06-390

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part C Hull Construction and Equipment

Guidance for the Survey and Construction of Steel Ships
Part C 2006 AMENDMENT NO.4

Notice No.75 30th November 2006
Resolved by Technical Committee on 17th November 2006

ClassNK
NIPPON KAIJI KYOKAI

Notice No.75 30th November 2006
AMENDMENT TO THE GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Guidance for the survey and construction of steel ships" has been partly amended as follows:

Part C HULL CONSTRUCTION AND EQUIPMENT

Amendment 4-1

C31A ADDITIONAL REQUIREMENTS FOR NEW BULK CARRIERS

C31A6 Double-side Skin Construction and Cargo Hold Construction

C31A.6.2 Cargo Hold Construction

Sub-paragraph -4 has been added as follows.

-4. With respect to the provisions of **31A.6.2-1.(3), Part C** of the Rules, the stiffener of cargo hold areas is to be in accordance with the buckling strength criteria as specified in the following **(1)** to **(5)**. The buckling strength can be examined by the provisions of **Chapter 6, Section 3, 4.2, Part CSR-B** of the Rules, in lieu of that specified in this section. When calculating the buckling strength, typical loading conditions are to be considered.

(1) Structural members to be considered
The term of "stiffener of cargo hold areas" means those complying with the following **(a)** to **(h)**. When the stiffeners are located forward and afterward the midship part of ship and they have been complying with the all requirements which are to be applied to the stiffeners, they are regarded as those complying with the provisions of this section, except the case where the Society deems it specially necessary.
(a) Longitudinal stiffeners provided on the inner bottom plates
(b) Longitudinal stiffeners provided on the hopper plates and sloping plates of topside tanks
(c) Longitudinal stiffeners provided on the longitudinal bulkheads (excluding corrugated bulkheads)
(d) Horizontal stiffeners provided on the hatch side coaming over 0.15L in length
(e) Vertical stiffeners provided on the transverse bulkheads (excluding corrugated bulkheads)
(f) Vertical stiffeners provided on the sloping plates and vertical plates of lower stool and upper stool of transverse bulkhead
(g) Hold frames (single side skin construction only)
(h) Stiffeners other than any those of above **(a)** to **(g)**, when high pressure and high axial compressive stress are acting to the stiffeners simultaneously.

(2) Pressure acting to stiffeners
The pressure p (kN/m^2) acting on the stiffener is given by the following **(a)** to **(c)** depending on the stiffener considered. When pressure is applied on the same side as the

stiffener, p is to be taken as negative value and when pressure is applied on the side opposite to the stiffener, p is to be taken as positive value.

(a) Pressure p (kN/m^2) due to dry bulk cargo is given by the following formula:

$$p = \gamma(1 + C_1)gK_C h_1$$

γ : Specific gravity of cargo given by the following formula:

$$\gamma = \frac{M}{V} \quad (t/m^3)$$

M : Maximum cargo mass given for each cargo hold (t)

V : Volume of the hold excluding its hatchway (m^3)

C_1: Coefficient obtained from **Table C31.6.2-1** depending on L. For intermediate values of L, C_1 is to be obtained by linear interpolation.

g : Gravity acceleration, taken as 9.81 (m/s^2)

K_C : Coefficient given by the followings:

For stiffeners provided on the hatch side coaming, sloping pates of topside tanks, sloping plates of upper stool (excluding vertical plates, see **Fig. C31A.6.2-1**) and hold frames: $K_C = 0$

For stiffeners other than above: $K_C = \cos^2 \alpha + (1 - \sin\psi)\sin^2 \alpha$

α : Angle of inclination of the panel considered on the side not facing the cargo hold with respect to the horizontal plane (*degrees*)

ψ : Angle of repose of cargo (*degrees*). The value given in **Table C31.6.2-2** may be used as standard value corresponding to the type of cargoes.

h_1: Vertical distance from the mid-point of the stiffener under consideration to the upper deck at centre line (m)

