Common Structural Rules for Bulk Carriers, January 2006

Background Document

CHAPTER 3 – STRUCTURAL DESIGN PRINCIPLES

NOTE:

- This TB is published to improve the transparency of CSRs and increase the understanding of CSRs in the industry.
- The content of the TB is not to be considered as requirements.
- This TB cannot be used to avoid any requirements in CSRs, and in cases where this TB deviates from the Rules, the Rules have precedence.
- This TB provides the background for the first version (January 2006) of the CSRs, and is not subject to maintenance.

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SECTION 1 – MATERIALS

1. GENERAL

1.1 Standard of material

1.1.1

1.1.1.a Since regulations related to material standards, material tests, and manufacturing methods exist in the rules of every classification society, general regulations have been specified to refer to them.

1.1.2

1.1.2.a Since regulations related to material standards, material tests, and manufacturing methods exist in the rules of every classification society, general regulations have been specified to refer to them.

1.2 Testing of materials

1.2.1

1.2.1.a Since regulations related to material standards, material tests, and manufacturing methods exist in the rules of every classification society, general regulations have been specified to refer to them.

1.3 Manufacturing processes

1.3.1

1.3.1.a Since regulations related to material standards, material tests, and manufacturing methods exist in the rules of every classification society, general regulations have been specified to refer to them.

2. HULL STRUCTURAL STEEL

2.1 General

2.1.1

2.1.1.a This regulation is in accordance with IACS UR W11.

2.1.2

2.1.2.a This regulation is in accordance with IACS UR W11.

2.1.3

2.1.3.a This regulation is in accordance with IACS UR W11.

2.1.4

2.1.4.a This regulation is in accordance with IACS UR W11.

2.1.5

2.1.5.a This regulation is in accordance with IACS UR W11.

2.2 Material factor *k*

2.2.1

2.2.1.a Material factor specified in 2.2 is arrived at by including the material factor of HT40, 0.68, specified in the regulation IACS UR S4. The material factor of HT40 has been established based on the existing treatment in each classification society, and is therefore consistent with the value in Part CSR-T.

2.3 Grades of steel

2.3.1

2.3.1.a Regulations related to steel grades specified in 2.3, 2.4, and usage categories of materials are the same as in IACS UR S6. CSR evaluates structural dimensions based on the net scantling approach, but the usage categories of steel are based on the gross scantlings (scantlings in drawings).

There is a requirement in Reg. 6.5.3, Chapter XII of the SOLAS Convention and its interpretation in Clause 4.2 of SLS. 14 Circ. 250 that states, "If the damage is a crack in the weld, its instantaneous propagation should be avoided. This should be realized by appropriate design and selection of material." To comply with this requirement, CSR has usage categories of material as in Table 4 in the rules. For BC-A and BC-B ships complying with Reg. 6.5.3, Chapter 12 of the SOLAS Convention, the material at locations in the range of 0.125 times the span of hold frames above and below the point of intersection of the hold frame lower bracket, side shell plating and bilge hopper slant plate in single side skin structure is required to be higher than grade D/DH.

2.3.2

2.3.2.a This regulation is in accordance with IACS UR S6.1.

2.3.3

2.3.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, Note 2 of Table 3.

2.3.4

2.3.4.a This regulation is based on BV Rules Part B Chapter 4 Section 1, Note 3 of Table 3.

2.3.5

2.3.5.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.4.

2.3.6

2.3.6.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.5.

2.3.7

2.3.7.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.6.

2.3.8

2.3.8.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.7.

2.3.9

2.3.9.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.8.

2.3.10

2.3.10.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.9.

2.3.11

2.3.11.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 2.4.10.

2.4 Structures exposed to low air temperature

2.4.1

2.4.1.a It is considered that for this topic, no information in addition to that shown in the Rules is necessary to explain the background.

2.4.2

2.4.2.a This regulation is in accordance with IACS UR S6.2.

2.4.3

2.4.3.a This regulation is in accordance with IACS UR S6.2.

2.4.4

2.4.4.a This regulation is in accordance with IACS UR S6.2.

2.4.5

2.4.5.a This regulation is in accordance with IACS UR S6.2.

2.4.6

2.4.6.a This regulation is in accordance with IACS UR S6.2.

3. STEELS FOR FORGING AND CASTING

3.1 General

3.1.1

3.1.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.1.1.

3.1.2

3.1.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.1.2.

3.1.3

3.1.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.1.3.

3.2 Steels for forging

3.2.1

3.2.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.2.2.

3.3 Steels for casting

3.3.1

3.3.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.3.1.

3.3.2

3.3.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.3.3.

3.3.3

3.3.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 3.3.4.

4. ALUMINIUM ALLOY STRUCTURES

4.1 General

4.1.1

4.1.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.1.1.

4.1.2

4.1.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.1.2.

4.1.3

4.1.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.1.3.

4.2 Extruded plating

4.2.1

4.2.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.2.1.

4.2.2

4.2.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.2.2.

4.2.3

4.2.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.2.3.

4.2.4

4.2.4.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.2.4.

4.3 Mechanical propertied of weld joints

4.3.1

4.3.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.3.1.

4.3.2

4.3.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.3.2.

4.3.3

4.3.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.3.3.

4.4 Material factor *k*

4.4.1

4.4.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.4.1.

4.4.2

4.4.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 4.4.2.

5. OTHER MATERIALS AND PRODUCTS

5.1 General

5.1.1

5.1.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 5.1.1.

5.1.2

5.1.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 5.1.2.

