RULES FOR CLASSIFICATION(STEEL SHIPS)

(Part 2 Materials and Welding)

- For development verification -

2023.09.

Development Verification

1. It was confirmed that the development output meets the development input requirements.
2. It has been confirmed that the amendment can be applied without conflict with related regulations.
3. It is expected that there will be no problems in complying with the intended use of the amendment by surveyors and customers (ship owners, shipyards, manufacturers, etc.).

Machinery Rule Development Team

- Main Amendments -

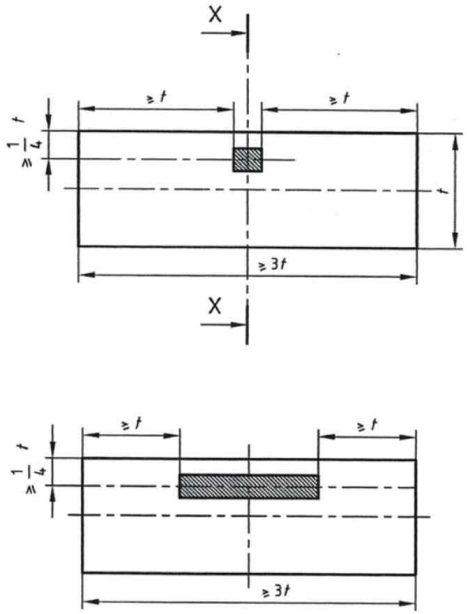
(1) Effective date : Immediately (Applicable retroactively after July 1, 2023)

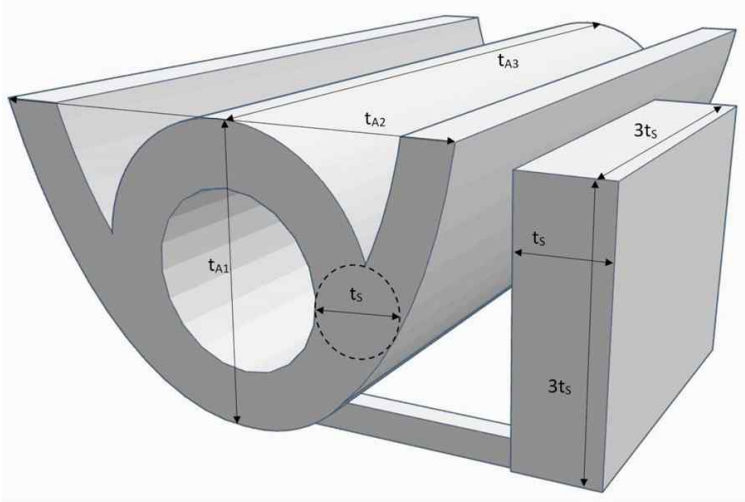
- Circular -

◉ To reflect Request for Establishment/Revision of Classification Technical Rules

The relevant industry's opinion that the size of the test block of the steel castings is excessive was received by IACS, and KR decided to reserve 6.3 & 6.4 of IACS URW8(Rev.3).

Present	Amendment
CHAPTER 1 MATERIALS	**CHAPTER 1 MATERIALS**
Section 1 ~ Section 4 <Omitted>	**Section 1 ~ Section 4 <Same as the present Rules>**
Section 5 Castings	**Section 5 Castings**
501. Steel castings	**501. Steel castings**
1. ~ 6. <Omitted>	**1. ~ 6.** <Same as the present Rules>
7. Selection of test specimens	**7. Selection of test specimens**
(1) At least one test block is to be provided for each casting. Unless otherwise agreed these test blocks are to be either integrally cast or gated to the castings. *(2023)*	(1) At least one test block is to be provided for each casting. Unless otherwise agreed these test blocks are to be either integrally cast or gated to the castings. One tensile test specimen and one set of impact tests are to be taken from each test block. These test blocks are to have a thickness of not less than 30 mm. Test material, sufficient for the required tests and for possible retest purposes is to be provided for each casting or batch of castings. *(2023) (2024)*
~~(2) The size of the test blocks for mechanical testing is to be such that the heat treatment and are to microstructure is representative for the section of the casting with the ruling section, i.e. the section for which the specified mechanical properties apply, see also ISO 683-1:2018 and ISO 683-2:2018, respectively.~~	(2) ~ (4) <Deleted>
~~(A) For C, C-Mn steel castings this is in general to be achieved as follows: The test block shall have a thickness (t_S) of not less than the ruling section of the casting, or 30 mm, whichever is larger.~~	
~~(B) For large thickness castings other than stern tube, stern frame, anchor and rudder horn, t_S normally need not to exceed 150 mm. Length and width of the test block is normally to be at least three times t_S, unless otherwise agreed with the Society, as shown in **Fig 2.1.14**. (Note that longer or wider test blocks may be necessary in order to accommodate the required test specimens.) For castings for stern tube, stern frame, anchor and rudder horn the test block thickness t_S shall represent the ruling section.~~	

Present	Amendment
(C) Shorter width or length may be accepted for test blocks where actual casting width or length (t_A) is in the range between t_S and $3t_S$. See the example below. (a) **Example 1**: For a general casting with dimensions 140 x 160 x 1250 mm the required test block size would typically be 140 x 160 x 420 mm (that is: t_S x t_A x $3t_S$). (b) **Example 2**: For a stern tube casting with ruling section t_S = 170 mm and width/height/length $t_{A1}/t_{A2}/t_{A3}$ = 1000/600/1800 mm, the required test block size would typically be 170 x 510 x 510 mm (that is: t_S x $3t_S$ x $3t_S$) see **Fig 2.1.15**.  Fig. 2.1.14 Specimen positions relative to the test block in accordance with ISO 4990:2015* *(2023)* * The figure taken from ISO 4990:2015, Steel castings — General technical delivery requirements, is reproduced with the permission of the International Organization for Standardization, ISO. This standard can be obtained from any ISO member and from the website of the ISO Central Secretariat at the following address: www.iso.org. Copyright remains with ISO.	(2) ~ (4) <Deleted>

Present	Amendment
 ~~Fig. 2.1.15 Example 2: test block gated to stern tube casting~~ *~~(2023)~~*	(2) ~ (4) <Deleted>
~~(3) For alloy steel castings the manufacturer shall propose dimensions for the test block and demonstrate the representative nature of it. *(2023)*~~ ~~(4) For test blocks with thickness ≤ 56 mm, the longitudinal axis of the test specimens is to be located at ≥ 14 mm from the surface in the thickness direction. For test blocks with thickness > 56 mm, the longitudinal axis of the test specimens is to be located at ≥ ¼ t_S from the surface. Test specimens shall be taken in such a way that no part of the gauge length is machined from material closer than t_S to any of the other surfaces. For impact testing, this requirement shall apply to the complete test specimen - refer to **Fig 2.1.14** for location of test specimens in relation to the test block. *(2023)*~~	
<hereafter, omitted>	<hereafter, same as the present Rules>

RULES FOR CLASSIFICATION(STEEL SHIPS)

(Part 2 Materials and Welding)

- For development verification -

2023.09

Development Verification

1. It was confirmed that the development output meets the development input requirements.
2. It has been confirmed that the amendment can be applied without conflict with related regulations.
3. It is expected that there will be no problems in complying with the intended use of the amendment by surveyors and customers (ship owners, shipyards, manufacturers, etc.).

Machinery Rule Development Team

- Main Amendments -

(1) Enter into force on 1 July 2024 (the date of application for certification of material & welding)

◉ To reflect IACS UR W31(Rev.3 Mar 2023)
◉ To reflect Request for Establishment/Revision of Classification Technical Rules

Present	Amendment	reason
CHAPTER 1 MATERIALS **Section 1 ~ Section 2 <Omitted>** **Section 3 Rolled Steels** **301. Rolled steels for hull structural** **1. ~ 2.** <Omitted> **3. Manufacturing process** (1) Where steel plates are manufactured from the continuous casting slabs, the maximum thickness for approval is to be determined, as a rule, with the roll ratio of 6 as standard. However, upon consideration of the manufacturing process, the roll ratio may be reduced to 4 (3 for steel plate thickness in excess of 50 mm). (2) <Omitted> **4. ~ 13.** <Omitted> **302. ~ 311. <Omitted>**	**CHAPTER 1 MATERIALS** **Section 1 ~ Section 2 <Same as the present Rules>** **Section 3 Rolled Steels** **301. Rolled steels for hull structural** **1. ~ 2.** <Same as the present Rules> **3. Manufacturing process** (1) Unless otherwise approved, the reduction ratio is to be at least 3 to 1. *(2024)* (2) <Same as the present Rules> **4. ~ 13.** <Same as the present Rules> **302. ~ 311. <Same as the present Rules>**	- Not specifically stated in the relevant IACS UR. Revised in consideration of industrial technology development.

Present

312. Brittle crack arrest steels *(2021)*

1. ~ **3.** <Omitted>

4. Brittle crack arrest properties

(1) In addition to the required mechanical properties of **301.** and **311.**, brittle crack arrest steels are to comply with the requirements specified in **Table 2.1.45**.

(2) <Omitted>

Table 2.1.45 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℃ ($N/mm^{3/2}$)[3]	Crack Arrest Temperature CAT (℃)[4]
BCA1	$50 < t \leq 100$	6,000 min.	-10 or below
BCA2	$80 < t \leq 100$	8,000 min.	[5]

Note

(1) Suffix "BCA1" or "BCA2" is to be affixed to the steel grade designation (e.g. *EH40-BCA1*, *EH47-H-BCA1*, *EH47-H-BCA2*, etc.).

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

(3) K_{ca} value is to be in accordance with the Guidance relating to the Rules specified by the Society. **【See Guidance】**

(4) CAT is to be obtained in accordance with the Guidance relating to the Rules specified by the Society. **【See Guidance】**

(5) Criterion of CAT for brittle crack arrest steels corresponding to K_{ca} =8,000 $N/mm^{3/2}$ is to be approved by the Society

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

5. <Omitted>

Amendment

312. Brittle crack arrest steels *(2021)*

1. ~ **3.** <Same as the present Rules>

4. Brittle crack arrest properties

(1) In addition to the required mechanical properties of **301.** and **311.**, brittle crack arrest steels are to comply with the requirements specified in **Table 2.1.45**.

(2) <Same as the present Rules>

Table 2.1.45 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℃ ($N/mm^{3/2}$)[3]	Crack Arrest Temperature CAT (℃)[4]
BCA1	$50 < t \leq 100$	6,000 min.	-10 or below
BCA2	$80 < t \leq 100$	8,000 min.	[5]

Note

(1) Suffix "BCA1" or "BCA2" is to be affixed to the steel grade designation (e.g. *EH40-BCA1*, *EH47-H-BCA1*, *EH47-H-BCA2*, etc.).

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

(3) K_{ca} value is to be in accordance with the Guidance relating to the Rules specified by the Society. **【See Guidance】**

(4) CAT is to be obtained in accordance with the Guidance relating to the Rules specified by the Society. **【See Guidance】**

(5) Criterion of CAT for brittle crack arrest steels corresponding to K_{ca} =8,000 $N/mm^{3/2}$ is to be approved by the Society

(6) Where small-scale tests are used for product testing (batch release testing), these test methods are to be approved by the Society in accordance with the Guidance relating to the Rules specified. **【See Guidance】** *(2024)*

5. <Same as the present Rules>

reason

- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
Section 4 <Omitted> **Section 5 Castings**	**Section 4** <Same as the present Rules> **Section 5 Castings**	
501. Steel castings	**501. Steel castings**	
1. ~ 5. <Omitted>	**1. ~ 5.** <Same as the present Rules>	
6. Mechanical properties (1) The mechanical properties of the steel castings are to comply with the requirements given in **Table 2.1.73**. ~~(2) Impact tests should be required on carbon steel castings intended for welded construction such as cast sternframes, rudder horns and shoepieces. The results of impact test is to be in accordance with the Guidance relating to the Rules specified by the Society. [See Guidance]~~	**6. Mechanical properties** (1) The mechanical properties of the steel castings are to comply with the requirements given in **Table 2.1.73**. (2) <Deleted>	- As Part 2 of the Rules has been amended to require the impact test of all steel castings for welded structures, the additionally required impact test requirement (2) has been deleted.
7. ~ 12. <Omitted>	**7. ~ 12.** <Same as the present Rules>	
13. Marking (1) ~ (2) <Omitted> ~~(3) Where carbon steel castings are intended for welded hull construction specified in **Table 2.1.71**, "W" is to be suffixed to the marking. (e.g, *RSC* 420-*W*)~~	**13. Marking** (1) ~ (2) <Same as the present Rules> (3) <Deleted>	- Since carbon steel castings for welding already add H to the material symbol, (3) is deleted. (e.g. RSC 440 H)
14. ~ 15. <Omitted>	**14. ~ 15.** <Same as the present Rules>	
502. ~ 507. <Omitted>	**502. ~ 507. <Same as the present Rules>**	
Section 6 ~ Section 8 <Omitted>	**Section 6 ~ Section 8** <Same as the present Rules>	

Present	Amendment	reason
CHAPTER 2 WELDING **Section 1 ~ Section 5 <Omitted>** **Section 6 Welding Consumables**	**CHAPTER 2 WELDING** **Section 1 ~ Section 5 <Same as the present Rules>** **Section 6 Welding Consumables**	
601. General	**601. General**	
1. ~ 4. <Omitted>	**1. ~ 4.** <Same as the present Rules>	
5. Periodical inspection The manufacturer of welding materials is to be subjected to the periodical inspection in the presence of Surveyor for each brands of the welding materials at each manufacturing plant ~~in a period not exceeding 12 months~~.	**5. Periodical inspection** The manufacturer of welding materials is annually to be subjected to the periodical inspection in the presence of Surveyor for each brands of the welding materials at each manufacturing plant. *(2024)*	- To match the Korean ver. <Korean ver.> : **5. 정기검사** 용접용재료의 제조자는 매년 우리 선급 검사원 입회하에 각 용접용재료마다 정해진 시험 및 검사를 받아야 한다.
6. ~ 9. <Omitted>	**6. ~ 9.** <Same as the present Rules>	
10. Packings and markings (1) The approved welding consumables are to be packed throughly to keep the quality during their transportation and storage. (2) All packages of approved welding consumables are to clearly marked with the following descriptions. *(2019)* (a) Brand (b) Specification and classification (c) Name of manufacturer and supplier (d) ~~Date and~~ number(lot, control or heat number) of production (e) Special notices on the treatment	**10. Packings and markings** (1) The approved welding consumables are to be packed throughly to keep the quality during their transportation and storage. (2) All packages of approved welding consumables are to clearly marked with the following descriptions. *(2019)* (a) Brand (b) Specification and classification (c) Name of manufacturer and supplier (d) Number(lot, control or heat number) of production *(2024)* (e) Special notices on the treatment	- From checking actual marking status and refer to AWS, ISO 544
602. ~ 609. <Omitted>	**602. ~ 609. <Same as the present Rules>**	
<hereafter, omitted>	<hereafter, same as the present Rules>	

GUIDANCE RELATING TO THE RULES FOR THE CLASSIFICATION OF STEEL SHIPS

(Guidance Part 2 Materials and Welding)

- For development verification -

2023. 09.

