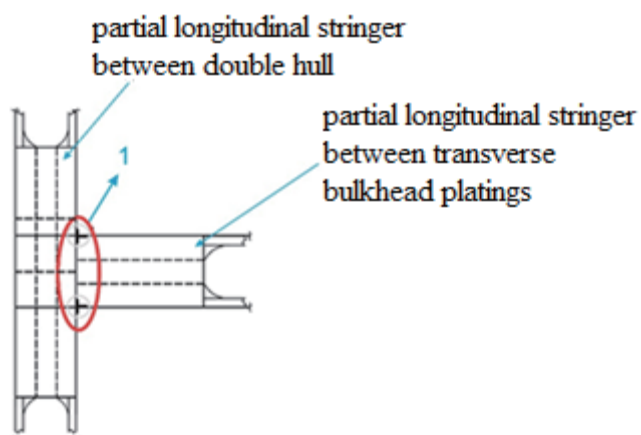


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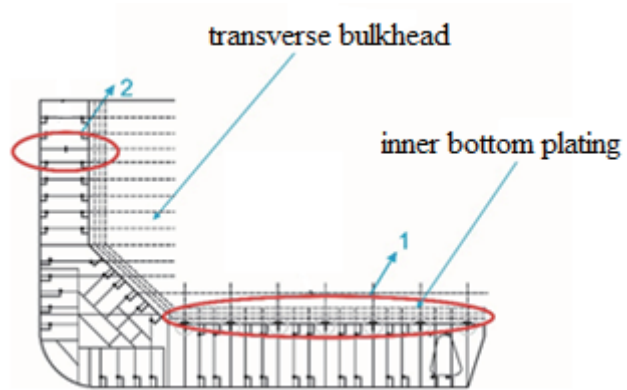


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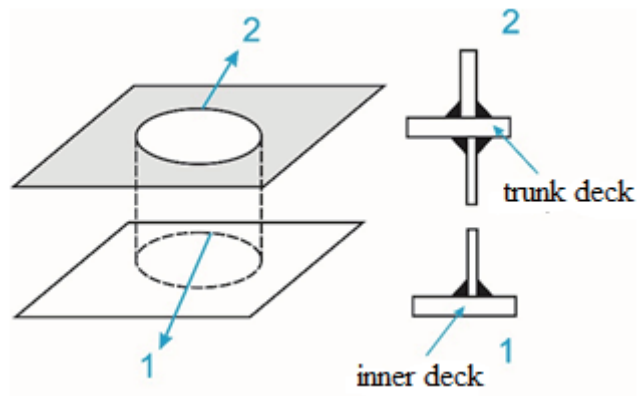


Figure A.4(7)

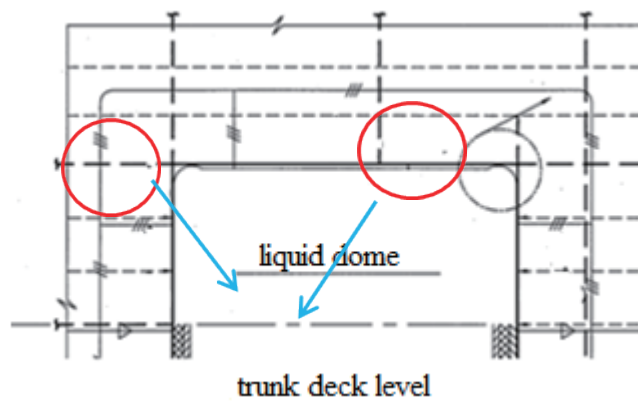


Figure A.4(8)