5.1.3

5.1.3.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 5.1.3.

5.2 Iron cast parts

5.2.1

5.2.1.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 5.2.1.

5.2.2

5.2.2.a This regulation is based on BV Rules Part B Chapter 4 Section 1, 5.2.2.

SECTION 2 – NET SCANTLING APPROACH

1. GENERAL PHILOSOPHY

1.1

1.1.1

1.1.1.a This regulation gives the concept of the net scantling approach. In CSR for Bulk Carriers, similar to CSR for Tankers, all strength regulations including those for fatigue strength assessment are based on the net scantling approach.

2. APPLICATION CRITERIA

2.1 General

2.1.1

2.1.1.a The structural scantlings in the Rules are based on the net scantling approach, but for massive structures such as superstructure, deck house, rudder structure, and massive pieces of forgings and castings, the scantlings of which are decided by empirical formulae, one cannot distinguish clearly the scantlings according to strength and the scantlings according to corrosion and thickness diminution; therefore, the non-application of the net scantling approach has been noted in 2.1.1.

2.1.2

2.1.2.a This regulation describes the strength properties for which the net scantling approach is applicable.

2.1.3

2.1.3.a This regulation shows that the as-built scantlings are greater than the required gross scantlings. If addition in plating thickness is requested by the shipowner, the as-built scantlings will include this addition. The required gross scantling is the scantling obtained by adding the corrosion addition specified in Section 3, Chapter 3 to the required net scantling, as described in the explanations on notations. The corrosion addition is in 0.5-mm units, but the required net scantlings are not in 0.5-mm units. To round off the required net scantlings to 0.5-mm units, the method adopted was to round off to one decimal digit by discarding the second decimal digit if its value is 2 and below, and adding 1 to the first digit if the value of the second digit is 3 and above. This method is consistent with the method used in CSR for Tankers.

3. NET SCANTLING APPROACH

3.1 Net scantling definition

3.1.1 Required thickness

3.1.1.a Definition of required thickness is specified.

This regulation has been set to define the net scantling approach. Net scantlings can be broadly divided into two parts as follows:

(a) Required thickness determined from rule formulae

(b) Scantling that determines the structural properties, such as section properties from rule formulae, or thickness assessed from direct strength calculations, longitudinal bending strength, or fatigue strength assessment.

The irem (a) mentioned above was defined as the required net scantling, while the item (b) mentioned above was defined as the offered net scantling, and the applicable method of corrosion addition for each case was clearly defined.

3.1.2 Offered thickness

3.1.2.a Definition of offered thickness is specified.

3.1.3 Net thickness for plate

3.1.3.a Definition of net thickness for plate (net thickness offered) is specified.

3.1.4 Net section modulus for stiffener

3.1.4.a This regulation is a clarification of net section modulus for stiffener.

3.2 Considered net scantling

3.2.1 Yielding check of the hull girder

3.2.1.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

Table 3.2.1 Application of corrosion addition

			Corrosion addition	HG stress
Local members and primary supporting members of ships below 150 m (rule formula)	Thickness (including minimum thickness)		t_{corr}	$0.5t_{corr}$
	Section characteristic		t_{corr}	$0.5t_{corr}$
FEA Primary supporting members of ships above 150 m	Stress assessment		$0.5t_{corr}$	$0.5t_{corr}$
	Buckling assessment		t_{corr}	$0.5t_{corr}$
	Minimum thickness		t_{corr}	
Hull Girder	Section characteristic		$0.5t_{corr}$	
	Buckling		t_{corr}	$0.5t_{corr}$
Hull girder ultimate strength			$0.5t_{corr}$	$0.5t_{corr}$
Fatigue strength	Stiffener		$0.5t_{corr}$	$0.5t_{corr}$
	FEA	General	$0.5t_{corr}$	$0.5t_{corr}$
		Detail	$0.5t_{corr}$	$0.5t_{corr}$

For assessment of overall strength by the direct strength calculation or assessment of hull girder strength, the assumption that the thickness of all structural members to be assessed reduces to the permissible wastage amount is an assumption on the side of excessive safety. Considering the variation in the corrosion phenomenon, reduction in thickness to the average wastage amount may be assumed, but half the corrosion addition may be considered as the average wastage amount. In assessing the buckling strength of stiffeners or panels, stresses acting on the stiffeners or panels are used assuming that complete structures are in a fully corroded state on the average. On the other hand, since critical buckling stresses in stiffeners or panels are for local structures, these structures are assumed to be in a fully corroded state of 100% of corrosion addition for assessment on the side of safety.

Repetitive loads encountered within the assumed service period were considered for fatigue strength assessment. Assessment is difficult for the elapsed period from the time of a new ship when the members to be assessed are not corroded at all, until the members to be assessed are in the wasted condition with the corrosion amount assumed for the assumed service period. It was therefore decided to assume an average corrosion and reduced thickness condition that occur during the assumed service period. In the application of average corrosion amount in the fatigue strength assessment, since corrosion is ignored during the period the painting is effective, the assessment is very much on the safe side. As a conclusion, two corrosion models are considered; that is 100% corrosion additions are taken for the local scantling formulae and buckling capacity assessment and 50% corrosion additions are taken for Hull girder check, FEA and Fatigue check.