Development Verification

1. It was confirmed that the development output meets the development input requirements.
2. It has been confirmed that the amendment can be applied without conflict with related regulations.
3. It is expected that there will be no problems in complying with the intended use of the amendment by surveyors and customers (ship owners, shipyards, manufacturers, etc.).

Machinery Rule Development Team

- Main Amendments -

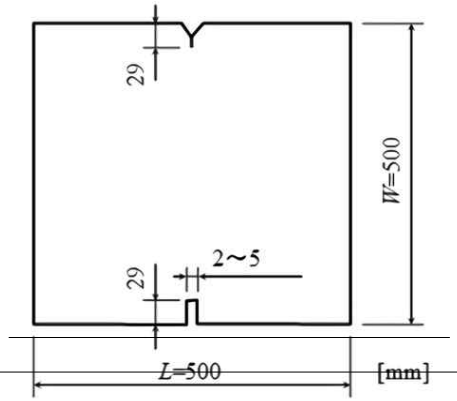
(1) Enter into force on 1 July 2024 (the date of application for certification of material & welding)

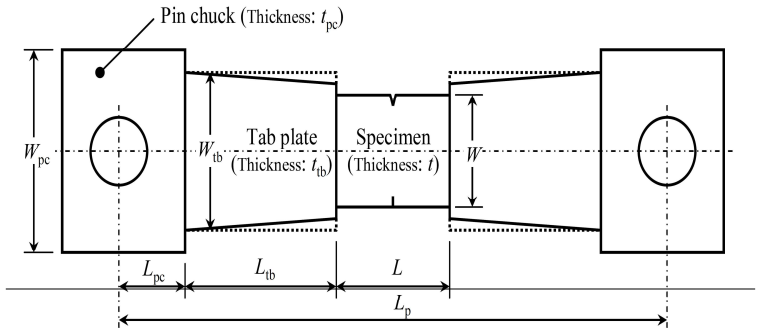
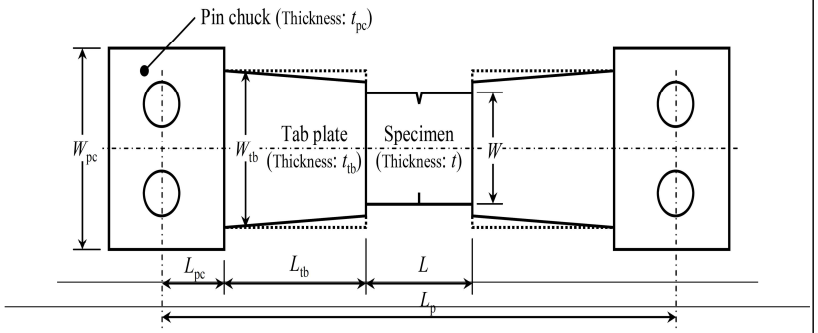
◉ To reflect IACS UR W31(Rev.3 Mar 2023)
◉ To reflect Request for Establishment/Revision of Classification Technical Rules

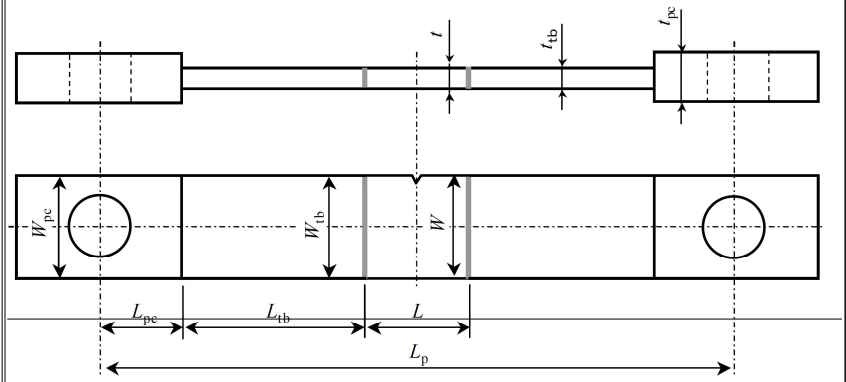
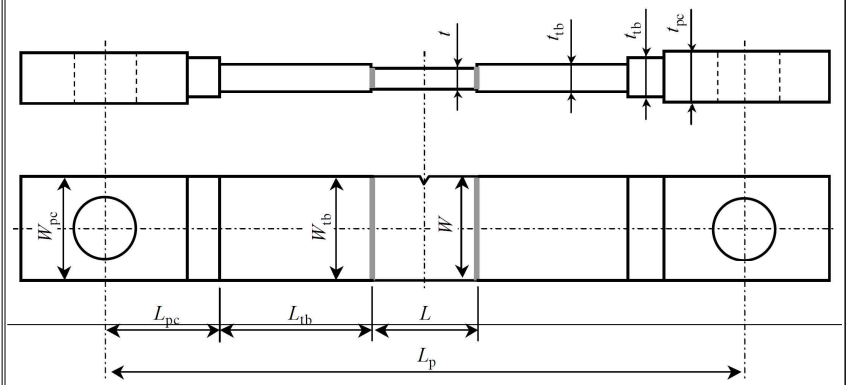
Present	Amendment	reason
CHAPTER 1 MATERIALS	**CHAPTER 1 MATERIALS**	
Section 1 <Omitted>	**Section 1** <Same as the present Guidance>	
Section 2 Test Specimens and Testing Procedures	**Section 2 Test Specimens and Testing Procedures**	
201. ~ 202. <Omitted>	**201. ~ 202.** <Same as the present Guidance>	
203. Testing procedure *(2017) (2021)*	**203. Testing procedure** *(2017) (2021)*	
1. Test method for Brittle crack arrest toughness, K_{ca} [See Rule]	**1. Test method for Brittle crack arrest toughness, K_{ca} [See Rule]**	
(1) Scope	(1) Scope	
(A) In application to **203.** of the Rules, this test method for brittle crack arrest toughness(i.e. K_{ca}) of steel using fracture mechanics parameter is applicable to hull structural steels with the thickness over 50 mm and not greater than 100 mm.	(A) In application to **203.** of the Rules, this test procedure for brittle crack arrest toughness(i.e. K_{ca}) of steel using fracture mechanics parameter is applicable to hull structural steels with the thickness over 50 mm and not greater than 100 mm. *(2024)*	- To reflect IACS UR W31(Rev.3 Mar 2023)
(B) <New>	(B) **ISO20064: 2019** provides a test method for the determination of brittle crack arrest toughness of steel by using wide plates with a temperature gradient. *(2024)*	
(C) <New>	(C) These requirements specify the test procedures for brittle crack arrest toughness (i.e. K_{ca}) of steel using fracture mechanics parameter and determination method of K_{ca} at a specific temperature which are specified in **ISO 20064:2019**. Additionally, this requirements specify the evaluation method of K_{ca} of test plate. *(2024)*	
~~(B) 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, K_{ca}, 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 K_{ca} at a specific temperature followed by the necessary evaluation, the method specified in **2.** can be used.~~	(B) <Deleted>	
~~(C) As a method for initiating a brittle crack, a secondary loading mechanism can also be used (see "Double tension type arrest test" specified in **3.**).~~	(C) <Deleted>	

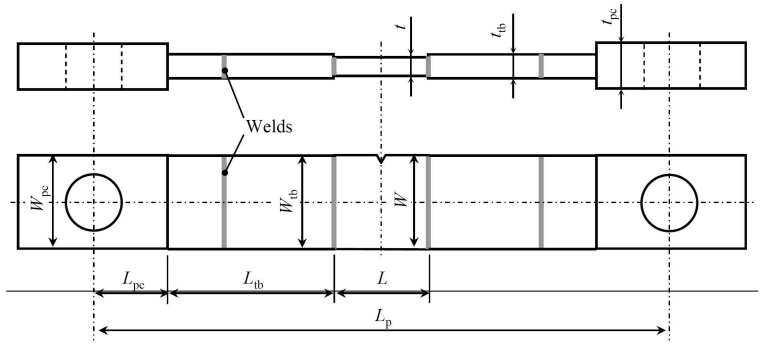
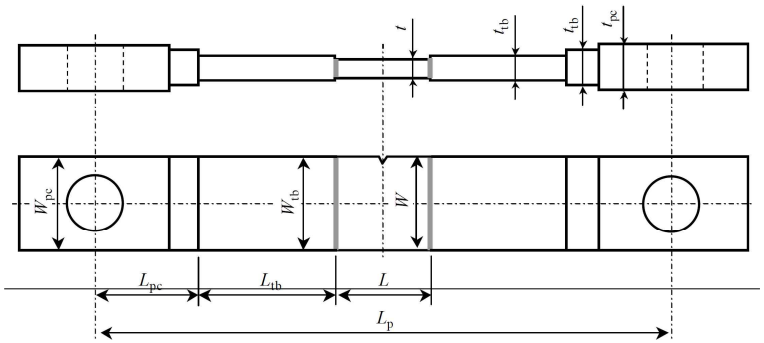
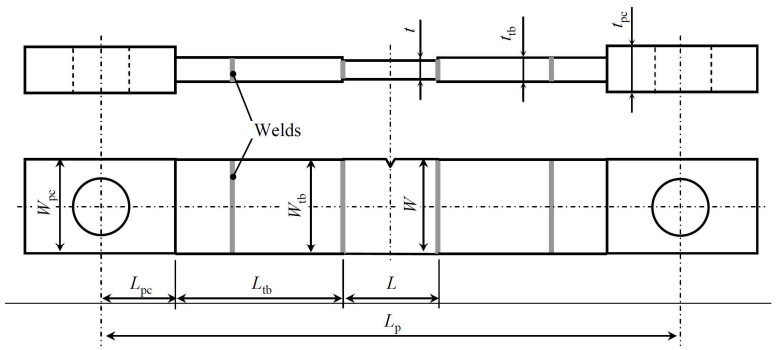
Present	Amendment	reason
(2) Symbols and their significance **Table 2.1.3 symbols and their significance** Symbol | Unit | Significance a | mm | Crack length or arrest crack length E | N/mm^2 | Modulus of longitudinal elasticity E_i | J | Impact energy E_s | J | Strain energy stored in a test specimen 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 | ℃ | 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	(2) <Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(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. ~~(A) Testing machine~~ ~~(a) 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.~~ ~~(b) 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.~~ ~~(c) Distance between the loading pins~~ ~~The distance between the loading pins shall be approximately 3.4W 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) (A).~~ ~~(B) Impact equipment~~ ~~(a) 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.~~	(2) Test procedures *(2024)* The test procedures including testing equipment, test specimens, test methods, determination of arrest toughness, reporting of test results, etc. are to be in accordance with **ISO 20064: 2019**. As a method for initiating a brittle crack, a secondary loading mechanism can be used in accordance with Annex D of **ISO 20064: 2019**, except that the first sentence in Annex B.2.4 of **ISO 20064: 2019** is revised to "Obtain the value $\{K_{ca}/[K_0*\exp(-c/T_{Kca})]\}$ for each data point". (A) ~ (B) <Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

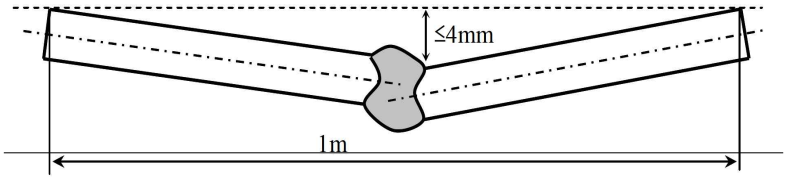
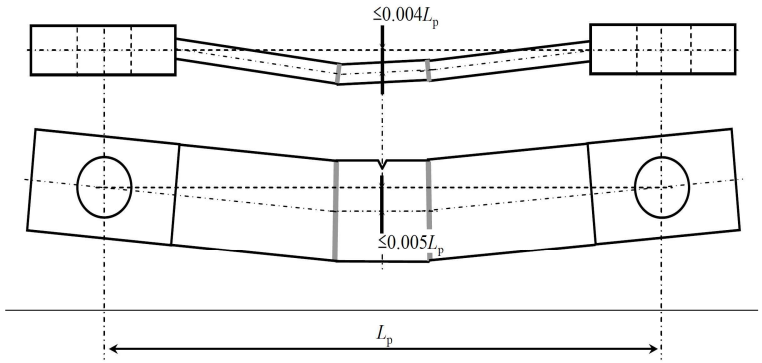
Present	Amendment	reason
~~(4) Test specimens~~ ~~(A) Test specimen shapes~~ ~~The standard test specimen shape is shown in Fig 2.1.2 of the Guidance. Table 2.1.4 of the Guidance shows the ranges of test specimen thicknesses, widths and width-to-thickness ratios. The test specimen length shall be, in principle, equal to or greater than its width.~~  **~~Fig 2.1.2 Standard test specimen shape~~** **~~Table 2.1.4 Thickness and width 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~~ ~~(B) Shapes of tab plates and pin chucks~~ ~~The definitions of the dimensions of the tab plates and pin chucks are shown in Fig 2.1.3 of the Guidance. Typical examples are shown in Fig 2.1.4 of the Guidance.~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
 **(a) Single-pin type**  **(b) Double-pin type** **Fig 2.1.3 Definitions of dimensions of tab plates and pin chucks**	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

