TÜRK LOYDU RULE CHANGE SUMMARY

TL NUMBER: 04/2020 DEC 2020

Latest editions of TL Rules incorporate all rule changes. The latest rule revisions of a published rule are shown with a vertical line. Changes after the publication of the rule are written in red colour.

Please note that within this document added items are written in red and for deleted items strikethrough is applied. After the publication of relevant rule, those revisions are to be indicated with a vertical line. Following Rule Changes presented in English are also implemented into Turkish Version of Rules.

RULE CHANGE SUMMARY

CLASSIFICATION AND SURVEYS

CHAPTER 1 - HULL

05	Section 29
06	Section 30

CHAPTER 2 – MATERIAL

No	Item
01	Section 3

CHAPTER 3 – WELDING

No	Item
01	Section 5

CHAPTER 4 - MACHINERY

No	Item
01	Section 2
02	Section 5
03	Section 16
04	Section18

CHAPTER 5 – ELECTRICAL INSTALLATION

No	Item
01	Section 7
02	Section 9

CHAPTER 8 – CHEMICAL TANKERS

No	Item
01	Section 1
02	Section 15
03	Section 16

CHAPTER 10 – LIQUEFIED GAS TANKERS

No	**Item**
01	Section 05
02	Section 11

CHAPTER 33 – CONSTRUCTION OF POLAR CLASS SHIPS

No	**Item**
01	Part I-A, Section 3

CHAPTER 35 – TENTATIVE RULES FOR SHIPS LESS THAN 500 GT

No	**Item**
01	Section 4

CHAPTER 50 - RULES FOR LIFTING APPLIANCES

No	**Item**
01	Section 1
02	Section 4
03	Section 5
04	Section 6

GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS

No	**Item**
01	Section B

CLASSIFICATION AND SURVEYS

01. Section 2 – Classification

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item C.2.2 was revised as below:

A ballast tank is a tank which is used primarily for ~~sea~~ salt water ballast.

For single skin or double skin bulk carriers, a ballast tank is a tank which is used solely for ~~sea~~ salt water ballast, or, where applicable, a space which is used for both cargo and ~~sea~~ salt water ballast is to be treated as a ballast tank when substantial corrosion has been found in that space. For double skin bulk carriers, a double side tank is to be considered as a separate tank even if it is in connection to either ther topside tank or the hopper side tank.

For oil tanker and chemical tankers, a ballast tank is a tank which is used solely for the carriage of ~~sea~~ salt water ballast.

Item C.2.3 was revised as below:

The cargo area is that part of the ship which contains cargo tanks, slop tanks and cargo/ballast pump-rooms, ~~including pump-rooms~~ cofferdams, ballast tanks or void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

Item C.2.8 was revised as below:

Critical structural areas are locations which have been identified from calculations to require monitoring or from service history of the subject ship or from similar or sister ships (if available), to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

Item C.2.15 was revised as below:

Representative tanks or spaces are those which are expected to reflect the condition of other tanks or spaces of similar type and service and with similar corrosion prevention systems. When selecting representative tanks or spaces, account is to be taken of the service and repair history on board and identifiable critical structural areas and/or suspect areas.

Item C.2.16 was revised as below:

Substantial corrosion is an extent of corrosion such that assessment of the corrosion pattern indicates wastage in excess of 75% of allowable margin, but within acceptable limits. For ships built under TL Common Structural Rules, substantial corrosion is an extent of corrosion such that the assessment of corrosion pattern indicates a measured thickness between t_{ren} + 0,5 mm and t_{ren}.

Item C.2.19 was revised as below:

A transverse section includes all longitudinal members ~~contributing to longitudinal strength~~, such as plating, longitudinals and girders at the deck, side, bottom, inner bottom and longitudinal bulkheads. For transversely framed ships, a transverse section includes adjacent frames and their end connections in way of transverse sections.

Item C.2.21 was added as below:

2.21 Renewal Thickness

Renewal thickness (t_{ren}) is the minimum allowable thickness, im mm, below which renewal of structural members is to be carried out.

Table 2.13.a was revised as below:

Class Notation	Description	Application	Rule Requirement, Design (1)	Rule Requirement, Survey
HSC-PASSENGER A	High-speed crafts (up to 450 passengers) meeting the requirements of category A	High-speed crafts	Part C Chapter 7 High Speed Crafts	Classification and Surveys Section 3
HSC-PASSENGER B	High-speed crafts (over 450 passengers) meeting the requirements of category B	High-speed crafts	Part C Chapter 7 High Speed Crafts	
HSC-CARGO	High-speed cargo crafts meeting the requirements of the cargo craft category	High-speed cargo crafts	Part C Chapter 7 High Speed Crafts	
HSDE	High-speed crafts constructed in essential parts according to **TL** Rule Chapter 7 and which are not subject to the IMO HSC Code	High-speed crafts	Part C Chapter 7 High Speed Crafts	
DSC	Ships which were built before 01 January 1996 and complying the main parts of TL Rules, Chapter 7 - High Speed Vessels (1993) and subject to the IMO DSC Code	High-speed crafts	Part C Chapter 7 High Speed Crafts, IMO DSC Code	
(1) *Refer to following TL-I HSCs and TL-I SC137 ~~Technical Circulars~~ as applicable;* *~~S-P 13/13 Unified Interpretations for HSC Code 1994 as amended~~*				

Revision Date: November 2020

Entry into Force Date: 1 January 2021

Item D.3.15 was added as below:

3.15 Lifting Appliances

Table 2.54 Notations for lifting appliances

Notation	Characteristics	Underlying rules

LA	The ship is equipped with lifting appliances, such as cranes or lifts which have been included in the Classification procedure.	**TL** Rules, Chapter 50, Rules for Lifting Appliances.
LA (CRANE)	The ship is equipped with classed lifting appliances like cranes, gantry cranes, A-frames, etc. .	**TL** Rules, Chapter 50, Rules for Lifting Appliances, Section 4.
LA (CL)	Cargo Lift – This notation is assigned in compliance with Chapter 50, Rules for Lifting Appliances, Section 5, E. to ships having classed cargo lifts.	**TL** Rules, Chapter 50, Rules for Lifting Appliances, Section 5, E.
LA (CR)	Cargo Ramp - This notation is assigned in compliance with Chapter 50, Rules for Lifting Appliances, Section 6, D. to ships having classed movable ship borne vehicle ramps .	**TL** Rules, Chapter 50, Rules for Lifting Appliances, Section 6, D.
LA (PL)	Passenger Lift - This notation is assigned in compliance with Chapter 50, Rules for Lifting Appliances, Section 5, D to ships having classed passenger lifts.	**TL** Rules, Chapter 50, Rules for Lifting Appliances, Section 5, D.

02. Section 3 – Surveys

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item A.1.3 was revised as below:

Bulk carrier is a ship ~~intended primarily to carry dry cargo in bulk and~~ which is constructed generally with single deck, double bottom, topside tanks and hopper tanks in cargo spaces and is intended primarily to carry dry cargo in bulk. Combination carriers are included.

Item A.1.12 and 1.13 were revised as below:

1.12 Spaces are separate compartments ~~within the hull and superstructures~~ including holds, tanks, cofferdams, and void spaces bounding cargo holds, decks and the outer hull .

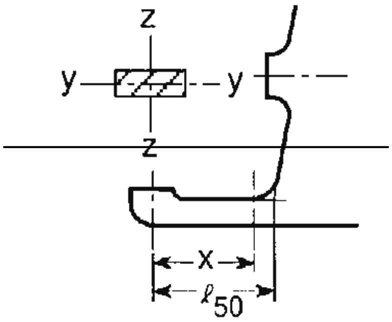
1.13 Special consideration or specially considered (in connection with close-up surveys and thickness measurements) means sufficient close-up inspection and thickness measurements are to be taken to confirm the actual average condition of the structure under the coating.

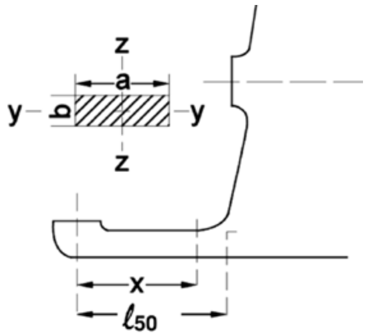
PART A – CHAPTER 1 HULL

01. Section 10 – Stern Frame

Revision Date: September 2020

Entry into Force Date: 1 October 2020





02. Section 18 – Rudder and Manoeuvring Arrangement

Revision Date: November 2020

Entry into Force Date: 1 January 2020

Item A.4.5 was revised according to UR S10 Rev.6 as below:

4.5 In general materials having a specified minimum yield stress R_{eH} of less than 200 N/mm^2 and a minimum tensile strength of less than 400 N/mm^2 or more than 900 N/mm^2 shall not be used for rudder stocks, pintles, keys and bolts.

The requirements of this Section are based on a material's specified minimum yield stress R_{eH} of 235 N/mm^2. If material is used having a specified minimum R_{eH} differing from 235 N/mm^2, the material factor k_r is to be determined follows:

$$k_r = \left[\frac{235}{R_{eH}}\right]^{0.75} \quad \text{for } R_{eH} > 235 \text{ N/mm}^2$$

$$k_r = \frac{235}{R_{eH}} \quad \text{for } R_{eH} \le 235 \text{ N/mm}^2$$

R_{eH} = specified minimum yield strength of material used in [N/mm^2],

………………..

Item A.4.6 was revised according to UR S10 Rev.6 as below:

4.6 Before significant reduction~~s~~ in rudder stock diameter are granted due to the application of steel~~s~~ with R_{eH}exceeding 235 N/mm^2 ~~are granted~~, **TL** may require the evaluation of the elastic rudder stock ~~deflections~~ deformations. Large ~~deflections should~~ deformations of the rudder stock are to be avoided in order to avoid excessive edge pressures in way of bearings.

Item A.5.2 was revised according to UR S10 Rev.6 as below:

5.2 In way of the rudder horn recess of semi-spade rudders the radii in the rudder plating except in way of solid part in cast steel are not to be less than 5 times the plate thickness, but in no case less than 100 mm. Welding in side plate are to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

Definition was added to item A.7 according to UR S10 Rev.6 as below:

………………..

A_{1a}, A_{2a} = Portion of A_1 and A_2 situated aft of the centre line of the rudder stock

………………..

Item B.1.1 was revised according to UR S10 Rev.6 as below:

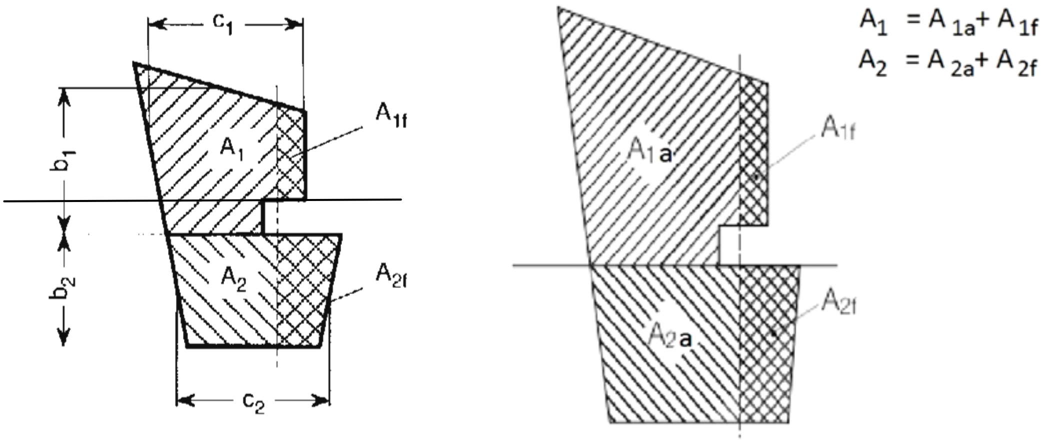
1.1 The rudder force is to be determined according to the following formula:

$$C_R = 132 \cdot A \cdot v^2 \cdot \kappa_1 \cdot \kappa_2 \cdot \kappa_3 \text{ [N]}$$

Table 18.1 was revised according to UR S10 Rev.6 as below:

Type of rudder/ profile	κ_2	
	Ahead condition	**Astern condition**
high lift rudders 	1,7	~~to be specially considered; if not known:~~ 1,3

Figure 18.2 was revised according to UR S10 Rev.6 as below:



Item C.2.2 was revised according to UR S10 Rev.6 as below:

2.2 Before significant reductions in rudder stock diameter are granted due to the application of steel~~s~~ with specified minimum yield stress~~es~~ exceeding 235 N/mm^2 ~~are granted~~, **TL** may require the evaluation of the rudder stock deformations. Large deformations of the rudder stock are to be avoided in order to avoid excessive edge pressures in way of bearings.

Item C.4 and C.4.1 were revised according to UR S10 Rev.6 as below:

4. Rudder Trunk

The requirements in this item apply to trunk configurations which are extended below stern frame and arranged in such a way that the trunk is stressed by forces due to rudder action.

4.1 Materials, welding and connection to hull

~~***Note:*** *This item 4 applies to both trunk configurations (extending or not below stern frame).*~~

Item C.4.1.3 was revised according to UR S10 Rev.6 as below:

………………..

$r = 0.1d_c$

without being less than:

r = 60 [mm]

when σ ≥ 40 / k [N/mm²]

r = ~~$0.1D_1$, (without being less than~~ 30 [mm] when σ < 40 / k [N/mm²]

………………..

Item C.4.2.1 was revised according to UR S10 Rev.6 as below:

4.2.1 ~~In case where the rudder stock is fitted with a rudder trunk welded in such a way the rudder trunk is loaded by the pressure induced on the rudder blade, as given in B.1.1,~~ The scantlings of the trunk are to be such that:

………………..

R_{eH}= specified minimum yield stress (N/mm^2) of the material used

………………..

Item D.3.1.1 was revised according to UR S10 Rev.6 as below:

3.1.1 Cone couplings without hydraulic arrangements for mounting and dismounting the coupling is to have a taper c on diameter of 1:8 to 1:12. The taper c is to be determiden by the formula below:

$$c = \frac{d_o - d_u}{\ell_c}$$

where;

d_0, d_u = Diameters, refer to Figure 18.9

ℓ_c = ~~Coupling~~ Cone length, refer to Figure 18.9b, not to be taken less than 1.5·d_o

Item D.3.1.3 was revised according to UR S10 Rev.6 as below:

………………..

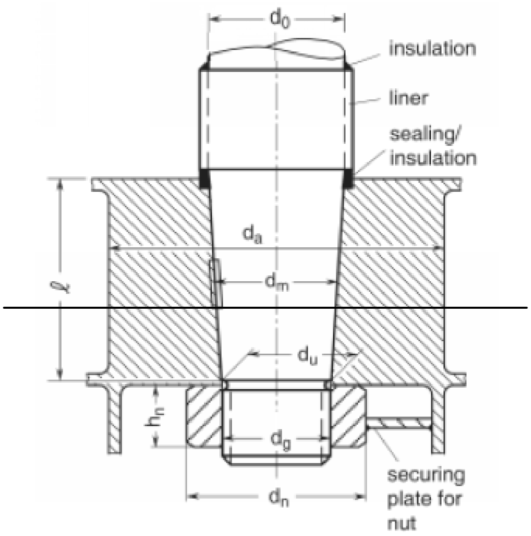
R_{eH1} = Specified minimum nominal upper yield point of the key material [N/mm^2].

Item D.3.1.4 was revised according to UR S10 Rev.6 as below:

………………..

R_{eH2} = Specified minimum yield strength of the key, stock or coupling material in (N/mm^2], whichever is less.

Figure 18.9 was revised according to UR S10 Rev.6 as below:



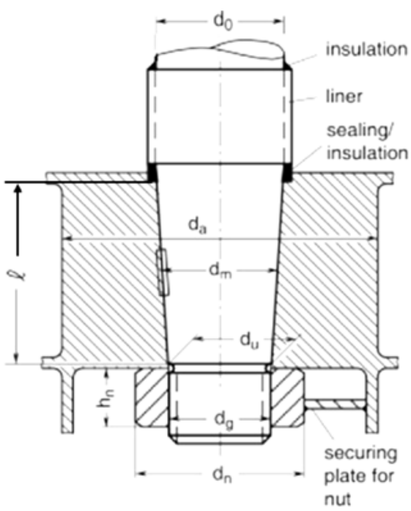


Figure 18.9a and 18.9b were added according to UR S10 Rev.6 as below:

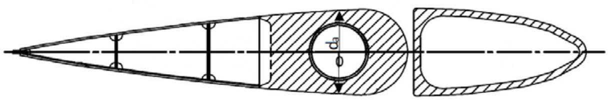


Figure 18.9a Gudgeon outer diameter(d_a) measurement

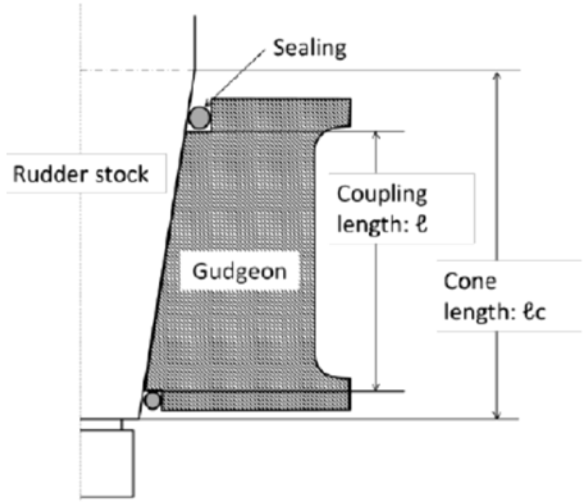
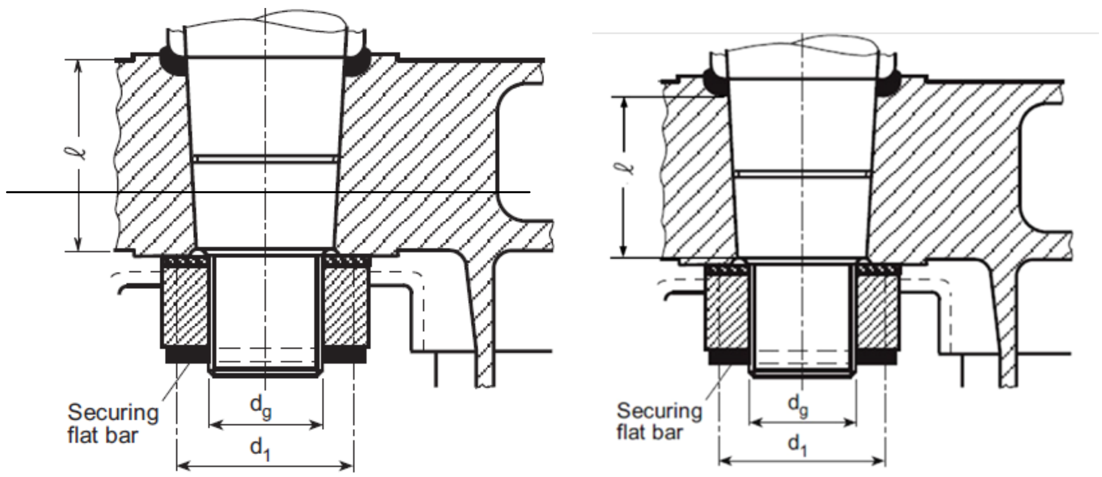


Figure 18.9b Cone length and coupling length

Figure 18.10 was revised according to UR S10 Rev.6 as below:



Item 3.2.3.1 was revised according to UR S10 Rev.6 as below:

………………..

ℓ = ~~Cone~~ Coupling length [mm],

………………..

R_{eH} = specified minimum yield ~~point~~ stress [N/mm^2] of the material of the gudgeon,

………………..

d_a = outer diameter of the gudgeon, in [mm], see Figure 18.9 and Figure 18.9a. (The least diameter is to be considered).

………………..

Figure 18.13 was revised according to UR S10 Rev.6 as below:

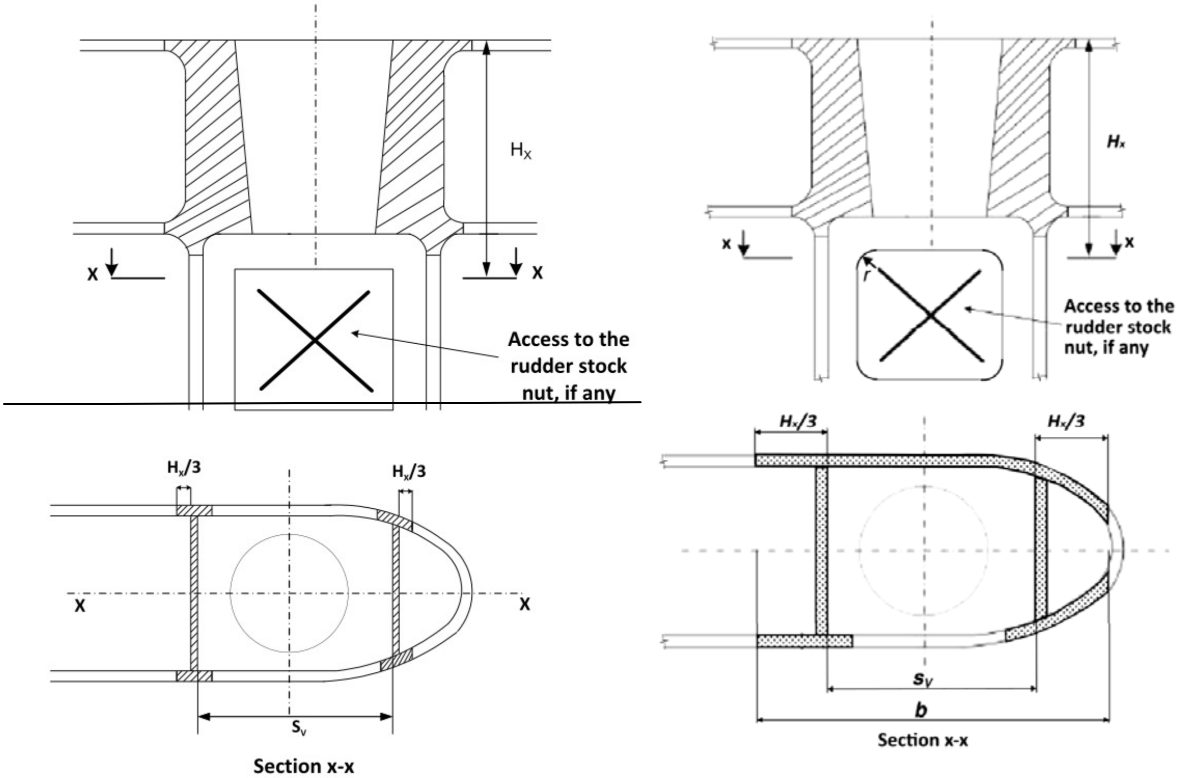


Figure 18.13 Cross-section of the connection between rudder blade structure and rudder stock housing, example with opening in only one side shown

Item E.5.4 was revised according to UR S10 Rev.6 as below:

……………….

q = Allowable surface pressure according to Table 18.3

Table 18.3 was revised according to UR S10 Rev.6 as below:

Table 18.3 ~~Permisble~~ Allowable surface pressure q

Bearing material	q [N/mm^2]
Lignum vitae	2.5
White metal, oil lubricated	4.5
synthetic material material with hardness ~~between 60 and 70~~ greater than 60 Shore **(1)**	5.5
Steel **(2)**, bronze and hot-pressed bronze-graphite materials	7.0
(1) *Synthetic materials to be of approved type. Indentation hardness test at 23 °C and with 50 % moisture, are to be carried out according to a recognized standard. Synthetic bearing materials are to be of an approved type. Surface pressures exceeding 5.5 N/mm^2 may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm^2.* **(2)** *Stainless and wear resistant steel in an approved combination with stock liner. Higher surface pressures than 7 N/mm^2 may be accepted if verified by tests.*	

03. Section 21 – Structural Fire Protection

Revision Date: November 2020

Entry into Force Date: 1 January 2020

Items B.4.2.2, B.4.3.2, C.4.1.3, E.2.3.2.3 were revised as below:

B. Rules on Fire Protection for Passenger Ships

……………….

4.2 Ships carrying more than 36 passengers

……………….

[1] Control stations

………………..

See also TL-I SC17 for Definitions of Control Stations (SOLAS Reg. II-2/3.18).

………………..

4.3 Ships carrying not more than 36 passengers

………………..

[1] Control stations

………………..

See also TL-I SC17 for Definitions of Control Stations (SOLAS Reg. II-2/3.18).

………………..

[6] Machinery spaces of category A

Spaces and trunks to such spaces which contain either:

………………..

C. Rules on Fire Protection for Cargo Ships of 500 GT and over

………………..

4. Fire Integrity of Bulkheads and Decks

………………..

[1] Control stations

………………..

See also TL-I SC17 for Definitions of Control Stations (SOLAS Reg. II-2/3.18).

………………..

[6] Machinery spaces of category A

Spaces and trunks to such spaces which contain either:

………………..

E. Rules on Fire Protection for Oil Tankers and Combination Carriers of 500 GT and Over

………………..

See also TL-I SC17 for Definitions of Control Stations (SOLAS Reg. II-2/3.18).

………………..

[6] Machinery spaces of category A

Spaces and trunks to such spaces which contain either:

………………..

04. Section 26 – Stability

Revision Date: November 2020

Entry into Force Date: 1 January 2020

Note under item A.2.32 was revised as below:

Note: *Fishing vessels should not be included in the definition of lifting operations. Reference is made to IS Code, as amended, paragraphs 2.1.2.2 and 2.1.2.8 of chapter 2 of part B. For anchor handling operations reference is made to section 2.7 of chapter 2 of part B.*

Item B.2.8 was revised as below:

2.8 Ships intended to carry timber deck cargoes

The loading conditions which should be considered for ships carrying timber deck cargoes are specified in 2.7. The stowage of timber deck cargoes should comply with the provisions of Chapter 2 of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011 (Resolution A.1048(27), as amended).

Note under item B.4.3.1.5 was revised as below:

Note:

Refer to 2008 IS Code, as amended, Part B, 6.3.2 for icing regions and Part B, 6.3.3 for causes of ice formation and its influence upon the seaworthiness of the vessel.

Item B.6 was revised as below:

6. Determination of Lightship Parameters

Every passenger ship regardless of size and every cargo ship having a length, as defined in the international Convention on Load Lines, 1966 or the protocol of 1988 relating thereto, as amended, as applicable, of 24 m and upwards, should be inclined upon its completion. For the details of an inclining test, refer to 2008 IS Code, as amended, Chapter 8 and Annex I

....

Item B.6.1 was revised as below:

....

Refer to 2008 IS Code, as amended, Chapter 8 and Annex I for further details

Item B.8.4 was revised as below:

8.4 The format of the stability booklet and the information included will vary dependent on the ship type and operation. In developing the stability booklet, consideration should be given to including the following information (Refer to 2008 IS Code, as amended, and MSC Circular 920 for further details):

Item D.8.4.1 was revised as below:

8.4.1 In addition to the stability criteria given in B.10.2, or the equivalent stability criteria given in chapter 4 of the explanatory notes to the 2008 IS Code, as amended, where the ship's characteristics render compliance with B.10.2 impracticable, the following stability criteria should be complied with.