3.2.2 Global stress such as stress due to hull girder bending moment and shear force

3.2.2.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

3.2.3 Buckling check of the hull girder

3.2.3.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

3.2.4 Ultimate strength check of the hull girder

3.2.4.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

3.2.5 Direct strength analysis

3.2.5.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

3.2.6 Fatigue check

3.2.6.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

3.2.7 Check of primary supporting members for ships less than 150m in length L

3.2.7.a The regulations of 3.2 show the application of corrosion addition for each strength assessment. A summary of the application of corrosion addition is shown in Table 3.2.1.

3.3 Available information on structural drawings

3.3.1

3.3.1.a The net scantling approach signifies thicknesses that become renewal criteria when the net scantling approach is applied. Accordingly, as-built thicknesses and renewal criteria should be stated in the structural drawings. If additional thicknesses requested by the shipowner exist, they should also be clearly specified on the drawings.

SECTION 3 – CORROSION ADDITIONS

1. CORROSION ADDITIONS

1.1 General

1.1.1

1.1.1.a Corrosion addition was set as the estimated value of corrosion amount in a 25-year period from progressive corrosion models based on the probabilistic theory and thickness measurement data of several hundred thousands of points. Regulations associating corrosion addition with painting requirements were set since members in ballast tank and cargo holds were required to be painted effectively. Since no data on steels other than carbon steel (general steel) exists, separate considerations are required for setting the corrosion addition.

1.2 Corrosion addition determination

1.2.1 Corrosion additions for steel

1.2.1.a The corrosion addition largely depends on the corrosive environment to which the steel is exposed. The factors for corrosive environment were analyzed and their results were summarized in Table 1 of the Rules. Corrosion addition for each structural member, particularly those that form the boundaries of compartments, is to be determined after considering the application to each side of the compartment.

The corrosion amount for each factor of the corrosive environment is in 0.1-mm units. However, considering the relationship of the corrosion amount with the renewal criteria and that the nominal thickness of steel is generally in 0.5-mm units, the value obtained by adding the value of the corrosive environment on one side to that of the other side is rounded up to 0.5-mm units, and to this value, the maximum value of corrosion amount estimated to progress during the survey interval (2.5 years) of 0.5 mm is added to arrive at the value of corrosion addition.

Regarding the application of corrosion addition, if a plate is subjected to multiple corrosion additions, the maximum corrosion addition of the plate will be applied.

1.2.2 Corrosion addition for aluminum alloys

1.2.2.a The Rules of each classification society require the use of corrosion-resistant aluminum alloys, in principle. Since the corrosion addition is taken as 0 mm in these Rules, CSR for Bulk Carriers has also followed the same provision.

SECTION 4 – LIMIT STATES

1. GENERAL

1.1 General principle

1.1.1

1.1.1.a The hull structure was classified into local structures considering local loads such as plates and stiffeners, primary supporting structures taking up loads on structural bodies such as girders, and the hull girder in which the entire hull structure is treated as a beam, for studying the strength characteristics to be assessed in CSR. The structural assessment items required for each structural category are shown in Table 1 in the rules.

1.1.2

1.1.2.a Strength characteristics are specified not only for the intact condition but also for assessing strength in the damaged condition (flooded condition that occurs as a result of damage).

1.2 Limit states

1.2.1 Serviceability limit state

1.2.1.a This regulation defines the limit states such that the definitions coincide with those in ISO 2394.

1.2.2 Ultimate limit state

1.2.2.a This regulation defines the limit states such that the definitions coincide with those in ISO 2394.

1.2.3 Fatigue limit state

1.2.3.a This regulation defines the limit states such that the definitions coincide with those in ISO 2394.

1.2.4 Accidental limit state

1.2.4.a This regulation defines the limit states such that the definitions coincide with those in ISO 2394. The flooded condition is considered as accidental limit states like IACS UR S17, S18 and S20.

2. STRENGTH CRITERIA

2.1 Serviceability limit states

2.1.1 Hull girder

2.1.1.a This regulation gives the load level for the yielding check of the hull girder corresponding to the serviceability limit state. The strength criterion is based on the working stress design method for the stress obtained by the beam theory. This philosophy is the same of IACS UR S11.

2.1.2 Plating

2.1.2.a This regulation gives the load level for the yielding and buckling strength check for platings constituting primary supporting members corresponding to the serviceability limit state. The stress of platings constituting primary supporting members are obtained by the Finite Element Analysis based on the elastic theory. The strength criterion is based on the working stress design method.

2.1.3 Ordinary stiffener

2.1.3.a This regulation gives the load level for the strength check for ordinary stiffener corresponding to the serviceability limit state. The strength criterion is based on the working stress design method for the stress of ordinary stiffeners obtained by the beam theory.

2.2 Ultimate limit state

2.2.1 Hull girder

2.2.1.a This regulation gives the load level for the ultimate strength check of the hull girder corresponding to the ultimate limit state. The strength criterion is based on the partial safety factor design method.

2.2.2 Plating

2.2.2.a This regulation gives the load level for the ultimate strength check of the platings corresponding to the ultimate limit state. The strength criterion is based on the working stress design method.

2.2.3 Ordinary stiffener

2.2.3.a This regulation gives the load level for the ultimate strength check of the ordinary stiffener corresponding to the ultimate limit state. This strength check is included in the buckling check of stiffeners.

2.3 Fatigue limit state

2.3.1 Structural details

2.3.1.a Fatigue strength of structural details such as connections of ordinary stiffeners and primary supporting members is assessed based on the linear cumulative fatigue damage procedure considering the cyclic loads during ship's life. This regulation gives the reference loads level for fatigue strength check.

2.4 Accidental limit state

2.4.1 Hull girder

2.4.1.a Refer to 1.2.4a.