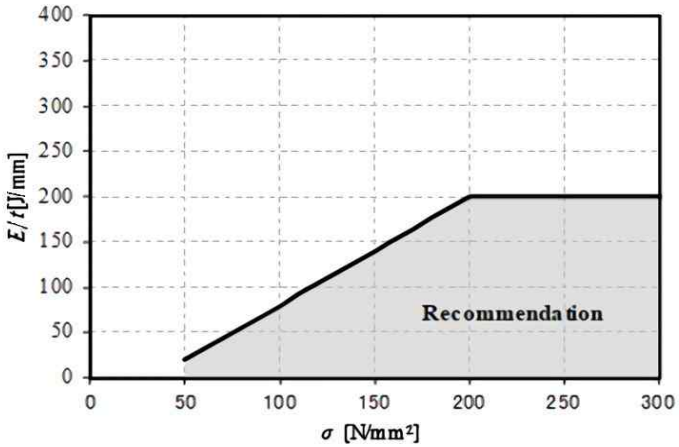
Present	Amendment	reason
 ~~(a) Example 1~~  ~~(b) Example 2~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
 **(c) Example 3**  **(d) Example 4**  **(e) Example 5** **Fig 2.1.4 Examples of the shapes of tab plates and pin chucks**	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(a) Tab plates The tolerances of tab plate dimensions are shown in Table 2.1.5 of the Guidance. 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, L_{tb}. **Table 2.1.5 Tolerances of tab plate dimensions** Tab plate thickness, t_{tb} : $0.8t \leq t_{tb} \leq 1.5t$ Tab plate width, W_{tb} : $W \leq W_{tb} \leq 2.0W$ Total length of a test specimen and tab plates, $L+2L_{tb}$ (Total length of a test specimen and a single tab plate, $L+L_{tb}$) : $3.0W \leq L+2L_{tb}$ ($2.0W \leq L+L_{tb}$) Tab plate length(L_{tb})/Tab plate width(W_{tb}) : $1.0 \leq L_{tb}/W_{tb}$ (b) Pin chucks The pin chuck width, W_{pc}, shall be in principle equal to or more than the tab plate width, W_{tb}. 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, L_{pc}. The distance between the pins, L_p, is obtained from the equation below. In the case as shown in Fig 2.1.4 (e), Example 5, L_p is obtained by setting $L_{pc} = 0$. $$L_p = L + 2L_{tb} + 2L_{pc}$$	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(C) Welding of test specimen and tab plates (a) Test specimen, tab plates, and pin chucks shall be connected by welding. The welds shall have a sufficient force bearing strength. (b) As shown in Fig 2.1.5 (a) of the Guidance, 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. (c) As shown in Fig 2.1.5 (b) of the Guidance, 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 Fig 2.1.5 Dimensional accuracy of weld between test specimen and tab plate	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

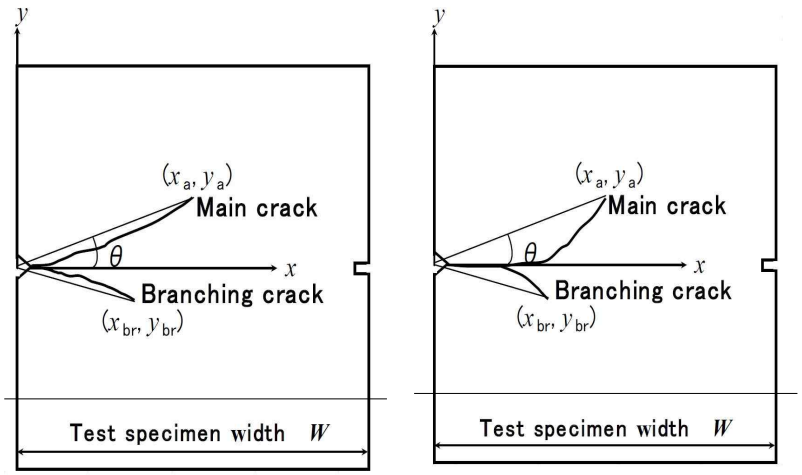
Present	Amendment	reason
~~(5) Test methods~~ ~~(A) Temperature control methods~~ ~~(a) A predetermined temperature gradient shall be established across a test specimen width by soldering at least nine thermocouples to the test specimen for temperature measurement and control.~~ ~~(b) Temperature gradient shall be established in accordance with the following conditions (i) through (iii).~~ ~~(i) A temperature gradient of 0.25 ~ 0.35°C/mm shall be established in a test specimen width range of 0.3W ~ 0.7W. 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 + 0.1t [mm]) minutes or more taking account of the time needed for soaking to the centre. If the temperature gradient at 0.3W ~ 0.7W 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.~~ ~~(ii) At the test specimen width centre position (i.e., 0.5W), 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.~~ ~~(iii) 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.~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

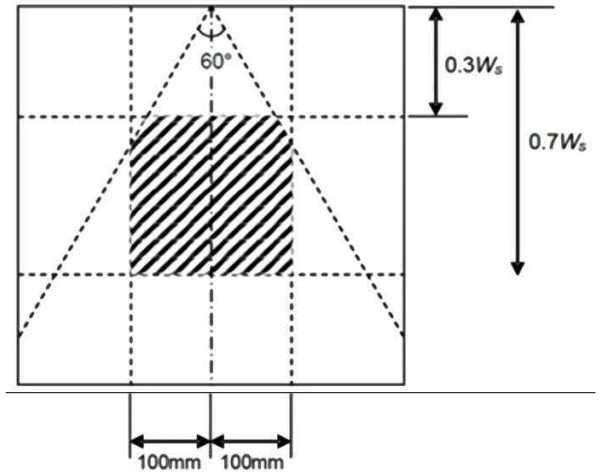
Present	Amendment	reason
~~(B) Crack initiation methods~~ ~~(a) Impact energy shall be applied to a test specimen to initiate a crack. However, if the energy is excessive, it may influence on the test results. In that case, the results shall be treated as invalid data in accordance with the judgment criteria specified in (7) (B).~~ ~~(b) It is desirable to use equation below and Fig 2.1.6 of the Guidance as guides for obtaining valid data.~~ ~~$\frac{E_i}{t} \leq \min(1.2\sigma - 40, 200)$~~ ~~Units : E_i[J], t[mm], $\sigma[N/mm^2]$~~ ~~Definition : min[the minimum of the two values]~~  ~~Fig 2.1.6 Recommended range of impact energy~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

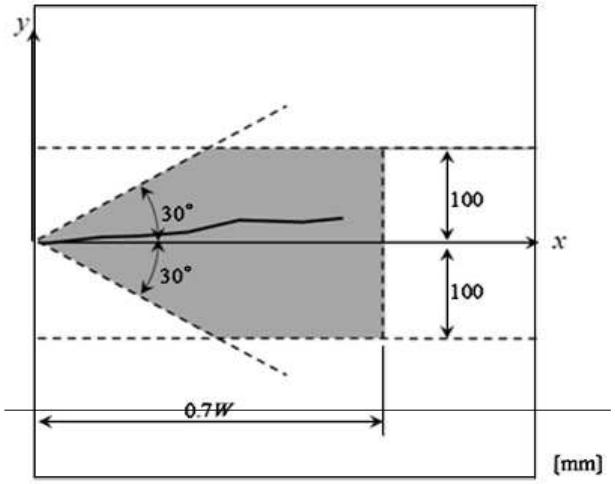
Present	Amendment	reason
~~(6) Test procedures~~ ~~(A) Pretest procedures~~ ~~(a) Install an integrated specimen in the testing machine.~~ ~~(b) Mount a cooling device on the test specimen. A heating device may also be mounted on the test specimen.~~ ~~(c) Install an impact apparatus specified in (3) (B), on the testing machine. Place an appropriate reaction force receiver as necessary.~~ ~~(d) The above procedures (a) through (c) do not necessarily specify the order of implementation, and they may be completed, for example, on the day before the test.~~ ~~(e) 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) (A).~~ ~~(f) Set an impact apparatus, as specified in (3) (B) so that it can supply predetermined energy to the test specimen.~~ ~~(g) 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 (i) and (ii) described below, respectively.~~ ~~(i) 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.~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
~~(ii) Applied stress/yield stress ratio~~ ~~Applied stress shall be within the range shown by equation.~~ $\sigma \leq \frac{2}{3}\sigma_{Y0}$ ~~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 above equation, the test may give a non-conservative result.~~ ~~(h) 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 0.3W ~ 0.7W. The test temperature in this case shall be the measured temperature obtained from the temperature record immediately before the further notch cooling.~~ ~~(i) Record the force value measured by a force recorder.~~ ~~(B) Loading procedures~~ ~~(a) 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.~~ ~~(b) After the impact, record the force value measured by the force recorder.~~ ~~(c) When the force after the impact is smaller than the test force, consider that crack initiation has occurred.~~ ~~(d) 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.~~ ~~(e) When crack initiation, propagation, and arrest are observed, remove the force.~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
~~(C) Procedures after testing~~ ~~(a) Remove the impact apparatus.~~ ~~(b) Remove the cooling device, thermocouples, and strain gauges.~~ ~~(c) 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.~~ ~~(d) 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.~~ ~~(D) Observation of fracture surfaces~~ ~~(a) Photograph the fracture surfaces and propagation path.~~ ~~(b) 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.~~ ~~(i) 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.~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(ii) 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 Fig 2.1.7 of the Guidance, obtain the angle Θ from the x-axis and define xa 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.  (a) Case of branching from notch (b) Case of branching during brittle crack propagation Fig 2.1.7 Measurement methods of main crack and branch crack lengths	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(c) 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.	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)
(7) Determination of arrest toughness	(3) Determination of K_{ca} at a specific temperature and the evaluation *(2024)*	
(A) <New>	(A) Method The method for conducting multiple tests to obtain K_{ca} value at a specific temperature is to be in accordance with Annex B of **ISO 20064: 2019**.	
(A) Judgment of arrested crack When an arrested crack satisfies all of the conditions (a) through (d) below as shown in **Fig 2.1.8** of the Guidance, the length of the arrested crack determined by (6) (D) is valid. If any of the conditions is not met, the arrest toughness calculated from (7) (C) is invalid.		
 **Fig 2.1.8 Necessary conditions of arrest crack position**		

Present	Amendment	reason
(a) ~~Conditions for crack propagation path~~ ~~All of the crack path from crack initiation to arrest shall be within the range shown in Fig 2.1.9 of the Guidance. 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 Ks for the main crack and a straight crack is obtained from equation below.~~ ~~$K = K_{\mathrm{I}} \cos^3(\frac{\Phi}{2}) + 3K_{\mathrm{II}} \cos^2(\frac{\Phi}{2}) \sin(\frac{\Phi}{2})$~~  **~~Fig 2.1.9 Allowable range of main crack propagation path~~**	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(b) Conditions for arrest crack length Equation (3) 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 (3) 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. $0.3 \leq (\frac{a}{W}) \leq 0.7$ ---------- (1) $(\frac{a}{W}) \geq 1.5$ ---------- (2) $(\frac{a}{L_p}) \leq 0.15$ ---------- (3) (c) Conditions for crack straightness $\lvert y_a \rvert \leq 50mm$ ----------(4) In the case where $50mm < \lvert y_a \rvert \leq 100mm$ and $\lvert \theta \rvert \leq 30^\circ$, the result is valid only when the temperature at x=0.5W and y=±100 mm falls within ± 2.5 ºC of that at x=0.5W and y=0. (d) Conditions for crack branching $(\frac{x_{br}}{x_a}) \leq 0.6$ ----------(5)	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(B) Assessment of impact energy Impact energy shall satisfy equation below. If it does not satisfy the equation, the value of arrest toughness calculated from the equations in (C) is invalid. Conditions for impact energy: $0.3 \le (\frac{a}{W}) \le 0.7$ ---------- (6) $\frac{E_i}{E_s + E_t} \le \frac{5a - 1050 + 1.4W}{0.7W - 150}$, units : a [mm], and W [mm]. E_i [impact energy calculated from the equation (7), J] E_s [energy calculated from the equation (8), J] E_t [energy calculated from the equation (9), J] If equation (6) is not satisfied, the influence of impact energy on the stress intensity factor is too large to obtain an accurate arrest toughness. In the case where the tab plates are multistage as shown in Fig 2.1.4 (b), calculate and total the strain energy of each tab plate using equation (8). In the case where tab plate widths are tapered as shown in Fig 2.1.4 (d), calculate the strain energy based on elastostatics. $E_i = mgh$ ---------- (7) $E_s = \frac{10^9 F^2}{2E} \frac{L}{W_t}$ ---------- (8) $E_t = \frac{10^9 F^2}{E} (\frac{L_{tb}}{W_{tb} t_{tb}} + \frac{L_{pc}}{W_{pc} t_{pc}})$ ---------- (9) Units: E_s[J], E_i[J], F[MN], E[N/mm^2], L[mm], W[mm], t[mm]	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