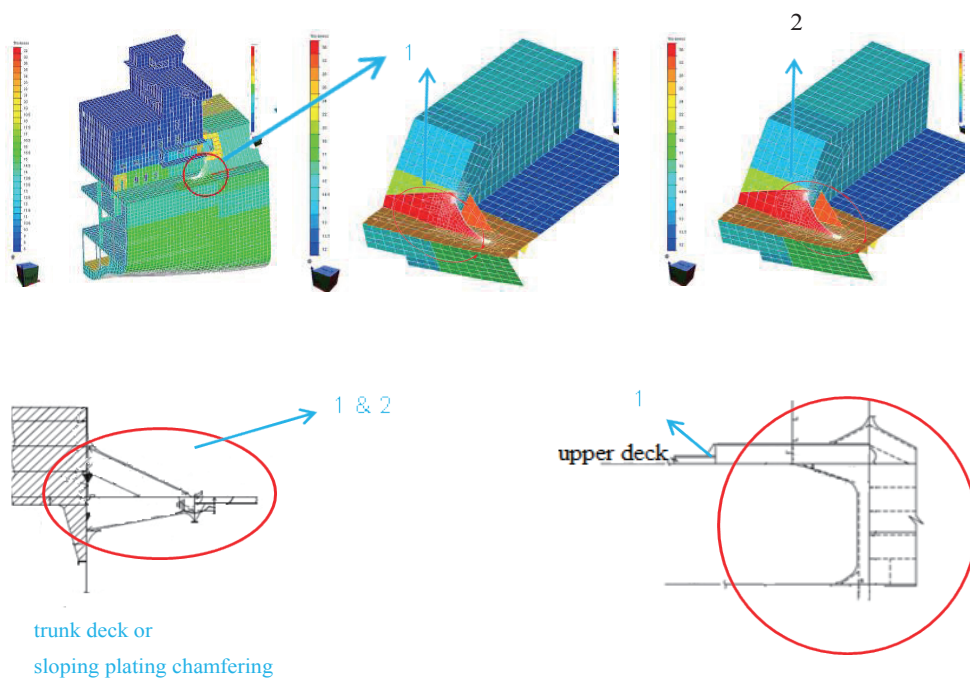


Figure A.4(9)

Appendix B

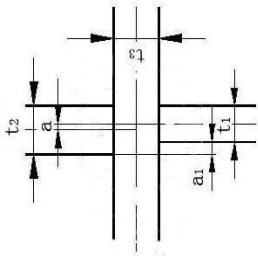
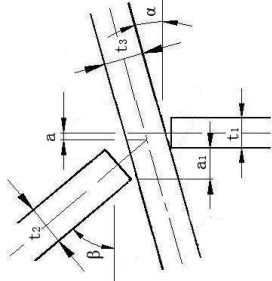
CONSTRUCTION MONITORING STANDARD (CMS)
FOR HULL STRUCTURES

1 General requirements

1.1 This Appendix gives fit-up and alignment requirements as well as possible remedial measures for critical locations of key hull structures.

1.2 In addition to the requirements given in this Appendix, other requirements for cutting, fit-up and repair are to comply with ship construction standards accepted by CCS.