2.4.2 Double bottom structure

2.4.2.a Refer to 1.2.4a.

2.4.3 Bulkhead structure

2.4.3.a Refer to 1.2.4a.

3. STRENGTH CHECK AGAINST IMPACT LOADS

3.1 General

3.1.1

3.1.1.a Impact loads differ from general wave loads, and it is difficult to debate the load level of an impact load. This regulation has been specified for general items, while only the concepts of strength criteria used in the Rules have been given in 3.1.2.

3.1.2

3.1.2.a This regulation has been specified for the concepts of strength criteria used in the Rules.

SECTION 5 – MEASURES AGAINST CORROSION

1. GENERAL

1.1 Structures to be protected

1.1.1

1.1.1.a Regulations for structures to be protected against corrosion are clearly specified based on the regulations of Chapter XII of the SOLAS Convention and the existing rules.

1.1.2

1.1.2.a Regulations for structures to be protected against corrosion are clearly specified based on the regulations of Chapter XII of the SOLAS Convention and the existing rules.

1.1.3

1.1.3.a In the existing rules, only the locations where paint is to be applied have been specified. Thus, compartments carrying fuel oil and narrow compartments not mentioned herein are subject to treatment similar to the existing rules. Narrow compartments can be filled generally with dry air.

1.1.4

1.1.4.a In the existing rules, only the locations where paint is to be applied have been specified. Thus, compartments carrying fuel oil and narrow compartments not mentioned herein are subject to treatment similar to the existing rules. Narrow compartments can be filled generally with dry air.

1.2 Protection of seawater ballast tanks and void double side skin spaces

1.2.1

1.2.1.a The regulation of IACS UR Z8 has been adopted as-is. Although "bright color" is a recommendation for the color of paint in the existing regulation, considering that paints have been applied to facilitate surveys, to facilitate detection of fatigue damage, and to have adequate anti-corrosive properties, and considering that ships that apply the Rules regulations because of these maintenance reasons are safer, this regulation was made a mandatory requirement in Rules.

1.2.2

1.2.2.a The "Performance Standard for Protective Coatings for ballast tanks and void spaces" that has been discussed at the IMO, was incorporated because of the strong demands of the shipowners. This matter was approved at the MO MSC81 meeting held in May 2006, and is scheduled to be adopted at the MSC82 meeting to be held in December 2006. When this requirement is adopted by the IMO, it will become applicable to ships contracted to be built on or after that date, earlier than the applicable date in the IMO.

1.3 Protection of cargo hold spaces

1.3.1 Coating

1.3.1.a This regulation is in accordance with IACS UR Z9.

1.3.2 Application

1.3.2.a This regulation is in accordance with IACS UR Z9.

1.3.3 Side areas to be coated

1.3.3.a This regulation is in accordance with IACS UR Z9.

1.3.4 Transverse bulkhead areas to be coated

1.3.4.a This regulation is in accordance with IACS UR Z9.

1.4 Protection of ballast hold spaces

1.4.1 Application

1.4.1.a This regulation is in accordance with IACS UR Z9.

2. SACRIFICIAL ANODES

2.1 General

2.1.1

2.1.1.a This regulation is in accordance with IACS UR F1.

2.1.2

2.1.2.a This regulation is in accordance with IACS UR F1.

2.1.3

2.1.3.a This regulation is in accordance with IACS UR F1.

3. PROTECTION OF INNER BOTTOM PLATING BY CEILING

3.1 General

3.1.1

3.1.1.a This regulation is based on BV Rules Part B Chapter 11 Section 1, 4, including a partial modification.

3.2 Arrangement

3.2.1

3.2.1.a This regulation is based on BV Rules Part B Chapter 11 Section 1, 4.2.1, including a partial modification.

3.2.2

3.2.2.a This regulation is based on BV Rules Part B Chapter 11 Section 1, 4.2.2, including a partial modification.

3.2.3

3.2.3.a This regulation is based on BV Rules Part B Chapter 11 Section 1, 4.2.3, including a partial modification.

3.2.4

3.2.4.a This regulation is based on BV Rules Part B Chapter 11 Section 1, 4.2.4, including a partial modification.

3.3 Scantlings

3.3.1

3.3.1.a This regulation is based on BV Rules Part B Chapter 11 Section 1, 4.3.1, including a partial modification.

SECTION 6 – STRUCTURAL ARRANGEMENT PRINCIPLES

1. APPLICATION

1.1

1.1.1

1.1.1.a Regulations have been established mainly for application of requirements for structural arrangement in cargo spaces. Structural arrangement and scantling requirements of forward and aft end parts are separately specified in Chapter 9 of the Rules.

2. GENERAL PRINCIPLES

2.1 Definition

2.1.1

2.1.1.a The spacing of primary supporting members and longitudinal stiffeners has been defined. Here, secondary stiffeners are assumed in principle, as "ordinary stiffeners" and stiffeners fitted to prevent buckling of webs of girders are not included.

2.2 Structural continuity

2.2.1 General

2.2.1.a General regulations related to continuity of longitudinal strength members are specified in 2.2.2 to 2.2.4.

2.2.2 Longitudinal members

2.2.2.a General regulations related to longitudinal members are specified.

2.2.3 Primary supporting members

2.2.3.a General regulations related to primary supporting members are specified.

2.2.4 Ordinary stiffeners

2.2.4.a General regulations related to ordinary stiffeners are specified.