Item D.8.4.2 was revised as below:

………………

φ_f = Angle of down-flooding as defined in part A, paragraph 2.3.1.4 of 2008 IS Code, as amended. Openings required to be fitted with weathertight closing devices under the ICLL but, for operational reasons, are required to be kept open should be considered as down-flooding points in stability calculation;

Item D.9.3.2 was revised as below:

9.3.2 All loading conditions utilized during the lifting operations are to comply with the stability criteria given in B.10.2 and B.11. Where the ship's characteristics render compliance with B.10.2.2 impracticable, the equivalent stability criteria given in chapter 4 of the explanatory notes to the 2008 IS Code, as amended, should apply. During the lifting operation, as determined by paragraphs 9.1, the following stability criteria should also apply:

Item D.9.7.1 was revised as below:

9.7.1 For the loading conditions intended for lifting, but before commencing the operation, the stability criteria given in B.10.2 and B.10.3 should be complied with. Where a ship's characteristics render compliance with B.10.2 impracticable, the equivalent stability criteria given in chapter 4 of the explanatory notes to the 2008 IS Code, as amended, should apply. During the lifting operation, as determined by paragraph 9.1, the following stability criteria should apply:

Item E.1.1.1 was revised as below:

1.1.1 All passenger vessels and all cargo vessels with $L_s \geq 80$ m excluding those ships covered by other damage stability regulations in conventions and codes have to fulfill the stability requirements of part B-1 of SOLAS as amended in conjunction with Resolution MSC.429(98)/Rev.1 Revised Explanatory Notes to the SOLAS Chapter II-1 Subdivision and Damage Stability Regulations.

Item F.4.2.8 was revised as below:

………………

- compliance with relevant intact stability criteria (i.e. 2008 IS Code, as amended): listing of all calculated intact stability criteria, the limiting values, the obtained values and the evaluation (criteria fulfilled or not fulfilled);

………………

Item F.6.1.5.3 was revised as below:

………………

- As per IS Code, as amended, Part A Chapter 2 and 3.

………………

Item G.1.3 was revised as below:

1.3 Before a voyage commences, care should be taken to ensure that the cargo, cargo handling cranes and sizeable pieces of equipment have been properly stowed or lashed so as to minimize the possibility of both longitudinal and lateral shifting, while at sea, under the effect of acceleration caused by rolling and pitching (refer to the Guidelines for the preparation of the Cargo Securing Manual, MSC.1/Circular.1353/Rev.2).

05. Section 29 – Tugs

Revision Date: November 2020

Entry into Force Date: 1 January 2020

Item C.3 was revised as below:

Companionways ~~leading~~ to spaces below ~~weather~~ deck are to have sill height not less than 600 mm and are to have ~~watertight~~ weathertight steel doors which can be opened and closed ~~watertight~~ (weathertight) from either side.

06. Section 30 – Passenger Ships

Revision Date: November 2020

Entry into Force Date: 1 January 2020

Item B.1 was revised as below:

1. ~~Permissible Length of~~ Compartmentations

Passenger ships are to be as efficiently subdivided as is possible having regard to the nature of the service for which they are intended. The degree of subdivision is to vary with the subdivision length (L_S) of the ship and with the service, in such manner that the highest degree of subdivision corresponds with the ships of greatest subdivision length (L_S). ~~The maximum permissible length of a compartment is to be determined according to SOLAS 74, Reg. II-1/4.4.~~

PART A – CHAPTER 2 MATERIAL

01. Section 3 –Rolled Steel Plates, Sections And Bars

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item J.1 was revised according to UR W31 Rev.2 as below:

……………….

J. Requirements for Use of Extremely Thick Steel Plates on Container Carriers

1. Application of TL-EH47 Steel Plates

1.1. ~~Application~~ Scope

1.1.1 General

1.1.1.1 This subsection defines the requirements on TL- EH47 steels and brittle crack arrest steels as required by TL- R S33

1.1.1.2 Unless otherwise specified in this subsection, TL- R W 11 is to be followed.

1.1.2 TL- EH47 steels

~~**1.1.1.1**~~ **1.1.2.1** Steel plates designated as TL-EH47, refer to steel plates with a specified minimum yield point of 460 N/mm^2. ~~The scope of application is defined in 1.1.1.2 and 1.1.2.~~

~~**1.1.1.2**~~ **1.1.2.2** The TL-EH47 steel can be applied to longitudinal structural members in the upper deck region of container carriers (such as hatch side coaming, hatch coaming top and the attached longitudinals). Special consideration is to be given to the application of TL-EH47 steel plate for other hull structures.

~~This subsection defines grade TL-EH47, its approval requirements, its certification requirements, welding consumables requirements and requirements for weld procedure qualification.~~

~~**1.1.1.3** In the case where TL-EH47 steel is applied as brittle crack arrest steel required by 2, the brittle crack arrest properties shall be in accordance with 1.2.1.2 of this subsection.~~

~~**1.1.1.4** Brittle fracture toughness of welded joints is to comply with Sec. 3.B (TL- R W11) and 1.2.2.3.b (TL- R W28).~~

~~**1.1.1.5** Unless otherwise specified in this subsection, Section 3 is to be followed.~~

~~**1.1.2** Thickness~~

~~**1.1.2.1**~~ **1.1.2.3** This ~~subsection~~ article gives the requirements for ~~steel plates~~ TL-EH 47 steels in thickness greater than 50mm and not greater than 100 mm intended for ~~hatch coamings and~~ the upper decks region of container ~~ships~~ carriers. ~~**1.1.2.2**~~ For ~~steel plates~~ TL-EH 47 steels outside scope of ~~this~~ said thickness range, special consideration is to be given by **TL**.

1.1.3 Brittle crack arrest steels

1.1.3.1 The brittle crack designation can be assigned to TL-EH 36 and TL-EH 40 steels specified in TL- R W11 and TL-EH 47 steels specified in this subsection, which meet the additional brittle crack arrest requirements and properties defined in this subsection.

1.1.3.2 The application of brittle crack arrest steels is to comply with TL- R S33, which covers longitudinal structural members in the upper deck region of container carriers (such as hatch side coaming, upper deck, hatch coaming top and the attached longitudinals, etc.).

1.1.3.3 The thickness range of brittle crack arrest steels is over 50 mm and not greater than 100mm as specified in Table 3.27 of this subsection.

~~**1.2. General**~~

~~**1.2.1**~~ **1.2 Material specifications**

1.2.1 TL- EH 47 steels

~~1.2.1.1~~ Material specifications for TL-EH47 steels ~~plates~~ are ~~defined~~ specified in Table 3.25 and Table 3.26.

~~The extent of testing is to be one set of three specimens taken from each piece defined in B.11.1.~~

~~**1.2.1.2** For the purpose of this subsection, brittle crack arrest steel is defined as steel plate with measured crack arrest properties at manufacturing approval stage, at -10o C, Kca ≥ 6,000 N/mm3/2 or other methods based o the determination of Crack Arrest Temperature (CAT).~~

~~*Note 1: The Crack Arrest Fracture Toughness Kca is to be determined by the ESSO Test shown in Annex 2 of this subsection or other alternative method. Crack Arrest Temperature (CAT) may also be determined by the Double Tension Wide Plate Test or equivalent. The use of small scale test parameters such as the Nil Ductility Test Temperature (NDTT) may be considered provided that mathematical relationships of NDTT to Kca or CAT can be shown to be valid.*~~

~~*Note 2: Where the thickness of the steel exceeds 80 mm the required Kca value or alternative crack arrest parameter for the brittle crack arrest steel plate is to be specifically agreed with TL.*~~

~~**(a) Charpy V-notch Impact Tests**~~

~~Generally Charpy V-notch impact testing is to be carried out in accordance with this Section 3.~~

~~Test samples are to be taken from the plate corresponding to the top of the ingot, unless otherwise agreed.~~

~~In the case of continuous castings, test samples are to be taken from a randomly selected plate.~~

~~The location of the test sample is to be at the square cut end of the plate, approximately onequarter width from an edge, as shown Figure 3.13.~~

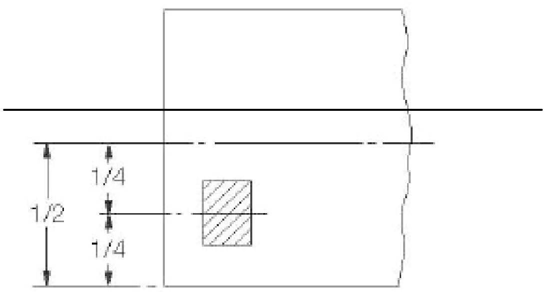
~~Samples are to be taken with respect to the principal rolling direction of the plate at locations representing the top and bottom of the plate as follows:~~

~~Longitudinal Charpy V-notch impact tests - Top and bottom, Transverse Charpy V-notch impact tests – Top only, Strain aged longitudinal Charpy V-notch impact test - Top only.~~

~~Charpy V-notch impact tests are required from both the quarter and mid thickness locations of the test samples.~~

~~One set of 3 Charpy V-notch impact specimens is required for each impact test.~~

~~The Charpy V-notch impact test temperature is to be -40°C.~~



~~**Figure 3.13 Plates and flats**~~

Table 3.25 Chemical composition and deoxidation practice for TL- EH 47 steels without specified brittle crack arrest properties

Grade	**TL- EH 47**
Deoxidation practice	Killed and fine grain treated
Chemical Composition % (ladle samples) (6) (7)	
C max.	0.18
Mn	0.90 – 2.00
Si max.	0.55
P max.	0.020
S max.	0.020
Al (acid soluble min)	0.015 (1) (2)
Nb	0.02 – 0.05 (2) (3)
V	0.05 – 0.10 (2) (3)
Ti max.	0.02 (3)
Cu max.	0.35
Cr max.	0.25
Ni max.	1.0
Mo max.	0.08
Ceq max.(4)	0.49
Pcm max.(5)	0.22

Notes:

1. The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020%.

2. The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of a fine graining element is not applicable.

3. The total niobium, vanadium and titanium content is not to exceed 0.12%.

4. The carbon equivalent Ceq value is to be calculated from the ladle analysis using the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

5. Cold cracking susceptibility Pcm value is to be calculated using the following formula:

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B(\%)$$

6. Where additions of any other element have been made as part of the steelmaking practice subject to approval by TL, the content is to be indicated on product inspection certificate.

7. Variations in the specified chemical composition may be allowed subject to approval of TL.

Table 3.256 Conditions of supply, grade and mechanical properties for TL-EH47 steels without specified brittle crack arrest properties (1)

Supply condition	Grade	Mechanical Properties Tensile test			Impact test			
		Yield Strength (N/mm^2) min.	Tensile Strength (N/mm^2)	Elongation (%) min	Test Temp. (^{o}C)	Average Impact Energy (J) min.		
						50 < t ≤ 70	70 < t ≤ 85	85 < t ≤ 100
						Longitudinal	Longitudinal	Longitudinal
TMCP* (2)	TL-EH47	460	570-720	17	-40^{o}C	53	64	75

t: thickness (mm)

Notes:

1. The additional requirements for TL- EH 47 steel with brittle crack arrest properties is specified in 2.2 of this subsection.

** 2. Other conditions of supply are to be in accordance with TL procedures.*

Table 3.26 Chemical compositions for TL-EH47 steel plates

Chemical composition	C_{eq}*1	P_{cm}*2
As approved by TL	≤ 0.49%	≤ 0.22%

Note:

**1 The carbon equivalent C_{eq} value is to be calculated from the ladle analysis using the following formula.*

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

**2 Cold cracking susceptibility is to be calculated using the following formula.*

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B(\%)$$

In addition to the determination of the energy value, the lateral expansion and the percentage crystallinity are also to be reported.

The strain aged samples are to be strained to 5% followed by heating to 250°C for 1 hour prior to testing.

Additionally at each location, Charpy V-notch impact tests are to be carried out with appropriate temperature intervals to properly define the full transition range.

(b) Brittle fracture initiation test

~~Deep notch test or Crack Tip Opening Displacement (CTOD) test is to be carried out and the result is to be reported.Test method is to be in accordance with **TL**'s practice.~~

~~**(c) Naval Research Laboratory (NRL) drop weight test**~~

~~The test method is to comply with ASTM E208 or equivalent method.~~

~~Nil Ductility Test Temperature (NDTT) is to be reported for reference and may be used in the qualification of production test methods.~~

~~**(d) Brittle crack arrest test**~~

~~ESSO test described in Annex 2 or other alternative test (e.g. double tension test etc.) is to be carried out in order to obtain the brittle crack arrest toughness for reference.~~

~~**1.2.2.4 Weldability test**~~

~~**(a) Charpy V-notch Impact Test**~~

~~Charpy V-notch impact tests are to be taken at a position of 1/4 thickness from the plate surface on the face side of the weld with the notch perpendicular to the plate surface.~~

~~One set of the specimens transverse to the weld is to be taken with the notch located at the fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line.~~

~~The fusion boundary is to be identified by etching the specimens with a suitable reagent.~~

~~One additional set of the specimens is to be taken from the root side of the weld with the notch located at the same position and at the same depth as for the face side.~~

~~The impact test temperature is -40°C.~~

~~Additionally at each location, impact tests are to be carried out with appropriate temperature intervals to properly define the full transition range.~~

~~**(b) Y- shape weld crack test (Hydrogen crack test)**~~

~~The test method is to be in accordance with recognized national standards such as KS B 0870, JIS Z 3158 or GB 4675.1.~~

~~Acceptance criteria are to be in accordance with **TL**'s practice.~~

~~**(c) Brittle fracture initiation test**~~

~~Deep notch test or CTOD test is to be carried out.~~

~~Test method and results are to be considered appropriate by **TL**.~~

1.2.2 Brittle crack arrest steels

1.2.2.1 Brittle crack arrest steels are defined as steel plate with the specified brittle crack arrest properties measured by either the brittle crack arrest toughness Kca or Crack Arrest Temperature (CAT).

1.2.2.2 In addition to the required mechanical properties of TL- R W11 for TL- EH36 and TL- EH40 and Table 3.26 of this subsection for TL- EH47, brittle crack arrest steels are to comply the requirements specified in Table 3.27 and Table 3.28 of this subsection.

1.2.2.3 The brittle crack arrest properties specified in Table 3.27 are to be evaluated for the products in accordance with the procedure approved by TL. Test specimens are to be taken from each piece (means “the rolled product from a single slab or ingot if this is rolled directly into plates” as defined in TL- R W11), unless otherwise agreed by TL.

Table 3.27 Requirement of brittle crack arrest properties for brittle crack arrest steels

Suffix to the steel grade **(1)**	Thickness range (mm)	Brittle crack arrest properties **(2) (6)**	
		Brittle crack arrest toughness K_{ca} at - 10°C (N/mm$^{3/2}$) **(3)**	Crackm arrest temperature CAT (°C) **(4)**
BCA 1	50 < t ≤ 100	6,000 min.	-10 or below
BCA 2	80 < t ≤ 100 **(7)**	8,000 min.	**(5)**

t : thickness

Notes:

1. Suffix “BCA1” or “BCA2” is to be affixed to the steel grade designation (e.g.TL- EH40-BCA1,TL- EH47-BCA1, TL- EH47-BCA2, etc.).

2. Brittle crack arrest properties for brittle crack arrest steels are to be verified by either the brittle crack arrest toughness Kca or Crack Arrest Temperature (CAT).

3. Kca value is to be obtained by the brittle crack arrest test specified in Annex 4 of this section.

4. CAT is to be obtained by the test method specified in Annex 5 of this section.

5. Criterion of CAT for brittle crack arrest steels corresponding to Kca=8,000 N/mm$^{3/2}$ is to be approved by the TL.

6. Where small-scale alternative tests are used for product testing (batch release testing), these test methods are to be approved by TL.

7. Lower thicknesses may be approved at the discretion of TL.

Table 3.28 Chemical composition and deoxidation practice for brittle crack arrest steels

Grade	**TL-EH36-BCA**	**TL-EH40-BCA**	**TL- EH47-BCA**
Deoxidation practice	Killed and fine grain treated		
Chemical Composition % (1)(7)(8) (ladle samples)			
C max.	0.18		0.18
Mn	0.90-2.00		0.90-2.00
Si max.	0.50		0.55
P max.	0.020		0.020
S max.	0.020		0.020
Al (acid soluble min)	0.015 (2) (3)		0.015 (2) (3)
Nb	0.02-0.05 (3) (4)		0.02-0.05 (3) (4)
V	0.05-0.10 (3) (4)		0.05-0.10 (3) (4)
Ti max.	0.02 (4)		0.02 (4)
Cu max.	0.50		0.50
Cr max.	0.25		0.50
Ni max.	2.00		2.00
Mo max.	0.08		0.08
Ceq max.(5)	0.47	0.49	0.55
Pcm max.(6)	-		0.24

Notes:

1. Chemical composition of brittle crack arrest steels shall comply with Table 3.28 of this subsection, regardless of chemical composition specified in TL- R W11 and Table 3.25 of this subsection.

2. The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020%.

3. The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of a fine graining element is not applicable.

4. The total niobium, vanadium and titanium content is not to exceed 0.12%.

5. The carbon equivalent Ceq value is to be calculated from the ladle analysis using the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

6. Cold cracking susceptibility Pcm value is to be calculated using the following formula:

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B(\%)$$

7. Where additions of any other element have been made as part of the steelmaking practice subject to approval by TL, the content is to be indicated on product inspection certificate.

8. Variations in the specified chemical composition may be allowed subject to approval of TL.

1.3. Manufacturing Approval Scheme

1.3.1 TL- EH 47 steels

Manufacturing approval scheme for TL- EH47 steels is to be in accordance with Annex 2 of this section.

1.3.2 Brittle crack arrest steels

Manufacturing approval scheme for brittle crack arrest steels is to be in accordance with Annex 3 of this section.

1.~~2.~~4. Welding Procedure Qualification Test

1.4.1 TL- EH47 steels

1.~~2.~~4.1.1 General

Approval test items, test methods and acceptance criteria not specified in this subsection are to be in accordance with the procedures of **TL**.

~~1.2.4.2~~ 1.4.1.2 Approval range

Chapter 3 Welding Section 12.F is to be followed for approval range.

~~1.2.4.3~~ 1.4.1.3 Impact test

Chapter 3 Welding Section 12.F is to be followed for impact test. 64J at -20°C is to be satisfied.

~~1.2.4.4~~ 1.4.1.4 Hardness

HV10, as defined in Chapter 3 Welding Section 12.F, is to be not more than 350. Measurement points are to include mid-thickness position in addition to the points required by Chapter 3 Welding Section 12.F.

~~1.2.4.5~~ 1.4.1.5 Tensile test

Tensile strength in transverse tensile test is to be not less than 570 N/mm^2.

~~1.2.4.6~~ 1.4.1.6 Brittle fracture initiation test

Deep notch test or CTOD test may be required.
Test method and acceptance criteria are to be considered appropriate by TL.

1.4.2 Brittle crack arrest steels

1.4.2.1 General

Where Welding Procedure Specification (WPS) for the non-BCA steels has been approved by TL, the said WPS is applicable to the same welding procedure applied to the same grade with suffix “BCA1” or “BCA2” specified in Table 3.27 of this subsection except high heat input processes over 50kJ/cm.

The requirements for welding procedure qualification test for brittle crack arrest steels is to be in accordance with the relevant requirements for each steel grade excluding suffix “BCA1” or “BCA2” specified in Table 3.27 of this subsection, except for 4.2.2 below.

1.4.2.2 Hardness

For TL- EH47 steels with brittle crack arrest properties, HV10, as defined in Chapter 3 Welding Section 12.F, is to be not more than 380. Measurement points are to include mid-thickness position in addition to the points required by Chapter 3 Welding Section 12.F.

1.5. Production Welding

1.5.1 TL- EH47 steels

~~1.2.3 Welding works~~

~~1.2.3.1~~ 1.5.1.1 Welder

Welders engaged in TL- EH47 welding work are to possess welder’s qualifications specified in Chapter 3 Welding Section 3.

~~1.2.3.2~~ 1.5.1.2 Short bead

Short bead length for tack and repairs of welds by welding are not to be less than 50mm.

In the case where Pcm is less than or equal to 0.19, 25 mm of short bead length may be adopted with approval of TL.

~~1.2.3.3~~ 1.5.1.3 Preheating

Preheating is to be 50°C or over when air temperature is 5°C or below.
In the case where Pcm is less than or equal to 0.19 and the air temperature is below 5°C but above 0°C ~~or below~~, alternative preheating requirements may be adopted with approval of TL.

~~1.2.3.4~~ 1.5.1.4 Welding consumable

Approval procedure, approval test items, test methods and acceptance criteria not specified in this subsection are to be in accordance with TL- R W17.
Specifications of welding consumables for TL- EH47 steel plates are to be in accordance with Table 3.29.

Table 3.29 Mechanical properties for deposited metal tests for welding consumables

Mechanical properties			Impact test	
Yield strength (N/mm^2) min.	Tensile strength (N/mm^2)	Elongation (%) min.	Test temp. (°C)	Average impact energy (J) min.
460	570-720	19	-20	~~53~~ 64

Consumable tests for butt weld assemblies are to be in accordance with Table 3.30.

Table 3.30 Mechanical properties for butt weld tests for welding consumables

Tensile strength (N/mm^2)	Bend test ratio: D/t	Charpy V-notch impact test		
		Test temp. (°C)	Average absorbed energy (J) min.	
			~~Downhand, horizontal-vertical, overhead~~	~~Vertical (upward and downward)~~
570-720	4	-20	~~53~~ 64	

~~1.2.3.5~~ 1.5.1.5 Others

Special care is to be paid to the final welding so that harmful defects do not remain.

Jig mountings are to be completely removed with no defects in general, otherwise the treatment of the mounting is to be accepted by TL.

1.5.2 Brittle crack arrest steels

Welding work (such as relevant welder's qualification, short bead, preheating, selection of welding consumable, etc.) for brittle crack arrest steels is to be in accordance with the relevant requirements for each steel grade excluding suffix "BCA1" or "BCA2" specified in Table 3.27 of this subsection.

Revision Date: October 2020

Entry into Force Date: 1 January 2021

Item J.2.1.1.3 was added and subsequent items are renumbered and revised and item J.2.1.1.5 was added according to UR S33 Rev.2 as below:

2.1.1.3 This Rule defines the following methods to apply to the extremely thick plates of container ships for preventing the crack initiation and propagation:

- Non-Destructive Testing (NDT) during construction detailed in 2,
- Periodic NDT after delivery detailed in 3,
- Brittle crack arrest design detailed in 4.

2.1.1.4 This rule gives the basic concepts for application of extremely thick steel plates to longitudinal

structural members in the upper deck ~~and hatch coaming structural~~ region ~~(i.e. upper deck plating, hatch side coaming and hatch coaming top)~~

2.1.1.5 For the application of this sub section, the upper deck region means the upper deck plating, hatch side coaming plating, hatch coaming top plating and their attached longitudinals.

Item J.2.1.2 was revised according to UR S33 Rev.2 as below:

2.1.2 Steel Grade

2.1.2.1 This subsection is to be applied when any of TL-EH36, TL-EH40 and TL-EH47 steel plates are used for the longitudinal structural members in the upper deck region.

Note:

TL-EH36, TL-EH40 and TL-EH47 refers to the minimum specified yield strength of steel ~~defined in TL- R W11 and TL- R W31:~~ 355, 390 and 460 N/mm^2, respectively as defined in TL- R W11 and TL- R W31.

2.1.2.2 In the case that TL-EH47 steel plates are used for longitudinal structural members in the upper deck region ~~such as upper deck plating, hatch side coaming and hatch coaming top and their attached longitudinals, the grade of TL-EH47~~ the steel plates ~~is~~ are to be as specified in Table 3.25 (TL- R W31).

Item J.2.1.4 was revised according to UR S33 Rev.2 as below:

2.1.4 Hull structures (for the purpose of design)

2.1.4.1 HT(K) factors (Material factor for TL-EH36, TL-EH40 and TL-EH47 steel) k

HT Material factors of TL-EH36 and TL-EH40 steels are to be taken as 0.72 or 0.68 as respectively.

The HT material factor (Material factor of high tensile steel, K) of TL-EH47 steel for the assessment of hull girder strength is to be taken as k=0.62.

2.1.4.2 Fatigue assessment

The fatigue assessment on of the longitudinal structural members is to be evaluated by **TL** on a case by case basis.

2.1.4.3 Details of construction design

Special consideration is to be paid to the construction details where extremely thick steel plates are applied as to structural members such as connections between outfitting and hull structures. Connections details are to be in accordance with **TL**'s requirements.

Item J.2.2 was revised according to UR S33 Rev.2 as below:

2.2 Non-Destructive Testing (NDT) during construction (Measure No.1 of Annex 1)

Where non-destructive testing (NDT) during construction is required in Annex 1, the NDT is to be in accordance with 2.2.1 and 2.2.2. Enhanced NDT as specified in 2.4.3.1(e) is to be carried out in accordance with the appropriate standard.

Item J.2.4.1.1 was added and subsequent items are renumbered and renumbered items J.2.4.1.2, 2.4.1.3 and 2.4.1.4 were revised according to UR S33 Rev.2as below:

2.4.1.1 The brittle crack arrest steel method detailed in 2.4 may be used when the measures No.3, 4 and 5 of Annex 1 are applied and the steel grade material of the upper deck is not higher than YP40. Otherwise other means for preventing the crack initiation and propagation shall be agreed with **TL**.

2.4.1.2 Measures for prevention of brittle crack propagation, which is the same meaning as Brittle crack arrest design, are to be taken within the cargo hold region. A brittle crack arrest design means a design using these measures.

2.4.1.3 The approach measures given in this section item 2.4 generally appliesy to the block-to-block joints but it should be noted that cracks can initiate and propagate away from such joints. Therefore, appropriate measures should also be considered in accordance with for the cases specified in 2.4.2.1 (b) (ii).

2.4.1.4 Brittle crack arrest steels is are defined in 1.2.1.2 item 1 (TL- R W31). Only for the scope of this rule, the definition in 1.2.1.2 also applies to TL-EH36 and TL-EH40 steels.

Item J.2.4.2.1 was revised according to UR S33 Rev.2 as below:

2.4.2.1 The purpose of the brittle crack arrest design is aimed at to arresting propagation of a crack at a proper position and to prevent large scale fracture of the hull girder.

(a) ~~The point of a brittle crack initiation is to be considered in the block-to-block butt joints both of hatch side coaming and upper deck.~~ The locations of most concern for brittle crack initiation and propagation are the block-to-block butt weld joints either on hatch side coaming or on upper deck plating. Other locations in block fabrication where joints are aligned may also present higher opportunity for crack initiation and propagation along butt weld joints.

***: "Other weld areas" includes the following (refer to Fig. 3.15):

1. Fillet welds ~~where~~ between hatch side coaming plating, including top plating, ~~meet~~ and longitudinals;

2. Fillet welds ~~where~~ between hatch side coaming plating, including top plating and longitudinals, ~~meet~~ and attachments. (e.g., Fillet welds ~~where~~ between hatch side top plating ~~meet~~ and hatch cover pad plating.);

3. Fillet welds ~~where~~ between hatch side coaming top plating ~~meet~~ and hatch side coaming plating;

4. Fillet welds ~~where~~ between hatch side coaming plating ~~meet~~ and upper deck plating;

5. Fillet welds ~~where~~ between upper deck plating ~~meet~~ and inner hull/bulkheads;

6. Fillet welds ~~where~~ between upper deck plating ~~meet~~ and longitudinal; and

7. Fillet welds ~~where~~ between sheer strakes ~~meet~~ and upper deck plating.

Item J.2.4.3.1 was revised according to UR S33 Rev.2 as below:

2.4.3.1 The following are considered to be acceptable examples of measures that can be used on a brittle crack arrest-design to prevent brittle crack propagations.

The detail design arrangements are to be submitted to **TL** for their approval ~~by **TL**~~. Other ~~concept designs~~ measures may be considered and accepted for review by **TL**.

………………..

(d) Where Arrest Insert Plates of brittle crack arrest steel or Weld Metal Inserts with high crack arrest toughness properties are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, additional countermeasures are to be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming. These countermeasures are to include the application of brittle crack arrest steel in hatch side coaming~~s~~ plating.