Alignment Standard for Critical Locations of Hull Structures **Table B1**

Joint type	Standard	Limit	Remedial measures
 Cross joint	Practical tolerance a_1: $\Delta t - a \leq a_1 \leq \Delta t + a$ where: $\Delta t = \frac{1}{2} (t_2 - t_1)$ a = theoretical alignment tolerance = $t_{\min}/4$ $t_{\min} = t_1, t_2$ or t_3, whichever is the smallest Note: Cross joint is a special case of oblique cross joint when $\alpha = 0^\circ, \beta = 90^\circ$	Practical tolerance a_1: $\Delta t - a \leq a_1 \leq \Delta t + a$ where: $\Delta t = \frac{1}{2} (t_2 - t_1)$ $a = t_{\min}/3$ and not greater than 5 mm $t_{\min} = t_1, t_2$ or t_3, whichever is the smallest Where a_1 goes beyond the above range, release and refit over a minimum 50 a to achieve compliance	Where tolerance is within the range below, weld leg may be increased by 10%~15%: $\Delta t - 1.5a \leq a_1 \leq \Delta t - a, \text{ or}$ $\Delta t + a \leq a_1 \leq \Delta t + 1.5a$ where: $\Delta t = \frac{1}{2} (t_2 - t_1)$ $a = t_{\min}/3$ and not greater than 5 mm $t_{\min} = t_1, t_2$ or t_3, whichever is the smallest Where a_1 goes beyond the above range, release and refit over a minimum 50 a to achieve compliance
 Oblique cross joint	Practical tolerance a_1: $\Delta t - a \leq a_1 \leq \Delta t + a$ where: $\Delta t = \frac{1}{2} \left(\frac{t_2 \cos \alpha}{\sin(\beta + \alpha)} + \frac{t_3 \cos \beta}{\sin(\beta + \alpha)} - t_1 \right)$ a = theoretical alignment tolerance = $t_{\min}/4$ $t_{\min} = t_1, t_2$ or t_3, whichever is the smallest Note: Heel of sloping plate t_2 is to be measured using a surface of vertical plate t_1 which intersects with plate t_3 as the baseline. If the tolerance a_1 is positive, heel is deemed on the outer side of the surface of the vertical plate t_1, if negative, inner side	Practical tolerance a_1: $\Delta t - a \leq a_1 \leq \Delta t + a$ where: $\Delta t = \frac{1}{2} \left(\frac{t_2 \cos \alpha}{\sin(\beta + \alpha)} + \frac{t_3 \cos \beta}{\sin(\beta + \alpha)} - t_1 \right)$ $a = t_{\min}/3$ and not greater than 5 mm $t_{\min} = t_1, t_2$ or t_3, whichever is the smallest Where a_1 goes beyond the above range, release and refit over a minimum 50 a to achieve compliance	Where tolerance is within the range below, weld leg may be increased by 10%~15%: $\Delta t - 1.5a \leq a_1 \leq \Delta t - a, \text{ or}$ $\Delta t + a \leq a_1 \leq \Delta t + 1.5a$ where: $\Delta t = \frac{1}{2} \left(\frac{t_2 \cos \alpha}{\sin(\beta + \alpha)} + \frac{t_3 \cos \beta}{\sin(\beta + \alpha)} - t_1 \right)$ $a = t_{\min}/3$ and not greater than 5 mm $t_{\min} = t_1, t_2$ or t_3, whichever is the smallest Where a_1 goes beyond the above range, release and refit over a minimum 50 a to achieve compliance

Appendix C

Sample Construction Monitoring Plan (CMP)

Construction Monitoring Plan for XXX,XXX DWT Bulk Carrier

(This appendix only serves as reference for development of CMP and not all details are covered)

1 Objective

1.1 The objective of this procedure is for, throughout design and construction phases and the ship's whole lifetime of service, monitoring all the critical locations that are prone to high stress or fatigue damage on the ship, so as to ensure that construction and construction workmanship of all the critical locations comply with the Construction Monitoring Standard (CMS) attached in this CMP and attain the requirement for the assignment and maintenance of the **CM** notation.

2 Control monitoring

2.1 Indication of critical locations and relevant construction requirements

The critical locations identified are to be indicated in the summary table of all critical locations of hull structures (see Annex 2).

In addition, structural design drawings for various critical locations are to contain all of the relevant information required for the accurate construction of the critical locations such as alignment tolerances, reference lines marking, welding details, fit-up information, etc. All critical locations are to be marked with **CM** on the structural design drawings.

2.2 Alignment

Alignment tolerances for critical structural components are given in the summary table in Annex 3.

Reference lines required for the alignment inspection of structural components during construction are to be clearly marked on both sides of the plate for examination prior to and after welding.

2.3 Welding

Prior to welding of all critical structural components, grooves and gaps are to be inspected in accordance with the CMS indicated in Annex 1 of this CMP.

2.4 Remedy of non-compliance

If misalignment or unacceptable welding is observed upon the examination of critical structural components during the process of construction, remedial measures are to be taken in compliance with the CMS given in Annex 1.

2.5 Monitoring of ships in service

The CMP is to be kept onboard for use in future surveys after the ship is delivered and put into service.

3 Monitoring during construction

3.1 Assembly of units

Prior to assembly of units at critical locations, the units are to be inspected for alignment and welding preparation to ensure that the CMS (see Annex 1) is complied with, and particularly to make sure that the reference lines are clearly and properly marked.