2.2.5 Platings

2.2.5.a When connecting plates of different thicknesses, the regulation of not permitting difference in thickness greater than 50% of the thickness of the thicker plate was specified as a practical measure. If the difference in thickness is greater than 50%, an intermediate plate has to be inserted, and the thicker plate is to be tapered to the thickness of the thinner plate to maintain continuity.

2.2.6 Stress concentrations

2.2.6.a Regulations for avoiding locations of structural stress concentration and arrangement of openings were specified referring to the regulations of various classification societies.

2.3 Connections with higher tensile steel

2.3.1 Connections with higher tensile steel

2.3.1.a Precautions for treatment of connections of high tensile steel members to structural members of lower strength were established referring to the regulations of various classification societies. Members fitted to deck or bottom shell such as bilge keel and hatch-side coaming are not installed as longitudinal strength members. However, since they are subjected to longitudinal bending effects, they are required to be of materials with the same strength as the materials of the deck and bottom shell. When stiffeners not continuous in the longitudinal direction are connected to girders installed as hatch coamings or longitudinal strength members such as stiffeners sniped at both ends and fitted to prevent buckling, the material of the stiffeners should have the same strength as the member to which they are fitted.

3. PLATING

3.1 Structural continuity of plating

3.1.1 Insert plate

3.1.1.a This regulation specifies ensuring the continuity of structure in case of difference in thickness of plating. Local reinforcement, such as the reinforcement around the opening has not been specified, but the requirement used conventionally and approved by classification societies may be used.

4. ORDINARY STIFFENER

4.1 Profile of stiffeners

4.1.1 Stiffener profile with a bulb section

4.1.1.a Since plating with bulb section is treated as equivalent section, the simplified formulae that give the equivalent section modulus, section area, and so on were incorporated from 3.1.2, Sec. 3, Chapter 4, Part B of the BV Rules.

4.2 Span of ordinary stiffener

4.2.1 Ordinary stiffeners

4.2.1.a The effective span of stiffener varies for the case where the primary structural member (face plate) is regarded as one plate flange while the primary supporting member (web plate) is regarded as two plates flanges like a double bottom structure. This regulation specifies the treatment of spans of such stiffeners. Moreover, this span is common to the assessment of bending strength and shear strength of stiffeners.

For the treatment of struts between primary supporting members (floors) in a double bottom structure, the regulation of 3.2.2, Sec. 3, Chapter 4, Part B of the BV Rules has been incorporated. For installing a strut, the demands of shipowners has been considered, and provision of struts is not approved in ships of length 120 m and greater.

4.2.2 Ordinary stiffener within a double hull

4.2.2.a Treatment of span of ordinary stiffener within a double hull is specified.

4.2.3 Ordinary stiffeners supported by struts

4.2.3.a Treatment of span of ordinary stiffener supported by struts is specified.

4.3 Attached plating

4.3.1 Effective breadth for yielding check

4.3.1.a To assess the bending strength of stiffeners, the sectional characteristics of stiffeners should be assessed. In this case, the effective width of the plating attached to the stiffener needs to be considered. The regulation of 1.1.13-3, Part C of NK Rules, which gives a simple index based on Shade's theory, is adopted for the effective width of plating.

4.3.2 Effective width for buckling check

4.3.2.a The regulation for buckling strength of the Rules is based on the GL Rules. The effective width for buckling strength assessment is also specified based on GL Rules.

4.4 Geometric property of ordinary stiffeners

4.4.1 General

4.4.1.a Since CSR has incorporated the net scantling approach, the strength characteristics of stiffener such as moment of inertia of section, section modulus, shear area, slenderness ratio of web also correspond to the net scantling approach. Therefore, the scantling obtained after deducting the corrosion addition from the offered scantling (scantling in the drawing) of stiffener will be used for assessment.

4.4.2 Stiffener not perpendicular to the attached plating

4.4.2.a When the stiffener is fitted not perpendicular to the plating such as shell plating, and if the angle between the stiffener and the plating is greater than 75 degrees, the difference in the section modulus when the stiffener is fitted perpendicular to the plating is small. Therefore, the section characteristics may be assumed as those when the stiffener is perpendicular. If the angle is between 50 degrees and 75 degrees, the requirement is that the angle should be considered and the section characteristics corrected. If the angle is less than 50 degrees, a tripping bracket is required to be provided. Although not specified, if the angle between the stiffener and the plating is less than 50 degrees, the section modulus of the stiffener will be according to direct strength calculation.

4.5 End connections of ordinary stiffeners

4.5.1 General

4.5.1.a Slots are provided in the primary structural members to allow the stiffener to pass through the primary supporting members. In this case, end fixation examples according to 3.5, Sec. 3, Chapter 4, Part B of the BV Rules are shown.

4.5.2 Structural continuity of stiffeners

4.5.2.a This regulation has been specified referring to the regulation in 3.5.2, Sec. 3, Chapter 4, Part B of the BV Rules and 1.1.15, Part C of NK Rules.

4.5.3 End connections

4.5.3.a This regulation has been specified referring to 3.5.3, Sec. 3, Chapter 4, Part B of the BV Rules.

5. PRIMARY SUPPORTING MEMBERS

5.1 General

5.1.1

5.1.1.a This is a general regulation related to structural continuity.

5.1.2

5.1.2.a This regulation is specified for the case where the requirement of arrangement of primary supporting members specified in the rules differs from the actual arrangement of primary supporting members.