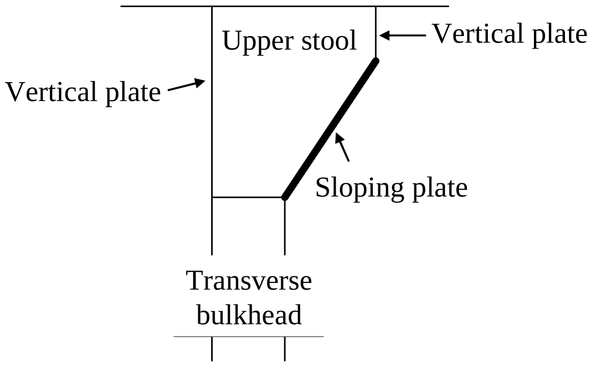
Table C31.6.2-1 Coefficient C_1

L (m)	150	200	250	300 and over
C_1	0.525	0.4	0.35	0.3

Table C31.6.2-2 Angle of repose

Type of cargo	Angle of repose ψ
General	30°
Iron ore, Coal	35°
Cement	25°

Fig. C31A.6.2-1



(b) Pressure p (kN/m^2) due to ballast water is given by the following formulae.

For ballast tanks excluding ballast hold: $p = 1.025(1 + C_2)gh_2$

For ballast hold: $p = 1.025(1 + C_2)gh_3$

C_2 : Coefficient obtained from **Table C31.6.2-3** depending on L. For intermediate values of L, C_2 is to be obtained by linear interpolation.

g : Gravity acceleration, taken as 9.81 (m/s^2)

h_2 : Vertical distance from the mid-point of the stiffener under consideration to the middle point of the distance from the tank top to the upper end of overflow pipe (m)

h_3 : Vertical distance form the mid-point of the stiffener under consideration to the top of the hatch coaming (m)

Table C31.6.2-3 Coefficient C_2

L (m)	150	200	250	300 and over
C_2	0.4	0.3	0.25	0.2

(c) Total external sea pressure p (kN/m^2) is given by the following formula.

$p = 1.025gh_4$

h_4 : Vertical distance from the mid-point of the hold frame or horizontal stiffener of hatch side coaming under consideration to the point of $d + 0.05L'$ above the top of keel. In case that the position of hatch side coaming is higher than $d + 0.05L'$ above the top of keel, h_4 is to be taken equal to zero.

L' : Length of ship (m). Where, L exceeds 230m, L' is to be taken as 230m.

(3) Reference Stress

Reference stress σ_{ref} (N/mm^2) of the stiffener is given by the following **(a)** to **(e)** depending on the type of stiffeners under consideration.

(a) In case of longitudinal stiffeners, reference stress is to be obtained from the following **i)** or **ii)**, whichever is greater.

i) Compressive stress due to longitudinal hull girder bending moment, obtained from the following formula, but not less than $30/K$. For members located above the horizontal neutral axis, sagging condition is to be considered and for members located below the horizontal neutral axis, hogging condition is to be considered.

$$\sigma_V = \frac{M_S + M_W}{I} z \times 10^5 \quad (N/mm^2)$$

M_S : Allowable still water bending moment (*kN-m*). However, in the case of ballast condition, M_S may be taken as the value as specified in following **1)** or **2)**, whichever is greater. In this case, M_S is to be calculated in hogging and sagging condition respectively.

1) 120% of the actual hull girder bending moment in the ballast condition specified in the Loading Manual (including intermediate conditions specified in **1.3.1-2** and **-3** in **Annex C34.1.2**, but need not to consider the assumed empty or full conditions for partially filled ballast tanks), but need not to exceed the allowable still water bending moment
2) Half of the allowable still water bending moment

M_W : Wave induced longitudinal bending moments as specified in **15.2.1, Part C** of the rules (*kN-m*)

z : Vertical distance from the horizontal neutral axis to the location of the member considered in the athwartship section under consideration (*m*)

I : Gross moment of inertia at the athwartship section considered (cm^4)

ii) Compressive stress due to horizontal hull girder bending moment, given by the following formula:

$$\sigma_H = C_3 \frac{2y}{B} \quad (N/mm^2)$$

C_3 : Coefficient given by the following formulae. For the intermediate values of L, C_3 is to be obtained by linear interpolation.

$$C_3 = \frac{6}{a} g \quad \text{where } L \text{ is 230 } m \text{ and below}$$

$$C_3 = \frac{10.5}{a} g \quad \text{where } L \text{ is 400 } m \text{ and over}$$

a : $\sqrt{K}$ when high tensile steels are used for not less than 80% of side shell plating at the athwartship section amidships, and 1.0 for other parts.