3.2 Block assembly

During block assembly phase, reference lines necessary for block construction are to be marked. Then the yard's quality control personnel are to inspect each critical location to ensure that they are fitted up in compliance with the CMP. Upon completion of the inspection, the yard is to notify the site Surveyor. The Surveyor is to inspect the records provided by the yard and do sample recheck. If the recheck results are satisfactory, welding will be carried out. Upon completion of welding, the yard's quality control personnel and site Surveyor are to inspect and recheck welding quality respectively. If critical locations are not aligned and welded in compliance with the requirements in the CMS, the yard is to take remedial measures strictly in line with the CMS.

3.3 Reports and records

The yard's quality control personnel are to record the inspection results of alignment of each critical structural component prior to welding and of welding quality after welding. The site Surveyor is to record the sample recheck results of alignment and welding quality of the critical structural components.

4 Monitoring of ships in service

4.1 After the ship is delivered, the CMP is to be maintained on board as finished documents. The shipowner and Surveyor are to give special attention to critical structural components indicated in the CMP during the service life of the ship.

Annexes

1. Construction monitoring standard for hull structures (see Appendix B of the Guidelines) (omitted)
2. Summary table and diagram of critical locations of hull structures
3. Hold No.X Critical Location Cross Alignment Tolerances — Summary and Node Figure (Example)
4. Records of Hull Structure Fit-up Monitoring Results
5. List of drawings and documents related to CMP

Annex 1
Construction Monitoring Standard for Hull Structures (CMS)

See Appendix B of the Guidelines (Omitted).

Annex 2
Summary Table and Diagram of Critical Locations of Hull Structures

Summary Table and Diagram of Critical Locations of Holds No.3 to No.7

No.	Critical location	Diagram	Key elements for control
S308-CX-101	Cargo hold hatch coaming longitudinal end bracket	Fig. C2-1 CM001	Cutting (lines, fairness, edge chamfering), end round weld, toe grinding
S308-CX-102	Connection of cargo hold hatch end beam to topside tank transverse web frames	Fig. C2-1 CM002	Fit-up (alignment, gap, groove angle), weld profile and quality
S308-CX-103	Connection of hatch coaming longitudinal end bracket to topside tank vertical plating	Fig. C2-1 CM003	Fit-up (alignment, gap, groove angle), weld profile and quality
S308-FXXX-201	Connection of hold main frame to topside tank web frames (in way of topside tank sloping plating)	Fig. C2-1 CM004	Fit-up (alignment, gap, groove angle), weld profile and quality
S308-FXXX-202	Connection of hold main frame to hopper tank web frames (in way of hopper tank sloping plating)	Fig. C2-1 CM005	Fit-up (alignment, gap, groove angle), weld profile and quality, surface grinding
S308-FXXX-203	Connection of hopper tank sloping plating to double bottom longitudinal girder (in way of inner bottom)	Fig. C2-1 CM006	Fit-up (alignment, gap, groove angle), weld profile and quality

Note: “CX” represents the serial number of cargo holds and “FXXX” the serial number of frames.

**Summary Table and Diagram of Critical Locations at
Transverse Bulkheads of Frames No.150 to 198**

No	Critical location	Diagram	Key elements for control
S308-FXXX-301	Connection of lower stool side plating to corrugated bulkhead (in way of stool top plating)	FigC2-2 CM007	Fit-up (alignment, gap, groove angle), weld profile and quality
S308-FXXX-302	Connection of lower stool sloping plating to corrugated bulkhead (in way of stool top plating)	FigC2-2 CM008	Fit-up (alignment, gap, groove angle), weld profile and quality
S308-FXXX-303	Connection of double bottom floor and lower stool side plating (in way of inner bottom)	FigC2-2 CM009	Fit-up (alignment, gap, groove angle), weld profile and quality
S308-FXXX-304	Connection of double bottom floor and lower stool sloping plating (in way of inner bottom)	FigC2-2 CM010	Fit-up (alignment, gap, groove angle), weld profile and quality

Note: “XXX” represents the serial number of frames.