5.2 Stiffening arrangement

5.2.1

5.2.1.a The stiffeners to which this regulation is applicable are those installed to stiffen the primary supporting members (girders). This regulation was established referring to the rules of various classification Societies.

5.2.2

5.2.2.a This regulation is based on 4.7.4, Section 3, Chapter 4, Part B of the BV Rules.

5.2.3

5.2.3.a This regulation is based on 4.7.5, Section 3, Chapter 4, Part B of the BV Rules.

5.2.4

5.2.4.a This regulation is based on 4.7.6, Section 3, Chapter 4, Part B of the BV Rules.

5.2.5

5.2.5.a This regulation is based on 4.7.7, Section 3, Chapter 4, Part B of the BV Rules.

5.3 Span of primary supporting members

5.3.1 Definitions

5.3.1.a This regulation is based on 1.1.16, Part C of NK Rules.

5.4 Effective breadth of primary supporting member

5.4.1 General

5.4.1.a In principle, this is taken to the space of the primary supporting members, but when the spaces of the adjacent supporting member vary, the average value is taken.

5.5 Geometric properties

5.5.1 General

5.5.1.a Same as for stiffeners.

5.6 Bracketed end connection

5.6.1 General

5.6.1.a This regulation is based on 4.4, Section 3, Chapter 4, Part B of the BV Rules and 1.1.14, Part C of NK Rules.

5.6.2 Dimensions of brackets

5.6.2.a This regulation is based on 4.4, Section 3, Chapter 4, Part B of the BV Rules and 1.1.14, Part C of NK Rules.

5.7 Cut-outs and holes

5.7.1

5.7.1.a This regulation is based on C15.2.3 of NK Guidance and 4.6.1, Section 3, Chapter 4, Part B of the BV Rules.

5.7.2

5.7.2.a This regulation is based on C15.2.3 of NK Guidance and 4.6.2, Section 3, Chapter 4, Part B of the BV Rules.

5.7.3

5.7.3.a This regulation is based on C15.2.3 of NK Guidance and 4.6.3, Section 3, Chapter 4, Part B of the BV Rules.

5.7.4

5.7.4.a This regulation is based on C15.2.3 of NK Guidance and 4.6.4, Section 3, Chapter 4, Part B of the BV Rules.

5.7.5

5.7.5.a This regulation is based on C15.2.3 of NK Guidance and 4.6.5, Section 3, Chapter 4, Part B of the BV Rules.

6. DOUBLE BOTTOM

6.1 General

6.1.1 Double bottom extend

6.1.1.a This is an installation requirement of double bottom based on the SOLAS Convention.

6.1.2 Framing system

6.1.2.a It is specified that the longitudinal framing system is mandatory for ships of length 120 m and greater.

6.1.3 Height of double bottom

6.1.3.a The regulation is based on Chapter 31 of Part C of NK Rules.

6.1.4 Dimensions of double bottom

6.1.4.a The regulation is base on C6.1.1-3 of NK Guidance.

6.1.5 Docking

6.1.5.a This regulation is based on 6.2.4 of Part C of NK Rules (including requirements for detailed arrangement). In CSR, however, since the requirements for arrangement varies according to the arrangement of blocks in the dock, detailed numerical values have not been specified.

6.1.6 Continuity of strength

6.1.6.a This is a general regulation related to continuity of strength. The thickness of the lowermost strake in the hopper tank has been increased considering the continuity with the inner bottom plating.

6.1.7 Reinforcement

6.1.7.a This regulation is based on 6.2.1, Part C, of the NK Rules.

6.1.8 Manholes and lightening holes

6.1.8.a This regulation is based on 6.1.2, Part C of the NK Rules.

6.1.9 Air holes and drain holes

6.1.9.a This regulation is based on 6.1.2, Part C of the NK Rules.

6.1.10 Drainage of tank top

6.1.10.a This regulation is based on 6.1.3, Part C of NK Rules.

6.1.11 Striking plate

6.1.11.a This regulation is based on 6.1.4, Part C of NK Rules.

6.1.12 Duct keel

6.1.12.a The arrangement of girder plating has been revised referring to the actual arrangements in existing ships and the 31.2.2-5, Part C of NK Rules.

6.2 Keel

6.2.1

6.2.1.a The width of one strake of the keel plate has been specified referring to the regulations of shear strake and bilge strake in 1.1.11, Part C of NK Rules.

6.3 Girders

6.3.1 Centre girder

6.3.1.a This regulation is specified referring to the regulation of 31.2.2 and 6.2.1 of Part C of NK Rules.

6.3.2 Side girder

6.3.2.a This regulation is specified referring to the regulation of 31.2.2 and 6.2.1 of Part C of NK Rules.

6.3.3 Spacing

6.3.3.a This regulation is specified referring to the regulation of 31.2.2 and 6.2.1 of Part C of NK Rules.

6.4 Floors

6.4.1 Spacing

6.4.1.a This regulation is specified referring to the regulation of 31.3.2 and 6.3.1 of Part C of NK Rules.

6.4.2 Floors in way of transverse bulkheads

6.4.2.a This regulation is specified referring to the regulation of 31.3.2 and 6.3.1 of Part C of NK Rules.

6.4.3 Web stiffeners

6.4.3.a This regulation is specified referring to the regulation of 31.3.2 and 6.3.1 of Part C of NK Rules.