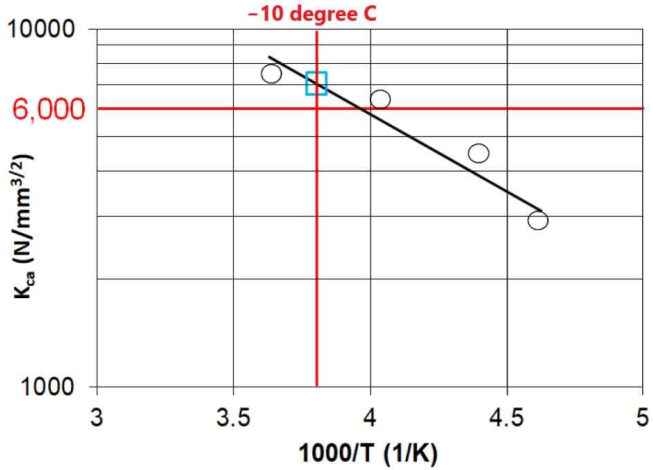
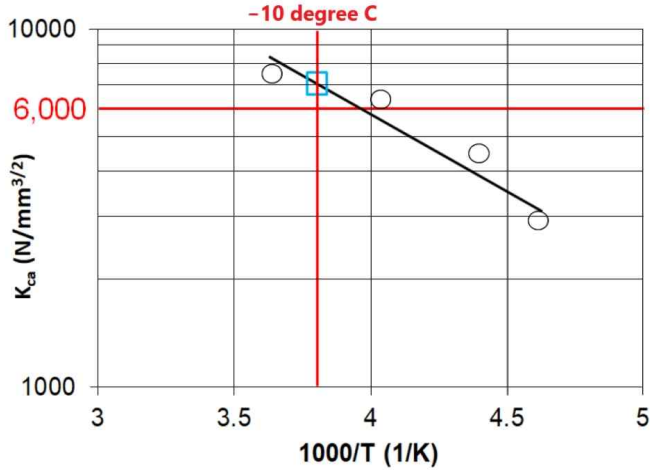
Present	Amendment	reason
(C) Calculation of arrest toughness The arrest toughness, K_{ca}, at the temperature, T, shall be calculated from equation (10) using the arrest crack length, a, and the applied stress, σ, judged by (A). Calculate σ from equation (11). $K_{ca} = \sigma\sqrt{\pi a}[\frac{2W}{\pi a}\tan(\frac{\pi a}{2W})]^{1/2}$ ----------(10) $\sigma = \frac{10^6 F}{Wt}$ ----------(11) Units : F[MN], W[mm], t[mm] If the conditions specified in (A) and (B) are not satisfied, the K_{ca} calculated from equation (10) is invalid. (8) Reporting Using Table 2.1.6, the following items shall be reported. (A) Test material: Steel type and yield stress at room temperature (B) Testing machine: Capacity of the testing machine (C) Test specimen dimensions: Thickness, width, length, angular distortion, and linear misalignment (D) Integrated specimen dimensions: Tab plate thickness, tab plate width, integrated specimen length including the tab plates, and distance between the loading pins (E) 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) (F) Test results (a) Judgment of arrest: Crack length, presence or absence of crack branching, main crack angle, presence or absence of crack re-initiation, and arrest temperature (b) Arrest toughness value (G) Temperature distribution at moment of impact: Thermocouple position, temperature value, and temperature distribution (H) Test specimen photographs: Crack propagation path (one side), and brittle crack fracture surface (both sides) (I) Dynamic measurement results(if necessary): History of crack propagation velocity, and strain change at pin chucks	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

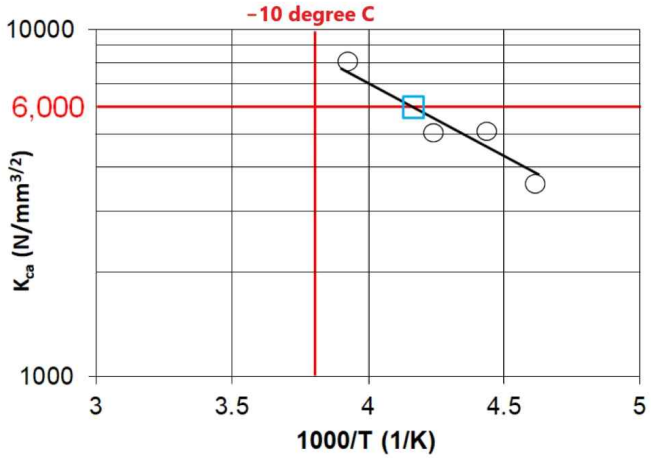
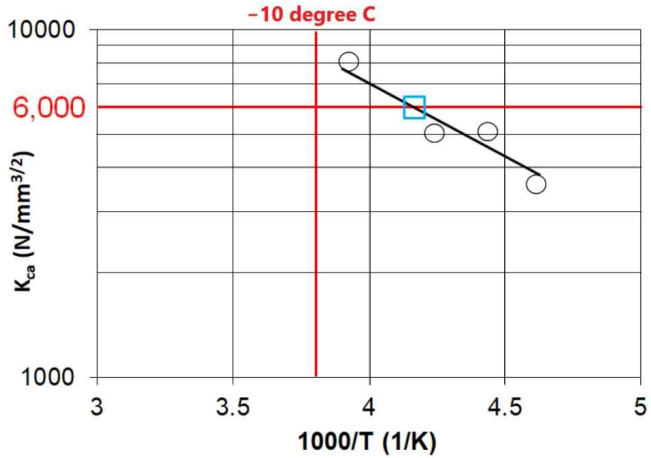
<Present> _ Deleted

Table 2.1.6 Report sheet for brittle crack arrest test results

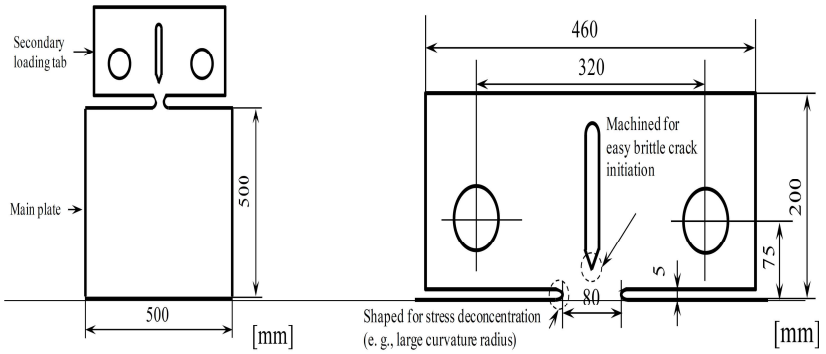
Item	Details		Symbol	Conditions / Results	Unit	Valid/ Invalid
(1) Test material	Steel type		—		—	—
	Yield stress at room temperature		σ_{Y0}		N/mm^2	—
(2) Test equipment	Testing machine capacity		—		MN	—
(3) Test specimen dimensions	Thickness		t		mm	
	Width		W		mm	
	Length		L		mm	
	Angular distortion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

Present	Amendment	reason
2. Method for Obtaining K_{ca} at a specific temperature and the evaluation (1) Application This requirement specifies the method for conducting multiple tests specified in 1. to obtain K_{ca} value at a specific temperature T_D. (2) Method A number of experimental data show dependency of K_{ca} on arrest temperature, as expressed by equation below, where T_K [K] (= T[°C] + 273), c and K_0 are constants. $$K_{ca} = K_0 \exp\left(\frac{c}{T_k}\right)$$ The arrest toughness at a required temperature T_D[K] can be obtained by following the procedures below. (A) Obtain at least four valid K_{ca} data. (B) 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 (A) by using the least square method. $$\log K_{ca} = \log K_0 + c\frac{1}{T_K}$$ (C) 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. (D) 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 (C) is not met, these estimated values are treated as reference values.	**2. <Deleted>**	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(3) Evaluation The straight-line approximation of arrhenius plot for valid K_{ca} data by interpolation method are to comply with either the following (A) or (B). (A) 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 2.1.10** of the Guidance.  **Fig 2.1.10 Example for evaluation of K_{ca} at -10 degree C**	(B) Evaluation The straight-line approximation of Arrhenius plot for valid K_{ca} data by interpolation method are to comply with either the following (a) or (b). (a) 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 2.1.2** of the Guidance.  **Fig 2.1.2 Example for evaluation of K_{ca} at -10 degree C**	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(B) 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 2.1.11 of the Guidance. (C) If both of (1) and (2) above are not satisfied, conduct additional tests to satisfy this condition.  **Fig 2.1.11 Example for evaluation of temperature corresponding to the required K_{ca}**	(b) 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 2.1.3** of the Guidance. (c) If both of (b) and (c) above are not satisfied, conduct additional tests to satisfy this condition.  **Fig 2.1.3 Example for evaluation of temperature corresponding to the required K_{ca}**	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
3. Double tension type arrest test (1) Application (A) 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 1.. (B) The specifications described in 1. shall be applied to conditions not mentioned in these requirements. (2) 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. (3) Test specimen shapes The recommended shapes of the entire double tension type arrest test specimen and the secondary loading tab are shown in (a) and (b) of Fig 2.1.12 of the Guidance, respectively. Clause (4) (B) of 1. is applied to the shapes of the tab plates and pin chucks.	**3. <Deleted>**	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
 **(a) Example of shape of entire test specimen (b) Example of shape of secondary loading tab** **Fig 2.1.12 Test specimen shapes for double tension type arrest test** (4) 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 1. (5). 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 1., 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 1..	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
~~(5) 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.~~ ~~(A) 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) 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) (B) of 1. is applied to the shapes of the tab plates and pin chucks.~~ ~~(C) 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.~~	<Deleted>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
4. Outline of requirements for undertaking isothermal Crack Arrest Temperature (1) Application (A) These requirements are to be applied according to the scope defined in **Pt 2, Ch 1, 312.** of the Rules. (B) These are 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). These requirements are applicable to steels with thickness over 50 mm and not greater than 100 mm. (C) This method uses an isothermal temperature in the test specimen being evaluated. Unless otherwise specified in these requirements, the other test parameters are to be in accordance with **1.**. (D) **Table 2.1.35** of **Pt 2, Ch 1, 312.** of the Rules gives the relevant requirements for the brittle crack arrest property described by the crack arrest temperature(CAT). (E) The manufacturer is to submit the test procedure to the Society for review prior to testing. (F) 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) (C).	**2. Outline of requirements for undertaking isothermal Crack Arrest Temperature** (1) Application (A) These requirements are to be applied according to the scope defined in **Pt 2, Ch 1, 312.** of the Rules. (B) These are 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). These requirements are applicable to steels with thickness over 50 mm and not greater than 100 mm. (C) This method uses an isothermal temperature in the test specimen being evaluated. Unless otherwise specified in these requirements, the other test parameters are to be in accordance with **ISO 20064:2019**. *(2024)* (D) **Table 2.1.35** of **Pt 2, Ch 1, 312.** of the Rules gives the relevant requirements for the brittle crack arrest property described by the crack arrest temperature(CAT). (E) The manufacturer is to submit the test procedure to the Society for review prior to testing. (F) 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) (C).	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present

(2) Symbols and their significance
Table 2.1.7 of the Guidance supplements Table 2.1.3 of the Guidance with specific symbols for the isothermal test.

Table 2.1.7 Symbols and their significance

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
$L_{EB-\min}$	mm	Minimum length between specimen edge and electron beam re-melting zone front
$L_{EB-s1,-s2}$	mm	Length between specimen edge and electron beam re-melting zone front appeared on both specimen side surfaces
L_{LTG}	mm	Local temperature gradient zone length for brittle crack runway
a_{arrest}	mm	Arrested crack length
T_{target}	℃	Target test temperature
T_{test}	℃	Defined test temperature
T_{arrest}	℃	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	℃	Crack arrest temperature, the lowest temperature, T_{arrest}, at which running brittle crack is arrested

Amendment

(2) Symbols and their significance
Table 2.1.3 of the Guidance supplements Table 1 in ISO 20064:2019 with specific symbols for the isothermal test.