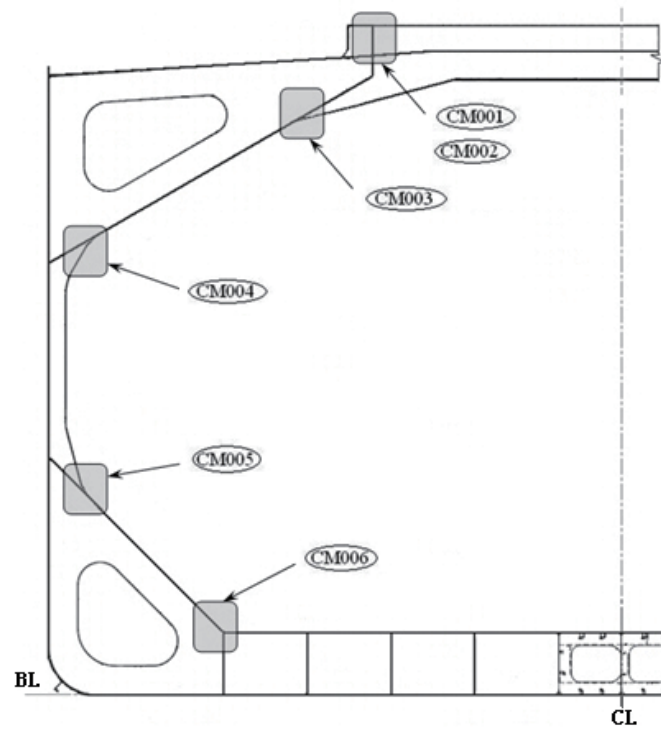


Figure C2-1 Diagram of Critical Locations at Transverse Sections

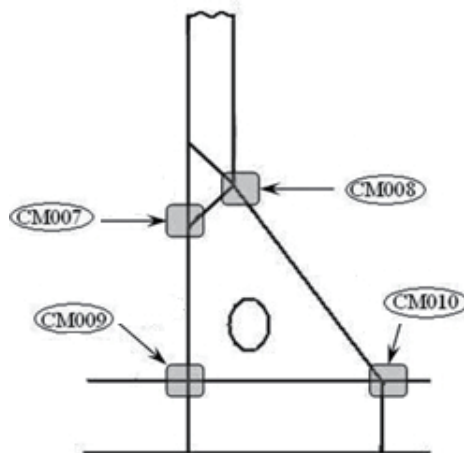


Figure C2-2 Diagram of Critical Locations at Transverse Bulkheads

Annex 3

Hold No.X Critical Location Cross Alignment Tolerances—Summary and Node Figure (Example)