………………..

2.4.4 Selection of brittle crack arrest steels

2.4.4.1 The brittle crack arrest steels fitted in the upper deck region of container ships are to comply with Table 3.31 where suffixes BCA1 and BCA2 are defined in TL-R W31.

2.4.4.2 The brittle crack arrest steel property is to be selected for each individual structural member with thickness above 50 mm according to Table 3.31.

Table 3.31 Brittle crack arrest steel requirement in function of structural members and thickness

Structural Members plating (*)	Thickness (mm)	Brittle crack arrest steel requirement
Upper deck	50 < t ≤ 100	Steel grade YP36 or 40 with suffix BCA1
Hatch coaming side	50 < t ≤ 80	Steel grade YP 40 or 47 with suffix BCA1
	80 < t ≤ 100	Steel grade YP 40 or 47 with suffix BCA2
(*) Excluding their attached longitudinals		

2.4.4.3 When brittle crack arrest steels as specified in Table 3.31 are used, the weld joints between the hatch coaming side and the upper deck are to be partial penetration weld details approved by **TL**.

In the vicinity of ship block joints, alternative weld details may be used for the deck and hatch coaming side connection provided additional means for preventing the crack propagation are implemented and agreed by **TL** in this connection area.

Annex 1 was revised according to UR S33 Rev.2 as below:

Annex 1

Measures for Extremely Thick Steel Plates

The thickness and the yield strength shown in the following table apply to the hatch coaming top plating and side plating, and are the controlling parameters for the application of the countermeasures given in 2.4.3.1. These controlling parameters are not applicable for the upper deck.

If the as built thickness of the hatch coaming top plating and side plating is below the values contained in the table, countermeasures are not necessary regardless of the thickness and yield strength of the upper deck.

Yield Strength (kgf/mm^2)	Thickness (mm)	Option	Measures			
			1	2	3+4	5
36	50 < t ≤ 85		.A.	.A.	.A.	.A.
	85 < t ≤ 100			.A.	.A.	.A.
40	50 < t ≤ 85			.A.	.A.	.A.

	85 < t ≤ 100			.A.		
			*	.A.**	.A.	
47 (FCAW)	50 < t ≤ 100			.A.		
			*	.A.**	.A.	
47 (EGW)	50 < t ≤ 100			.A.		

"X" means "To be applied".
"N.A." means "Need not to be applied".

"A", "B":.selectable options

**: See J.2.4.3.1 (e).*
***: may be required at the discretion of **TL**.*

Measures:

1 NDT other than visual inspection on all target block joints (during construction) See J.2.2

2 Periodic NDT other than visual inspection on all target block joints (after delivery) See J.2.3.

3 Brittle crack arrest design against straight propagation of brittle crack along weldline to be taken (during construction) See J.2.4.3.1 (b), (c) and (d).

4 Brittle crack arrest design against deviation of brittle crack from weldline (during construction) See J.2.4.3.1 (a).

5 Brittle crack arrest design against propagation of cracks from other welds *** such as fillets and attachment welds, as defined in item J.2.4.2.1 (b), (during construction) See J.2.4.3.1 (a).

~~**Symbols:**~~

~~(a) "X" means "To be applied".~~

~~(b) "N.A." means "Need not to be applied".~~

~~(c) Selectable from option "A" and "B".~~

~~**Note:**~~

~~*: See J.2.4.3 (e).~~

~~**: may be required at the discretion of TL~~

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Annex 2 was deleted according to UR W31 Rev.2 as below:

~~**Annex 2**~~

~~**ESSO Test**~~

1. Scope

1.1 The ESSO test method is used to estimate the brittle crack arrest toughness value Kca of rolled steel plates for hull of thickness 100 mm or less.

2. Symbols

Table 1 Nomenclature

Symbol	**Unit**	**Meaning**
t_S	mm	Thickness of test specimen
W_S	mm	Width of test specimen
L_S	mm	Length of test specimen
t_r	mm	Thickness of tab plate
W_r	mm	Width of tab plate
L_r	mm	Length of tab plate
L_P	mm	Distance between pins
a	mm	Length of crack projected on surface normal to the line of load
a_a	mm	Maximum crack length at brittle crack arrest position
T	ºC	Temperature of test specimen
dT/da	ºC/mm	Temperature gradient of test specimen
σ	N/mm^2	Gross stress in tested part (*load / W_S .t_S*)
K_{ca}	$N/mm^{3/2}$	Brittle crack arrest toughness value

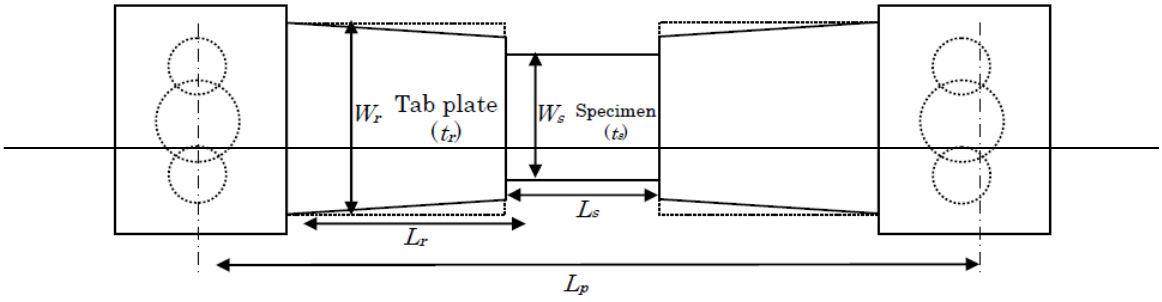
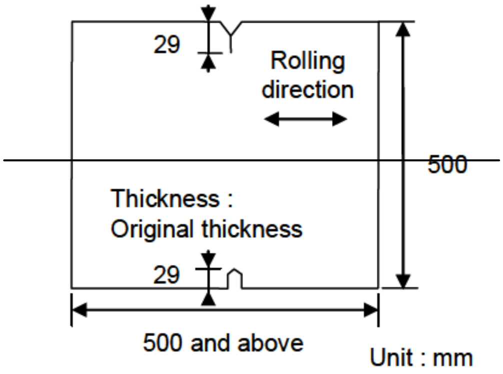


Figure 1 Conceptual view of test specimen, tab and load jig3. Purpose

3.1 The purpose of this test is to encourage the performance of a standard test for assessment of brittle crack arrest toughness with temperature gradient and to obtain the corresponding brittle crack arrest toughness value K_{ca}.

4. Standard test specimen

4.1 Figure 2 shows the shape and size of the standard test specimen.



~~**Figure 2 Shape and size of specimen**~~

~~**4.2** The thickness and width of the test specimen are to be in accordance with Table 2.~~

~~**Table 2 Thickness and width of test specimen**~~

~~T~~	~~100 mm and below~~
~~Width of test~~	~~500~~

~~***Note:***~~

~~*If the width of the test specimen cannot be made at 500 mm, it may be taken as 600 mm.*~~

~~**4.3** The test specimens are to be taken from the same steel plate.~~

~~**4.4** Test specimens are to be taken in such a way that the axial direction of the load is parallel to the rolling direction of the steel plate.~~

~~**4.5** The thickness of the test specimen is to be the same as the thickness of the steel plate to be used in the vessel structure.~~

~~**5 Test equipment**~~

~~**5.1** The test equipment to be used is to consist of pin load type hydraulic test equipment capable of tensile tests.~~

~~**5.2** The distance between the pins is to be not less than 2,000 mm. The distance between pins refers to the distance between the centres of the pin diameters.~~

~~**5.3** Drop weight type or air gun type impact equipment may be used for the impact energy required for generating brittle cracks.~~

~~**5.4** The wedge is to have an angle greater than the upper notch of the test specimen, and an opening force is to be applied on the notch.~~

~~**6 Test preparations**~~

~~**6.1** The test piece is to be fixed directly to the pin load jig or by means of weld joint through the tab plate. The overall length of the test specimen and tab plate is to be not less than 3Ws. The thickness and width of the tab plate are to be in accordance with Table 3.~~

~~**Table 3 Allowable dimensions of tab plate**~~

	~~**Thickness: t_r**~~	~~**Width: W_r**~~
~~Dimensions of tab plate~~	~~$0.8t_S$(Notes 1 and 2) ≤ t_r ≤ $1.5t_S$~~	~~W_S ≤ W_r ≤ $2W_S$~~

~~**Note 1:** ts : Thickness of test specimen~~

~~**Note 2:** If the tab plate has a thickness smaller than the test specimen, the reflection of stress wave will be on the safer side for the assessment; therefore, considering the actual circumstances for conducting the test, the lower limit of thickness is taken as 0.8ts.~~

~~**6.2** Thermocouples are to be fitted at 50 mm pitch on the notch extension line of the test specimen.~~

~~**6.3** If the brittle crack is estimated to deviate from its presumed course, thermocouples are to be fitted at two points separated by 100 mm on the line of loadfrom the notch extension line at the centre of width of the test specimen.~~

~~**6.4** If dynamic measurements are necessary, strain gauges and crack gauges are to be fitted at specific locations.~~

~~**6.5** The test specimen is to be fixed to the testing machine together with the tab plate after welding and the pin load jig.~~

~~**6.6** The impact equipment is to be mounted. The construction of the impact equipment is to be such that the impact energy is correctly transmitted. An appropriate jig is to be arranged to minimize the effect of bending load due to the impact equipment.~~

~~**7. Test method**~~

~~**7.1** To eliminate the effect of residual stress or correct the angular deformation of tab welding, a preload less than the test load may be applied before cooling.~~

~~**7.2** Cooling and heating may be implemented from one side on the side opposite the side on which the thermocouple is fitted, or from both sides.~~

~~**7.3** The temperature gradient is to be controlled in the range of 0.25°C/mm to 0.35°C/mm in the range of width from 0.3Ws to 0.7Ws at the central part of the test specimen.~~

~~**7.4** When the specific temperature gradient is reached, the temperature is to be maintained for more than 10 minutes, after which the specified test load may then be applied.~~

~~**7.5** After maintaining the test load for at least 30 seconds, a brittle crack is to be generated by impact. The standard impact energy is taken as 20 to 60 J per 1 mm plate thickness. If the brittle crack initiation~~

characteristics of the base metal are high, and it is difficult to generate a brittle crack, the impact energy may be increased to the upper limit of 120 J per 1 mm plate thickness.

7.6 Loading is stopped when the initiation, propagation, and arrest of crack have been confirmed. Normal temperature is restored, and if necessary, the ligament is broken by gas cutting and forcibly the specimen is broken by using the testing machine. Or, after the ductile crack has been propagated to an adequate length with the testing machine, the ligament is broken by gas cutting.

7.7 After forcing the fracture, photos of the fractured surface and the propagation route are to be taken, and the crack length is to be measured.

8 Test results

8.1 The distance from the top of the test specimen including the notch to the maximum length in the plate thickness direction of the arrested crack tip is to be measured. If the crack surface deviates from the surface normal to the line of load of the test specimen, the projected length on the surface normal to the line of load is to be measured. In this case, if the trace of brittle crack arrest is clearly visible on the fractured surface, the first crack arrest position is taken as the arrest crack position.

8.2 From the results of thermocouple measurement, the temperature distribution curve is to be plotted, and the arrest crack temperature is to be measured corresponding to the arrest crack length.

8.3 The brittle crack arrest toughness value (Kca value) of each test is to be determined by using the following formula:

$$K_{ca} = \sigma \sqrt{\pi a} \sqrt{\left(\frac{2 W_s}{\pi a}\right) \tan\left(\frac{\pi a}{2 W_s}\right)}$$

9 Report

9.1 The following items are to be reported:

(i) Testing machine specifications; testing machine capacity, distance between pins (Lp) (ii) Load jig dimensions; tab plate thickness (tr), tab plate width (Wr), test specimen length including tab plate (Ls + 2Lr)

(iii) Test specimen dimensions; plate thickness (ts); test specimen width (Ws) and length (Ls)

(iv) Test conditions; preload stress, test stress, temperature distribution (figure or table) impact energy

(v) Test results; crack arrest length (aa), temperature gradient at arrest position, brittle crack arrest toughness (Kca)

(vi) Dynamic measurement results (if measurement is carried out); crack growth rate, strain change

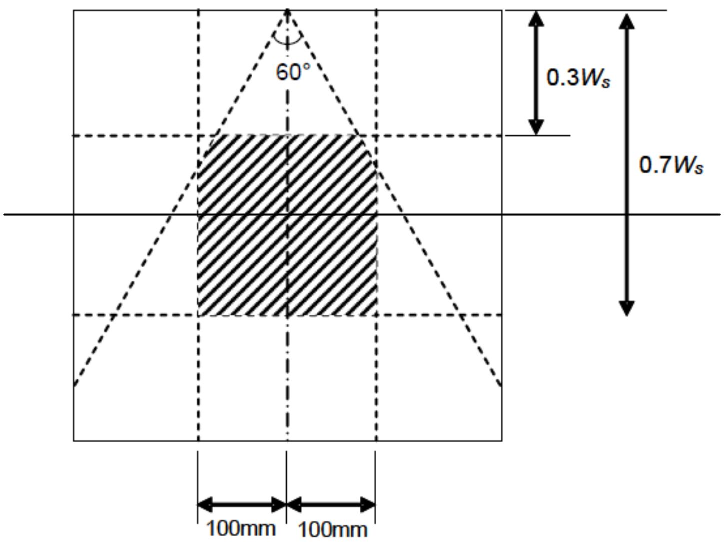
(vii) Test specimen photos; fracture route, fractured surface

9.2 If the conditions below are not satisfied, the test results are to be treated as reference values.

(i) The brittle crack arrest position is to be in the range of the hatched part shown in Figure 3.

~~In this case, if the brittle crack arrest position is more than 50 mm away from the centre of the test specimen in the longitudinal direction of the test specimen, the temperature of the thermocouple at the ±100 mm position is to be within ±3°C of the thermocouple at the centre.~~

~~(ii) The brittle crack should not have a distinct crack bifurcation while it propagates.~~



~~**Figure 3 Necessary conditions of arrest crack position**~~

~~**9.3** From effective test results measured at more than 3 points, the linear approximation equation is to be determined on the Arrhenius plot, and Kca at the desired temperature is to be calculated. In this case, data should exist on both sides, that is, the high temperature and low temperature sides around the assessed temperature.~~

Annex 2, 3, 4 and 5 were added according to UR W31 Rev.2 as below:

Annex 2

Manufacturing Approval Scheme for TL- EH47 Steels

1. Scope

1.1 This Annex specifies, as given in J.3.1 of this section, the manufacturing approval scheme for TL- EH 47 grade steels.

1.2 Unless otherwise specified in this Annex, Appendix A2 of TL- R W11 is to be followed.

2. Approval Tests

2.1 Extent of the approval tests

3.1 (c) and (d), Appendix A2 of TL- R W11 are not applied to manufacturing approval of TL- EH47 steels.

2.2 Type of tests

2.2.1 Brittle fracture initiation test

Deep notch test or Crack Tip Opening Displacement (CTOD) test is to be carried out. Test method is to be in accordance with TL's practice.

2.2.2 Weldability test

(a) Y-groove weld cracking test (Hydrogen crack test)

The test method is to be in accordance with recognized national standards such as JIS Z 3158-2016 or CB/T 4364-2013. Acceptance criteria are to be in accordance with TL's practice.

(b) Brittle fracture initiation test

Deep notch test or CTOD test is to be carried out. Test method and results are to be considered appropriate by TL.

2.2.3 Other tests

In addition to the requirement specified in 2.2.1 and 2.2.2 above, the approval tests required for steels specified in Appendix A2 of TL- R W11 are to be carried out. Additional tests may be required when deemed necessary by TL.

Annex 3

Manufacturing Approval Scheme for Brittle Crack Arrest Steels

1. Scope

1.1 This Annex specifies, as given in J.3.2 of this section, the manufacturing approval scheme for brittle crack arrest steels.

1.2 Unless otherwise specified in this Annex, Appendix A2 of TL- R W11 and/or Annex 2 of this section are to be followed.

2. Approval Application

2.1 Documents to be submitted

The manufacturer is to submit to TL the following documents together with those required in 2.1, Appendix A2 of TL- R W11:

a) In-house test reports of the brittle crack arrest properties of the steels intended for approval

b) Approval test program for the brittle crack arrest properties (see 3.1 below)

c) Production test procedure for the brittle crack arrest properties.

3. Approval Tests

3.1 Extent of the approval tests

3.1.1 The extent of the test program is specified in 3.2, 3.3 and 3.4 of this Annex.
If the manufacturing process and mechanism to ensure the brittle crack arrest properties for the steels intended for approval are same, 3.1, Appendix A2 of TL- R W11 is to be followed for the extent of the approval tests.

3.1.2 The number of test samples and test specimens may be increased when deemed necessary by TL, based on the in-house test reports of the brittle crack arrest properties of the steels intended for approval specified in 2.1 a).

3.2 Type of tests

3.2.1 Brittle crack arrest tests are to be carried out in accordance with 3.3 of this Annex in addition to the approval tests specified in Appendix A2 of TL- R W11 and/or Annex 2 of this section.

3.2.2 In the case of applying for addition of the specified brittle crack arrest properties for TL- EH36, TL- EH40 and TL- EH47 steels of which, manufacturing process has been approved by TL (i.e. The aim analyses, method of manufacture and condition of supply are similar and the steelmaking process, deoxidation and fine grain practice, casting method and condition of supply are the same), brittle crack arrest tests, chemical analyses, tensile test and Charpy V-notch impact test are to be carried out in accordance with Annex 3 of this section and Appendix A2 of TL- R W11.

3.3 Test specimens and testing procedure of brittle crack arrest tests

3.3.1 The test specimens of the brittle crack arrest tests are to be taken with their longitudinal axis parallel to the final rolling direction of the test plates.

3.3.2 The loading direction of brittle crack tests is to be parallel to the final rolling direction of the test plates.

3.3.3 The thickness of the test specimens of the brittle crack arrest tests is to be the full thickness of the test plates.

3.3.4 The test specimens and repeat test specimens are to be taken from the same steel plate.

3.3.5 The thickness of the test specimen is to be the maximum thickness of the steel plate requested for approval.

3.3.6 In the case where the brittle crack arrest properties are evaluated by Kca, the brittle crack arrest test method is to be in accordance with Annex 4 of this section. In the case where the brittle crack arrest properties are evaluated by CAT, the test method is to be in accordance with Annex 5 of this section.

3.4 Other tests

Additional tests may be required when deemed necessary by TL in addition to the tests specified in 3.3.

4. Results

Appendix A2 of TL- R W11 is to be followed for the results.
Additionally, results of test items and the procedures shall comply with the test program approved by TL. In the case where the brittle crack arrest properties are evaluated by Kca or CAT, the manufacturer also is to submit to TL the brittle crack arrest test reports in accordance with Annex 4 for Kca and Annex 5 for CAT of this section.

5. Approval and Certification

Upon satisfactory completion of the survey and tests, approval is granted by TL with the grade designation having the suffix “BCA1” or “BCA2” (e.g. TL-EH40-BCA1, TL-EH47-BCA1, TL-EH47-BCA2, etc.).

6. Renewal of Approval

The manufacturer is also to submit to TL actual manufacturing records of the approved brittle crack arrest steels within the term of validity of the manufacturing approval certificate.

Note: Chemical composition, mechanical properties, brittle crack arrest properties (e.g. brittle crack arrest test results or small-scale alternative test results) and nominal thickness are to be described in the form of histogram or statistics.

Annex 4

Test Method for Brittle Crack Arrest Toughness, K_{ca}

Setting a temperature gradient in the width direction of a test specimen, and applying uniform stress to the test specimen, strike the test specimen to initiate a brittle crack from the mechanical notch at the side of the test specimen and causes crack arrest (temperature gradient type arrest testing). Using the stress intensity factor, calculate the brittle crack arrest toughness, *Kca*, from the applied stress and the arrest crack length. This value is the brittle crack arrest toughness at the temperature of the point of crack arrest (arrest temperature). To obtain *Kca* at a specific temperature followed by the necessary evaluation, the method specified in Appendix A of this Annex 4 can be used.

As a method for initiating a brittle crack, a secondary loading mechanism can also be used (see Appendix B of this Annex 4 “Double tension type arrest test”).

1. Scope

Annex 4 specifies the test method for brittle crack arrest toughness (i.e. *Kca*) of steel using fracture mechanics parameter. This Annex 4 is applicable to hull structural steels with the thickness over 50 mm and not greater than 100 mm specified in TL- R W11 or this section.

2. Symbols and Their Significance

The symbols and their significance used in this Annex are shown in Table A4-1.

3. Testing Equipment

The following specifies the testing machine needed for conducting the brittle crack arrest test. Testing machine is used to apply tensile force to an integrated specimen, and impact equipment is used to generate a brittle crack on the test specimen.

3.1 Testing machine

3.1.1 Loading method

Tensile load to an integrated specimen shall be hydraulically applied.

The loading method to an integrated specimen using the testing machine shall be of a pin type. The stress distribution in the plate width direction shall be made uniform by aligning the centres of the loading pins of both sides and the neutral axis of the integrated specimen.

3.1.2 Loading directions

The loading directions shall be either vertical or horizontal. In the case of the horizontal direction, test specimen surfaces shall be placed either perpendicular to the ground.

3.1.3 Distance between the loading pins

The distance between the loading pins shall be approximately 3.4 *W* or more, where *W* is the width of the test specimen. Since the distance between the loading pins sometimes has an effect on the load drop associated with crack propagation, the validity of the test results is determined by the judgment method described in 7.1.

3.2 Impact equipment

3.2.1 Impact methods

Methods to apply an impact load to an integrated specimen shall be of a drop weight type or of an air gun type.

The wedge shall be hard enough to prevent significant plastic deformation caused by the impact. The wedge thickness shall be equal to or greater than that of the test specimen, and the wedge angle shall be greater than that of the notch formed in the test specimen and have a shape capable of opening up the notch of the test specimen.

Table A-4-1 Symbols and their significance

Symbol	Unit	Significance
a	mm	Crack length or arrest crack length
E	N/mm^2	Modulus of longitudinal elasticity
E_i	J	Impact energy
E_s	J	Strain energy stored in a test specimen
E_t	J	Total strain energy stored in tab plates and pin chucks
F	MN	Applied load
K	$N/mm^{3/2}$	Stress intensity factor
K_{ca}	$N/mm^{3/2}$	Arrest toughness
L	mm	Test specimen length
L_p	mm	Distance between the loading pins
L_{pc}	mm	Pin chuck length
L_{tb}	mm	Tab plate length
T	°C	Temperature or arrest temperature
t	mm	Test specimen thickness
t_{tb}	mm	Tab plate thickness
t_{pc}	mm	Pin chuck thickness
W	mm	Test specimen width
W_{tb}	mm	Tab plate width
W_{pc}	mm	Pin chuck width
X_a	mm	Coordinate of a main crack tip in the width direction
X_{br}	mm	Coordinate of the longest branch crack tip in the width direction
y_a	mm	Coordinate of a main crack tip in the stress loading direction
y_{br}	mm	Coordinate of the longest branch crack tip in the stress loading direction
σ	N/mm^2	Applied stress
σ_{y0}	N/mm^2	Yield stress at room temperature

4. Test Specimens

4.1 Test specimen shapes

The standard test specimen shape is shown in Figure A4-1. Table A4-2 shows the ranges of test specimen thicknesses, widths and width-to-thickness ratios.

The test specimen length shall be, in principle, equal to or greater than its width.

4.2 Shape of tab plates and pin chucks

The definitions of the dimensions of the tab plates and pin chucks are shown in Figure A4-2. Typical examples are shown in Figure A4-3.