Table 2.1.3 Nomenclature supplementary to Table 1 in ISO 20064:2019 *(2024)*

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
$L_{EB-\min}$	mm	Minimum length between specimen edge and electron beam re-melting zone front
$L_{EB-s1,-s2}$	mm	Length between specimen edge and electron beam re-melting zone front appeared on both specimen side surfaces
L_{LTG}	mm	Local temperature gradient zone length for brittle crack runway
a_{arrest}	mm	Arrested crack length
T_{target}	℃	Target test temperature
T_{test}	℃	Defined test temperature
T_{arrest}	℃	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	℃	Crack arrest temperature, the lowest temperature, T_{arrest}, at which running brittle crack is arrested

reason

- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(3) Testing equipment (A) 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. (B) The temperature control system is to be equipped to maintain the temperature in the specified region of the specimen within ±2 ℃ from T_{target}. (C) Methods for initiating the brittle crack may be of drop weight type, air gun type or double tension tab plate type. (D) The detailed requirements for testing equipment are specified in 1. (3). (4) Test specimens (A) Impact type crack initiation (a) Test specimens are to be in accordance with 1. (4), unless otherwise specified in these requirements. (b) Specimen dimensions are shown in Fig 2.1.13 of the Guidance. The test specimen width, W shall be 500mm. The test specimen length, L shall be equal to or greater than 500mm.	(3) Testing equipment (A) 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. (B) The temperature control system is to be equipped to maintain the temperature in the specified region of the specimen within ±2 ℃ from T_{target}. (C) Methods for initiating the brittle crack may be of drop weight type, air gun type or double tension tab plate type. (D) The detailed requirements for testing equipment are specified in **ISO 20064:2019**. *(2024)* (4) Test specimens (A) Impact type crack initiation (a) Test specimens are to be in accordance with **ISO 20064:2019**, unless otherwise specified in these requirements. *(2024)* (b) Specimen dimensions are shown in Fig 2.1.4 of the Guidance. The test specimen width, W shall be 500mm. The test specimen length, L shall be equal to or greater than 500mm.	- To reflect IACS UR W31(Rev.3 Mar 2023)

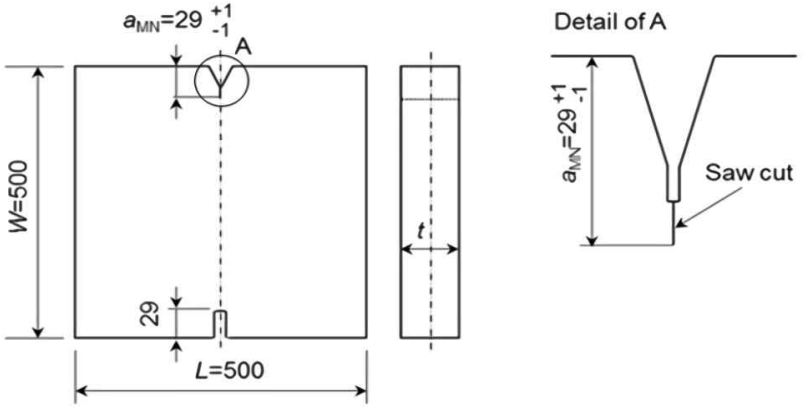


Fig 2.1.13 Test specimen dimensions for an impact type specimen

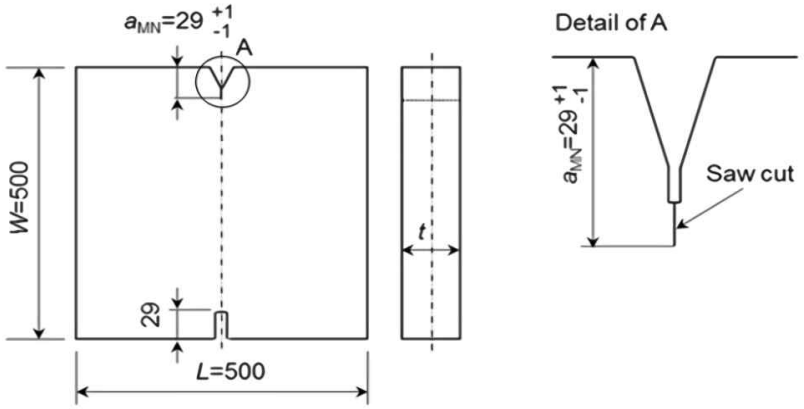


Fig 2.1.4 Test specimen dimensions for an impact type specimen

Present	Amendment	reason
(c) 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 ±1 mm. (d) Requirements for side grooves are described in (D). (B) Double tension type crack initiation (a) Reference shall be made to **3.** for the shape and sizes in secondary loading tab and secondary loading method for brittle crack initiation. (b) In a double tension type test, the secondary loading tab plate may be subject to further cooling to enhance an easy brittle crack initiation. (C) Embrittled zone setting (a) 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. (b) 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. (c) 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. (d) The EBW embrittlement is recommended to be prepared before specimen contour machining. (e) In EBW embrittlement, zone shall be of an appropriate quality. (f) 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.	(c) 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 ±1 mm. (d) Requirements for side grooves are described in (D). (B) Double tension type crack initiation (a) Reference shall be made to Annex D in **ISO 20064:2019** for the shape and sizes in secondary loading tab and secondary loading method for brittle crack initiation. *(2024)* (b) In a double tension type test, the secondary loading tab plate may be subject to further cooling to enhance an easy brittle crack initiation. (C) Embrittled zone setting (a) 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. (b) 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. (c) 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. (d) The EBW embrittlement is recommended to be prepared before specimen contour machining. (e) In EBW embrittlement, zone shall be of an appropriate quality. (f) 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.	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(g) 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. (D) Side grooves (a) 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. (b) 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 1 mm in thickness in either side then side grooves should be machined to suppress the shear lips. (c) In LTG embrittlement, side grooves are mandatory. Side grooves with the same shape and size shall be machined on both side surfaces. (d) The length of side groove, L_{SG} shall be no shorter than the sum of the required embrittled zone length ~~of 150mm~~. (e) 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 1 mm thickness in either side. An example of side groove dimensions are shown in **Fig 2.1.14** of the Guidance.	(g) 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. (D) Side grooves (a) 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. (b) 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 1 mm in thickness in either side then side grooves should be machined to suppress the shear lips. (c) In LTG embrittlement, side grooves are mandatory. Side grooves with the same shape and size shall be machined on both side surfaces. (d) The length of side groove, L_{SG} shall be no shorter than the sum of the required embrittled zone length. (e) 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 1 mm thickness in either side. An example of side groove dimensions are shown in **Fig 2.1.5** of the Guidance.	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(f) 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.	(f) 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.	- To reflect IACS UR W31(Rev.3 Mar 2023)

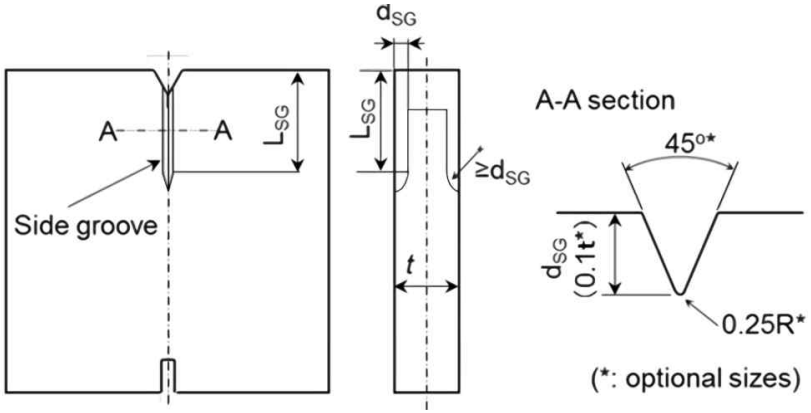
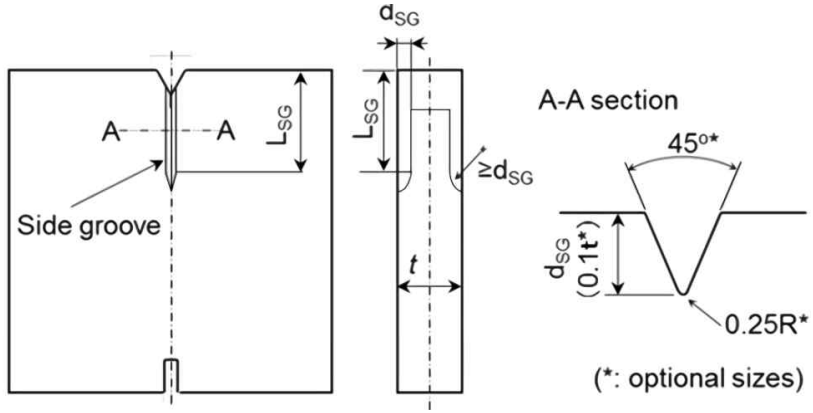
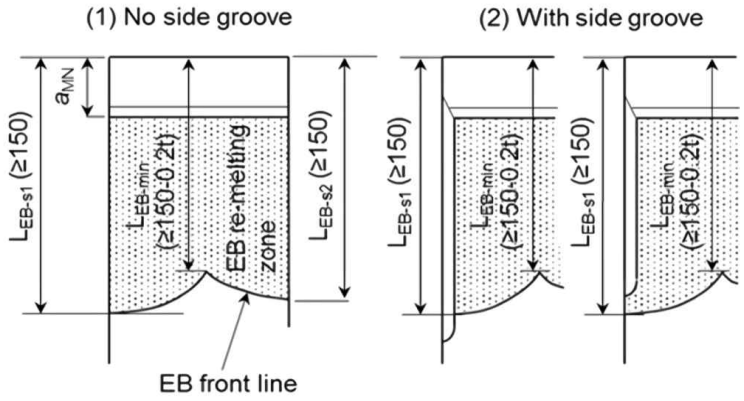
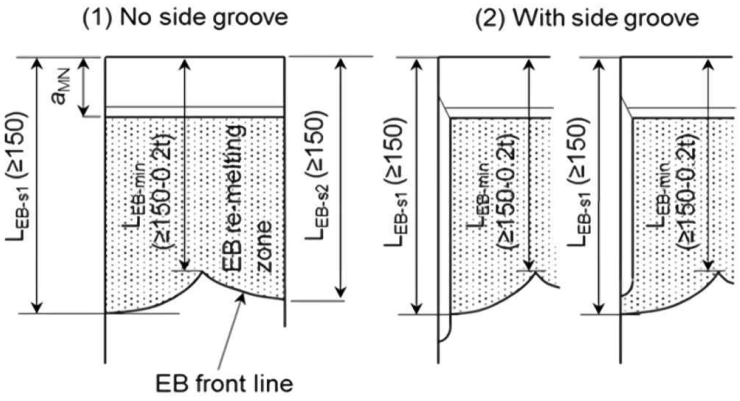

	

Fig 2.1.14 Side groove configuration and dimensions	**Fig 2.1.5 Side groove configuration and dimensions**	
(E) Nominal length of embrittled zone (a) The length of embrittled zone shall be nominally equal to 150 mm in both systems of EBW and LTG.	(E) Nominal length of embrittled zone (a) The length of embrittled zone shall be at least 150 mm.	
		
(a) No side groove (b) With side groove	**(a) No side groove (b) With side groove**	
Fig 2.1.15 Side groove configuration and dimension	**Fig 2.1.6 Side groove configuration and dimension**	

Present	Amendment	reason
(b) EBW zone length is regulated by three measurements on the fracture surface after test as shown in Fig 2.1.15 of the Guidance, $L_{EB-\min}$ between specimen edge and EBW front line, and L_{EB-s1} and L_{EB-s2}.	(b) EBW zone length is regulated by three measurements on the fracture surface after test as shown in Fig 2.1.6 of the Guidance, $L_{EB-\min}$ between specimen edge and EBW front line, and L_{EB-s1} and L_{EB-s2}.	- To reflect IACS UR W31(Rev.3 Mar 2023)
(c) The minimum length between specimen edge and EBW front line, $L_{EB-\min}$ should be no smaller than 150 mm. However, it can be acceptable even if $L_{EB-\min}$ is no smaller than 150mm-0.2t, where t is specimen thickness. When $L_{EB-\min}$ is smaller than 150 mm, a temperature safety margin shall be considered into T_{test} (See (8) (A) (b)).	(c) The minimum length between specimen edge and EBW front line, $L_{EB-\min}$ should be no smaller than 150 mm. However, it can be acceptable even if $L_{EB-\min}$ is no smaller than 150mm-0.2t, where t is specimen thickness. When $L_{EB-\min}$ is smaller than 150 mm, a temperature safety margin shall be considered into T_{test} (See (8) (A) (b)).	
(d) Another two are the lengths between specimen edge and EBW front appeared on both side surfaces, as denoted with L_{EB-s1} and L_{EB-s2}. Both of L_{EB-s1} and L_{EB-s2} shall be no smaller than 150 mm.	(d) Another two are the lengths between specimen edge and EBW front appeared on both side surfaces, as denoted with L_{EB-s1} and L_{EB-s2}. Both of L_{EB-s1} and L_{EB-s2} shall be no smaller than 150 mm.	
(e) In LTG system, L_{LTG} is set as 150 mm.	(e) In LTG system, L_{LTG} is set as 150 mm.	
(F) Tab plate / pin chuck details and welding of test specimen to tab plates The configuration and size of tab plates and pin chucks shall be referred to 1. (4) (B). The welding distortion in the integrated specimen, which is welded with specimen, tab plates and pin chucks, shall be also within the requirement in 1. (4) (C).	(F) Tab plate / pin chuck details and welding of test specimen to tab plates The configuration and size of tab plates and pin chucks shall be referred to **ISO 20064:2019**. The welding distortion in the integrated specimen, which is welded with specimen, tab plates and pin chucks, shall be also within the requirement in **ISO 20064:2019**. *(2024)*	
(5) Test method (A) Preloading 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 ℃.	(5) Test method (A) Preloading 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 ℃.	