No.	Critical location	Data	Alignment tolerance (mm)	Node Figure
S308-CX-102	Connection of cargo hold hatch end beam to topside tank transverse web frames (in way of topside tank vertical plating)	$t_1=14\text{mm}, t_2=18\text{mm}, t_3=26\text{mm}$ $\theta_1=\theta_2=\theta_3=\theta_4=0^\circ$ $p_1=t_1, p_2=t_2, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 4.7$, or $\alpha_1=-2.7\sim 6.7$	Fig. C3-1
S308-CX-103	Connection of hatch coaming longitudinal end bracket to topside tank vertical plating	$t_1=14.5\text{mm}, t_2=13\text{mm}, t_3=26\text{mm}$ $\theta_1=50^\circ, \theta_2=0^\circ, \theta_3=50^\circ, \theta_4=0^\circ$ $p_1=p_2=0\sim 3\text{mm}, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 4.3$, or $\alpha_1=-5.1\sim 3.5$	Fig. C3-1
S308-FXXX-201	Connection of hold main frame to topside tank web frames (in way of topside tank sloping plating)	$t_1=13\text{mm}, t_2=16\text{mm}, t_3=16\text{mm}$ $\theta_1=\theta_2=\theta_3=\theta_4=0^\circ$ $p_1=t_1, p_2=t_2, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 4.3$, or $\alpha_1=-2.8\sim 5.8$	Fig. C3-1
S308-FXXX-202	Connection of hold main frame to hopper tank web frames (in way of hopper tank sloping plating)	$t_1=14\text{mm}, t_2=18\text{mm}, t_3=20\text{mm}$ $\theta_1=\theta_2=\theta_3=\theta_4=0^\circ$ $p_1=t_1, p_2=t_2, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 4.7$, or $\alpha_1=-2.7\sim 6.7$	Fig. C3-1
S308-FXXX-203	Connection of hopper tank sloping plating to double bottom longitudinal girder (in way of inner bottom)	$t_1=14\text{mm}, t_2=22.5\text{mm}, t_3=25.5\text{mm}$ $\theta_1=45^\circ, \theta_2=45^\circ, \theta_3=50^\circ, p_1=0\sim 3\text{mm}$ $\beta=45^\circ, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 4.7$, or $\alpha_1=+17.0\sim 26.3$	Fig. C3-2
S308-FXXX-301	Connection of lower stool side plating to corrugated bulkhead (in way of stool top plating)	$t_1=23\text{mm}, t_2=23\text{mm}, t_3=23\text{mm}$ $\theta_1=\theta_2=45^\circ, \alpha=45^\circ$ $g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 5.0$, or $\alpha_1=-5.0\sim 5.0$	Fig. C3-3
S308-FXXX-302	Connection of lower stool sloping plating to corrugated bulkhead (in way of stool top plating)	$t_1=23\text{mm}, t_2=23\text{mm}, t_3=23\text{mm}$ $\theta_1=50^\circ, \theta_2=45^\circ, \alpha=45^\circ, \beta=55^\circ$ $g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 5.0$, or $\alpha_1=-1.5\sim 8.5$	Fig. C3-4
S308-FXXX-303	Connection of double bottom floor and lower stool side plating (in way of inner bottom)	$t_1=18\text{mm}, t_2=16\text{mm}, t_3=22.5\text{mm}$ $\theta_1=\theta_2=45^\circ, \theta_3=\theta_4=45^\circ, p_1=6\text{mm}$ $p_2=0\sim 3\text{mm}, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 5.0$, or $\alpha_1=-6.0\sim 4.0$	Fig. C3-1
S308-FXXX-304	Connection of double bottom floor and lower stool sloping plating (in way of inner bottom)	$t_1=18\text{mm}, t_2=21.5\text{mm}, t_3=22.5\text{mm}$ $\theta_1=\theta_2=45^\circ, \theta_3=50^\circ, p_1=6\text{mm}$ $\beta=55^\circ, g_1=g_2=0\sim 2\text{mm}$	$\alpha=\pm 5$, or $\alpha_1=+7.0\sim 17.0$	Fig. C3-2