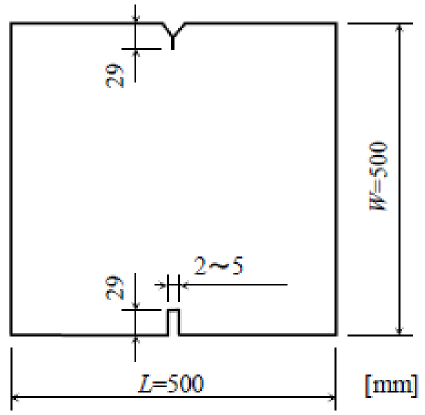


Figure A4-1 Standard test specimen shape

Table A4-2 Dimensions of test specimen

Test specimen thickness, t	50 mm ≤ t ≤ 100 mm
Test specimen width, W	350 mm ≤ W ≤ 1000 mm (Standard width: W=500 mm)
Test specimen width/test specimen thickness, W/t	W/t ≥ 5

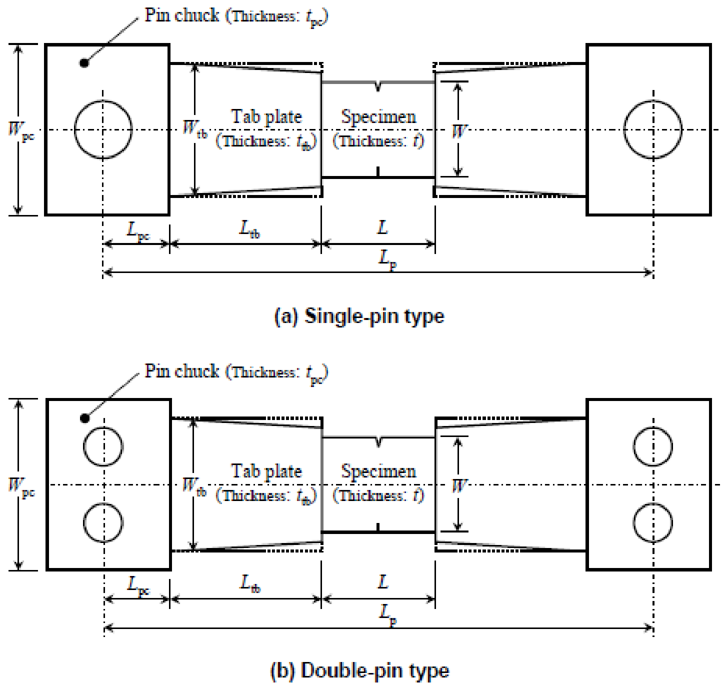
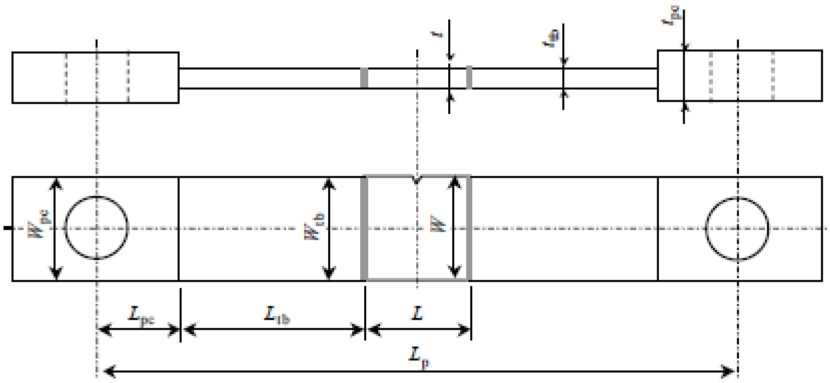
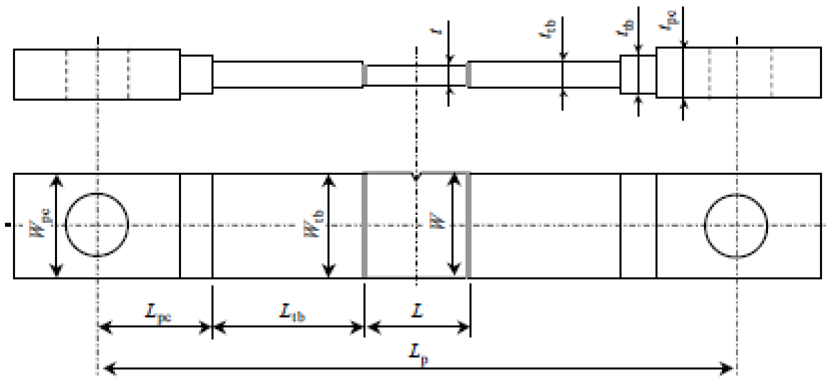


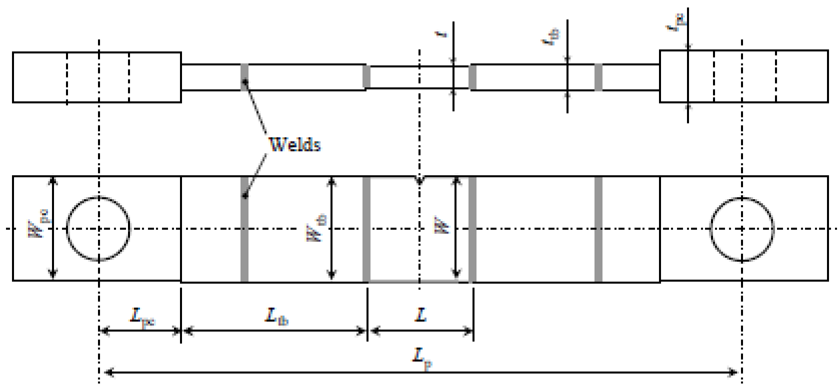
Figure A4-2 Definitions of dimensions of tab plates and pin chucks



(a) Example 1

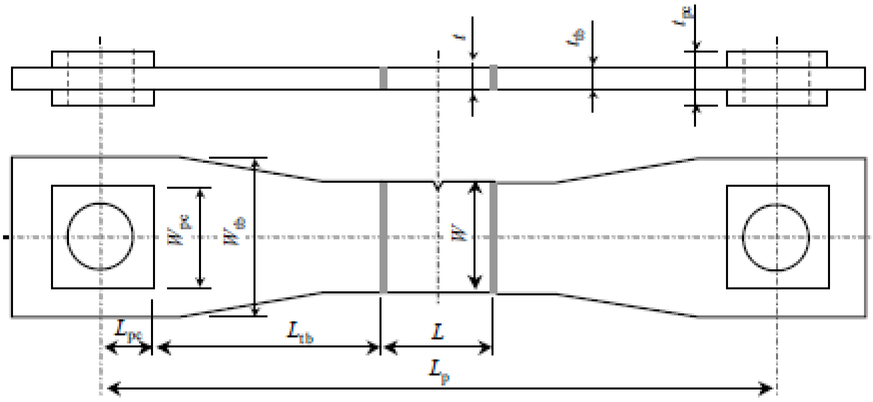


(b) Example 2

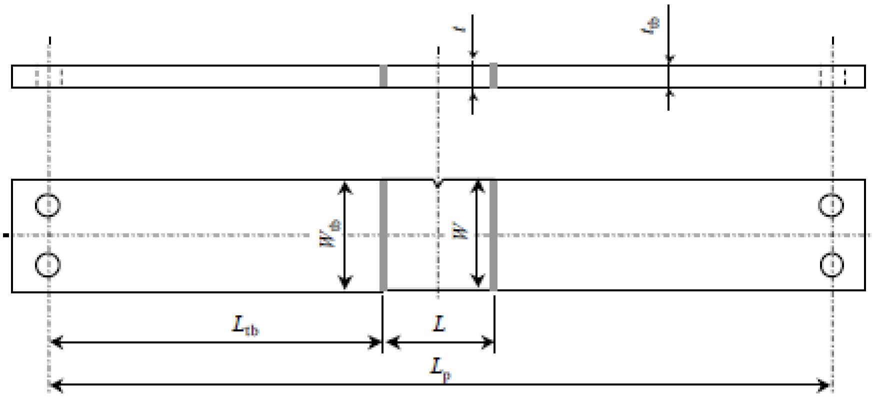


(c) Example 3

Figure A4-3 Examples of the shapes of tab plates and pin chucks



(d) Example 4



(e) Example 5

Figure A4-3 Examples of shapes of tab plates and pin chucks (cont'd)

Table A4-3 Tolerances of tab plate dimensions

Tab plate thickness, t_{tb}	$0{,}8\ t \leq t_{tb} \leq 1{,}5\ t$
Tab plate width, W_{tb}	$W \leq W_{tb} \leq 2{,}0\ W$
Total length of a test specimen and tab plates, $L + 2L_{tb}$ (Total length of a test specimen and a single tab plate $L + L_{tb}$)	$L + 2\ L_{tb} \geq 3{,}0\ W$ $(L + L_{tb} \geq 2{,}0\ W)$
Tab plate length (L_t)/Tab plate width (W)	$L_{tb} / W \geq 1{,}0$

4.2.1 Tab plates

The tolerances of tab plate dimensions are shown in Table A4-3. When the lengths of the tab plates attached to both ends of a test specimen are different, the shorter length shall be used as the tab length, *Ltb*.

4.2.2 Pin chucks

The pin chuck width, *Wpc*, shall be in principle equal to or more than the tab plate width, *Wtb*.

The pin chucks shall be designed to have a sufficient load bearing strength. When pin chucks attached to both ends of an integrated specimen are asymmetric, the length of the shorter one shall be used as the pin chuck length, *Lpc*.

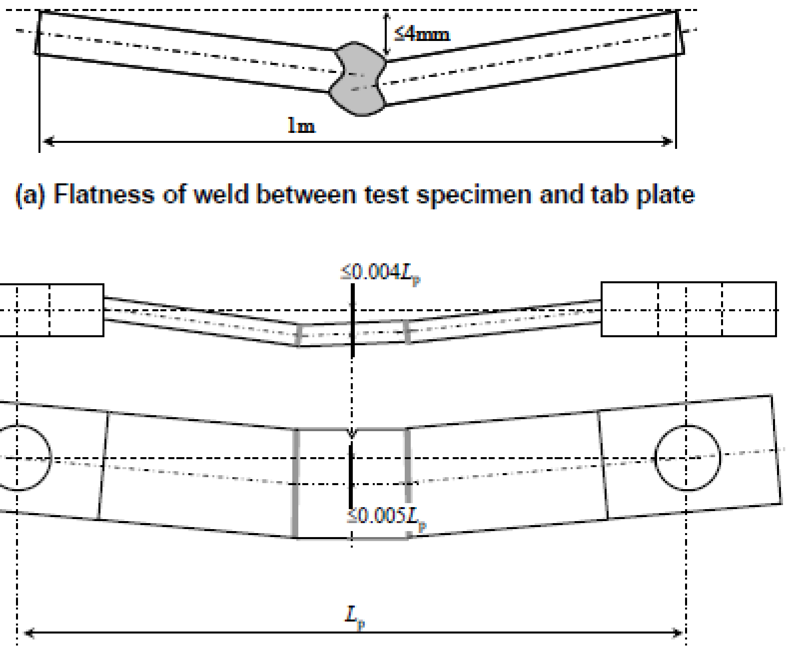
The distance between the pins, *Lp*, is obtained from the equation (1). In the case as shown in Figure A4-3 (e), Example 5, Lp is obtained by setting *Lpc* = 0.

$L_p = L + 2\,L_{tb} + 2\,L_{pc}$ ……………………………………**(1)**

4.3 Welding of test specimen and tab plates

Test specimen, tab plates, and pin chucks shall be connected by welding. The welds shall have a sufficient force bearing strength.

As shown in Figure A4-4 (a), the flatness (angular distortion, linear misalignment) of the weld between a test specimen and a tab plate shall be 4 mm or less per 1 m. In the case of preloading, however, it is acceptable if the value after preloading satisfies this condition. As shown in Figure A4-4 (b), the accuracy of the in-plane loading axis shall be 0.5% or less of the distance between the pins, and the accuracy of the out-of-plane loading axis shall be 0.4% or less of the distance between the pins.



(a) Flatness of weld between test specimen and tab plate

(b) Accuracy of in-plane and out-of-plane loading axes

Figure A4-4 Dimensional accuracy of weld between test specimen and tab plate

5. Test Methods

The following specifies methods for conducting the arrest toughness test.

5.1 Temperature control methods

A predetermined temperature gradient shall be established across a test specimen width by soldering at least nine thermocouples to the test specimen for temperature measurement and control.

Temperature gradient shall be established in accordance with the following conditions (1) through (3).

Test(1) A temperature gradient of 0.25 - 0.35°C/mm shall be established in a test specimen width range of 0.3*W* - 0.7*W*. When measuring the temperatures at the centre position of the test specimen thickness, it shall be kept within ±2°C for 10 minutes or more, whereas when measuring the temperatures on the front and back surface positions of the test specimen, it shall be kept within ±2°C for (10＋0.1*t* [mm]) minutes or more taking account of the time needed for soaking to the centre. If the temperature gradient at 0,3*W* - 0,7*W* is less than 0.25°C/mm, crack arrest may become difficult, and if the gradient is larger than 0.35°C/mm, the obtained arrest toughness may be too conservative.

(2) At the test specimen width centre position (i.e., 0.5*W*), and in the range of ±100 mm in the test specimen length direction, the deviation from the temperature at the centre position in the length direction shall be controlled within ±5°C. However, when temperature measurement is not performed at the centre position in the length direction, the average temperature at the closest position shall be used as the temperature at the centre position in the length direction.

(3) At the same position in the width direction, the deviation of the temperature on the front and back surfaces shall be controlled within ±5°C.

5.2 Crack initiation methods

Impact energy shall be applied to a test specimen to initiate a crack. However, if the energy is excessive, it may influence on the test results. In that case, the results shall be treated as invalid data in accordance with the judgment criteria specified in 7.2. It is desirable to use equation (2) and Figure A4-5 as guides for obtaining valid data.

$$\frac{E_i}{t} \leq min(1.2\sigma - 40, 200) \quad \text{.............................(2)}$$

Where the variables have the following units: E_i [J], t [mm], and σ [N/mm^2], and *min* means the minimum of the two values.

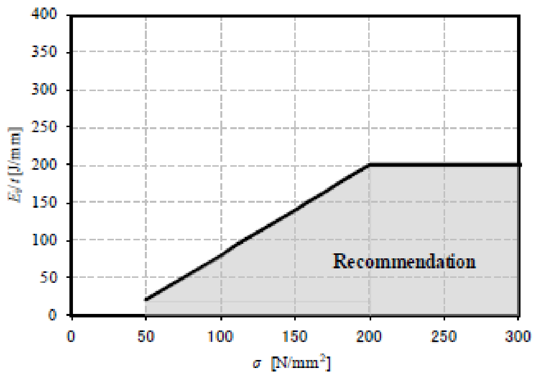


Figure A4-5 Recommended range of impact energy

6. Test Procedures

The following specifies the procedures for testing brittle crack arrest toughness.

6.1 Pretest procedures

(1) Install an integrated specimen in the testing machine.

(2) Mount a cooling device on the test specimen. A heating device may also be mounted on the test specimen.

(3) Install an impact apparatus specified in 3.2, on the testing machine. Place an appropriate reaction force receiver as necessary.

Note: The above procedures (1) through (3) do not necessarily specify the order of implementation, and they may be completed, for example, on the day before the test.

(4) After checking that all measured values of the thermocouples indicate room temperature, start cooling. The temperature distribution and the holding time shall be as provided in the specifications in 5.1.

(5) Set an impact apparatus, as specified in 3.2 so that it can supply predetermined energy to the test specimen.

(6) Apply force to the test specimen until it reaches the predetermined value. This force is applied after temperature control to prevent autonomous crack initiation during force increase. Alternatively, temperature control may be implemented after loading. The loading rate and applied stress shall satisfy the conditions (a) and (b) described below, respectively.

(a) Loading rate

There is no specification of loading rate, but it shall be determined considering that an excessively slow loading rate may prolong the temperature control period, thereby allowing the temperature distribution to depart from the desired condition and an excessively fast loading rate may cause over-shooting of the load.

(b) Applied stress/yield stress ratio

Applied stress shall be within the range shown by equation.

$$\sigma \leq \frac{2}{3}\sigma_{Y0} \quad \text{..................................}\mathbf{(3)}$$

As a guide, a value equal to 1/6 of σ_{Y0} or more is desirable. If applied stress is larger than that specified by equation (3), the test may give a non-conservative result.

(7) To initiate a crack, the notch may be cooled further immediately before impact on the condition that the cooling does not disturb the temperature in the range of 0.3*W* - 0.7*W*. The test temperature in this case shall be the measured temperature obtained from the temperature record immediately before the further notch cooling.

(8) Record the force value measured by a force recorder.

6.2 Loading procedures

(1) After holding a predetermined force for 30 seconds or more, apply an impact to the wedge using the impact apparatus. If a crack initiates autonomously and the exact force value at the time of the crack initiation cannot be obtained, the test is invalid.

(2) After the impact, record the force value measured by the force recorder.

(3) When the force after the impact is smaller than the test force, consider that crack initiation has occurred.

Note: An increase in the number of times of impact may cause a change in the shape of the notch of the test specimen. Since the number of impact has no effect on the value of brittle crack arrest toughness, no limit is specified for the number of impact. However, because the temperature gradient is often distorted by impact, the test shall be conducted again, beginning from temperature control when applying repeated impact to the wedge.

(4) When crack initiation, propagation, and arrest are observed, remove the force.

6.3 Procedures after testing

(1) Remove the impact apparatus.

(2) Remove the cooling device, thermocouples, and strain gauges.

(3) Return the temperature of the test specimen to room temperature. For that purpose, the test specimen may be heat-tinted using a gas burner or the like. If it is necessary to prevent heating of the fracture surface, this method shall be avoided.

(4) After gas-cutting an uncracked ligament, use the testing machine to cause ductile fracture, as necessary. Alternatively, it is also possible to gas-cut the uncracked ligament after using the testing machine to develop a ductile crack to a sufficient length.

6.4 Observation of fracture surfaces

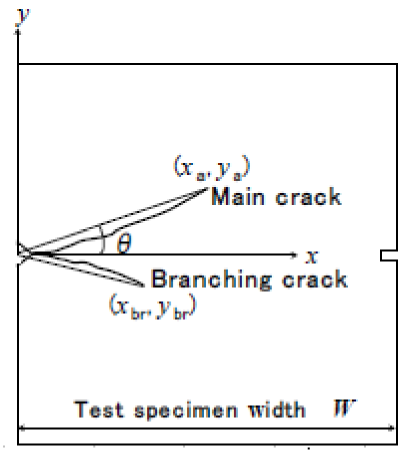
(1) Photograph the fracture surfaces and propagation path.

(2) Measure the longest length of the arrest crack tip in the plate thickness direction, and record the result as the arrest crack length. The arrest crack length shall include the notch length. In the case where a crack deviates from the direction vertical to the loading direction, the length projected to the plane vertical to the loading line is defined as the arrest crack length. In the following cases, however, judge the results according to the methods described for each case.

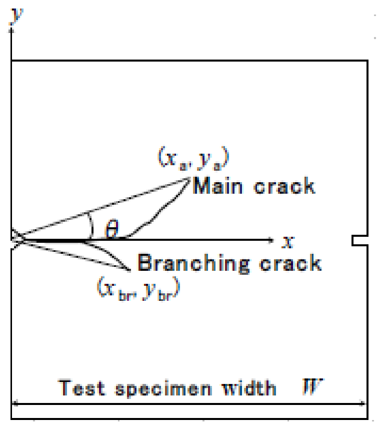
(a) Crack re-initiation.In the case where a brittle crack has re-initiated from an arrested crack, the original arrest position is defined as the arrest crack position. Here re-initiation is defined as the case where a crack and re-initiated cracks are completely separated by a stretched zone and brittle crack initiation from the stretched zone can be clearly observed. In the case where a crack continuously propagates partially in the thickness direction, the position of the longest brittle crack is defined as the arrest position.

(b) Crack branching In the case where a crack deviates from the direction vertical to the loading direction, the length projected to the plane vertical to the loading line is defined as the arrest crack length. Similarly, in the case of crack branching, the length of the longest branch crack projected to the plane vertical to the loading line is defined as the branch crack length. More specifically, from the coordinates (x_a, y_a) of the arrest crack tip position and the coordinates (x_{br}, y_{br}) of the branch crack tip position shown in Figure A4-6, obtain the angle θ from the *x*-axis and define x_a as the arrest crack length, *a*. Here, *x* is the coordinate in the test specimen width direction, and the side face of the impact side is set as $x = 0$; *y* is the coordinate in the test specimen length direction, and the notch position is set as $y = 0$.

(3) Prepare a temperature distribution curve (line diagram showing the relation between the temperature and the distance from the test specimen top side) from the thermocouple measurement results, and obtain the arrest temperature *T* corresponding to the arrest crack length.



(a) Case of branching from notch



(b) Case of branching during brittle crack propagation

Figure A4-6 Measurement methods of main crack and branch crack lengths

7. Determination of Arrest Toughness

7.1 Judgement of arrested crack

When an arrested crack satisfies all of the conditions (a) through (d) below as shown in Figure A4-7, the length of the arrested crack determined by 6.4 is valid. If any of the conditions is not met, the arrest toughness calculated from 7.3 is invalid.

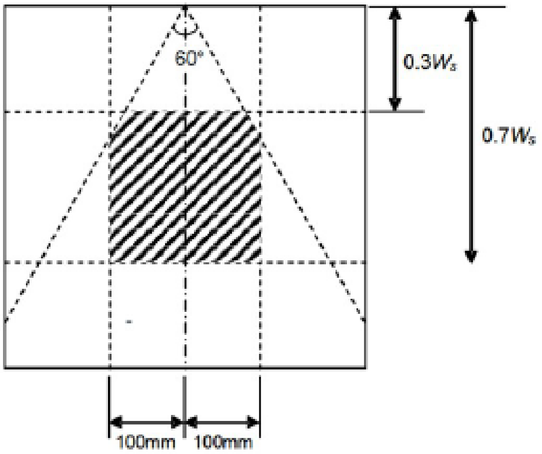


Figure A4-7 Necessary conditions of arrest crack position

(a) Conditions for crack propagation path:

All of the crack path from crack initiation to arrest shall be within the range shown in Figure A4-8. However, in the case where a main crack tip lies within this range but a part of the main crack passes outside the range, the arrest toughness may be assessed as valid if the temperature at the most deviated position of the main crack in the *y* direction is lower than that at *y* = 0, and also *K* for the main crack falls within ± 5% of *K* for a straight crack of the same *a*. The calculation method of K_s for the main crack and a straight crack is obtained from equation (4).

$$K = K_I \cos^3\left(\frac{\phi}{2}\right) + 3K_{II}\cos^2\left(\frac{\phi}{2}\right)\sin\left(\frac{\phi}{2}\right) \qquad \text{............(4)}$$

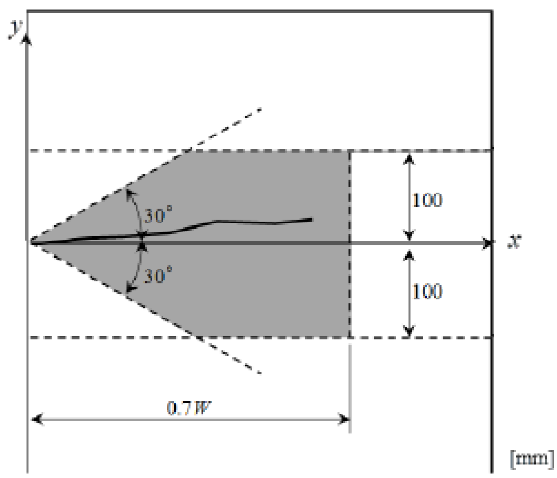


Figure A4-8 Allowable range of main crack propagation path

(b) Conditions for arrest crack length:

$$0.3 \leq \left(\frac{a}{W}\right) \leq 0.7 \quad \text{.............................(5)}$$

$$\left(\frac{a}{t}\right) \geq 1.5 \quad \text{.....................................(6)}$$

$$\left(\frac{a}{L_p}\right) \leq 0.15 \quad \text{................................(7)}$$

Note: Equation (7) ensures minimal influence of force drop at the centre of the specimen which might be caused by crack propagation and reflection of the stress wave at the two ends of the specimen. However, application of equation (7) is not necessarily required if the strain and the crack length have been dynamically measured and the value of the strain at the time of arrest is 90% or more of the static strain immediately before crack initiation.

(c) Conditions for crack straightness:

$$|y_a| \leq 50 \text{ mm} \quad \text{.................................(8)}$$

In the case where 50 mm < y_a ≤ 100 mm and θ ≤ 30°, the result is valid only when the temperature at x = 0.5W and y = ±100 mm falls within ± 2.5°C of that at x = 0.5W and y = 0.

(d) Conditions for crack branching:

$$\left(\frac{x_{br}}{x_a}\right) \leq 0.6 \quad \text{................................(9)}$$

7.2 Assessment of impact energy

Impact energy shall satisfy equation (10). If it does not satisfy the equation, the value of arrest toughness calculated from the equations in 7.3 is invalid.

Conditions for impact energy:

$$\frac{E_i}{E_s + E_t} \leq \frac{5a - 1050 + 1.4W}{0.7W - 150} \quad \text{where}$$

$$0.3 \leq \left(\frac{a}{W}\right) \leq 0.7 \quad \text{.......................................(10)}$$

where the variables have the following units: a [mm], and W [mm]. Ei is impact energy calculated from the equation (11). Es and Et are calculated from equations (12) and (13), respectively.

Note 1: If equation (10) is not satisfied, the influence of impact energy on the stress intensity factor is too large to obtain an accurate arrest toughness.

Note 2: In the case where the tab plates are multistage as shown in Figure A4-3 (b), calculate the total strain energy of each tab plate using equation (12).

Note 3: In the case where tab plate widths are tapered as shown in Figure A4-3 (d), calculate the strain energy based on elastostatics.

$$E_i = m\,g\,h$$ ………………………………….**(11)**

$$E_s = \frac{10^9 F^2}{2E}\frac{L}{W t}$$ ………………………….**(12)**

$$E_t = \frac{10^9 F^2}{E}\left(\frac{L_{tb}}{W_{tb}\,t_{tb}} + \frac{L_{pc}}{W_{pc}\,t_{pc}}\right)$$ ………..**(13)**

where the variables have the following units: E_s [J], E_t [J], F [MN], E [N/mm^2], L [mm], W [mm], and t [mm].

7.3 Calculation of arrest toughness

The arrest toughness, K_{ca}, at the temperature, T, shall be calculated from equation (14) using the arrest crack length, a, and the applied stress, σ, judged by 7.1. Calculate σ from equation (15).

$$K_{ca} = \sigma\sqrt{\pi a}\left[\frac{2W}{\pi a}\tan\left(\frac{\pi a}{2W}\right)\right]^{1/2}.$$ …………………**(14)**

$$\sigma = \frac{10^6 F}{W t}$$ ……………………………………………..**(15)**

where the variables have the following units: F [MN], W [mm], and t [mm].

If the conditions specified in 7.1 and 7.2 are not satisfied, the K_{ca} calculated from equation (14) is invalid.

8. Reporting

Using Table A4-4, the following items shall be reported:

(1) Test material: Steel type and yield stress at room temperature

(2) Testing machine: Capacity of the testing machine

(3) Test specimen dimensions: Thickness, width, length, angular distortion, and linear misalignment

(4) Integrated specimen dimensions: Tab plate thickness, tab plate width, integrated specimen length including the tab plates, and distance between the loading pins

(5) Test conditions: Applied force, applied stress, temperature gradient, impact energy, and the ratio of impact energy to the strain energy stored in the integrated specimen (sum of test specimen strain energy and tab plate strain energy)

(6) Test results

(a) Judgment of arrest: Crack length, presence or absence of crack branching, main crack angle, presence or absence of crack re-initiation, an arrest temperature

(b) Arrest toughness value

(7) Temperature distribution at moment of impact: Thermocouple position, temperature value, and temperature distribution

(8) Test specimen photographs: Crack propagation path (one side), and brittle crack fracture surface (both sides)

(9) Dynamic measurement results: History of crack propagation velocity, and strain change at pin chucks

Note: Item (9) shall be reported as necessary.

Table A4-4 Report sheet for brittle crack arrest test results

<table>
<tr><th>Item</th><th colspan="2">Details</th><th>Symbol</th><th>Conditions/ Results</th><th>Unit</th><th>Valid/ Invalid</th></tr>
<tr><td rowspan="2">(1) Test material</td><td colspan="2">Steel type</td><td>-</td><td></td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Yield stress at room temperature</td><td>σ_{Y0}</td><td></td><td>N/mm^2</td><td>-</td></tr>
<tr><td>**(1)** Test equipment</td><td colspan="2">Testing machine capacity</td><td>-</td><td></td><td>MN</td><td>-</td></tr>
<tr><td rowspan="4">**(2)** Test specimen dimensions</td><td colspan="2">Thickness</td><td>t</td><td></td><td>mm</td><td></td></tr>
<tr><td colspan="2">Width</td><td>W</td><td></td><td>mm</td><td></td></tr>
<tr><td colspan="2">Length</td><td>L</td><td></td><td>mm</td><td></td></tr>
<tr><td colspan="2">Angular distorsion + lineer misalignment</td><td>-</td><td></td><td>mm/m</td><td></td></tr>
<tr><td rowspan="4">**(3)** Integrated specimen dimensions</td><td colspan="2">Tab plate thickness</td><td>t_{tb}</td><td></td><td>mm</td><td></td></tr>
<tr><td colspan="2">Tab plate width</td><td>W_{tb}</td><td></td><td>mm</td><td></td></tr>
<tr><td colspan="2">Test specimen length including a tab plate</td><td>$L+L_{tb}$</td><td></td><td>mm</td><td></td></tr>
<tr><td colspan="2">Distance between loading pins</td><td>L_p</td><td></td><td>mm</td><td></td></tr>
<tr><td rowspan="5">**(4)** Test conditions</td><td colspan="2">Applied force</td><td>F</td><td></td><td>MN</td><td></td></tr>
<tr><td colspan="2">Applied stress</td><td>σ</td><td></td><td>N/mm^2</td><td></td></tr>
<tr><td colspan="2">Temperature gradient</td><td>-</td><td></td><td>°C/mm</td><td></td></tr>
<tr><td colspan="2">Impact energy</td><td>E_i</td><td></td><td>J</td><td></td></tr>
<tr><td colspan="2">Ratio of impact energy to strain energy stored in integrated specimen</td><td>$E_i/(E_s+E_t)$</td><td></td><td>-</td><td></td></tr>
<tr><td rowspan="7">**(5)** Test results</td><td rowspan="6">Judgement of crack propagation/ arrest</td><td>Crack length</td><td>a</td><td></td><td>mm</td><td></td></tr>
<tr><td>Presence/absence of crack branching</td><td>-</td><td></td><td>-</td><td>-</td></tr>
<tr><td>Ratio of branch crack length to main crack</td><td>X_{br}/X_a</td><td></td><td>-</td><td></td></tr>
<tr><td>Main crack angle</td><td>θ</td><td></td><td>(°)</td><td></td></tr>
<tr><td>Presence/absence of crack re-initiation</td><td>-</td><td></td><td>-</td><td></td></tr>
<tr><td>Temperature at crack arrest position</td><td>T</td><td></td><td>°C</td><td></td></tr>
<tr><td colspan="2">Arrest toughness value</td><td>K_{ca}</td><td></td><td>N/mm$^{3/2}$</td><td></td></tr>
<tr><td rowspan="3">**(6)** Temperature distribution at moment of impact</td><td colspan="2">Temperature measurement position</td><td>-</td><td>Attached</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Temperature at each temperature measurement position</td><td>-</td><td>Attached</td><td>°C</td><td>-</td></tr>
<tr><td colspan="2">Temperature distribution curve</td><td>-</td><td>Attached</td><td>-</td><td></td></tr>
<tr><td rowspan="2">**(7)** Test specimen photographs</td><td colspan="2">Crack propagation path</td><td>-</td><td>Attached</td><td>-</td><td></td></tr>
<tr><td colspan="2">Brittle crack fracture surface (both sides)</td><td>-</td><td>Attached</td><td>-</td><td></td></tr>
<tr><td rowspan="2">**(8)** Dynamic measurement results</td><td colspan="2">History of crack propagation velocity</td><td>-</td><td>Attached</td><td>-</td><td></td></tr>
<tr><td colspan="2">Strain change at pin chucks</td><td>-</td><td>Attached</td><td>-</td><td></td></tr>
</table>

Annex 4 - Appendix A

Method for Obtaining K_{ca} at a Specific Temperature and the Evaluation

A.1 General

This Appendix specifies the method for conducting multiple tests specified in Annex 4 of this section to obtain K_{ca} value at a specific temperature T_D.