Present	Amendment	reason
(B) Temperature measurement and control (a) Temperature control plan showing the number and position of thermocouples is to be in accordance with this section. (b) Thermocouples are to be attached to both sides of the test specimen at a maximum interval of 50 mm in the whole width and in the longitudinal direction at the test specimen centre position (0.5 W) within the range of ±100 mm from the centreline in the longitudinal direction, refer to Fig 2.1.16 of the Guidance.	(B) Temperature measurement and control (a) Temperature control plan showing the number and position of thermocouples is to be in accordance with this section. (b) Thermocouples are to be attached to both sides of the test specimen at a maximum interval of 50 mm in the whole width and in the longitudinal direction at the test specimen centre position (0.5 W) within the range of ±100 mm from the centreline in the longitudinal direction, refer to Fig 2.1.7 of the Guidance.	- To reflect IACS UR W31(Rev.3 Mar 2023)

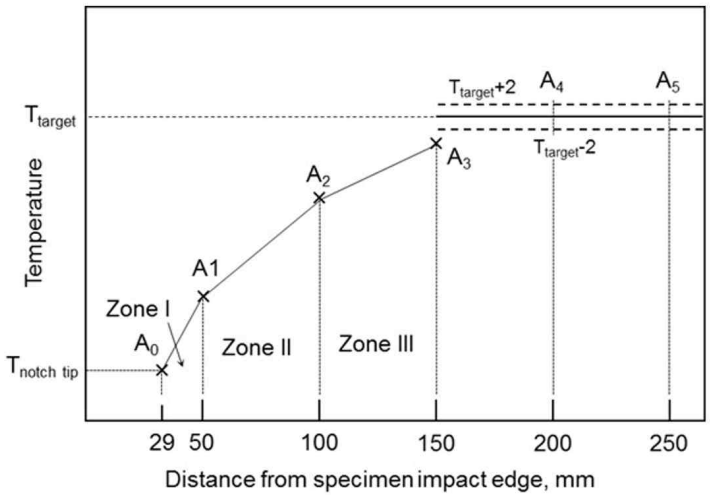
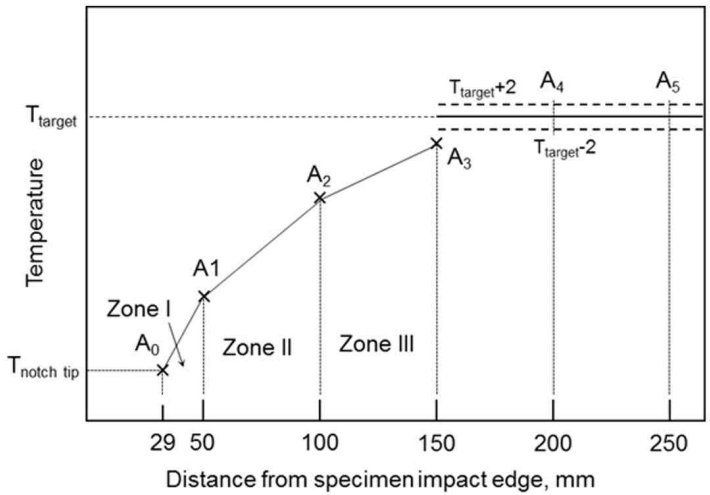
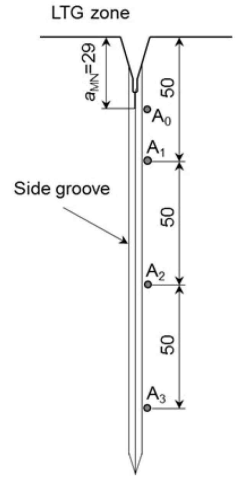
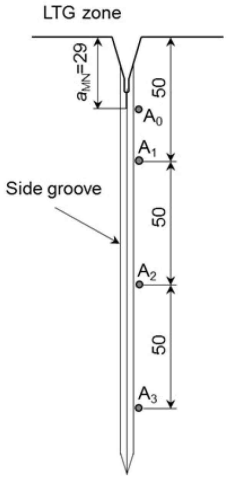

	

Fig 2.1.16 Locations of temperature measurement	**Fig 2.1.7 Locations of temperature measurement**	

Present	Amendment	reason
(c) For EBW embrittlement (i) The temperatures of the thermocouples across the range of 0.3W~0.7W in both width and longitudinal directions are to be controlled within ± 2 °C of the target test temperature, T_{target}. (ii) When all measured temperatures across the range of 0.3W~0.7W 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. (iii) 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 0.3W~0.7W. (d) For LTG embrittlement (i) In LTG system, in addition to the temperature measurements shown in Fig 2.1.16 of the Guidance, the additional temperature measurement at the machine notch tip, A_0 and B_0 is required. Thermocouples positions within LTG zone are shown in Fig 2.1.17 of the Guidance.	(c) For EBW embrittlement (i) The temperatures of the thermocouples across the range of 0.3W~0.7W in both width and longitudinal directions are to be controlled within ± 2 °C of the target test temperature, T_{target}. (ii) When all measured temperatures across the range of 0.3W~0.7W 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. (iii) 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 0.3W~0.7W. (d) For LTG embrittlement (i) In LTG system, in addition to the temperature measurements shown in Fig 2.1.7 of the Guidance, the additional temperature measurement at the machine notch tip, A_0 and B_0 is required. Thermocouples positions within LTG zone are shown in Fig 2.1.8 of the Guidance.	- To reflect IACS UR W31(Rev.3 Mar 2023)
 **Fig 2.1.17 Detail of LTG zone and additional thermocouple A_0**	 **Fig 2.1.8 Detail of LTG zone and additional thermocouple A_0**	

Present	Amendment	reason
(ii) The temperatures of the thermocouples across the range of 0.3W~0.7W in both width and longitudinal directions are to be controlled within ± 2 °C of the target test temperature, T_{target}. However, the temperature measurement at 0.3W (location of A_3 and B_3)shall be in accordance with (f) below. (iii) Once the all measured temperatures across the range of 0.3W~0.7W 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, then the test load is applied. (iv) 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 Fig 2.1.18 of the Guidance. (v) 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 2.1.8. (vi) 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 ℃ T at A_2 < T at A_3 - 5 ℃ T at B_2 < T at B_3 - 5 ℃ (vii) 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. (viii) The temperatures from A_0, B_0 to A_3, B_3 should be decided at test planning stage refer to Table 2.1.8 which gives the recommended temperature gradients in three zones, Zone I, Zone II and Zone III in LTG zone.	(ii) The temperatures of the thermocouples across the range of 0.3W~0.7W in both width and longitudinal directions are to be controlled within ± 2 °C of the target test temperature, T_{target}. However, the temperature measurement at 0.3W (location of A_3 and B_3)shall be in accordance with (f) below. (iii) Once the all measured temperatures across the range of 0.3W~0.7W 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, then the test load is applied. (iv) 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 Fig 2.1.9 of the Guidance. (v) 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 2.1.4. (vi) 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 ℃ T at A_2 < T at A_3 - 5 ℃ T at B_2 < T at B_3 - 5 ℃ (vii) 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. (viii) The temperatures from A_0, B_0 to A_3, B_3 should be decided at test planning stage refer to Table 2.1.4 which gives the recommended temperature gradients in three zones, Zone I, Zone II and Zone III in LTG zone.	- To reflect IACS UR W31(Rev.3 Mar 2023)

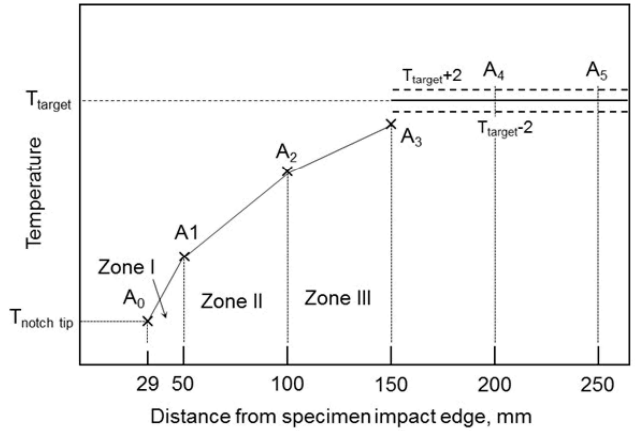
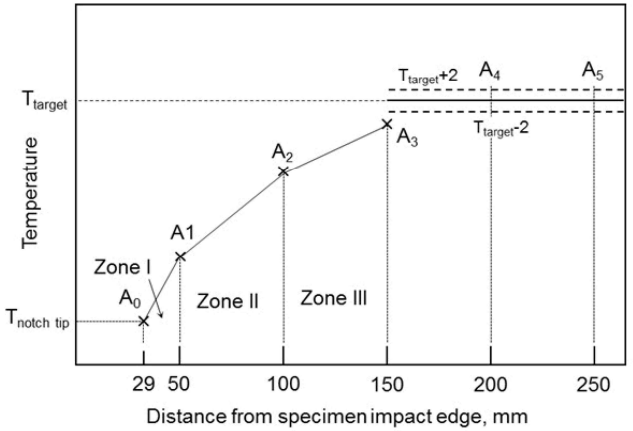
Present	Amendment	reason
		- To reflect IACS UR W31(Rev.3 Mar 2023)
Fig 2.1.18 Schematic temperature gradient profile in LTG zone	**Fig 2.1.9 Schematic temperature gradient profile in LTG zone**	

Table 2.1.8 Acceptable LTG range

Zone	Location from edge	Acceptable range of temperatur gradient
Zone Ⅰ	29 mm~50 mm	2.00 ℃/mm ~ 2.30 ℃/mm
Zone Ⅱ	50 mm~100 mm	0.25 ℃/mm ~ 0.60 ℃/mm
Zone Ⅲ(1)	100 mm~150 mm	0.10 ℃/mm ~ 0.20 ℃/mm
NOTES: (1) The Zone Ⅲ arrangement is mandatory		

(ix) 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.

(x) The acceptance of LTG in the test shall be decided from Table 2.1.8 based on the measured temperatures from A_0 to A_3.

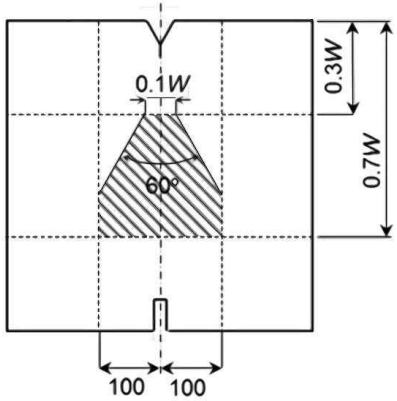
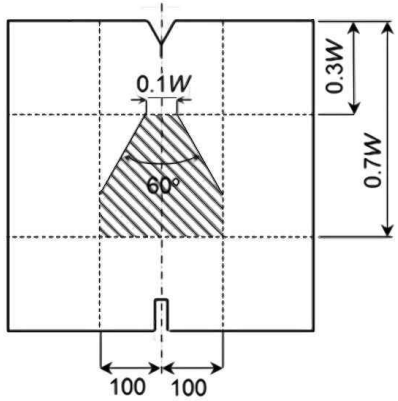
Table 2.1.4 Acceptable LTG range

Zone	Location from edge	Acceptable range of temperatur gradient
Zone Ⅰ	29 mm~50 mm	2.00 ℃/mm ~ 2.30 ℃/mm
Zone Ⅱ	50 mm~100 mm	0.25 ℃/mm ~ 0.60 ℃/mm
Zone Ⅲ(1)	100 mm~150 mm	0.10 ℃/mm ~ 0.20 ℃/mm
NOTES: (1) The Zone Ⅲ arrangement is mandatory		

(ix) 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.

(x) The acceptance of LTG in the test shall be decided from Table 2.1.4 based on the measured temperatures from A_0 to A_3.

Present	Amendment	reason
(e) For double tension type crack initiation specimen Temperature control and holding time at steady state shall be the same as the case of EBW embrittlement specified in (c) or the case of LTG embrittlement specified in Section (d). (C) Loading and brittle crack initiation (a) Prior to testing, a target test temperature(T_{target}) shall be selected. (b) Test procedures are to be in accordance with 1. (6) except that the applied stress is to be ⅔ of SMYS of the steel grade tested. (c) The test load shall be held at the test target load or higher for a minimum of 30 seconds prior to crack initiation. (d) 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 (A) Brittle crack initiation and validation (a) 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. (b) 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. (B) Crack path examination and validation (a) 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. (b) All of the crack path from embrittled zone end shall be within the range shown in Fig 2.1.19 of the Guidance. If not, the test shall be considered as invalid.	(e) For double tension type crack initiation specimen Temperature control and holding time at steady state shall be the same as the case of EBW embrittlement specified in (c) or the case of LTG embrittlement specified in Section (d). (C) Loading and brittle crack initiation (a) Prior to testing, a target test temperature(T_{target}) shall be selected. (b) Test procedures are to be in accordance with **ISO 20064:2019** except that the applied stress is to be ⅔ of SMYS of the steel grade tested. *(2024)* (c) The test load shall be held at the test target load or higher for a minimum of 30 seconds prior to crack initiation. (d) 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 (A) Brittle crack initiation and validation (a) 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. (b) 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. (B) Crack path examination and validation (a) 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. (b) All of the crack path from embrittled zone end shall be within the range shown in Fig 2.1.10 of the Guidance. If not, the test shall be considered as invalid.	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
 **Fig 2.1.19 Allowable range of main crack propagation path** (C) Fracture surface examination, crack length measurement and their validation (a) 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. (b) When crack initiation trigger point is clearly detected at side groove root, other than the V-notch tip, the test shall be invalid. (c) In EBW embrittlement setting, EBW zone length is quantified by three measurements of L_{EB-s1}, L_{EB-s2} and $L_{EB-\min}$, which are defined in 4.5. When either or both of L_{EB-s1} and L_{EB-s2} are smaller than 150mm, the test shall be invalid. When $L_{EB-\min}$ is smaller than 150mm-0.2t, the test shall be invalid. (d) When the shear lip with thickness over 1 mm 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. (e) 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.	 **Fig 2.1.10 Allowable range of main crack propagation path** (C) Fracture surface examination, crack length measurement and their validation (a) 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. (b) When crack initiation trigger point is clearly detected at side groove root, other than the V-notch tip, the test shall be invalid. (c) In EBW embrittlement setting, EBW zone length is quantified by three measurements of L_{EB-s1}, L_{EB-s2} and $L_{EB-\min}$, which are defined in 4.5. When either or both of L_{EB-s1} and L_{EB-s2} are smaller than 150mm, the test shall be invalid. When $L_{EB-\min}$ is smaller than 150mm-0.2t, the test shall be invalid. (d) When the shear lip with thickness over 1 mm 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. (e) 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.	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
(f) 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 Fig 2.1.20 of the Guidance). When the defects line fraction is larger than 10 %, the test shall be invalid.	(f) 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 Fig 2.1.11 of the Guidance). When the defects line fraction is larger than 10 %, the test shall be invalid.	- To reflect IACS UR W31(Rev.3 Mar 2023)