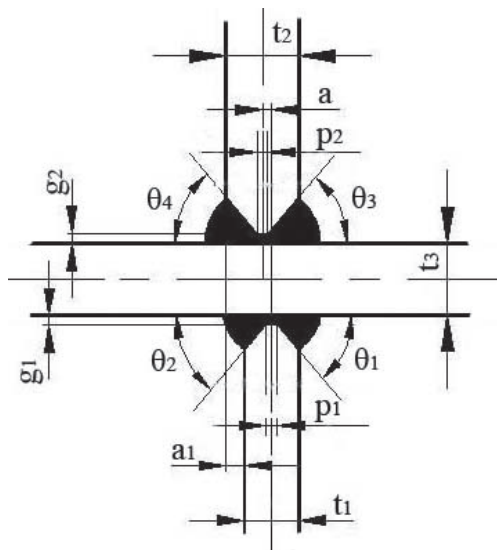


Figure C3-1 Cross joint

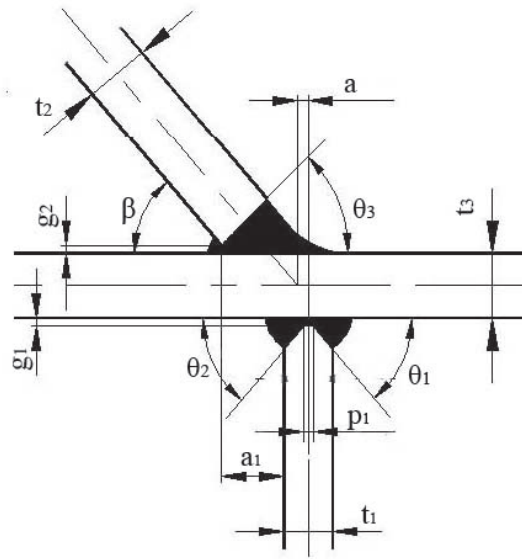


Figure C3-2 Oblique cross joint

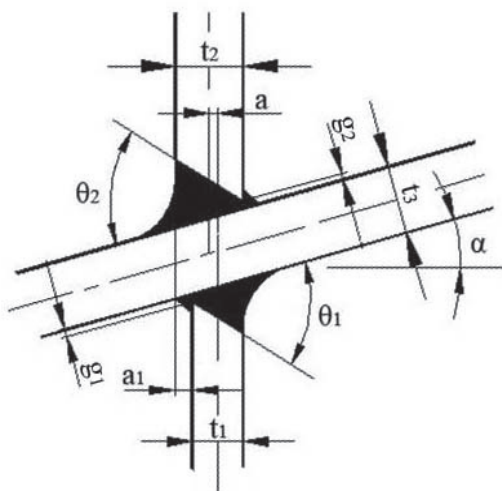


Figure C3-3 Cross joint with angled diaphragm

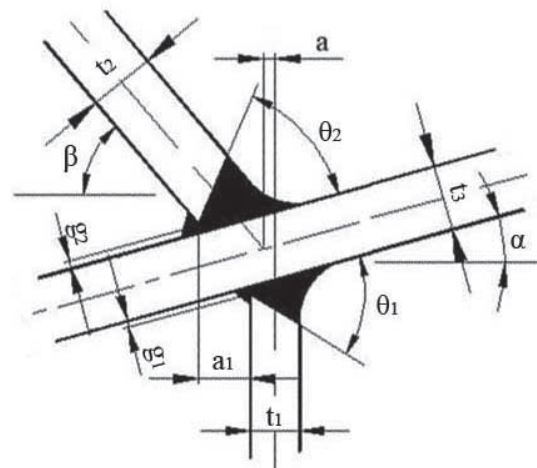


Figure C3-4 Oblique cross joint with angled diaphragm

Annex 4

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Annex 5
List of Drawings and Documents Related to CMP

1. Structural drawing of cargo hold
2. Typical transverse section drawing

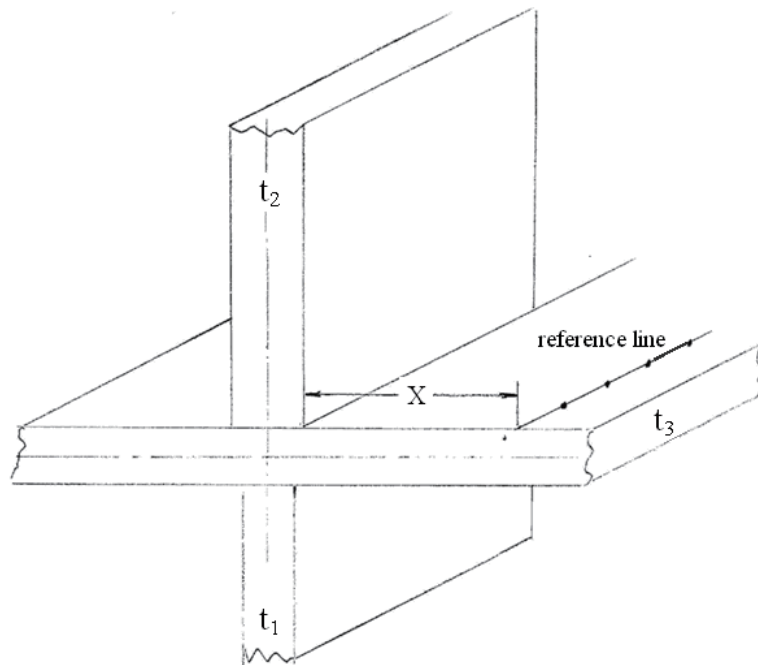
Appendix D

References Lines Marking for Alignment Inspection

For cross or oblique cross joints with diaphragms in between, references lines are to be marked on the diaphragm to ensure alignment. Location of reference lines are determined by the following formulae respective for three different types of joints:

It is assumed in the figure that the distance between the reference line and the intersection of the three plates is 50 mm. t_3 is the thickness of the diaphragm, t_1 , the thickness of the plate pre-fitted to the diaphragm, and t_2 , the thickness of the plate to be aligned and fixed.