A.2 Method

A number of experimental data show dependency of K_{ca} on arrest temperature, as expressed by equation (A.1), where T_K [K] (= T [°C]＋273), c and K_0 are constants.

$$K_{ca} = K_0 \exp\left(\frac{c}{T_K}\right) \qquad \text{(A.1)}$$

The arrest toughness at a required temperature T_D [K] can be obtained by following the procedures.

(1) Obtain at least four valid K_{ca} data.

(2) Approximating log K_{ca} by a linear expression of $1/T_K$, determine the coefficients log K_0 and c for the data described in paragraph (1) by using the least square method.

$$\log K_{ca} = \log K_0 + c\frac{1}{T_K} \qquad \text{(A.2)}$$

(3) Obtain the value of $(K_{ca}/K_0)\exp(c/T_K)$ for each data item. When the number of data outside the range of 0.85 through 1.15 does not exceed, the least square method used in paragraph (2) is considered valid. Here is an integer obtained by rounding down the value of (number of all data divided by 6). If this condition is not met, conduct additional tests to add at least two data and apply the procedure in paragraph (2) to the data.

(4) The value of $K_0 \exp(c/T_D)$ is defined as the estimated value of K_{ca} at T_D. The estimated value for the temperature corresponding to a specific value of K_{ca} can be obtained from $T_K = c/\log(K_{ca}/K_0)$. If the condition specified in paragraph (3) is not met, these estimated values are treated as reference values.

A.3 Evaluation

The straight-line approximation of arrhenius plot for valid K_{ca} data by interpolation method are to comply with either the following (1) or (2):

(1) The evaluation temperature of K_{ca} (i.e. - 10 degree C) is located between the upper and lower limits of the arrest temperature, with the K_{ca} corresponding to the evaluation temperature not lower than the required K_{ca} (e.g. 6,000 N/mm$^{3/2}$ or 8,000 N/mm$^{3/2}$), as shown in Fig. A4-A.1.

(2) The temperature corresponding to the required K_{ca} (e.g. 6,000 N/mm$^{3/2}$ or 8,000 N/mm$^{3/2}$) is located between the upper and lower limits of the arrest temperature, with the temperature corresponding to the required K_{ca} not higher than the evaluation temperature (i.e. -10 degree C), as shown in Fig. A4-A.2.

If both of (1) and (2) above are not satisfied, conduct additional tests to satisfy this condition.

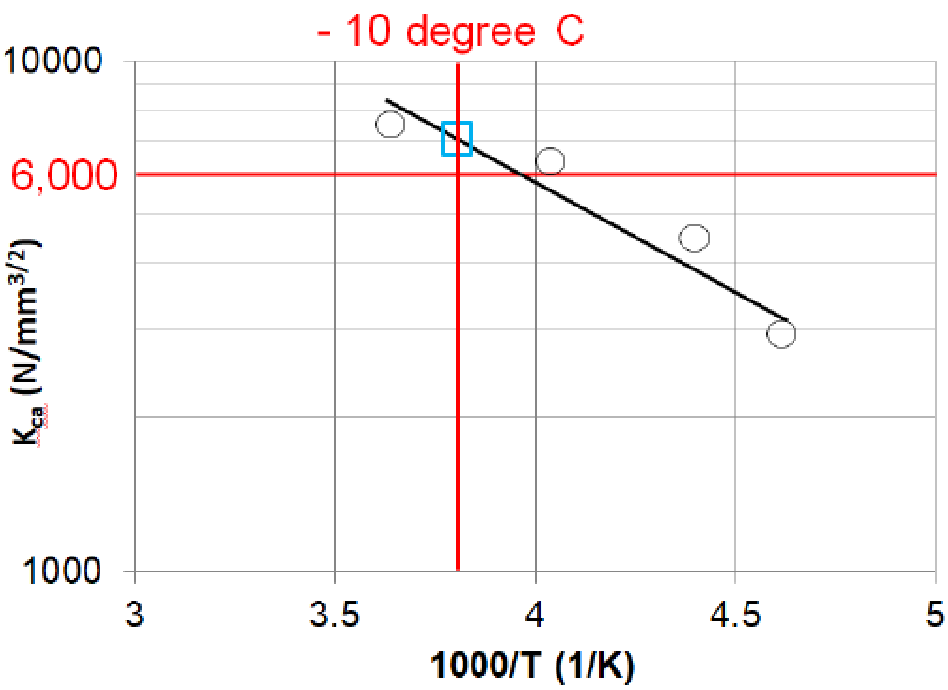


Figure A4-A.1 Example for evaluation of K_{ca} at – 10 °C

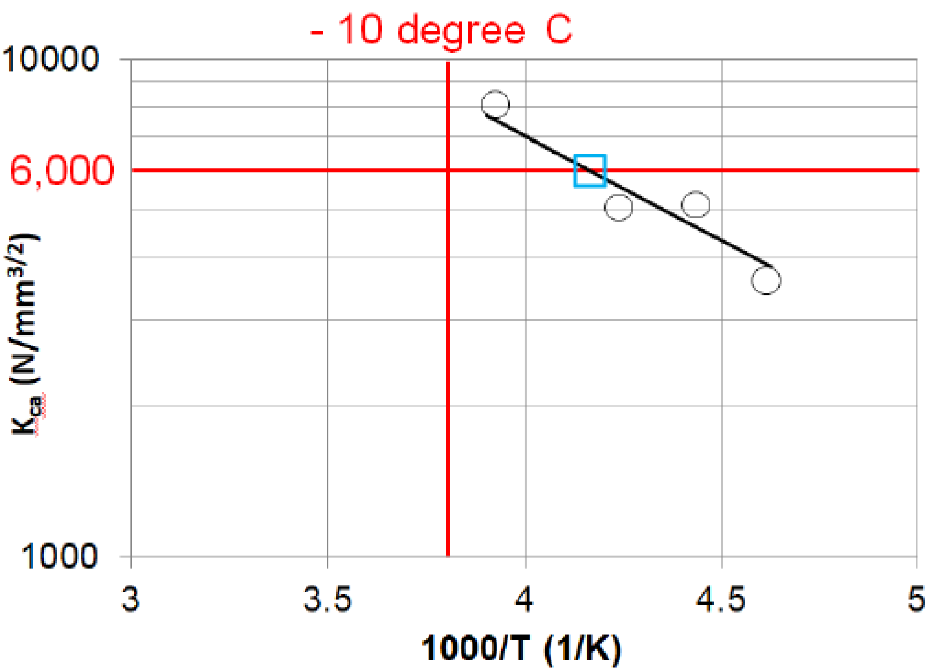


Figure A4-A.2 Example for evaluation of temperature corresponding to the required K_{ca}

Annex 4 - Appendix B

Double Tension Type Arrest Test

B.1 Features of This Test Method

A double tension type arrest test specimen consists of a main plate and a secondary loading tab. The main plate is a test plate for evaluating brittle crack arrest toughness. The secondary loading tab is a crack starter plate for assisting a brittle crack to run into the main plate. After applying a predetermined tension force and a temperature gradient to the main plate, a secondary force is applied to the secondary loading tab by a secondary loading device to cause a brittle crack to initiate and run into the main plate. The arrest toughness is evaluated from the arrest temperature and the crack length in the main plate.

The narrow connection part of the main plate and the secondary loading tab in this test suppress the flow of the tension stresses of the secondary loading tab into the main plate. The values of arrest toughness obtained by this method can be considered the same as the results obtained by the brittle crack arrest toughness test specified in Annex 4 of this section.

The specifications described in Annex 4 of this section shall be applied to conditions not mentioned in this Appendix B.

B.2 Test Specimen Shapes

The recommended shapes of the entire double tension type arrest test specimen and the secondary loading tab are shown in Figures A4-B.1 and A4-B.2, respectively. Clause 4.2 of Annex 4 of this section is applied to the shapes of the tab plates and pin chucks.

Note: Because of the narrowness of the connection part, slight crack deviation may lead to failure of the crack to enter the main plate. The optimum shape design of the secondary loading tab depends on the type of steel and testing conditions.

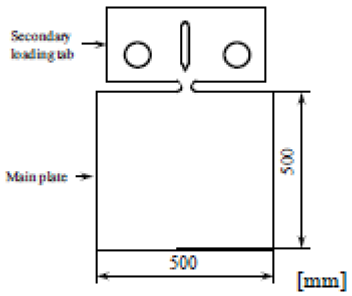


Figure A4-B.1 Example of shape of entire test specimen

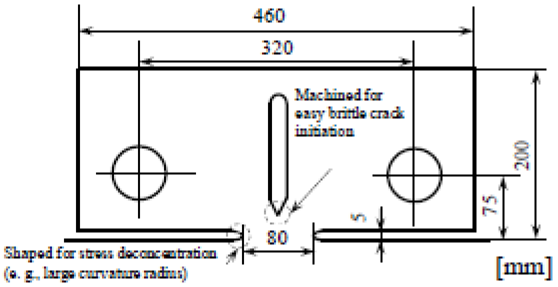


Figure A4-B.2 Example of shape of secondary loading tab

B.3 Temperature Conditions and Temperature Control Methods

Establish a temperature gradient in the main plate in order to evaluate its brittle crack arrest toughness. The specifications for temperature gradients and methods for establishing the temperature gradient are described in clause 5**,** Annex 4 of this section. In addition, in the double tension type arrest test, the secondary loading tab must be cooled. The secondary loading tab is cooled without affecting the temperature gradient of the main plate. As in the cooling method for test specimens described in Annex 4 of this section, cooling may be applied using a cooling box and a coolant. The temperature of the secondary loading tab can be measured using thermocouples as described in Annex 4 of this section.

B.4 Secondary Loading Method

A secondary loading device is used to apply force to the secondary loading tab. The secondary loading device shall satisfy the conditions below.

B.4.1 Holding methods of secondary loading device

To avoid applying unnecessary force to the integrated specimen, the secondary loading device must be held in an appropriate way. Suspension type or floor type holding methods can be used. In the suspension type method, the secondary loading device is suspended and held by using a crane or a similar device. In the floor type method, the secondary loading device is lifted and held by using a frame or a similar device.

B.4.2 Loading system

A hydraulic type loading system is most suitable for applying a force to the secondary loading tab. However, other methods may be used. Clause 4.2 of Annex 4 of this section is applied to the shapes of the tab plates and pin chucks.

B.4.3 Loading method

The method of loading the secondary loading tab shall be a pin type loading method. A loading method other than a pin type may be used by agreement among the parties concerned. The loading rate is not specifically specified because it does not have a direct influence on the crack arrest behavior of the main plate.

Annex 5

Outline of Requirements for Undertaking Isothermal Crack Arrest Temperature (CAT) Test

1. Scope of Application

1.1 Annex 5 is to be applied according to the scope defined in TL- R W31.

1.2 Annex 5 specifies the requirements for test procedures and test conditions when using the isothermal crack arrest test to determine a valid test result under isothermal conditions and in order to establish the crack arrest temperature (CAT). Annex 5 is applicable to steels with thickness over 50 mm and not greater than 100 mm.

1.3 This method uses an isothermal temperature in the test specimen being evaluated. Unless otherwise specified in this Annex 5 , the other test parameters are to be in accordance with Annex 4.

1.4 Table 3 of TL- R W31 gives the relevant requirements for the brittle crack arrest property described by the crack arrest temperature (CAT).

1.5 The manufacturer is to submit the test procedure to TL for review prior to testing.

2. Symbols and Their Significance

2.1 Table A5-1 supplements Table A4-1 in Annex 4 with specific symbols for the isothermal test.

3. Testing Equipment

3.1 The test equipment to be used is to be of the hydraulic type of sufficient capacity to provide a tensile load equivalent to ⅔ of SMYS of the steel grade to be approved.

3.2 The temperature control system is to be equipped to maintain the temperature in the specified region of the specimen within ±2 °C from T_{target}.

3.3 Methods for initiating the brittle crack may be of drop weight type, air gun type or double tension tab plate type.

3.4 The detailed requirements for testing equipment are specified in 3 of Annex 4.

4. Test Specimens

4.1 Impact type crack initiation

4.1.1 Test specimens are to be in accordance with 4 of Annex 4, unless otherwise specified in this Annex.

4.1.2 Specimen dimensions are shown in Figure A5-1. The test specimen width, *W* shall be 500 mm. The test specimen length, *L* shall be equal to or greater than 500 mm.

4.1.3 V-shape notch for brittle crack initiation is machined on the specimen edge of the impact side. The whole machined notch length shall be equal to 29 mm with a tolerance range of ±1mm.

4.1.4 Requirements for side grooves are described in 4.4.

4.2 Double tension type crack initiation

4.2.1 Reference shall be made to Appendix B in Annex 4 for the shape and sizes in secondary loading tab and secondary loading method for brittle crack initiation.

4.2.2 In a double tension type test, the secondary loading tab plate may be subject to further cooling to enhance an easy brittle crack initiation.

4.3 Embrittled zone setting

4.3.1 An embrittled zone shall be applied to ensure the initiation of a running brittle crack. Either Electron Beam Welding (EBW) or Local Temperature Gradient (LTG) may be adopted to facilitate the embrittled zone.

4.3.2 In EBW embrittlement, electron beam welding is applied along the expected initial crack propagation path, which is the centre line of the specimen in front of the machined V- notch.

Table A5-1 Nomenclature supplementary to Table A4-1

Symbol	Unit	Significance
t	mm	Test specimen thickness
L	mm	Test specimen length
W	mm	Test specimen width
a_{MN}	mm	Machined notch length on specimen edge
L_{SG}	mm	Side groove length on side surface from the specimen edge. L_{SG} is defined as a groove length with constant depth except a curved section in depth at side groove end.
d_{SG}	mm	Side groove depth in section with constant depth
$L_{EB\text{-}min}$	mm	Minimum length between specimen edge and electron beam re-melting zone front
$L_{EB\text{-}s1,\ \text{-}s2}$	mm	Length between specimen edge and electron beam re-melting zone front appeared on both specimen side surfaces
L_{LGT}	mm	Local temperature gradient zone length for brittle crack runway
a_{arrest}	mm	Arrested crack length
T_{target}	°C	Target test temperature
T_{test}	°C	Defined test temperature
T_{arrest}	°C	Target test temperature at which valid brittle crack arrest behaviour is observed
σ	N/mm^2	Applied test stress at cross section of W x t
SMYS	N/mm^2	Specified minimum yield strength of the tested steel grade to be approved
CAT	°C	Crack arrest temperature, the lowest temperature, T_{arrest}, at which running brittle crack is arrested

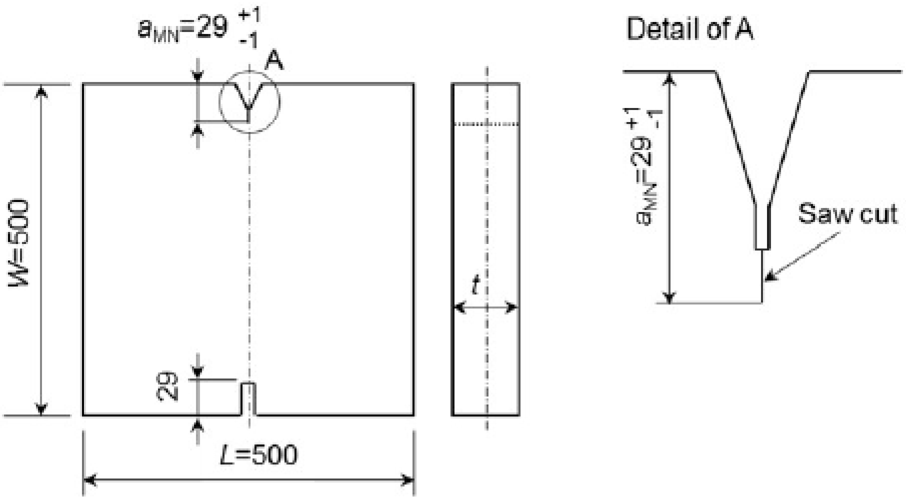


Figure A5-1 Test specimen dimensions for an impact type specimen

4.3.3 The complete penetration through the specimen thickness is required along the embrittled zone. One side EBW penetration is preferable, but dual sides EB penetration may be also adopted when the EBW power is not enough to achieve the complete penetration by one side EBW.

4.3.4 The EBW embrittlement is recommended to be prepared before specimen contour machining.

4.3.5 In EBW embrittlement, zone shall be of an appropriate quality.

Note: EBW occasionally behaves in an un-stable manner at start and end points. EBW line is recommended to start from the embrittled zone tip side to the specimen edge with an increasing power control or go/return manner at start point to keep the stable EBW.

4.3.6 In LTG system, the specified local temperature gradient between machined notch tip and isothermal test region is regulated after isothermal temperature control. LTG temperature control is to be achieved just before brittle crack initiation, nevertheless the steady temperature gradient through the thickness shall be ensured.

4.4 Side grooves

4.4.1 Side grooves on side surface can be machined along the embrittled zone to keep brittle crack propagation straight. Side grooves shall be machined in the specified cases as specified in this section.

4.4.2 In EBW embrittlement, side grooves are not necessarily mandatory. Use of EBW avoids the shear lips. However, when shear lips are evident on the fractured specimen, e.g. shear lips over 1mm in thickness in either side then side grooves should be machined to suppress the shear lips.

4.4.3 In LTG embrittlement, side grooves are mandatory. Side grooves with the same shape and size shall be machined on both side surfaces.

4.4.4 The length of side groove, L_{SG} shall be no shorter than the sum of the required embrittled zone length of 150mm.

4.4.5 When side grooves would be introduced, the side groove depth, the tip radius and the open angle are not regulated, but are adequately selected in order to avoid any shear lips over 1mm thickness in either side. An example of side groove dimensions are shown in Figure A5-2.

4.4.6 Side groove end shall be machined to make a groove depth gradually shallow with a curvature larger than or equal to groove depth, d_{SG}. Side groove length, L_{SG} is defined as a groove length with constant depth except a curved section in depth at side groove end.

4.5 Nominal length of embrittled zone

4.5.1 The length of embrittled zone shall be nominally equal to 150 mm in both systems of EBW and LTG.

4.5.2 EBW zone length is regulated by three measurements on the fracture surface after test as shown in Figure A5-3, $L_{EB\text{-}min}$ between specimen edge and EBW front line, and $L_{EB\text{-}s1}$ and $L_{EB\text{-}s2}$.

4.5.3 The minimum length between specimen edge and EBW front line, $L_{EB\text{-}min}$ should be no smaller than 150 mm. However, it can be acceptable even if $L_{EB\text{-}min}$ is no smaller than 150 mm-0.2*t*, where *t* is specimen thickness. When $L_{EB\text{-}min}$ is smaller than 150 mm, a temperature safety margin shall be considered into T_{test} (See 8.1.2).

4.5.4 Another two are the lengths between specimen edge and EBW front appeared on both side surfaces, as denoted with $L_{EB\text{-}s1}$ and $L_{EB\text{-}s2}$. Both of $L_{EB\text{-}s1}$ and $L_{EB\text{-}s2}$ shall be no smaller than 150 mm.

4.5.5 In LTG system, L_{LTG} is set as 150 mm.

4.6 Tab plate / pin chuck details and welding of test specimen to tab plates

4.6.1 The configuration and size of tab plates and pin chucks shall be referred to 4.2 of Annex 4. The welding distortion in the integrated specimen, which is welded with specimen, tab plates and pin chucks, shall be also within the requirement in 4.3 of Annex 4.

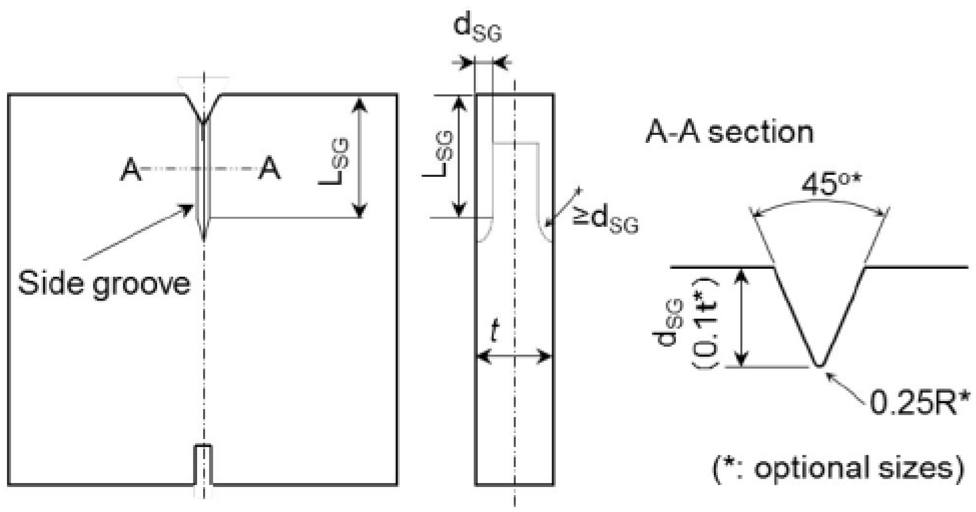


Figure A5-2 Side groove configuration and dimensions

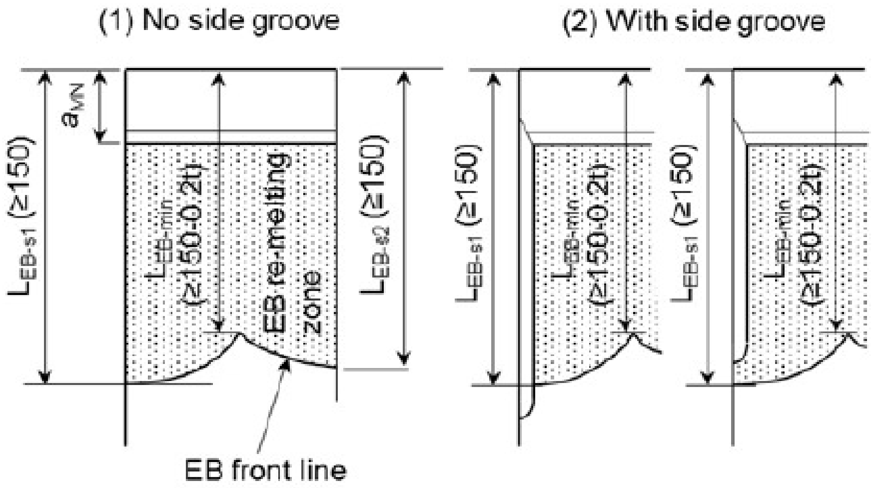


Figure A5-3 Definition of EBW length

5. Test Method

5.1 Preloading

5.1.1 Preloading at room temperature can be applied to avoid unexpected brittle crack initiation at test. The applied load value shall be no greater than the test stress. Preloading can be applied at higher temperature than ambient temperature when brittle crack initiation is expected at preloading process. However, the specimen shall not be subjected to temperature higher than 100 °C.

5.2 Temperature measurement and control

5.2.1 Temperature control plan showing the number and position of thermocouples is to be in accordance with this section.

5.2.2 Thermocouples are to be attached to both sides of the test specimen at a maximum interval of 50mm in the whole width and in the longitudinal direction at the test specimen centre position (0.5 *W*) within the range of ±100mm from the centreline in the longitudinal direction, refer to Figure A5-4.

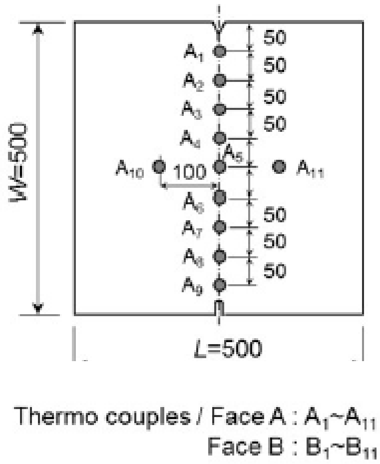


Figure A5-4 Locations of temperature measurement

5.2.3 For EBW embrittlement

5.2.3.1 The temperatures of the thermocouples across the range of 0.3*W*~0.7*W* in both width and longitudinal directions are to be controlled within ± 2°C of the target test temperature, T_{target}.

5.2.3.2 When all measured temperatures across the range of 0.3*W*~0.7*W* have reached T_{target}, steady temperature control shall be kept at least for 10 + 0.1 x *t* [mm] minutes to ensure a uniform temperature distribution into mid-thickness prior to applying test load.

5.2.3.3 The machined notch tip can be locally cooled to easily initiate brittle crack. Nevertheless, the local cooling shall not disturb the steady temperature control across the range of 0.3*W*~0.7*W*.

5.2.4 For LTG embrittlement:

5.2.4.1 In LTG system, in addition to the temperature measurements shown in Figure A5-4, the additional temperature measurement at the machine notch tip, A_0 and B_0 is required. Thermocouples positions within LTG zone are shown in Figure A5-5.

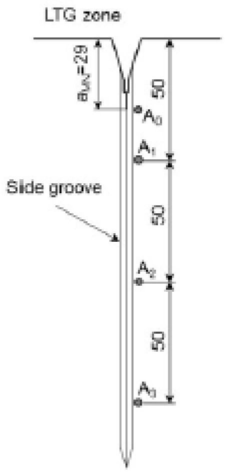


Figure A5-5 Detail of LTG zone and additional thermocouple A_0

5.2.4.2 The temperatures of the thermocouples across the range of 0.3*W*~0.7*W* in both width and longitudinal directions are to be controlled within ± 2°C of the target test temperature, *Ttarget*. However, the temperature measurement at 0.3*W* (location of A_3 and B_3) shall be in accordance with 5.2.4.6 below.

5.2.4.3 Once the all measured temperatures across the range of 0.3*W*~0.7*W* have reached *Ttarget*, steady temperature control shall be kept at least for 10 + 0.1 x *t* [mm] minutes to ensure a uniform temperature distribution into mid-thickness, then the test load is applied.

5.2.4.4 LTG is controlled by local cooling around the machined notch tip. LTG profile shall be recorded by the temperature measurements from A_0 to A_3 shown in Figure A5-6.

5.2.4.5 LTG zone is established by temperature gradients in three zones, Zone I, Zone II and Zone III. The acceptable range for each temperature gradient is listed Table A5-2.

5.2.4.6 Two temperature measurements at A_2, B_2 and A_3, B_3 shall be satisfied the following requirements:

T at A_3, T at $B_3 < T_{target} - 2$ °C
T at $A_2 < T$ at $A_3 - 5$ °C
T at $B_2 < T$ at $B_3 - 5$ °C

5.2.4.7 No requirements for T at A_0 and T at A_1 temperatures when T at A_3 and T at A_2 satisfy the requirements above. Face B is the same.