6.5 Bilge strake and bilge keel

6.5.1 Bilge strake

6.5.1.a

6.5.2 Bilge keel

6.5.2.a Since a large number of comments from shipowners have been received about bilge keel and prevention of damage to its ends, it was decided that the material of the bilge keel should have the same strength as the bilge strake. Similar to long hatch

side coamings of 0.15L specified in the IACS UR S6, if the length of the bilge keel is greater than 0.15L, the material of the bilge keel is required to be the same as that of the bilge strake.

7. DOUBLE SIDE STRUCTURE

7.1 Application

7.1.1

7.1.1.a The framing system of double skin side structure was considered to be either longitudinal of transverse framing systems, and the application of each system has been specified.

7.2 Design principles

7.2.1

7.2.1.a If the double side skin part is to be used as a void space, and cargo of high density is to be carried in the cargo holds, then local loads are not presumed to act on the side structure of the cargo hold on the double skin side. Even in such cases, appropriate thickness exceeding the minimum thickness is considered necessary. As a conclusion, even if the double skin side part is a void space, it is treated as a ballast tank and assessment of local strength is specified. Corrosion addition for the actual service environment, that is, void space, is also specified.

7.3 Structural arrangement

7.3.1 General

7.3.1.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.3.2 Primary supporting member spacing

7.3.2.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.3.3 Primary supporting member fitting

7.3.3.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.3.4 Transverse ordinary stiffeners

7.3.4.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.3.5 Longitudinal ordinary stiffeners

7.3.5.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.3.6 Sheer strake

7.3.6.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.3.7 Plating connection

7.3.7.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.4 Longitudinally framed double side

7.4.1 General

7.4.1.a In principle, continuity of structure similar to that in double bottom structure has been specified.

7.5 Transversely framed double side

7.5.1 General

7.5.1.a The principle for the continuity of structure in case of strut connection has been specified.

8. SINGLE SIDE STRUCTURE

8.1 Application

8.1.1

8.1.1.a Transverse framing system is used for the hold frames for stiffening the side structure. However, when web frames are installed or transverse girders are installed, the requirement of arrangement for primary supporting members is used.

8.2 General arrangement

8.2.1

8.2.1.a This regulation is specified referring to the regulation IACS UR S12 and considering the net scantlings approach.

8.3 Side frames

8.3.1 General

8.3.1.a This regulation is specified referring to the regulation IACS UR S12 and considering the net scantlings approach.

8.4 Upper and lower brackets

8.4.1

8.4.1.a This regulation is specified referring to the regulation IACS UR S12 and considering the net scantlings approach.

8.4.2

8.4.2.a This regulation is specified referring to the regulation IACS UR S12 and considering the net scantlings approach.

8.5 Tripping brackets

8.5.1

8.5.1.a This regulation is specified referring to the regulation IACS UR S12 and considering the net scantlings approach.

8.6 Support structure

8.6.1

8.6.1.a This regulation is specified referring to the regulation IACS UR S12 and considering the net scantlings approach.

9. DECK STRUCTURE

9.1 Application

9.1.1

9.1.1.a In principle, the topside tank structure is required to use the longitudinal framing system regardless of the length of the ship.

9.2 General arrangement

9.2.1

9.2.1.a The arrangement of girders of the topside tanks is specified here considering longitudinal strength, lateral loads, hatches, bulkhead positions and so on, and the spacing of the girders is specified referring to the existing arrangements.

9.2.2

9.2.2.a It is considered that for this topic, no information in addition to that shown in the Rules is necessary to explain the background.

9.2.3 Deck between hatches

9.2.3.a The deck structure between hatches, the so-called cross-deck structure, is required to use the transverse framing system, in principle, since in-plane compressive loads in the breadth direction of the ship transmitted from the side shell plating are dominant. Beams to which the rule "beams shall be supported by appropriate girders, and shall extend to the second longitudinal stiffener toward the bulwark from the hatch side girder" applies, are generally girders of the transverse framing system that do not fall under the scope of general stiffeners.

9.2.4 Topside tank structures

9.2.4.a The continuity of structure with transverse members has been specified. The transverse girder arrangement of topside tanks depends on the bulkhead arrangement and the arrangement of hatch coamings. For the girder arrangement in

a double side skin structure, the continuity with the double bottom structure is considered, and since all the transverse members are not installed in practice in the same plane, the installation of large brackets supporting the girders of the double skin side structure in the topside tanks has been approved.

9.2.5 Stringer plate

9.2.5.a The regulation for usage categories of steel in Section 1, Chapter 3 incorporating IACS UR S6 is for stringer plates in the region of 0.4L amidships. This regulation applies to the entire cargo region.

9.2.6

9.2.6.a The continuity of structure with bracket connection has been specified.

9.2.7

9.2.7.a General regulations for supporting structures fitted on the heavy equipment are specified.

9.2.8

9.2.8.a General regulations for supporting structures fitted on the heavy equipment are specified.

9.2.9

9.2.9.a General regulation for the discontinuity part such as ends and corners of deckhouses or superstructures are specified.

9.2.10 Connection of hatch end beams with deck structures

9.2.10.a

9.2.11 Construction of deck plating

9.2.11.a General regulation in order to stress concentration around the openings are specified.

9.3 Longitudinally framed deck

9.3.1 General

9.3.1.a Regulations related to continuity of strength in longitudinal framing systems are specified.

9.4 Transversely framed deck

9.4.1 General

9.4.1.a Regulations related to continuity of strength in transverse framing systems are specified.

9.5 Hatch supporting structures

9.5.1

9.5.1.a Regulations related to continuity of strength of hatch supporting structures are specified.

9.5.2

9.5.2.a Regulations related to continuity of strength of hatch supporting structures are specified.