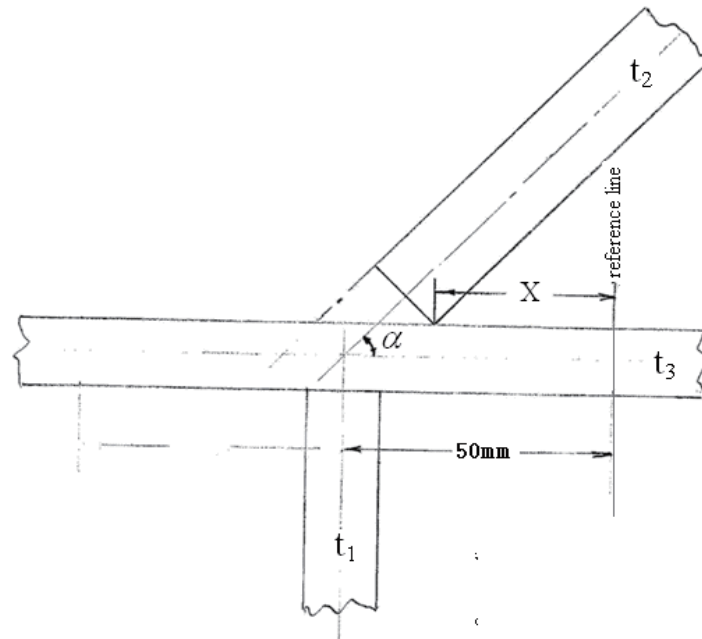
1 Cross joint



Distance between the reference line and heel of Plate t_2 is: $X = 50 - \frac{t_3}{2}$ mm

2 Oblique cross joint

1. The diaphragm t_3 is horizontal:

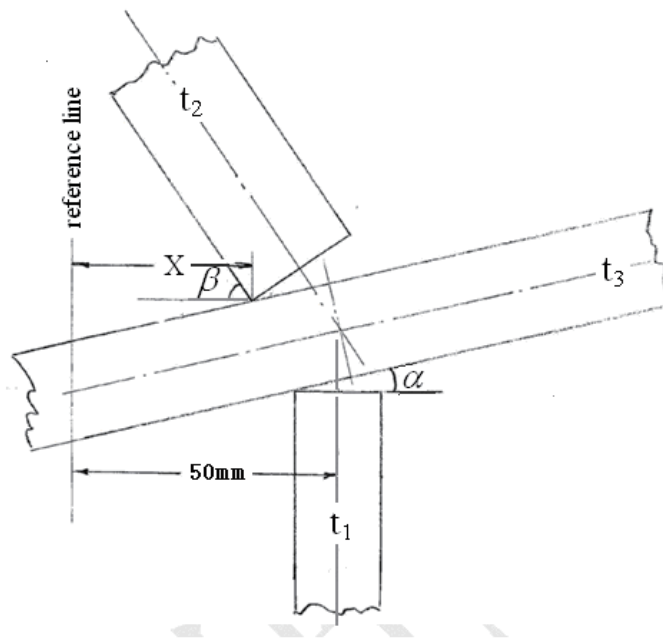


The reference line used for alignment of Plate t_2 is to be marked on the side of the acute angle as far as possible, then:

$$X = 50 - \frac{1}{2} \left(\frac{t_2}{\sin \alpha} + \frac{t_3}{\tan \alpha} \right) \quad \text{mm}$$

2. The diaphragm t_3 is inclined in the angle α :

Angle of Plate t_2 to the horizontal is β , as shown in the figure below:



Horizontal distance between heel of Plate t_2 and the reference line marked on Plate t_3 on the side of the acute angle is:

$$X = 50 \cdot \frac{1}{2} \left[\frac{t_2 \cos \alpha}{\sin(\alpha + \beta)} + \frac{t_3 \cos \beta}{\sin(\alpha + \beta)} \right] \quad \text{mm}$$