5.2.4.8 The temperatures from A_0, B_0 to A_3, B_3 should be decided at test planning stage refer to Table A5-2 which gives the recommended temperature gradients in three zones, Zone I, Zone II and Zone III in LTG zone.

5.2.4.9 The temperature profile in LTG zone mentioned above shall be ensured after holding time at least for 10 + 0.1 x t [mm] minutes to ensure a uniform temperature distribution into mid-thickness before brittle crack initiation.

5.2.4.10 The acceptance of LTG in the test shall be decided from Table A5-2 based on the measured temperatures from A_0 to A_3.

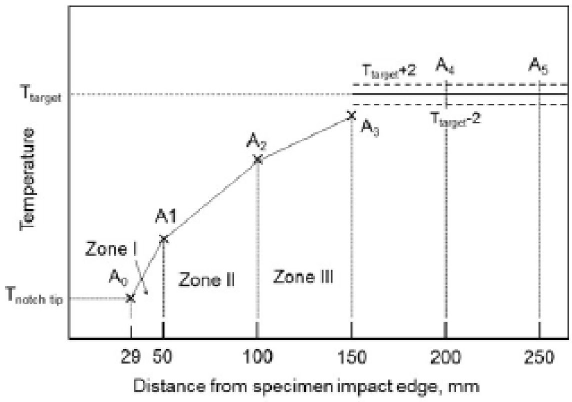


Figure A5-6 Schematic temperature gradient profile in LTG zone

Table A5-2 Acceptable LTG range

Zone	**Location from edge**	**Acceptable range of temperature gradient**
Zone I	29-50 mm	2,00-2,30 °C/mm
Zone II	50-100 mm	0,25-0,60 °C/mm
Zone III	100-150 mm	0,10-0,20 °C/mm

5.2.5 For double tension type crack initiation specimen:

5.2.5.1 Temperature control and holding time at steady state shall be the same as the case of EBW embrittlement specified in 5.2.3 or the case of LTG embrittlement specified in 5.2.4.

5.3 Loading and brittle crack initiation

5.3.1 Prior to testing, a target test temperature (T_{target}) shall be selected.

5.3.2 Test procedures are to be in accordance with 6 of Annex 4 except that the applied stress is to be ⅔ of SMYS of the steel grade tested.

5.3.3 The test load shall be held at the test target load or higher for a minimum of 30 seconds prior to crack initiation.

5.3.4 Brittle crack can be initiated by impact or secondary tab plate tension after all of the temperature measurements and the applied force are recorded.

6. Measurements After Test and Test Validation Judgement

6.1 Brittle crack initiation and validation

6.1.1 If brittle crack spontaneously initiates before the test force is achieved or the specified hold time at the test force is not achieved, the test shall be invalid.

6.1.2 If brittle crack spontaneously initiates without impact or secondary tab tension but after the specified time at the test force is achieved, the test is considered as a valid initiation. The following validation judgments of crack path and fracture appearance shall be examined.

6.2 Crack path examination and validation

6.2.1 When brittle crack path in embrittled zone deviates from EBW line or side groove in LTG system due to crack deflection and/or crack branching, the test shall be considered as invalid.

6.2.2 All of the crack path from embrittled zone end shall be within the range shown in Figure A5-7. If not, the test shall be considered as invalid.

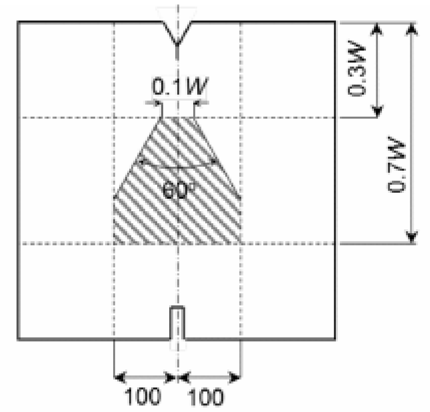


Figure A5-7 Allowable range of main crack propagation path

6.3 Fracture surface examination, crack length measurement and their validation

6.3.1 Fracture surface shall be observed and examined. The crack "initiation" and "propagation" are to be checked for validity and judgements recorded. The crack "arrest" positions are to be measured and recorded.

6.3.2 When crack initiation trigger point is clearly detected at side groove root, other than the V-notch tip, the test shall be invalid.

6.3.3 In EBW embrittlement setting, EBW zone length is quantified by three measurements of $L_{EB\text{-}s1}$, $L_{EB\text{-}s2}$ and $L_{EB\text{-}min}$, which are defined in 4.5. When either or both of $L_{EB\text{-}s1}$ and $L_{EB\text{-}s2}$ are smaller than 150 mm, the test shall be invalid. When $L_{EB\text{-}min}$ is smaller than 150 mm-0.2t, the test shall be invalid.

6.3.4 When the shear lip with thickness over 1mm in either side near side surfaces of embrittled zone are visibly observed independent of the specimens with or without side grooves, the test shall be invalid.

6.3.5 In EBW embrittlement setting, the penetration of brittle crack beyond the EBW front line shall be visually examined. When any brittle fracture appearance area continued from the EB front line is not detected, the test shall be invalid.

6.3.6 The weld defects in EBW embrittled zone shall be visually examined. If detected, it shall be quantified. A projecting length of defect on the thickness line through EB weld region along brittle crack path shall be measured, and the total occupation ratio of the projected defect part to the total thickness is defined as defect line fraction (See Figure A5-8). When the defects line fraction is larger than 10 %, the test shall be invalid.

6.3.7 In EBW embrittlement by dual sides' penetration, a gap on embrittled zone fracture surface which is induced by miss meeting of dual fusion lines is visibly detected at an overlapped line of dual side penetration, the test shall be invalid.

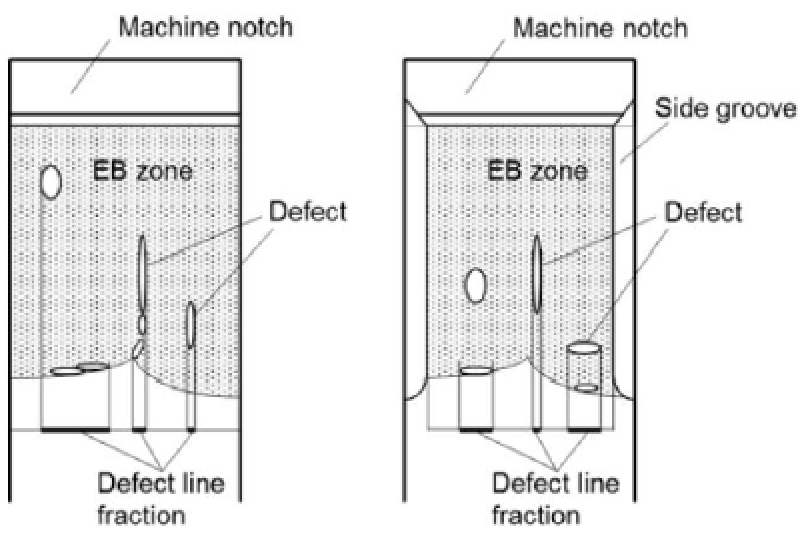


Figure A5-8 Counting procedure of defect line fraction

7. Judgement of "Arrest" or "Propagate"

7.1 The final test judgment of "arrest", "propagate" or "invalid" is decided by the following requirements of 7.2 through 7.6.

7.2 If initiated brittle crack is arrested and the tested specimen is not broken into two pieces, the fracture surfaces should be exposed with the procedures specified in 6.3 and 6.4 of Annex 4.

7.3 When the specimen was not broken into two pieces during testing, the arrested crack length, a_{arrest} shall be measured on the fractured surfaces. The length from the specimen edge of impact side to the arrested crack tip (the longest position) is defined as a_{arrest}.

7.4 For LTG and EBW, a_{arrest} shall be greater than L_{LTG} and $L_{EB\text{-}s1}$, $L_{EB\text{-}s2}$ or $L_{EB\text{-}min}$. If not, the test shall be considered as invalid.

7.5 Even when the specimen was broken into two pieces during testing, it can be considered as "arrest" when brittle crack re-initiation is clearly evident. Even in the fracture surface all occupied by brittle fracture, when a part of brittle crack surface from embrittled zone is continuously surrounded by thin ductile tear line, the test can be judged as re-initiation behaviour. If so, the maximum crack length of the part surrounded tear line can be measured as a_{arrest}. If re-initiation is not visibly evident, the test is judged as "propagate".

7.6 The test is judged as "arrest" when the value of a_{arrest} is no greater than 0.7*W*. If not, the test is judged as "propagate".

8. T_{test}, T_{arrest} and CAT Determination

8.1 T_{test} determination

8.1.1 It shall be ensured on the thermocouple measured record that all temperature measurements across the range of 0.3*W* ~ 0.7*W* in both width and longitudinal direction are in the range of T_{target} ±2°C at brittle crack initiation. If not, the test shall be invalid. However, the temperature measurement at 0.3*W* (location of A_3 and B_3) in LTG system shall be exempted from this requirement.

8.1.2 If $L_{EB\text{-}min}$ in EBW embrittlement is no smaller than 150 mm, T_{test} can be defined to equal with T_{target}. If not, T_{test} shall be equaled with T_{target} + 5˚C.

8.1.3 In LTG embrittlement, T_{test} can be equaled with T_{target}.

8.1.4 The final arrest judgment at T_{test} is concluded by at least two tests at the same test condition which are judged as "arrest".

8.2 T_{arrest} determination

8.2.1 When at least repeated two "arrest" tests appear at the same T_{target}, brittle crack arrest behaviour at T_{target} will be decided (T_{arrest} = T_{target}).When a "propagate" test result is included in the multiple test results at the same T_{target}, the T_{target} cannot to be decided as T_{arrest}.

8.3 CAT determination

8.3.1 When CAT is determined, one "propagate" test is needed in addition to two "arrest" tests. The target test temperature, T_{target} for "propagate" test is recommended to select 5 °C lower than T_{arrest}. The minimum temperature of *Tarrest* is determined as CAT.

8.3.2 With only the "arrest" tests, without "propagation" test, it is decided only that CAT is lower than T_{test} in the two "arrest" tests, i.e. not deterministic CAT.

9. Reporting

The following items are to be reported:

(i) Test material: grade and thickness

(ii) Test machine capacity

(iii) Test specimen dimensions: thickness *t*; width *W* and length *L*; notch details and length a_{MN}, side groove details if machined;

(iv) Embrittled zone type: EBW or LTG embrittlement

(v) Integrated specimen dimensions: Tab plate thickness, tab plate width, integrated specimen unit length including the tab plates, and distance between the loading pins, angular distortion and linear misalignment

(vi) Brittle crack trigger information: impact type or double tension. If impact type, drop weight type or air gun type, and applied impact energy.

(vii) Test conditions; Applied load; preload stress, test stress

- Judgements for preload stress limit, hold time requirement under steady test stress.

(viii) Test temperature: complete temperature records with thermocouple positions for measured temperatures (figure and/or table) and target test temperature.

- Judgements for temperature scatter limit in isothermal region.
- Judgement for local temperature gradient requirements and holding time requirement after steady local temperature gradient before brittle crack trigger, if LTG system is used.

(ix) Crack path and fracture surface: tested specimen photos showing fracture surfaces on both sides and crack path side view; Mark at "embrittled zone tip" and "arrest" positions.

- Judgment for crack path requirement.
- Judgment for cleavage trigger location (whether side groove edge or V-notch edge).

(x) Embrittled zone information:

When EBW is used: $L_{EB\text{-}s1}$, $L_{EB\text{-}s2}$ and $L_{EB\text{-}min}$

- Judgement for shear lip thickness requirement
- Judgment whether brittle fracture appearance area continues from the EBW front line
- Judgement for EBW defects requirement
- Judgement for EBW lengths, L_{EB-s1}, L_{EB-s2} and L_{EB-min} requirements

When LTG is used: L_{LTG}

- Judgment for shear lip thickness requirement

Test results:

When the specimen did not break into two pieces after brittle crack trigger, arrested crack length a_{arrest}

When the specimen broke into two pieces after brittle crack trigger,

- judgement whether brittle crack re-initiation or not.

If so, arrested crack length a_{arrest}:

- Judgement for a_{arrest} in the valid range ($0.3W < a_{arrest} \leq 0.7W$)
- Final judgement either “arrest”, “propagate” or “invalid”

(xi) Dynamic measurement results: History of crack propagation velocity, and strain change at pin chucks, if needed

10. Use of Test for Material Qualification Testing

Where required, the method can also be used for determining the lowest temperature at which a steel can arrest a running brittle crack (the determined CAT) as the material property characteristic in accordance with 8.3.

PART A – CHAPTER 3 – WELDING

01. Section 5 – Welding Consumables And Auxiliary Materials

Revision Date: November 2021

Entry into Force Date: 1 January 2021

Item A.4.7 and K.2.2 were revised as below:

4.7 Welding consumables and auxiliary materials for welding of **copper and copper alloys** are subject to classification, designation and approval according to a quality grade corresponding to the code designation for the welding consumable according to the standard (EN ISO 17777 or TSE equivalent), e.g. quality grade CuNi30Fe. For other base materials covered by the respective approval, see Table 5.24

2.2 The chemical composition shall be determined and certified in a manner analogous to that prescribed in B.2.2. The results of the analysis shall not exceed the limits specified in the standards (e.g. EN ISO 17777) or by the manufacturer, the narrower tolerances being applicable in each case.

PART B – CHAPTER 4 MACHINERY

01. Section 2 – Internal Combustion Engines and Air Compressors

Revision Date: November 2020

Entry into Force Date: 1 January 2021

New item A.3 in Section 2 of Chapter 4 was added for clarifying the machine certification requirement as below:

A. General

1. Application

The requirements in this Section apply to internal combustion engines used as main propulsion units and auxiliary units (including emergency units) as well as to air compressors.

………………..

3. Engine Certificate

Each diesel engine manufactured for a shipboard application is to have an engine certificate. The certification process details for obtaining the engine certificate are in TL-R M44 (Section 5). This process consists of the engine builder/licensee obtaining design approval of the engine application specific documents, submitting a comparison list of the production drawings to the previously approved engine design drawings (see B.), forwarding the relevant production drawings and comparison list for the use of the Surveyors at the manufacturing plant and shipyard if necessary, engine testing (see E.) and upon satisfactorily meeting the Rule requirements, the issuance of an engine certificate.

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item M.1 was generally revised and,

1. General

………………..

In case of Exhaust Gas Recirculation (EGR) method is used Resolution MEPC 307(73)[*] should be considered. In case of engines fitted with Selective Catalytic Reduction system, Resolution MEPC.291(71) as amended by MEPC 313(74) should be taken into account in addition to NOx Technical Code 2008.

For detailed requirements for Exhaust Gas Cleaning Systems, refer to TL Guidelines, Guidelines for Exhaust Gas Cleaning Systems.

……………….

~~*(*) The resolution should apply to a marine diesel engine fitted with an EGR device having a bleed-off water discharge arrangement, for which the EIAPP Certificate is first issued on or after 1 June 2019.*~~

……………….

Item M.5.4.2 was revised and M.5.4.3 & 5.4.4 was deleted according to UR M77 Rev.1 as below:

5.4.2 For detailed requirements in respect of storage and use of SCR reductants, are to be applied **TL** Guidelines, Guidelines for Exhaust Gas Cleaning Systems,item B.6.2.

~~**Reductant using urea based ammonia (e.g. 40%/60% urea/water solution)**~~

~~**5.4.2.1** Where urea based ammonia (e.g. AUS 40 – aqueous urea solution specified in ISO 18611-1) is introduced, the storage tank is to be arranged so that any leakage will be contained and prevented from making contact with heated surfaces. All pipes or other tank penetrations are to be provided with manual closing valves attached to the tank. Tank and piping arrangements are to be approved.~~

~~**5.4.2.2** The storage tank may be located within the engine room.~~

~~**5.4.2.3** The storage tank is to be protected from excessively high or low temperatures applicable to the particular concentration of the solution. Depending on the operational area of the ship, this may necessitate the fitting of heating and/or cooling systems. The physical conditions recommended by applicable recognized standards (such as ISO 18611-3) are to be taken into account to ensure that the contents of the aqueous urea tank are maintained to avoid any impairment of the urea solution during storage.~~

~~**5.4.2.4** If a urea storage tank is installed in a closed compartment, the area is to be served by an effective mechanical supply and exhaust ventilation system providing not less than 6 air changes per hour which is independent from the ventilation system of accommodation, service spaces, or control stations. The ventilation system is to be capable of being controlled from outside the compartment and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly air purged. If the ventilation stops, an audible and visual alarm shall be provided outside the compartment adjacent to each point of entry and inside the compartment, together with a warning notice requiring the use of such ventilation.~~

~~Alternatively, where a urea storage tank is located within an engine room a separate ventilation system is not required when the general ventilation system for the space is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly air purged.~~

~~**5.4.2.5** Each urea storage tank is to be provided with temperature and level monitoring arrangements. High and low level alarms together with high and low temperature alarms are also to be provided.~~

~~**5.4.2.6** Where urea based ammonia solution is stored in integral tanks, the following are to be considered during the design and construction:~~

- These tanks may be designed and constructed as integral part of the hull, (e.g. double bottom, wing tanks).
- These tanks are to be coated with appropriate anti-corrosion coating and cannot be located adjacent to any fuel oil and fresh water tank.
- These tanks are to be designed and constructed as per the structural requirements applicable to hull and primary support members for a deep tank construction.
- These tanks are to be fitted with but not limited to level gauge, temperature gauge, high temperature alarm, low level alarm, etc.
- These tanks are to be included in the ship's stability calculation.

5.4.2.7 The reductant piping and venting systems are to be independent of other ship service piping and/or systems. Reductant piping systems are not to be located in accommodation, service spaces, or control stations. The vent pipes of the storage tank are to terminate in a safe location on the weather deck and the tank venting system is to be arranged to prevent entrance of water into the urea tank.

5.4.2.8 Reductant related piping systems, tanks, and other components which may come into contact with the reductant solution are to be of a suitable grade of non-combustible compatible material established to be suitable for the application.

5.4.2.9 For the protection of crew members, the ship is to have on board suitable personnel protective equipment. Eyewash and safety showers are to be provided, the location and number of these eyewash stations and safety showers are to be derived from the detailed installation arrangements.

5.4.2.10 Urea storage tanks are to be arranged so that they can be emptied of urea, purged and vented.

5.4.3 Reductant using aqueous ammonia (28% or less concentration of ammonia)

Aqueous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant. Where an application is made to use aqueous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

5.4.4 Reductant using anhydrous ammonia (99.5% or greater concentration of ammonia by weight)

Anhydrous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant and where the Flag Administration agrees to its use. Where it is not practicable to use a urea reductant then it is also to be demonstrated that it is not practicable to use aqueous ammonia. Where an application is made to use anhydrous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item D.3 in Appendix IV of Section 2 was revised according to UR M53 Rev.4 as below:

3. Use of results and crankshaft acceptability

In order to combine tested bending and torsion fatigue strength results in calculation of crankshaft acceptability (see Section 2 item D.7), the Gough-Pollard approach and the maximum principal equivalent stress formulation can be applied for the following cases:

……………….

Related to crankpin oil bore:

~~$Q = \left(\sqrt{\left(\frac{\sigma_{BO}}{\sigma_{DWOT}}\right)^2 + \left(\frac{\tau_{TO}}{\tau_{DWOT}}\right)^2} \right)^{-1}$~~

$$Q = \frac{\sigma_{DWOT}}{\sigma_v};$$

$$\sigma_v = \frac{1}{3} \cdot \sigma_{BO} \cdot \left[1 + 2 \cdot \sqrt{1 + \frac{9}{4} \cdot \left(\frac{\sigma_{TO}}{\sigma_{BO}}\right)^2} \right]$$

where:

σ_{DWOT} ~~fatigue strength by bending testing~~ fatigue strength by means of largest principal stress from torsion testing

~~τ_{DWCT} fatigue strength by torsion testing~~

02. Section 5 – Main Shafting

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item C.6.2.2.2, 6.2.4 was revised according to UR M52 Rev.2 as below:

6.2.2.2 Oil lubricated synthetic material bearings

……………….

Synthetic materials for application as oil lubricated stern tube bearings are to be Type Approved.

6.2.4 Grease lubricated bearings

~~Where the propeller shaft runs in grease-lubricated, grey cast iron bushes the lengths of the after and forward stern tube bearings should be approximately 2.5 · d_a and 1.0 · d_a respectively.~~

~~The peripheral speed of propeller shafts shall not exceed:~~

~~- 2.5 to a maximum of 3 m/s for grey cast iron bearings with grease lubrication~~

~~- 6 m/s for rubber bearings~~

~~- 3 to a maximum of 4 m/s for lignum vitae bearings with water lubrication~~

The length of a grease lubricated bearing is to be not less than 4.0 times the rule diameter of the shaft in way of the bearing.

03. Section 16 – Pipe Lines, Valves, Fittings and Pumps

Revision Date: October 2020

Entry into Force Date: 1 January 2021

Item P.1.3.6 was added as below:

P. Ballast Systems

1. Ballast Lines

………………..

1.3.6 Sample points are to be provided to take samples from the discharge lines, as near to the point of discharge as practicable, during ballast water discharge whenever possible (See MEPC.173(58)).

Revision Date: November 2020

Entry into Force Date: 1 January 2021

Reference given in Note (6) was deleted as below:

---

(6) With regard to the installation on ships of oily water separators, filter plants, oil collecting tanks, oil discharge lines and a monitoring and control system or a 15 ppm alarm device in the water outlet of oily water separators, compliance is required with the provisions of the International Convention for the Prevention of Pollution from Ships. 1973, (MARPOL) and the Protocol of 1978. Also if existed national Regulations are to be considered. ~~*See TL- I MPC99.*~~

04. Section 18 – Fire Protection and Fire Fighting Equipment

Revision Date: December 2020

Entry into Force Date: 1 January 2021

Items L.2.3.1, 2.3.2, 2.3.3 and footnote (28) were revised according to MSC.1/Circ.1430/Rev.2 as below:

2.3.1 Fixed water-based fire fighting systems for protection of vehicle, special category and ro-ro spaces shall be designed in accordance with the guidelines of MSC.1/Circ.1430/Rev.2 **(28)**.

(28) *Refer to IMO MSC.I/Circ.1430/Rev.2, "Revised Guidelines for the Approval of Fixed Water-Based Fire-Fighting Systems for Ro-Ro Spaces and Special Category Spaces*

2.3.2 Water spray systems shall be designed acc. to sections 3 and 4 of MSC.1/Circ.1430/Rev.2. The water spray nozzles shall be approved as per item 3.11 of the guidelines.

2.3.3 Water mist systems shall be type approved and be designed acc. to sections 3 and 5 of MSC.1/Circ.1430/Rev.2.

Revision Date: October 2020

Entry into Force Date: 1 January 2021

Table 18.11 was revised according to MSC 462(101) as below:

Bulk Cargo Shipping Name (BCSN)	Class	Requirements															
		Fire-extinguishing system	Water supplies	Sources of ignition	Temperature measurement	Gas detection	Acidity of bilge water	Ventilation	Additional provisions on ventilation	Bilge pumping	Personnel protection	No smoking signs	Machinery space boundaries	Other boundaries	Gas sampling points	Weathertightness	Fuel tanks
FISHMEAL (FISHSCRAP), STABILIZED UN 2216	9	Q.2.1	Q.3		Q.5.1.2	Q.5.2.5		Q.6.1 Q.6.2 Q.6.3			Q.8.1.2 Q.8.2.2						
FLUE DUST, CONTAINING LEAD AND ZINC	MHB	Q.2.1.1									Q.8.1.1 Q.8.2.1						
FLUORSPAR	MHB	Q.2.2.1									Q.8.1.1						
GRANULATED NICKEL MATTE (LESS THAN 2% MOISTURE CONTENT)	MHB	Q.2.2.1									Q.8.1.1 Q.8.2.1						
IRON OXIDE, SPENT or IRON SPONGE, SPENT UN 1376	4.2	Q.2.1	Q.3	Q.4 IIA T2.IP55		Q.5.2.5 Q.5.2.8		Q.6.1 Q.6.2 Q.6.3			Q.8.1.2 Q.8.2.2	Q.9	Q.10.1				
LEAD NITRATE UN 1469	5.1	Q.2.2	Q.3					Q.6.1 Q.6.2			Q.8.1.2 Q.8.2.2						
LIME (UNSLAKED)	MHB	Q.2.2.1									Q.8.1.1						
LINTED COTTON SEED	MHB	Q.2.1				Q.5.2.5					Q.8.2.1					Q.13	
MAGNESIA (UNSLAKED)	MHB	Q.2.2.1									Q.8.1.1						
MAGNESIUM NITRATE UN 1474	5.1	Q.2.2	Q.3					Q.6.1 Q.6.2			Q.8.1.2 Q.8.2.2						
MATTE CONTAINING COPPER AND LEAD	MHB	Q.2.2.1									Q.8.1.1 Q.8.2.1						
METAL SULPHIDE	MHB	Q.2.1				Q.5.2.5					Q.8.1.1						

CONCENTRATES						Q.5.2.7					Q.8.2.1						
METAL SULPHIDE CONCENTRATES, CORROSIVE UN 1759	8	Q.2.1				Q.5.2.5 Q.5.2.7					Q.8.1.2 Q.8.2.1						
METAL SULPHIDE CONCENTRATES, SELF-HEATING UN 3190	4.2	Q.2.1	Q.3		Q.5.1.2	Q.5.2.5 Q.5.2.7					Q.8.1.2 Q.8.2.1		Q.10.1				
MONOAMMONIUM PHOSPHATE (M.A.P.), MINERAL ENRICHED COATING	MHB	Q.2.2.1									Q.8.1.2 Q.8.2.1						
MONOCALCIUMPHOSPHATE (MCP)	MHB	Q.2.2.1									Q.8.1.2 Q.8.2.1						
PEAT MOSS	MHB	Q.2.2.1				Q.5.2.5		Q.6.1 Q.6.2			Q.8.1.1						
PETROLEUM COKE (calcined or uncalcined)	MHB	Q.2.2.1									Q.8.1.1 Q.8.2.1						
PITCH PRILL	MHB	Q.2.2.1						Q.6.1 Q.6.2			Q.8.1.1 Q.8.2.1						Q.14.2.1
POTASSIUM NITRATE UN 1486	5.1	Q.2.2	Q.3					Q.6.1 Q.6.2			Q.8.1.2 Q.8.2.2						
PYRITES, CALCINED	MHB	Q.2.2.1									Q.8.1.1						
RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) UN 2912 **(*)**	7	Q.2.2.1									Q.8.1.1 Q.8.2.1						
RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I) UN 2913**(*)**	7	Q.2.2.1									Q.8.1.1 Q.8.2.1						
SAND, MINERAL CONCENTRATE, RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) UN 2912	7	Q.2.2.1									Q.8.1.2 Q.8.2.1						
SAWDUST	MHB	Q.2.1						Q.6.1 Q.6.2									
SEED CAKES AND OTHER RESIDUES OF PROCESSED OILY VEGETABLES	MHB	Q.2.1		Q.4 IIC T3	Q.5.1.2	Q.5.2.5		Q.6.1 Q.6.2 Q.6.3	Q.6.7.1		Q.8.2.1		Q.10.1			Q.13	
SEED CAKE, containing vegetable oil un 1386 (a)	4.2	Q.2.1	Q.3		Q.5.1.2	Q.5.2.5		Q.6.1 Q.6.2			Q.8.1.2 Q.8.2.2	Q.9	Q.10.1			Q.13	
SEED CAKE, containing vegetable oil un 1386 (b) mechanically expelled seeds	4.2	Q.2.1	Q.3	Q.4 IC T3	Q.5.1.2			Q.6.1 Q.6.4	Q.6.7.1		Q.8.1.2 Q.8.2.2	Q.9	Q.10.1			Q.13	
SEED CAKE, containing vegetable oil un 1386 (b) solvent extracted seeds	4.2	Q.2.1	Q.3	Q.4 IIC T3	Q.5.1.2	Q.5.2.5		Q.6.1 Q.6.4	Q.6.7.1		Q.8.1.2 Q.8.2.2	Q.9	Q.10.1			Q.13	
SEED CAKE UN 2217	4.2	Q.2.1	Q.3	Q.4 IIA T3	Q.5.1.2	Q.5.2.5		Q.6.1 Q.6.4	Q.6.7.1		Q.8.1.2 Q.8.2.2	Q.9	Q.10.1				
SILICONMANGANESE	MHB	Q.2.2.1		Q.4 IIC T1		Q.5.2.3 Q.5.5, .6		Q.6.1 Q.6.3			Q.8.2.1	Q.9				Q.13	

SODIUM NITRETE UN 1498	5.1	Q.2.2	Q.3					Q.6.1 Q.6.2			Q.8.1.2 Q.8.2.2						
SODIUM NITRATE AND POTASIUM NITRATE MIXTURE UN 1499	5.1	Q.2.2	Q.3					Q.6.1 Q.6.2			Q.8.1.2 Q.8.2.2						
SOLIDIFIED FUELS RECYCLED FROM PAPER AND PLASTICS	MHB	Q.2.1		Q.4 T3, IP55		Q.5.2.5					Q.8.1.1	Q.9					
SUGARCANE BIOMASS PELLETS	MHB	Q.2.1									Q.8.2.1						
SULPHUR UN 1350	4.1	Q.2.2.1	Q.3	Q.4 T4, IP55				Q.6.1 Q.6.2	Q.6.7.1		Q.8.1.2 Q.8.2.2	Q.9	Q.10.1				
TANKAGE	MHB	Q.2.1			Q.5.1.2						Q.8.1.1 Q.8.2.1						
VANADIUM ORE	MHB	Q.2.2.1									Q.8.1.1 Q.8.2.1						
WOODCHIPS having a moisture content of 15% or more	MHB	Q.2.2.1				Q.5.2.5 Q.5.2.10		Q.6.1 Q.6.2			Q.8.2.1						
WOODCHIPS having a moisture content of less than 15%	MHB	Q.2.1				Q.5.2.5 Q.5.2.10		Q.6.1 Q.6.2			Q.8.2.1						
WOOD PELLETS CONTAINING ADDITIVES AND/OR BINDERS	MHB (WF)	Q.2.1				Q.5.2.2 Q.5.2.5 Q.5.2.10 Q.5.2.11		Q.6.1 Q.6.2			Q.8.2.1						
WOOD PELLETS NOT CONTAINING ANY ADDITIVES AND/OR BINDERS	MHB (OH)	Q.2.2				Q.5.2.2 Q.5.2.5 Q.5.2.10 Q.5.2.11		Q.6.1 Q.6.2			Q.8.2.1						
WOOD PRODUCTS - General_	MHB	Q.2.2.1				Q.5.2.5 Q.5.2.10		Q.6.1 Q.6.2			Q.8.2.1						
WOOD TORREFIED	MHB	Q.2.1		Q.4 T3, IP55		Q.5.2.2 Q.5.2.5 Q.5.2.10 Q.5.2.11					Q.8.1.1 Q.8.2.1						
ZINC ASHES UN 1435	4.3	Q.2.2.1		Q.4 IIC T2		Q.5.2.3		Q.6.1 Q.6.5	Q.6.7.2		Q.8.1.2 Q.8.2.2	Q.9	Q.10.1				
ZINC OXIDE ENRICHED FLUE DUST	MHB	Q.2.2.1									Q.8.1.1 Q.8.2.1						

(*) *The cargo spaces carrying this cargo shall not be ventilated during voyage.*

Revision Date: November 2020

Entry into Force Date: 1 January 2021

Note on the item P.1.1.2 was revised according to UI SC86 (Rev.1) Del as below:

P. Carriage of Dangerous Goods in Packaged Form

1. General

…………………

Note :

A purpose built container space is a cargo space fitted with cell guides for stowage securing of containers.