9.5.3

9.5.3.a Regulations related to continuity of strength of hatch supporting structures are specified.

9.5.4

9.5.4.a Regulations related to continuity of strength of hatch supporting structures are specified.

9.6 Openings in the strength deck

9.6.1 General

9.6.1.a This regulation is based on 6.1.1, Section 6, Chapter 4, Part B of the BV Rules.

9.6.2 Small opening location

9.6.2.a This regulation is based on 6.1., Section 6, Chapter 4, Part B of the BV Rules.

9.6.3 Corner of hatchways

9.6.3.a This regulation is based on 6.2., Section 6, Chapter 4, Part B of the BV Rules.

10. BULKHEAD STRUCTURE

10.1 Application

10.1.1

10.1.1.a This regulation is applicable to longitudinal bulkheads also considering double skin side structure.

10.1.2 Plane bulkheads

10.1.2.a The type of bulkhead structure is described, based on 1.1.2, Section 7, Chapter 4, Part B of the BV Rules.

10.2 General

10.2.1

10.2.1.a This regulation is based on 1.2.7, Section 7, Chapter 4, Part B of the BV Rules. However, although this regulation applies to longitudinal bulkheads in the original document, generally the lateral loads considered in the lower part of the bulkhead

are greater than the loads on the upper part of the bulkhead, therefore, this regulation applies to all the bulkheads.

10.2.2

10.2.2.a This regulation is based on 2.1.6, Section 7, Chapter 4, Part B of the BV Rules.

10.3 Plane bulkheads

10.3.1 General

10.3.1.a In principle, this regulation is based on the regulations 2.1.1 to 2.1.5, Section 7, Chapter 4, Part B of the BV Rules.

10.3.2 End connection of ordinary stiffeners

10.3.2.a This regulation is based on the regulations 2.2.1 and 2.2.2, Section 7, Chapter 4, Part B of the BV Rules.

10.3.3 Sniped end of ordinary stiffener

10.3.3.a This regulation is based on the regulation 2.2.4, Section 7, Chapter 4, Part B of the BV Rules.

10.3.4 Bracketed ordinary stiffeners

10.3.4.a In principle, this regulation is based on the regulations 2.3.1 and 2.3.2, Section 7, Chapter 4, Part B of the BV Rules.

10.4 Corrugated bulkheads

10.4.1 General

10.4.1.a CSR requires that strength assessment of primary supporting members be performed based on the direct strength calculation, and also requires hull girder ultimate strength and fatigue strength assessment to be performed for ships of length 150 m and greater. This regulation also covers strength requirements during flooding of IACS UR S17, S18, S20, and also IACS URS25 specified for ships of 150 m and greater. These applications are considered for consistent treatment. The treatment of stools in corrugated bulkheads considering construction that is more robust than used currently, has been made more stringent by application of the regulations for ships of length 190 m and greater in UR S18 to ships of length 150 m and greater.

10.4.2 Construction

10.4.2.a In principle, this regulation is based on IACS UR S18.

10.4.3 Actual section modulus of corrugations

10.4.3.a In principle, this regulation is based on IACS UR S18.

10.4.4 Span of corrugations

10.4.4.a In principle, this regulation is based on IACS UR S18.

10.4.5 Structural arrangement

10.4.5.a In principle, this regulation is based on IACS UR S18.

10.4.6 Bulkhead stools

10.4.6.a In principle, this regulation is based on IACS UR S18.

10.4.7 Lower stool

10.4.7.a In principle, this regulation is based on IACS UR S18.

10.4.8 Upper stool

10.4.8.a In principle, this regulation is based on IACS UR S18.

10.4.9 Alignment

10.4.9.a In principle, this regulation is based on IACS UR S18.

10.4.10 Effective width of the compression flange

10.4.10.a In principle, this regulation is based on IACS UR S18.

10.4.11 Effective shedder plates

10.4.11.a In principle, this regulation is based on IACS UR S18.

10.4.12 Effective gusset plates

10.4.12.a In principle, this regulation is based on IACS UR S18.

10.4.13 Section modulus at the lower end of corrugations

10.4.13.a In principle, this regulation is based on IACS UR S18.

10.4.14 Section modulus at sections other than the lower end of corrugations

10.4.14.a In principle, this regulation is based on IACS UR S18.

10.4.15 Shear area

10.4.15.a In principle, this regulation is based on IACS UR S18.

10.5 Non-tight bulkheads

10.5.1 Non-tight bulkheads not acting as pillars

10.5.1.a This regulation is based on 4.1.1, Section 7, Chapter 4, Part B of the BV Rules.

10.5.2 Non-tight bulkheads acting as pillars

10.5.2.a This regulation is based on 4.2, Section 7, Chapter 4, Part B of the BV Rules.

10.6 Watertight bulkheads of trunks and tunnels

10.6.1

10.6.1.a This regulation is in accordance with a part of the rule 19 of Chapter II-1 of the SOLAS.

11. PILLARS

11.1 General

11.1.1

11.1.1.a This regulation is based on 4.1.1, Section 6, Chapter 4, Part B of the BV Rules.

11.1.2

11.1.2.a This regulation is based on 4.1, Section 6, Chapter 4, Part B of the BV Rules.

11.1.3

11.1.3.a This regulation is based on 4.1.3, Section 6, Chapter 4, Part B of the BV Rules.

11.1.4 Connections

11.1.4.a This regulation is based on 4.2, Section 6, Chapter 4, Part B of the BV Rules.