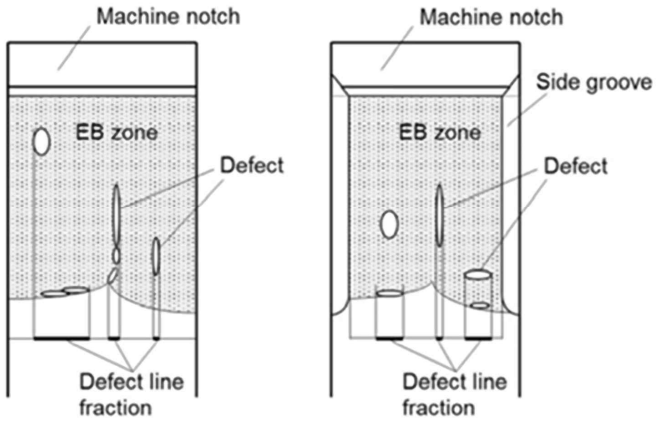
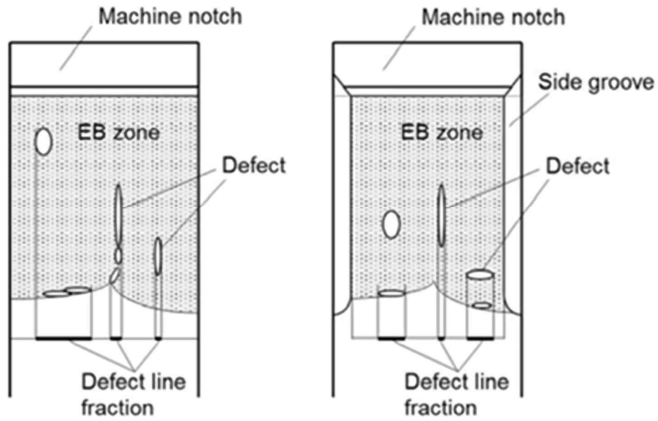

	

Fig 2.1.20 Counting procedure of defect line fraction	Fig 2.1.11 Counting procedure of defect line fraction	
(g) In EBW embrittlement by dual sides' penetration, a gap on embrittled zone fracture surface which is induced by miss meeting of dual fusion lines is visibly detected at an overlapped line of dual side penetration, the test shall be invalid.	(g) 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.	

Present	Amendment	reason
(7) Judgement of “arrest” or “propagate” The final test judgment of “arrest”, “propagate” or “invalid” is decided by the following requirements of (A) through (E). (A) 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 (C) and (D) of 1.. (B) 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}. (C) For LTG and EBW, a_{arrest} shall be greater than L_{LTG} and L_{EB-s1}, L_{EB-s2} or $L_{EB-\min}$. If not, the test shall be considered as invalid. (D) 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”. (E) The test is judged as “arrest” when the value of aarrest is no greater than 0.7W. If not, the test is judged as “propagate”. (8) ~ (9) <Omitted>	(7) Judgement of “arrest” or “propagate” The final test judgment of “arrest”, “propagate” or “invalid” is decided by the following requirements of (A) through (E). (A) 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 **ISO 20064:2019**. *(2024)* (B) 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}. (C) For LTG and EBW, a_{arrest} shall be greater than L_{LTG} and L_{EB-s1}, L_{EB-s2} or $L_{EB-\min}$. If not, the test shall be considered as invalid. (D) 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”. (E) The test is judged as “arrest” when the value of aarrest is no greater than 0.7W. If not, the test is judged as “propagate”. (8) ~ (9) <Same as the present Guidance>	- To reflect IACS UR W31(Rev.3 Mar 2023)

Present	Amendment	reason
Section 3 Rolled Steels	**Section 3 Rolled Steels**	- To reflect IACS UR W31(Rev.3 Mar 2023)
301. ~ 310. <Omitted>	**301. ~ 310. <Same as the present Guidance>**	
312. Brittle crack arrest steels *(2021)*	**312. Brittle crack arrest steels *(2021)***	
1. Brittle crack arrest properties	**1. Brittle crack arrest properties**	
(1) The K_{ca} value in **Table 2.1.45** Note (3) of **312.** of the Rules are obtained by performing a brittle crack arrest test in accordance with **Pt 2**, **Ch 1**, **203. 1.** of the Guidance. **【See Rule】**	(1) The K_{ca} value in **Table 2.1.45** Note (3) of **312.** of the Rules are obtained by performing a brittle crack arrest test in accordance with **Pt 2**, **Ch 1**, **203. 1.** of the Guidance. **【See Rule】**	
(2) The CAT in **Table 2.1.45** Note (4) of **312.** of the Rules are obtained by performing a test in accordance with **Pt 2**, **Ch 1**, **203. 4.** of the Guidance. **【See Rule】**	(2) The CAT in **Table 2.1.45** Note (4) of **312.** of the Rules are obtained by performing a test in accordance with **Pt 2**, **Ch 1**, **203. 2.** of the Guidance. **【See Rule】**	
2. <New>	**2. Approval Scheme of Small-scale Test Methods for Brittle Crack Arrest Steels *(2024)***	: Annex 5
	(1) Scope	
	(A) These requirements specify the approval scheme of small-scale test methods which are used for product testing (batch release testing) of brittle crack arrest steels specified as **Table 2.1.45** Note (6) of **312.** of the Rules.	
	(B) Unless otherwise specified in these requirements, **Pt 2**, **Ch 1**, **203. 1.** and **2.** of the Guidance are to be followed.	
	(2) Approval Application	
	(A) The manufacturer is to submit to the Society the following documents.	
	(a) Application for approval of small-scale test procedure specification	
	(b) Small-scale test procedure specification including the following items at least	
	(i) Applicable material grades, thickness range, deoxidation practice, heat treatment, etc.	
	(ii) Types and methods of small-scale tests	
	(iii) Sampling positions in plate thickness direction and final rolling direction of test specimens	
	(iv) Size and dimension of test specimens	
	(v) Number of test specimens	
	(vi) Test conditions, such as test temperature	
	(vii) Acceptance criterion	

Present	Amendment	reason
	(viii) Example of format of test report (ix) Example of product inspection certificate including small-scale test results (x) Handling of the products when small-scale test results do not satisfy the criterion (c) Mechanism of achieving the brittle crack arrest properties of brittle crack arrest steels (d) Technical background for enabling the evaluation of brittle crack arrest properties by small-scale test methods considering the mechanism specified in above (c). (e) Procedure of the evaluation for the brittle crack arrest properties of brittle crack arrest steels by small-scale test results. (f) Data records which validate the correlation between small-scale test results and the large brittle crack arrest test results of brittle crack arrest steels whose number can satisfy the requirement for minimum data number given in (3) (C). (g) Proposed test plan for approval (B) Small-scale test procedure specification is to be prepared in accordance with (3). (C) Where the manufacturer proposes to change any part of the approved small-scale test procedure specification, then the manufacturer is to submit to the Society the documents which can cover all items specified in **2.** (2) (A). (D) The documents confirming the reason for the change shall be submitted to identify the impact of those changes on the existing procedure, and the proposed actions to address any such impacts. (3) Establishment of Procedure Specification for Small-scale Testing (A) General (a) Small-scale test methods are to be determined based on the manufacturer's own technical philosophy with regard to achieving the brittle crack arrest properties of brittle crack arrest steels. Furthermore, description of an appropriate correlation between large scale brittle crack arrest properties and small-scale test results is to be required, and the acceptance criterion of the small-scale test are to be determined, based on the followings.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

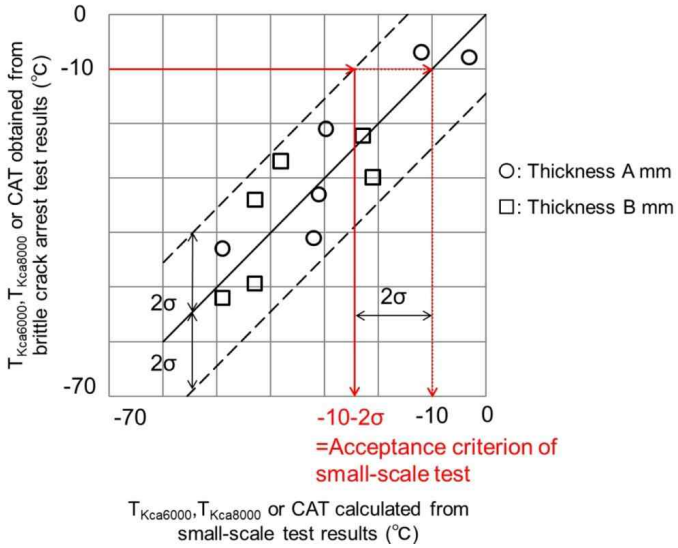
Present	Amendment	reason
	(i) Mechanism of achieving the suitable brittle crack arrest properties (ii) Sampling position and direction (iii) Frequency of sampling (iv) Small-scale test methodology (v) Demonstrated correlation between brittle crack arrest test results and small-scale test results (vi) Derivation of small scale testing acceptance criterion based on the statistical analysis (b) The manufacturer shall prepare the small-scale test procedure specification in accordance with the following (B) through (E). (B) Types and Methods of Testing (a) Types, methods, dimension and positions as well as direction of test specimens, etc. of small-scale tests are to be specified by the manufacturer, and approved in accordance with these requirements. (b) In general, the test method should reproduce the crack initiation, propagation and arrest feature by such as the following test method. (i) Combination of test methods, e.g. NRL drop weight test and V-notch Charpy impact test (ii) One test method, e.g. press-notch Charpy impact test or side-section drop weight test (c) In general, brittle crack arrest properties of brittle crack arrest steels are to be predicted using a regression equation on the relationship between small scale test result (e.g. transition temperature obtained by small scale tests) and large scale brittle crack arrest test result (e.g. K_{ca} or temperature corresponding to the specific brittle crack arrest properties). Other approaches can be used subject to the approval of the Society.(NOTE: **Table 2.1.5**, **Table 2.1.6** and **Table 2.1.7** give the examples of small scale test methods.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

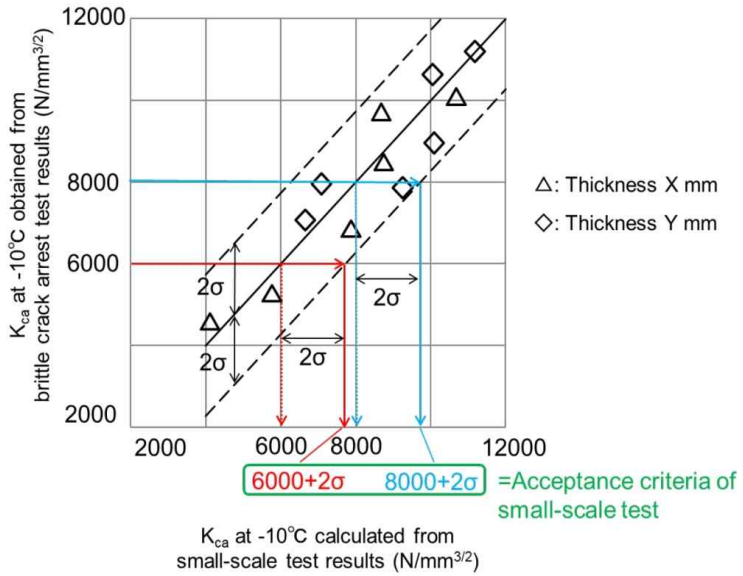
Present	Amendment	reason
	(d) For determination of test methods, the manufacturer should confirm the applicability of these test methods to their brittle crack arrest steels theoretically taking into account the methodology of test methods, their own mechanism of achieving the brittle crack arrest properties, and sampling positions of test specimens (See (A) (a)). Then, the manufacturer should also submit the technical background for determination of small-scale test methods to the Society as given in (2) (A). (C) Testing Data (a) Selection of test plates (i) Brittle crack arrest tests and small-scale tests are to be conducted for each material grade (including all suffixes) of brittle crack arrest steels in accordance with (C). (ii) Brittle crack arrest tests and small-scale tests are to be carried out on at least 12 test plates, in accordance with (iii), by which these test results can reliably estimate brittle crack arrest properties of brittle crack arrest steels.(NOTE: “One test plate” means “the rolled product from a single slab or ingot if this is rolled directly into plates”) (iii) In order to ensure appropriate correlation between small-scale test results and brittle crack arrest properties with various manufacturing conditions of steel plates, the steel plates should be representative for each combination of thickness range and heat sample to include: - The intended maximum and minimum plate thickness; - Different heats are to be chosen for each thickness Furthermore, the above test plates are to include a fixed number of steel plate(s) whose brittle crack arrest properties (i.e. brittle crack arrest test results) do not comply with the requirements specified in Table 2.1.45 of Pt 2, Ch 1, 312. of the Rules. Such a number should be at least one, but not exceeding one quarter of all test plates. Manufacturing process	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	of these test plates can be different (or intentionally altered from the approved manufacturing process) from that of the brittle crack arrest steels to which the small-scale test method is applied. It is recommended that the strength grade of these test plates (non-compliant with the relevant requirements of brittle crack arrest properties) are similar to that of the brittle crack arrest steels. Where the manufacturer has requested approval for only a single thickness, the thickness of test plates can be only a single thickness. In this case, at least four steel plates for each combination of thickness (single thickness) and heats (three different heats) should be used, and the applicable thickness of the small scale test is only that single thickness condition. (iv) Brittle crack arrest steels used for the approval test of manufacturing process of these steels (and its approval test results) can also be used as the test plates specified in (iii). (v) Brittle crack arrest test specimens and small-scale test specimens are to be taken from the same test plate. (vi) A decrease of the total of the indicated number of test plates may be accepted by the Society in the following ⓐ or ⓑ cases: ⓐ When the manufacturer applies a small-scale test procedure specification to multiple material grades, and the manufacturing process and mechanism to ensure the brittle crack arrest properties of these different material grades are the same. ⓑ When a small-scale test procedure specification is already approved by the Society for one or some material grades, and the manufacturer applies similar small-scale test procedure specification to the other material grade(s), and the manufacturing process and mechanism to ensure the brittle crack arrest properties of these different material grades are same.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	(b) Brittle crack arrest tests (i) Brittle crack arrest tests are to be carried out for each test plate in accordance with **Ch. 2**, **Sec. 2-8** of the **Guidance for Approval of Manufacturing Process and Type Approval, Etc.**. (ii) Where brittle crack arrest tests are carried out for evaluation of K_{ca}, K_{ca} at a specific temperature is to be obtained in accordance with **203. 1.** (3) of the Guidance. (iii) Where brittle crack arrest tests are carried out for evaluation of CAT, deterministic (actual) CAT is to be obtained in accordance with **203. 2.** (8) (C) of the Guidance. (c) Small-scale tests (i) Small-scale tests are to be carried out in accordance with small-scale test procedure specification to be approved for each test plate. (ii) In general, the test specimens of small-scale tests are to be taken with their longitudinal axis parallel to the final rolling direction of the test plates. (iii) The test specimens of small-scale tests are to be taken from the specified positions in plate thickness direction of the test plates, as given in (B) (c). (D) Validation of Correlation (a) A regression equation on the relationship between brittle crack arrest property obtained from brittle crack arrest test and single or multiple small-scale test results is to be established. For brittle crack arrest properties, a specific temperature (e.g. $T_{Kca6000}$ in BCA1, $T_{Kca8000}$ in BCA2 or CAT) or the K_{ca} value at -10℃ may be used.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	(b) The validity of the regression equation shall be examined to predict brittle crack arrest properties with enough accuracy. The correlation in brittle crack arrest properties between the calculated values from small scale tests and the brittle crack arrest test results shall be assured by using the value of twice the standard deviation (2σ). When using temperature for brittle crack arrest property, 2σ shall not be greater than 20℃. In other cases (e.g. K_{ca} value at -10℃), an upper limit of 2σ shall be established with the agreement of the Society. Calculation procedure of the standard deviation (σ) is given as follows: $$\sigma = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(y_i - x_i)^2}$$ n: number of test plates y_i: brittle crack arrest property obtained from brittle crack arrest test for one test plate x_i: brittle crack arrest property estimated from small scale tests for one test plate (E) Acceptance Criterion (a) Acceptance criterion of brittle crack arrest steels by the small-scale tests is to be proposed by the manufacturer based on the regression equation which is assured in the correlation with brittle crack arrest properties in (D) above. The criterion is to be determined so that regression equation can predict brittle crack arrest properties on safety side, considering the scatter of brittle crack arrest properties from the predicted value by the regression equation. (b) Unless otherwise agreed by the Society, an acceptance criterion of small-scale tests is to be determined by following procedures. (i) For correlation by means of temperature ⓐ The required temperature (see **Fig 2.1.12**) is obtained by subtracting 2σ(℃) from the brittle crack arrest steel specification in **Table 2.1.45** of **Pt 2, Ch 1, 312.** of the Rules, that is -10-2σ(℃), where 2σ is given in (D) (b).	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	$T_{K\alpha 6000}$ and $T_{K\alpha 8000}$ in **Fig 2.1.12** are the temperatures at which the K_{α} value of steel plates equals $6000N/mm^{3/2}$ and $8000N/mm^{3/2}$, respectively. ⓑ The temperature predicted from the small-scale test results through the regression equation shall be no higher than the value of −10-2σ(℃).  **Fig 2.1.12 Example for determination of acceptance criterion o small-scale test for correlation by means of temperature** **(Note: This is only a schematic and may not represent the actua data obtained)**	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