Ro-ro spaces include special category spaces (Reg. 20) and vehicle spaces.

~~*For the purposes of a ro-ro space fully open above and with full openings in both ends may be treated as a weather deck.*~~

PART B – CHAPTER 5 ELECTRICAL INSTALLATION

01. Section 7 – Power Equipment

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item 6.11 in Section 7 was revised according to UR E25 Rev.1 as below:

6.11 System response upon failure (1)

6.11.1 The failures (as defined but not limited to those in 6.10.1) likely to cause uncontrolled movements of rudder are detected, the rudder ~~should~~ is to stop in the current position without manual intervention or, subject to the discretion of TL, is to return to the midship/neutral position. ~~For systems and/or operational modes where midship position is considered to be the least critical condition, this may also be accepted.~~

Note: For hydraulic locking failure, refer also to TL- R M42.12.2 and 42.13.

02. Section 9 – Control, Monitoring and Ship's Safety Systems

Revision Date: November 2020

Entry into Force Date: 1 January 2021

Item D.3.1.26 in Section 9 was revised according to UI SC117 Del as below:

3.1.26 Cables forming part of the fire detection system shall be so arranged as to avoid to touch galleys, category A machinery spaces and other closed spaces with a high fire risk, except if it is necessary to transmit a fire signal from these spaces, to initiate a fire alarm in these spaces, or to make the connection to the appropriate source of electrical power.

A section with individually identifiable capability shall be arranged so that it cannot be damaged at more than one point by a fire.

Fixed ~~F~~fire detection and fire alarm systems with ~~a loop-wise indication~~ individually identifiable fire detectors shall be so designed that:

- means are provided to ensure that any fault (e.g., power break, short circuit, earth, etc.) occurring in the section will not prevent the continued individual identification of the remainder of the connected detectors in the section; ~~A loop cannot be damaged at more than one point by a fire, is considered satisfied by arranging the loop such that the data highway will not pass through a space covered by a detector more than once. When this is not practical (e.g for large public spaces), the part of the loop which by necessity passes through the space for a second time should be installed at the maximum possible distance from the other parts of the loop.~~

- all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (e.g., electrical, electronic, informatics, etc.); ~~The requirement that a system be so arranged to ensure that any fault occurring in the loop will not render the whole loop ineffective, is considered satisfied when a fault occurring in the loop only renders ineffective a part of the loop not being larger than a section of a system without means of remotely identifying each detector.~~

- the first initiated fire alarm will not prevent any other detector from initiating further fire alarms; and

- no section will pass through a space twice. When this is not practical (e.g., for large public spaces), the part of the section which by necessity passes through the space for a second time shall be installed at the maximum possible distance from the other parts of the section.

~~Definitions:~~

- ~~Loop means electrical circuit linking detectors of various sections in a sequence and connected (input and output) to the indicating unit(s)~~

- ~~Zone address identification capability means a system with individually identifiable fire detectors.~~

- ~~Equipment is available which ensures that a fault in the loop (e.g. wire break, short circuit, earth fault) does not cause failure of the entire control unit,~~

- ~~All possible precautions have been taken to allow the function of the system to be restored in the event of a failure (electrical, electronic, affecting data processing),~~

- ~~The first fire alarm indicated does not prevent the indication of further alarms by other fire detectors in other loops.~~

03. Section 14 – Additional Rules for Passenger Vessels

Item B.4 in Section 14 was revised according to UI SC17 Rev.3 as below:

B. Installation of Electrical Equipment

……………………………………………………………………….

4. Spaces containing, for instance, the following battery sources shall ~~should~~ be regarded as control stations regardless of battery capacity:

……………………………………………………………………….

PART C – CHAPTER 8 CHEMICAL TANKERS

01. Section 01 –General

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item B was revised according to MEPC 318(74) as below:

……………….

Recognized organization is an organization authorized by an Administration in accordance with MARPOL Annex II regulation 8.2.2 and SOLAS regulation XI-1/1.

……………….

02. Section 15 – Special Requirements

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item 15.8.25.1 was revised according to MEPC 318(74) as below:

15.8.25.1 The piping system for tanks to be loaded with these products shall be separated (as defined in 3.1.4) from piping systems for all other tanks, including empty tanks. If the piping system for the tanks to be loaded is not independent (as defined in 1.3.19), the required piping separation shall be accomplished by the removal of spool-pieces, valves, or other pipe section and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections, such as common inert-gas supply lines.

Item 15.15 was revised according to MEPC 318(74) as below:

15.15 Hydrogen sulphide (H2S) detection equipment for bulk liquids

Hydrogen sulphide (H_2S) detection equipment shall be provided on board ships carrying bulk liquids prone to H_2S formation. It should be noted that scavengers and biocides, when used, may not be 100% effective in controlling the formation of H_2S. Toxic vapour detection instruments complying with the requirement in 13.2.1 of the Code for testing for H_2S may be used to satisfy this requirement.

03. Section 16 – Operational Requirements

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item 16.2.7 was revised according to MEPC 318(74) as below:

16.2.7 Where *column o* in the table of chapter 17 refers to this paragraph, the cargo is subject to the prewash requirements in regulation 13.7.1.4 of Annex II of MARPOL.

PART C – CHAPTER 10 Liquefied Gas Carriers

01. Section 5 – Process Pressure Vessels and Liquid, Vapour and Pressure Piping Systems

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Items 5.11.5 and 5.13.1 was revised according to UR G3 Rev.7 as below:

5.11.5 Stress analysis

When the design temperature is -110°C or lower, a complete stress analysis, taking into account all the stresses due to the weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system shall be submitted to the Administration. For temperatures above -110°C, a stress analysis may be required by the Administration in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration shall be given to thermal stresses even though calculations are not submitted.

This analysis is to take into account the various loads such as pressure, weight of piping with insulation and internal medium, loads due to the contraction, for the various operating conditions. The analysis may be carried out according to a code of practice acceptable to the Administration.

..

5.13.1 Type testing of piping components

Note: For tests of piping components and pumps prior to installation on board, refer to ~~TL Technical Circular S-P 05/13 which is developed based on requirements of~~ TL- R G.3.6.

02. Section 11 – Fire Protection and Extinction

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item 11.3.4.1 was added according to UI GC30 New and item 11.3.4.2 was added according to UI GC22 Rev.1 as below:

11.3.4 The boundaries of superstructures and deckhouses normally manned, and lifeboats, liferafts and muster areas facing the cargo area, shall also be capable of being served by one of the fire pumps or the emergency fire pump, if a fire in one compartment could disable both fire pumps.

11.3.4.1

.1 *In paragraph 11.3.4 the term "fire pumps" where not qualified by the word "emergency" refers to the fire pumps required in accordance with SOLAS Reg.II-2/10.2.2.2.2.*

.2 *If all the fire pumps mentioned in paragraph 1 above supplying the water spray system (for covering the superstructures and deckhouses) are disabled due to a fire in any one compartment; then the emergency fire pump shall be sized to cover:*

> ***.1*** *the water spray system for the boundaries of the superstructures and deckhouses, and lifeboats, liferafts and muster areas facing the cargo area, (as per paragraph 11.3.4); and*
>
> ***.2*** *two fire hydrants (as per paragraph 11.2).*

.3 When the ship is also fitted with a total flooding high expansion foam system protecting the engine-room (to comply with SOLAS II-2/10.4.1.1.2 and 10.5.1.1) and the emergency fire pump is intended to supply sea water to this system, then, the emergency fire pump shall also be sized to cover the foam system for dealing with an engine-room fire, when the main fire pumps are disabled.

.4 On the basis of the principle of dealing with one single fire incident at a time, the emergency fire pump does not need to be sized to cover all three systems in 2 and 3 above (i.e. water spray, hydrants and foam) at the same time and shall need only be sized to cover the most demanding area and required systems, as follows:

.1 the foam system + two hydrants; or

.2 the water spray system + two hydrants;

whichever is greater.;

11.3.4.2 Fire pumps used as spray pumps (IGC Code, Paragraph 11.3.4)

In cases where the emergency fire pump is used to meet this requirement, its capacity, in addition to being capable of maintaining two jets of water as required by paragraph 12.2.2.1.1 of the FSS Code, shall be increased taking into account the spray application rates stated in paragraph 11.3.2.1, but limiting coverage to boundaries of normally manned superstructures and deckhouses, survival crafts and their muster areas. For the purpose of this interpretation:

.1 the expression "one of the fire pumps or emergency fire pump" is related to fire pumps required by SOLAS regulation II-2/10.2.2 installed outside the space where spray pump(s) are located; and

.2 the expression "fire in one compartment" means a compartment provided with A-class boundaries in which is located the fire pump(s), or the source of power of the fire pump(s), serving the water-spray system in accordance with paragraph 11.3.3.

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Note was added to item 11.4.8 according to UI GC31 New as below:

11.4.8 After installation, the pipes, valves, fittings and assembled systems shall be subjected to a tightness test and functional testing of the remote and local release stations. The initial testing shall also include a discharge of sufficient amounts of dry chemical powder to verify that the system is in proper working order. All distribution piping shall be blown through with dry air to ensure that the piping is free of obstructions.

Note:

Testing arrangements are to involve the discharge using dry chemical powder from all monitors and hand hose lines on board, but it is not required that there is a full discharge of the installed quantity of dry powder. This testing can also be used to satisfy the requirement that the piping is free of obstructions, in lieu of blowing through with dry air all the distribution piping. However, after the completion of this testing, the system, including all monitors and hand hose lines, are to be blown through with dry air; but only for the purpose of the system subsequently being clear from any residues of dry chemical powder.

PART C – CHAPTER 33 Polar Class Ships

01. Section 3 – Ship Structure

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item 3.4 was added and subsequent items were renumbered; renumbered items 3.5, 3.6, 3.15 and 3.16 in Section 3 of Part I-A was revised according to UR I2 Rev.4 as below:

3.3 Regulations

3.3.1 In order to comply with the functional requirements of paragraph 3.2.1 above, materials of exposed structures in ships shall be approved by TL, taking into account Chapter 1 Hull Section 3 or other standards offering an equivalent level of safety based on the polar service temperature.

3.3.2 In order to comply with the functional requirements of paragraph 3.2.2 above, the following apply:

.1 scantlings of category A ships shall be approved by TL, taking into account requirements for Polar Class 1-5 defined in item from 3.4 to 3.21 or other standards offering an equivalent level of safety;

.2 scantlings of category B ships shall be approved by TL, taking into account requirements for Polar Class 6-7 defined in item from 3.4 to 3.21 or other standards offering an equivalent level of safety;

....

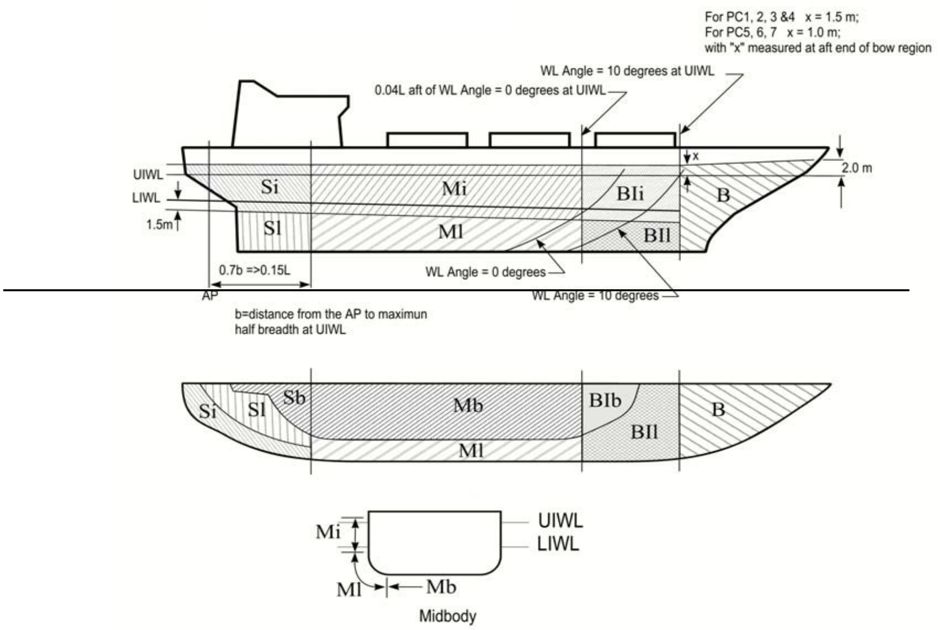
3.4 Definitions

3.4.1 *The length L_{UI} is the distance, in m, measured horizontally from the fore side of the stem at the intersection with the upper ice waterline (UIWL) to the after side of the rudder post, or the centre of the rudder stock if there is no rudder post. L_{UI} is not to be less than 96%, and need not be greater than 97%, of the extreme length of the upper ice waterline (UIWL) measured horizontally from the fore side of the stem. In ships with unusual stern and bow arrangement the length L_{UI} will be specially considered.*

3.4.2 *The ship displacement D_{UI} is the displacement, in kt, of the ship corresponding to the upper ice waterline (UIWL). Where multiple waterlines are used for determining the UIWL, the displacement is to be determined from the waterline corresponding to the greatest displacement.*

3.5 Hull Areas

....



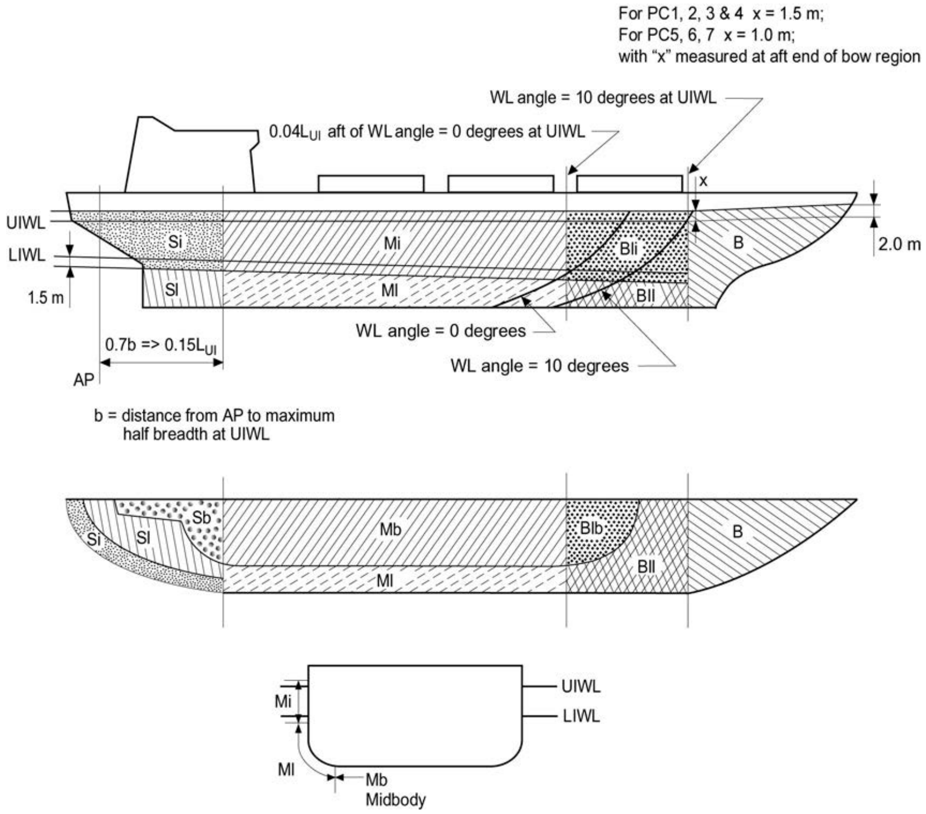


Figure 3 - Hull Area Extents

………………………………………………………..

~~3.4.4~~3.5.4 Figure 3 notwithstanding, the aft boundary of the Bow region need not be more than 0.45 L_{UI} aft of the fore side of the stem at the intersection with the upper ice waterline (UIWL) ~~forward perpendicular (FP)~~.

~~L = ship length as defined in Chapter 1, Hull, Section 1, H.2.1, but measured on the upper ice waterline (UIWL) [m]~~

………………………………………………………..

~~3.4.7~~3.5.7 Figure 3 notwithstanding, if the ship is assigned the additional notation "Icebreaker", the forward boundary of the stern region is to be at least 0.04 L_{UI} forward of the section where the parallel ship side at the upper ice waterline (UIWL) ends.

………………………………………………………..

~~3.5.1.4~~3.6.1.5 Design ice forces calculated according to 3.~~5~~6.2.1.3 are applicable for bow forms where the buttock angle γ at the stern is positive and less than 80 deg. and the normal frame angle β' at the centre of the foremost sub-region, as defined in 2.3.2.1(i), is greater than 10 deg.

~~3.5.1.5~~3.6.1.6 Design ice forces calculated according to 3.~~5~~6.2.1.4 are applicable for ships which are assigned the Polar Class PC6 or PC7 and have a bow form with vertical sides. This includes bows where the normal frame angles β' at the considered sub-regions, as defined in 3.~~5~~6.2.1.1 are between 0 and 10 deg.

~~3.5.1.6~~3.6.1.7 For ships which are assigned the Polar Class PC6 or PC7, and equipped with bulbous bows, the design ice forces on the bow are to be determined according to 3.~~5~~6.2.1.4. In addition, the design forces are not to be taken less than those given in 3.~~5~~6.2.1.3, assuming fa = 0.6 and AR = 1.3.

~~3.5.1.7~~3.6.1.8 For ships with bow forms other than those defined in 3.~~5~~6.1.5 to 3.~~5~~6.1.7, design forces are to be specially considered by the Classification Society.

……………………………………………………….

3.6.2.1.3 The Bow area load characteristics for bow forms defined in 3.~~5~~6.1.5 are determined as follows:

……………………………………………………….

$fa_{i,1} = (0.097 - 0.68 \cdot (x/L_{UI} - 0.15)^2) \cdot \alpha_i \;/ (\beta'_i)^{0.5}$

$fa_{i,2} = 1.2 \cdot CF_F \;/ (\sin (\beta'_i) \cdot CF_C \cdot D_{UI}^{0.64})$

……………………………………………………….

$F_i = fa_i \cdot CF_C \cdot D_{UI}^{0.64}$ *[MN]*

……………………………………………………….

L_{UI} = ~~ship~~ length as defined in 3.4.1 ~~Chapter 1, Hull, Section 1, H.2.1, but measured on the upper ice waterline (UIWL)~~ [m]

x = distance from the fore side of the stem at the intersection with the upper ice waterline (UIWL) ~~forward perpendicular (FP)~~ to station under consideration [m]

……………………………………………………….

D_{UI} = ~~ship~~ displacement as defined in 3.4.2, not to be taken less than 5 [kt]

……………………………………………………….

3.5.2.1.1 ~~3.5.2.1.4~~3.6.2.1.4 The Bow area load characteristics for bow forms defined in 3.~~5~~6.1.6 are determined as follows:

……………………………………………………….

$F_i = fa_i \cdot CF_{CV} \cdot D_{ui}^{0.47}$ *[MN]*

……………………………………………………….

D_{UI} = ~~ship~~ displacement as defined in 3.4.2, not to be taken less than 5 [kt]

~~3.5.2.2~~3.6.2.2 Hull Areas Other Than the Bow

DF = ship displacement factor

$= D_{UI}^{0.64}$ if $D_{UI} \le CF_{DIS}$

$= CF_{DIS}^{0.64} + 0.10 \cdot (D_{UI} - CF_{DIS})$ if $D_{UI} > CF_{DIS}$

D_{UI} = ~~ship~~displacement as defined in 3.4.2, not to be taken less than 10 [kt]

……………………………………………………..

~~3.5.3.2~~3.6.3.2 *In hull areas other than those covered by 3.~~5~~6.3.1, the design load patch has dimensions of width, w_{NonBow}, and height, b_{NonBow}, defined as follows:*

$w_{NonBow} = F_{NonBow} / Q_{NonBow}$ [m]

$b_{NonBow} = w_{NonBow} / 3.6$ [m]

where

F_{NonBow} = *force as defined in 3.~~5~~6.2.2.1 (a) [MN]*

Q_{NonBow} = *line load as defined in 3.~~5~~6.2.2.1 (b) [MN/m]*

……………………………………………………..

~~3.6.1~~3.7.1 *The required minimum shell plate thickness, t, is given by:*

$t = t_{net} + t_s$ [mm]

where

t_{net} = *plate thickness required to resist ice loads according to 3.~~6~~7.2[mm]*

t_s = *corrosion and abrasion allowance according to 3.~~13~~14 [mm]*

……………………………………………………..

P_{avg} = *average patch pressure as defined in 3.~~5~~6.4 [MPa]*

……………………………………………………..

l = distance between frame supports, i.e. equal to the frame span as given in 3.~~7~~8.5, but not reduced for any fitted end brackets [m]. When a load-distributing stringer is fitted, the length l need not be taken larger than the distance from the stringer to the most distant frame support.

……………………………………………………..

~~3.7.3~~3.8.3 *The strength of a framing member is dependent upon the fixity that is provided at its supports. Fixity can be assumed where framing members are either continuous through the support or attached to a supporting section with a connection bracket. In other cases, simple support is to be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity is to be ensured at the support of any framing which terminates within an ice-strengthened area. See also 3.~~18~~19.1.*

……………………………………………………..

t_c = corrosion deduction [mm] to be subtracted from the web and flange thickness (not less than t_s as required by 3.~~13~~14.3)

………………………………………………………

h, t_{wn}, t_c, and ϕ_w are as given in 3.~~7~~8.7 and s as given in 3.~~6~~7.2.

A_{pn} = net cross-sectional area of the local frame [cm^2]

t_{pn} = fitted net shell plate thickness [mm] (complying with t_{net} as required by 3.~~6~~7.2)

………………………………………………………

~~3.7.9~~3.8.9 *In the case of oblique framing arrangement (70 deg > Ω > 20 deg, where Ω is defined as given in 3.~~6~~7.2), linear interpolation is to be used.*

………………………………………………………

~~3.8.2~~3.9.2 *The actual net effective shear area of the frame, A_w, as defined in 3.~~7~~8.7, is to comply with the following condition: $A_w \geq A_t$, where:*

$$A_t = 100^2 \cdot 0.5 \cdot LL \cdot s \cdot (AF \cdot PPF_t \cdot P_{avg}) / (0.577 \cdot \sigma_y) \ [cm^2]$$

………………………………………………………

a = local frame span as defined in 3.~~7~~8.5 [m]

b = height of design ice load patch as defined in 3.~~5~~6.3.1 or 3.~~5~~6.3.2 [m]

………………………………………………………

P_{avg} = average pressure within load patch as defined in 3.~~5~~6.4 [MPa]

………………………………………………………

~~3.8.3.~~3.9.3 *The actual net effective plastic section modulus of the plate/stiffener combination, Z_p, as defined in 3.~~7~~8.8, is to comply with the following condition: $Z_p \geq Z_{pt}$, where Z_{pt} is to be the greater calculated on the basis of two load conditions: a) ice load acting at the midspan of the local frame, and b) the ice load acting near a support. The A1 parameter in defined below reflects these two conditions:*

………………………………………………………

A_F, PPF_t , P_{avg}, LL, b, s, a and σ_y are as given in 3.~~8~~9.2.

………………………………………………………

A_t = minimum shear area of the local frame as given in 3.~~8~~9.2 [cm^2]

A_w = effective net shear area of the local frame (calculated according to 3.~~7~~8.7) [cm^2]

$k_w = 1 / (1 + 2 \cdot A_{fn} / A_w)$ with A_{fn} as given in 3.~~7~~8.8

………………………………………………………

t_{fn} = net flange thickness [mm]

= $t_f - t_c$ (t_c as given in 3.~~7~~8.7)

t_f = as-built flange thickness [mm], see Figure 7

t_{pn} = the fitted net shell plate thickness [mm] (not to be less than t_{net} as given in 3.~~6~~7.2)

……………………………………………………….

Z_p = net effective plastic section modulus of the local frame (calculated according to 3.~~7~~8.8) [cm^3]

~~3.8.4~~3.9.4 *The scantlings of the local frame are to meet the structural stability requirements of 3.~~11~~12.*

……………………………………………………….

~~3.9.2~~3.10.2 *The actual net effective shear area of the frame, A_w, as defined in 3.~~7~~8.7, is to comply with the following condition: $A_w \geq A_L$, where:*

……………………………………………………….

P_{avg} = average pressure within load patch s defined in 3.~~5~~6.4 [MPa]

……………………………………………………….

b = height of design ice load patch as defined in 3.~~5~~6.3.1 or 3.~~5~~6.3.2 [m]

……………………………………………………….

a = effective span of longitudinal local frame as given in 3.~~7~~8.5 [m]

……………………………………………………….

~~3.9.3~~3.10.3 *The actual net effective plastic section modulus of the plate/stiffener combination, Z_p, as defined in 3.~~7~~8.8, is to comply with the following condition: $Z_p \geq Z_{pL}$, where:*

$$Z_{pL} = 100^3 \cdot (AF \cdot PPF_s \cdot P_{avg}) \cdot b_1 \cdot a^2 \cdot A_4 / (8 \cdot \sigma_y) \ [cm^3]$$

where

AF, PPF_s, P_{avg}, b_1, a and σ_y are as given in 3.~~9~~10.2

$$A_4 = 1\ (2+k_{wl}\cdot[(1-a_4^2)^{0.5}-1])$$

$$a_4 = A_L / A_w$$

A_L = minimum shear area for longitudinal as given in 3.~~9~~10.2 [cm^2]

A_w = net effective shear area of longitudinal (calculated according to 3.~~7~~8.7) [cm^2]

k_{wl} = $1 / (1 + 2 \cdot A_{fn} / A_w)$ with A_{fn} as given in 3.~~7~~8.8

~~3.9.4~~3.10.4 *The scantlings of the longitudinals are to meet the structural stability requirements of 3.~~11~~12.*

~~3.10~~3.11 *Framing - Web Frames and Load Carrying Stringers*

~~3.10.1~~3.11.1 Web frames and load-carrying stringers are to be designed to withstand the ice load patch as defined in 3.~~5~~6. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised.

……………………………………………………..

~~3.10.3~~3.11.3 For determination of scantlings of load carrying stringers, web frames supporting local frames, or web frames supporting load carrying stringers forming part of a structural grillage system, appropriate methods as outlined in 3.~~19~~20 are normally to be used.

~~3.10.4~~3.11.4 The scantlings of web frames and load-carrying stringers are to meet the structural stability requirements of 3.~~11~~12.

……………………………………………………..

~~3.11.2~~3.12.2 Framing members for which it is not practicable to meet the requirements of 3.12.1 (e.g. load carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners are to ensure the structural stability of the framing member. The minimum net web thickness for these framing members is given by:

……………………………………………………..

~~3.12.3~~3.13.3 The stability of the plated structure is to adequately withstand the ice loads defined in 3.~~5~~6.

……………………………………………………..

~~3.14.1~~3.15.1 Steel grades of plating for hull structures are to be not less than those given in Tables 9 based on the as-built thickness, the Polar Class and the Material Class of structural members according to 3.~~14~~15.2.

Table 8 - Material Classes for Structural Members

Structural Members	***Material***
Shell plating within the bow and bow intermediate icebelt hull areas (B, B_{Ii})	*II*
All weather and sea exposed SECONDARY and PRIMARY, as defined in Chapter 1, Hull, Section 3, Table 3.2, structural members outside 0.4L_{UI} amidships	*I*
Plating materials for stem and stern frames, rudder horn, rudder, propeller nozzle, shaft brackets, ice skeg, ice knife and other appendages subject to ice impact loads	*II*
All inboard framing members attached to the weather and sea-exposed plating, including any contiguous inboard member within 600 mm of the plating	*I*
Weather-exposed plating and attached framing in cargo holds of ships which by nature of their trade have their cargo hold hatches open during cold weather operations	*I*
All weather and sea exposed SPECIAL, as defined in Chapter 1, Hull, Section 3, Table 3.2, structural members within 0.2L_{UI} from FP	*II*

~~3.14.2~~3.15.2 Material classes specified in Chapter 1, Hull, Section 3, Table 3.2 are applicable to Polar Class ships regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed plating are given in Table ~~7~~8. Where the material classes in Table ~~7~~8 and those in Chapter 1, Hull, Section 3, Table 3.2 differ, the higher material class is to be applied.

~~3.14.3~~3.15.3 Steel grades for all plating and attached framing of hull structures and appendages situated below thelevel of 0.3 m below the lower waterline, as shown in Figure 9, are to be obtained from Chapter 1, Hull, Section 3, Table 3.7 and 3.8 based on the Material Class for Structural Members in Table ~~7~~8 above, regardless of Polar Class.

....

Table 9 - Steel Grades for Weather Exposed Plating

Thickness, t [mm]	Material Class I				Material Class II				Material Class III					
	PC1-5		PC6&7		PC1-5		PC6&7		PC1-3		PC4&5		PC6&7	
	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
t ≤ 10	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
10 < t ≤ 15	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
15 < t ≤ 20	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
20 < t ≤ 25	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
25 < t ≤ 30	D	DH	B	AH	E	EH2	D	DH	E	EH	E	EH	E	EH
30 < t ≤ 35	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
35 < t ≤ 40	D	DH	D	DH	E	EH	D	DH	~~F~~Ø	FH	E	EH	E	EH
40 < t ≤ 45	E	EH	D	DH	E	EH	D	DH	~~F~~Ø	FH	E	EH	E	EH
45 < t ≤ 50	E	EH	D	DH	E	EH	D	DH	~~F~~Ø	FH	~~F~~Ø	FH	E	EH

Ø Not applicable

Notes:

1) *Includes weather-exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0.3 m below the lowest ice waterline.*

2) *Grades D, DH are allowed for a single strake of side shell plating not more than 1.8 m wide from 0.3 m below the lowest ice waterline.*

....

~~3.15.1.2~~3.16.1.2 Intentional ramming is not considered as a design scenario for sihps which are designed with vertical or bulbous bows, see 5.6. hence the longitudinal strength requirements given in 3.~~15~~16 is not to be considered for ships with stern angle γ_{stem} equal to or larger than 80 deg.

....

~~3.15.2~~3.16.2 Design Vertical Ice Force at the Bow

....

$$F_{IB,1} = 0.534 \cdot K_I^{0.15} \cdot \sin^{0.2}(\gamma_{stem}) \cdot (D_{UI} \cdot K_h)^{0.5} \cdot CF_L \ [MN]$$

....

$$K_f = (2 \cdot C \cdot B_{UI}^{1-eb} / (1 + e_b))^{0.9} \cdot \tan(\gamma_{stem})^{-0.9 \cdot (1 + eb)}$$

....

$$C = 1 / (2 \cdot (L_B / B_{UI})^{eb})$$

B_{UI} = ~~greatest ship~~moulded breadth *corresponding to the upper ice waterline (UIWL)* [m]

L_B = *bow length used in the equation* $y = B_{UI} / 2 \cdot (x/L_B)^{eb}$ *[m] (see Figures 10 and 11)*

D_{UI} = ~~ship~~*displacement as defined in 3.4.2, not to be taken less than 10 [kt]*

A_{wp} = ~~ship~~*waterplane area corresponding to the upper ice waterline (UIWL)* [m^2]

CF_F = *Flexural Failure Class Factor from Table 1*

~~*Where applicable, draught dependent quantities are to be determined at the waterline corresponding to the loading condition under consideration.*~~

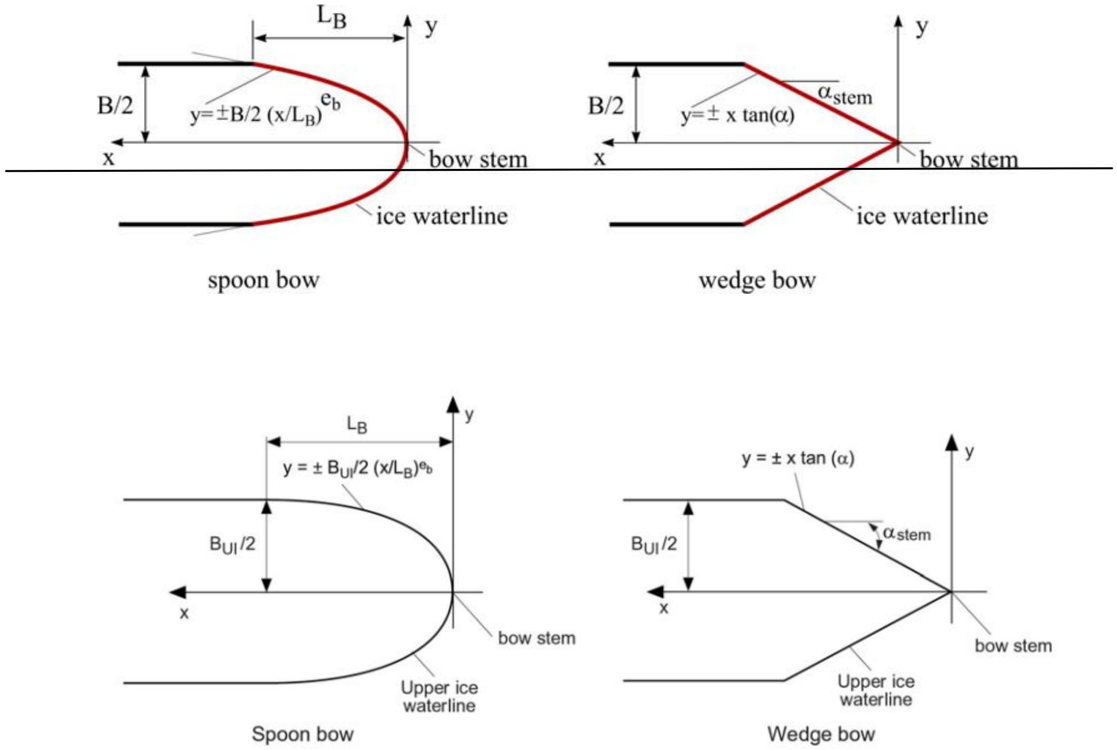
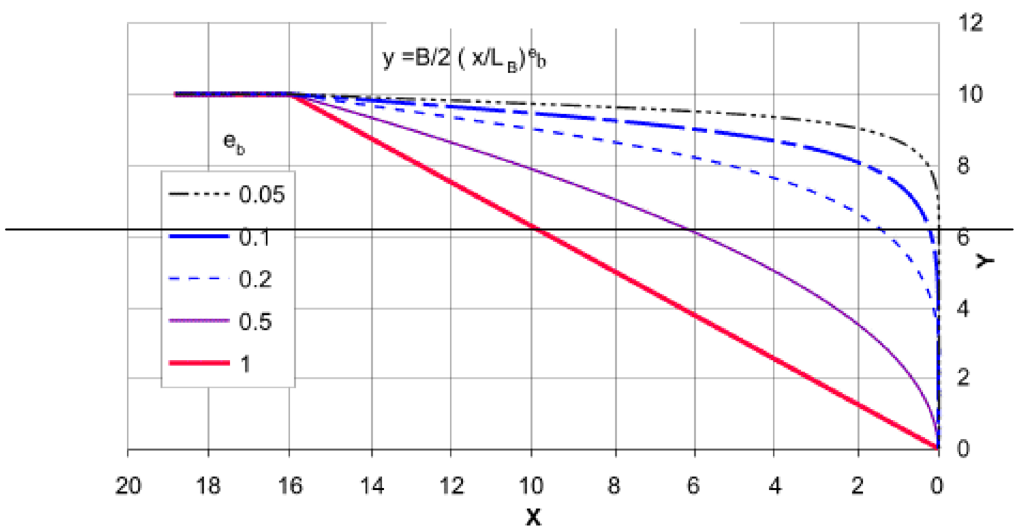


Figure 10 - Bow Shape Definition



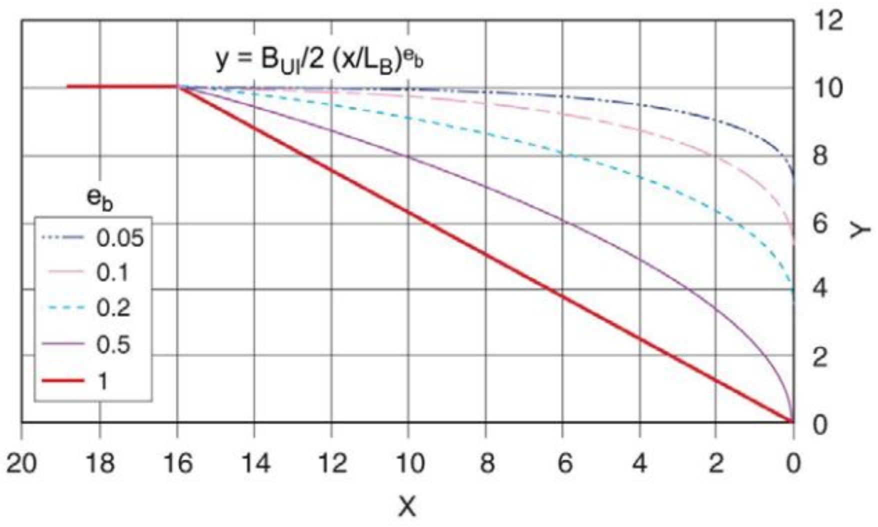


Figure 11 - Illustration of e_b Effect on the Bow Shape for B_{UI} = 20 and L_B =16

~~3.15.3~~3.16.3 ***Design Vertical Shear Force***

………………………………………………………..

C_f = 0.0 between the aft end of L_{UI} and 0.6L_{UI} from aft

C_f = 1.0 between 0.9 L_{UI} from aft and the forward end of L_{UI}

(b) Negative shear force

C_f = 0.0 at the aft end of L_{UI}

C_f = -0.5 between 0.2 L_{UI} and 0.6L_{UI} from aft

C_f = 0.0 between 0.8 L_{UI} from aft and the forward end of L_{UI}

~~3.15.4.1~~3.16.4.1 *The design vertical ice bending moment, MI, along the hull girder is to be taken as:*
$M_I = 0.1 \cdot C_m \cdot L_{ui} \cdot \sin^{-0.2}(\gamma_{stem}) \cdot F_{IB}$ *[MNm]*

where

L_{UI} = ~~ship~~length as defined in 3.4.1 ~~Chapter 1, Hull, Section 1, H.2.1, but measured on the upper ice waterline [UIWL]~~ [m]

γ_{stem} is as given in 3.1~~5~~6.2.

F_{IB} = design vertical ice force at the bow [MN]

C_m = longitudinal distribution factor for design vertical ice bending moment to be taken as follows:

C_m = 0.0 at the aft end of L_{UI}

C_m = 1.0 between 0.5L_{UI} and 0.7L_{UI} from aft

C_m = 0.3 at 0.95L_{UI} from aft

C_m = 0.0 at the forward end of L_{UI}

Intermediate values are to be determined by linear interpolation.

~~*Where applicable, draught dependent quantities are to be determined at the waterline corresponding to the loading condition under consideration.*~~

~~3.15.4.2~~3.16.4.2 The applied vertical bending stress, σa, is to be determined along the hull girder in a similar manner as in Chapter 1, Hull, Section 3, Table 3.23a and 3.23b, by substituting the design vertical ice bending moment for the design vertical wave bending moment. The ship still water bending moment is to be taken as the permissible still water bending moment in sagging condition ~~maximum sagging moment~~.

……………………………………………………….

~~3.17.2~~3.18.2 *All manoeuvring arrangements, e.g. rudder stocks, rudder couplings, rudder bearings, rudder bodies, ice horns, propeller nozzles, podded propulsors, azimuth thrusters etc., are to be dimensioned to withstand the design ice force defined in 3.~~5~~**6.**2.2.1, adjusted by the appropriate hull area factor in Table 5. Alternative design ice force definitions, including reduced design ice forces below the lower ice waterline (LIWL) and longitudinal design ice forces (where applicable), may be agreed with TL.*

……………………………………………………….

~~3.17.4~~3.18.4 *The thickness of rudder and nozzle plating is to be determined according to 3.~~6~~7.*

~~3.17.5~~3.18.5 *Rudders and rudder stocks shall be protected from ice loads with an ice horn which is fitted directly abaft the rudder and which extends a minimum distance of 1.5 CFD [m] below the lower ice waterline (LIWL) defined in 7. When dimensioning the ice horn and the uppermost part of the rudder, it may be assumed that the design ice patch is acting over both structures, i.e. the design ice force defined in 3.~~17~~18.2 may be distributed between them.*

……………………………………………………….

~~3.19.1~~3.20.1 *Direct calculations are not to be utilised as an alternative to the analytical procedures prescribed for the shell plating and local frame requirements given in 3.~~6~~7, 3.~~8~~9 and 3.~~9~~10*

……………………………………………………….

~~3.19.3~~3.20.3 *Where direct calculations are used to check the strength of structural arrangements (e.g. arrangements which may need to be specially considered), the load patch specified in 3.~~5~~6 is to be applied, without being combined with any other loads. The load patch is to e applied at locations where the capacity of these members under the combined effects of bending and sheer is minimized. Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.*

~~3.19.4~~3.20.4 .the strength evaluation of web frames and stringers may be performed based on linear or non-linear analysis. Recognized structural idealization and calculation methods are to be applied, but the detailed requirements are to be specified by TL. In the strength evaluation, the guidance given in 3.~~19~~20.5 and 3.~~19~~20.6 may generally be considered.

PART C – CHAPTER 35 TENTATIVE RULES FOR SHIPS LESS THAN 500 GRT

01. D-Fire Safety - Section 4 – Structural Fire Protection

Revision Date: November 2020

Entry into Force Date: 1 January 2021

Item B.2.2.2.2 in Section 4 of D-Fire Safety of Chapter 35 was revised as below:

(1) Control stations

……………………..

See also TL-I SC17 for Definitions of Control Stations(SOLAS Reg. II-2/3.18).

PART D – CHAPTER 50 – RULES FOR LIFTING APPLIANCES

01. Section 01 – Instruction for Use

Revision Date: November 2021

Entry into Force Date: 1 January 2021

Item D.2.1.3 was revised as below:

2.1.3 Classified lifting appliances

(These are lifting appliances of all kinds, which, at the operator's request, undergo a comprehensive approval, testing and examination for the issue of a certificate of class.)

- The approval procedure for the allocation of class encompasses the steel structure, fittings for the absorption and transmission of forces,rope drives, winches, slewing/swinging, luffing and travelling gear, drives including the prime mover, power supply lines, steering gear, as well as control and safety devices.

Ships equipped with lifting appliances complying with these rules are given **LA** class notation.

02. Section 04 – Cranes and Crane Foundations

Revision Date: November 2021

Entry into Force Date: 1 January 2021

Item A.7 was added as below:

7. Ships equipped with classed lifting appliances like cranes, gantry cranes, A-frames, etc. complying with this Section are given **LA (CRANE)** class notation.

03. Section 05 – Lifts and Lifting Platforms

Revision Date: November 2021

Entry into Force Date: 1 January 2021

Items D.1.4 and E.1.3 were added as below:

1.4 Ships equipped with classed passenger lifts complying with this subsection are given **LA (PL)** class notation.

1.3 Ships equipped with classed cargo (good) lifts complying with this subsection are given **LA (CL)** class notation.

04. Section 06 – Special Lifting Appliances And Means of Transport

Revision Date: November 2021

Entry into Force Date: 1 January 2021

Item D.1.5 was added as below:

1.5 Ships equipped with classed movable ship borne vehicle ramps complying with this subsection are given **LA (CR)** class notation

GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS

01. Section B – SCR – Selective Catalytic Reduction Systems

Revision Date: September 2020

Entry into Force Date: 1 January 2021

Item B.6.2.1, B.6.2.3 and B.6.2.5 was revised in Guidelines for Exhaust Gas Cleaning Systems according to UR M77 Rev.1 as below:

6.2 Reductant Piping Systems – Urea Solution

The requirements for the reductant piping systems detailed in this Subsection are based on the use of ammonia as a reductant introduced in a urea/water solution at 32% or 40% concentrations.

6.2.1 Reductant Tank, Piping and Connections

i) In general, pipe fittings and joints are to meet the requirements of **TL**, Part B, Chapter 4, Machinery, Section 16 for certification.

ii) The reductant piping and venting systems are to be independent of other ship service piping and/or systems.

iii) Reductant piping systems are not to be located in accommodation, service, or control spaces.

iv) Supply, bunkering, and transfer lines for reductant systems, with the exception of those associated with injector equipment, are not to be located over boilers or in close proximity to steam piping, exhaust systems, hot surfaces required to be insulated, or other sources of ignition.

v) Reductant tanks are to be of steel or other equivalent material with a melting point above 925 degrees C.

Pipes/piping systems are to be of steel or other equivalent material with melting point above 925 degrees C, except downstream of the tank valve, provided this valve is metal seated and arranged as fail-to-closed or with quick closing from a safe position outside the space in the event of fire; in such case, type approved plastic piping may be accepted even if it has not passed a fire endurance test. Reductant tanks and pipes/piping systems are to be made with a material compatible with reductant or coated with appropriate anti-corrosion coating.

~~The material of the reductant related piping systems, tanks, and other components which may come into contact with the reductant solution is to be of a suitable grade of non-combustible alloyed steel, plastic, or other compatible material established to be suitable for the application.~~

Non-alloyed steels, copper, copper containing alloys, and zinc-coated steels are not to be used for reductant storage or piping systems.

~~**vi)** Pipes and piping components made of thermoplastic or thermosetting plastic materials, with or without reinforcement, may be used in piping systems subject to compliance with the requirements of TL, Part B, Chapter 4, Machinery, Section 16 (in particular B 2.6). For the purpose of these Rules, "plastic" means both thermoplastic and thermosetting plastic materials, with or without reinforcement, such as PVC and FRP. Plastic piping is to meet Level 3 fire endurance testing requirements (see TL, Part B, Chapter 4, Machinery, Section 16, B 2.6.9).~~

vi~~i~~) Flexible hoses are to comply with the requirements of of **TL**, Part B, Chapter 4, Machinery, Section 16 (in particular D.10, and U).

6.2.2 Filters and Strainers

Filters are to be provided in reductant piping systems to minimize the entry of harmful foreign material that may affect operation and closure of regulating valves, dosing valves, or other essential system components. The filters are to be designed to withstand the maximum working pressure of the system.

6.2.3 Arrangement of the Urea Storage Tank

6.2.3.1 Reductant using urea based ammonia (e.g. 40%/60% urea/water solution)

i) Where urea based ammonia (e.g. AUS 40 – aqueous urea solution specified in ISO 18611-1) is introduced, the storage tank is to be arranged so that any leakage will be contained and prevented from making contact with heated surfaces. All pipes or other tank penetrations are to be provided with manual closing valves attached to the tank. Tank and piping arrangements are to be approved.

~~The urea storage tank is not to be situated where spillage or leakage therefrom can constitute a hazard by falling onto combustibles or heated surfaces and is to be located in a well-ventilated area away from heat sources~~

ii) The urea storage tank may be located within the engine room. ~~If installed in a separate compartment, the area is to be served by an effective mechanical exhaust ventilation system with ventilation inlets located where any vapors would be expected to accumulate. In addition, if located in a separate compartment, the ventilation system is to be capable of being controlled from outside the compartment.~~

iii) The urea storage tank is to be protected from excessively high or low temperatures applicable to the particular urea concentration of the solution (e.g., above 30°C and below 0°C for a 40% solution). Depending on the operational area of the vessel, this may necessitate the fitting of heating and/or cooling systems. The physical conditions recommended by applicable recognized standards (such as ISO 18611-3) are to be taken into account to ensure that the contents of the aqueous urea tank are maintained to avoid any impairment of the urea solution during storage.

~~iii) Every pipe emanating from a tank containing urea, which, if damaged, would allow urea to escape from the tank, is to be provided with a manual closing valve located directly on the tank.~~

iv) If a urea storage tank is installed in a closed compartment, the area is to be served by an effective mechanical ventilation system of extraction type providing not less than 6 air changes per hour which is independent from the ventilation system of accommodation, service spaces, or control stations. The ventilation system is to be capable of being controlled from outside the compartment. A warning notice requiring the use of such ventilation before entering the compartment shall be provided outside the compartment adjacent to each point of entry.

Alternatively, where a urea storage tank is located within an engine room a separate ventilation system is not required when the general ventilation system for the space is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly ventilated.

v) ~~The urea storage tank is to be provided with temperature and level monitoring arrangements.~~ Each urea storage tank is to be provided with temperature and level monitoring arrangements. High and low level alarms together with high and low temperature alarms are also to be provided.

vi) Where urea based ammonia solution is stored in integral tanks, the following are to be considered during the design and construction:

- These tanks may be designed and constructed as integral part of the hull, (e.g. double bottom, wing tanks).
- These tanks are to be coated with appropriate anti-corrosion coating and cannot be located adjacent to any fuel oil and fresh water tank.
- These tanks are to be designed and constructed as per the structural requirements applicable to hull and primary support members for a deep tank construction.
- These tanks are to be included in the ship's stability calculation.

vii) The requirements specified in iv) also apply to closed compartments normally entered by persons:

- when they are adjacent to the urea integral tanks and there are possible leak points (e.g. manhole, fittings) from these tanks; or
- when the urea piping systems pass through these compartments, unless the piping system is made of steel or other equivalent material with melting point above 925 degrees C and with fully welded joints.

viii) The reductant piping and venting systems are to be independent of other ship service piping and/or systems. Reductant piping systems are not to be located in accommodation, service spaces, or control stations. The vent pipes of the storage tank are to terminate in a safe location on the weather deck and the tank venting system is to be arranged to prevent entrance of water into the urea tank.

~~iv)~~ix) The urea storage tank is to be provided with vent pipes complying with **TL**, Part B, Chapter 4, Machinery, Section 16, R and the outlets are to terminate in a safe location (Vent outlets are to be situated where possibility of ignition of the gases issuing therefrom is remote) in the weather.

The vents that are open to the weather should not be subject to deterioration due to the concentrations involved and the arrangement is to be such that the potential source of moisture from the vents does not present any danger to the crew or vessel. Alternatively, the tanks are to be fitted with appropriately sized pressure/vacuum valves.

x) Urea storage tanks are to be arranged so that they can be emptied of urea and ventilated by means of portable or permanent systems.

6.2.3.2 Reductant using aqueous ammonia (28% or less concentration of ammonia)

Aqueous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant. Where an application is made to use aqueous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

6.2.3.3 Reductant using anhydrous ammonia (99.5% or greater concentration of ammonia by weight)

Anhydrous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant and where the Flag Administration agrees to its use. Where it is not practicable to use a urea reductant then it is also to be demonstrated that it is not practicable to use aqueous ammonia. Where an application is made to use anhydrous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

6.2.4 Spill Trays

Urea storage tanks with a capacity of 500 liters and above are to be located within spill trays fitted with a high level alarm.

6.2.5 Personnel Protection

For the protection of crew members, the vessel shall have on board suitable protective equipment consisting of large aprons, rubber gloves with long sleeves, rubber boots, coveralls of chemical-resistant material, dust respirator, and tight-fitting chemical safety goggles or face shields or both. ~~An e~~Eyewash are to be provided, the location and number of these eyewash stations are to be derived from the detailed installation arrangements ~~and safety shower should be nearby~~.

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