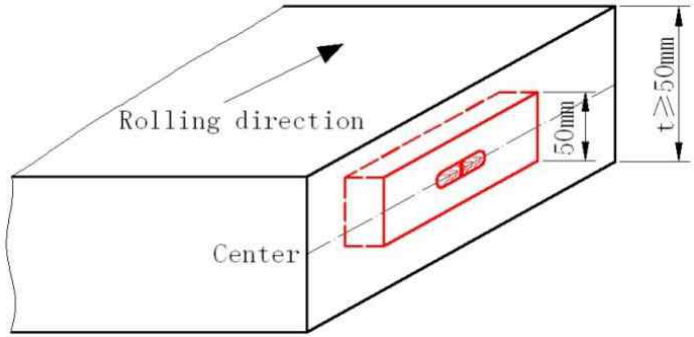
Present	Amendment	reason
	(ii) For correlation by means of brittle crack arrest toughness (K_{ca}): ⓐ The required K_{ca} (see **Fig 2.1.13**) is obtained by adding 2σ ($N/mm^{3/2}$) to the brittle crack arrest steel specification in **Table 2.1.45** of **Pt 2, Ch 1, 312.** of the Rules, that is either 6,000+2σ ($N/mm^{3/2}$) in BCA1 or 8,000+2σ($N/mm^{3/2}$) in BCA2, where 2σ is given in (D) (b). ⓑ The K_{ca} value predicted from the small-scale test results through the regression equation shall be no smaller than the value of 6000+2σ ($N/mm^{3/2}$) for BCA1, or 8000+2σ($N/mm^{3/2}$) for BCA2.  **Fig 2.1.13 Example for determination of acceptance criteria of small-scale test for correlation by means of brittle crack arrest toughness (K_{ca})** **(Note: This is only a schematic and may not represent the actual data obtained)**	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	(4) Approval Tests (A) General (a) In order to confirm the validity of the submitted technical documents specified in (2) (A), approval tests are to be carried out. (b) Approval test plan is to be approved by the Society prior to testing. (c) Considering the contents of the submitted technical documents specified in (2) (A), the Society may require additional tests in the following cases: (i) When the Society determines that the number of brittle crack arrest tests or small-scale tests is too few to adequately confirm the validity of the acceptance criterion of small-scale tests (See (3) (C) (a)); (ii) When the Society determines that the testing data obtained for setting the acceptance criterion of small-scale tests varies too widely (See (3) (D) (b)), or that the data is clustered producing a biased correlation curve; (iii) When the Society determines that the validity of brittle crack arrest test results or small-scale test results for setting the acceptance criterion of small-scale tests is insufficient, or has some flaws during tests and/or for test results (See (3) (C) (b) and (3) (C) (c)); and (iv) Others as deemed necessary by the Society. (B) Extent of the approval tests Extent of the approval tests is to be in accordance with extent of the approval tests for approval of manufacturing process. (C) Type of tests (a) Brittle crack arrest tests (i) Brittle crack arrest tests are to be carried out in accordance with **Ch. 2**, **Sec. 2-8**, **3.** (1) of the **Guidance for Approval of Manufacturing Process and Type Approval, Etc.**. (ii) Where brittle crack arrest tests are carried out for evaluation of K_{ca}, K_{ca} at a specific temperature ($T_{Kca6000}$ or $T_{Kca8000}$) is to be obtained in accordance with **Pt 2**, **Ch 1**, **203. 1.** (3) of the Guidance.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	(iii) Where brittle crack arrest tests are carried out for evaluation of CAT, deterministic CAT is to be obtained in accordance with **Pt 2**, **Ch 1**, **203. 2.** (8) (C) of the Guidance. (b) Small-scale tests Small-scale tests are to be carried out in accordance with (3) (C) (c). (5) Results (A) Results of test items and the procedures shall comply with the test program approved by the Society. (B) For the brittle crack arrest test results, the manufacturer is to submit to the Society the brittle crack arrest test reports in accordance with **Pt 2**, **Ch 1**, **203. 1.** of the Guidance for K_{ca} and **Pt 2**, **Ch 1**, **203. 2.** of the Guidance for CAT. (C) For small-scale test results, the manufacturer is to submit to the Society the small-scale test reports in accordance with the example of format of test reports submitted as specified in (2) (A) (b). (6) Approval Upon satisfactory completion of the survey and tests, and satisfactory confirmation of the submitted technical documents, the approval for small scale test procedure specification is granted by the Society.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	Table 2.1.5 Example of small-scale test method using NRL drop weight test and V-notch Charpy impact test (Informative) Test type: NRL drop weight test and V-notch Charpy impact test Standard: **ASTM E208:2020** and **ISO 148-1:2016** Sampling positions of test specimens: NRL drop weight test: at surface; V-notch charpy impact test: 1/4 of thickness Length direction of test specimen : Parallel to the final rolling direction of test plate Regression equation: $T_{K\alpha} = \alpha \cdot (NDTT+10) + \beta \cdot vTrs + 153(t-5)^{1/13} - 170.5$ $T_{K\alpha}$: Temperature at K_α of $6000N/mm^{3/2}$ or K_α of $8000N/mm^{3/2}$(℃) NDTT : Nil-ductility transition temperature (℃) $vTrs$: Transition temperature of the absorbed energy (℃) t: thickness $\alpha, \beta^{(1)}$: constant Note : (1) α and β are determined by comparing small-scale test results with brittle crack arrest test results. **Table 2.1.6 Example of small-scale test method using pressed-notch Charpy impact test (Informative)** Test type: Pressed-notch Charpy impact test Standard: Dimension, shape, introducing method of notch: Manufacturer's proposal; Others: **ISO148-1:2016** Sampling position of test specimen: 1/2 of thickness Length direction of test specimen: Parallel to the final rolling direction of test plate Regression equation: $T_{K\alpha} = \alpha_p T_{E_{\gamma J}} + \beta$ $T_{K\alpha}$: Temperature at K_α of $6000N/mm^{3/2}$ or K_α of $8000N/mm^{3/2}$, (℃) $pT_{E_{\gamma J}}$: Test temperature at absorbed energy of γ(J), (℃) α, β : Constant γ : Absorbed energy at brittle fracture surface ratio of δ(%), (J) Note : (1) α, β, γ and δ are determined by comparing small-scale test results with brittle crack arrest test results.	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Present	Amendment	reason
	Table 2.1.7 Example of small-scale test method using Side-section drop weight test (Informative)	- To reflect IACS UR W31(Rev.3 Mar 2023) : Annex 5

Test type	Side-section drop weight test
Standard	Dimension: P-2 type of **ASTM E 208 2020**
Sampling positions of test specimens	1/2 of thickness and side-section 
Length direction of test specimen	Parallel to the final rolling direction of test plate
Regression equation	$T_{K\alpha} = \alpha + \beta \cdot T_{NDT}^{side} + \gamma \cdot t^{1.5}$ $T_{K\alpha}$: Temperature at K_{α} of $6000N/mm^{3/2}$ or K_{α} of $8000N/mm^{3/2}$, (℃) T_{NDT}^{side}: Nil-ductility transition temperature obtained by side-section drop weight test, (℃) t: thickness $\alpha, \beta, \gamma^{(1)}$: constant
Note : (1) α, β and γ are to be determined by comparing small-scale test results with brittle crack arrest test results.	

Present	Amendment	reason
Section 4 <Omitted>	**Section 4** <Same as the present Guidance>	
Section 5 Castings	**Section 5 Castings**	
501. Steel castings	**501. Steel castings**	
1. <Omitted>	**1.** <Same as the present Guidance>	
~~**2. Mechanical properties** [See Rule]~~ ~~(1) In application to 501. 6. (2) of the Rules, the results of impact test is to comply with the requirements of Table 2.1.19 of the Guidance.~~	**2.** <Deleted>	- Deleted because Part 2 of the Rules requires the impact test of all steel castings intended for welding to be the same as Table 2.1.19 of the Guidance.
~~**Table 2.1.19 Impact Test Requirements**~~ ~~Grade / Impact test / Test temp.(℃) / Average absorbed energy(J)~~ ~~*RSC* 410, *RSC* 450, *RSC* 480, *RSC* 560, *RSC* 600 / 0 / 27 min.~~		
~~(2) In application to 501. 6. (2) of the Rules, carbon steel castings intended for welded construction which required impact test includes upper rudder casting.~~		
3. ~ 5. <Omitted>	**2. ~ 4.** <Same as the present Guidance>	

Present

CHAPTER 2 WELDING

Section 1 <Omitted>
Section 3 Welding Works and Inspection

303. ~ 305. <Omitted>

306. Main welding

1. In application of 306. 2 of the Rules, minimum preheating temperature for welding hull steels at low temperature is to comply with Table 2.2.4 of the Guidance. 【See Rule】

Table 2.2.4 Preheating for Welding Hull Steels at Low Temperature

Grades	Standard	
	Base metal temperature needed preheating	Minimum preheating temperature
Normal strength steels (*A, B, D, E*)	below 0℃	20℃ or over (1)
Higher strength steels (*AH* 32, *DH* 32, *EH* 32, *AH* 36, *DH* 36, *EH* 36)		

Note :
(1) This level of preheat is to be applied unless the approved welding procedure specifies a higher level

〈hereafter, omitted〉

Amendment

CHAPTER 2 WELDING

Section 1 <Same as the present Guidance>
Section 3 Welding Works and Inspection

303. ~ 305. <Same as the present Guidance>

306. Main welding

1. In application of 306. 2 of the Rules, minimum preheating temperature for welding hull steels at low temperature is to comply with Table 2.2.4 of the Guidance. 【See Rule】

Table 2.2.4 Preheating for Welding Hull Steels at Low Temperature *(2024)*

Grades	Standard	
	Base metal temperature needed preheating	Minimum preheating temperature
Normal strength steels (*A, B, D, E*)	below -5℃	20℃ or over (1)
Higher strength steels (*AH* 32, *DH* 32, *EH* 32, *AH* 36, *DH* 36, *EH* 36)	below 0℃	

Note :
(1) This level of preheat is to be applied unless the approved welding procedure specifies a higher level

〈hereafter, same as the present Guidance〉

reason

- To reflect Table 6.12 of IACS Rec.47