K : Coefficient corresponding to the kinds of steels of side shell plating, e.g.1.0 for mild steel and the values specified in **1.1.7-2, Part C** for high tensile steel

y : Athwartship distance from centerline of the hull to the point under consideration (*m*)

(b) In case of horizontal stiffeners of hatch side coaming, reference stress is given by the following **i)** or **ii)**:

i) When the stiffener is fitted on a continuous hatch side coaming, preceding **(a)** is to be applied as a longitudinal stiffener.

ii) When the stiffener is fitted on a discontinuous hatch side coaming, bending stress at deck according to preceding **(a)** is to be applied.

(c) In case of vertical stiffeners of slant and vertical plating of upper and lower stool of transverse bulkhead and transverse bulkhead excluding corrugated bulkhead, reference stress is given by the following **i)** or **ii)**, depending on the loading condition and loading pattern. When the axial compressive stress at the mid-point of the stiffener is calculated by direct strength analysis, the value may be used as the reference stress, but not to be less than $30/K$ (See **Fig. C31A.6.2-2**).

i) When relatively high axial compressive stress is acting to the stiffener (e.g. vertical stiffeners of the stool facing the hold which became empty in a fully loaded condition or those facing the hold which is adjacent to the heavy ballast hold in a heavy ballast condition), reference stress is given by the following formula:

$\sigma_{ref} = 145/K$ (N/mm^2)

ii) In other case, given by the following formula:

$\sigma_{ref} = 30 / K$ (N/mm^2)

K : Coefficient corresponding to the kinds of steels of attached plating, e.g. 1.0 for mild steel and the values specified in **1.1.7-2, Part C** for high tensile steel

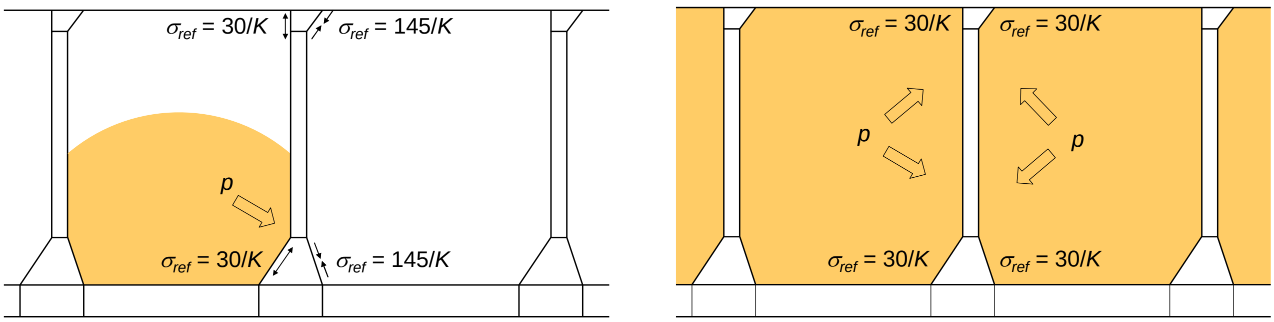
(d) In case of hold frames, reference stress is obtained from the following formula:

$\sigma_{ref} = 30 / K$ (N/mm^2)

K : As specified in preceding **(c)**

(e) In case of members other than any of those in above **(a)** to **(d)**, reference stress is to be in accordance with the discretion of the Society.

Fig. C31A.6.2-2. Example of Reference Stress



(4) Buckling Stress

Buckling stress σ_{Uxp} (N/mm^2) of the stiffener considered is given by the following **(a)** or **(b)** corresponding to the pressure acting on the stiffener. When calculating the buckling stress, thickness standard deductions equal to the values given in **Table C31.6.2-4** are to be considered for t_b, t_w and t_f.

(a) In case $0 \le p \le p_{cr}$ or $-p_{cr} \le p \le 0$:

$$\sigma_{Uxp} = \min[\sigma_{PI}, \sigma_{SI}]$$

$$\sigma_{PI} = \frac{A_e}{2A}\left\{P_C\left(\frac{1}{A_e}+\frac{y_p}{I_e}\left(w_s+\frac{5\ell^4 s|p|}{384\times10^3 EI_e}\right)\right)+\sigma_Y-\frac{p\ell^2 s}{8\times10^3}\frac{y_p}{I_e}\right.$$
$$\left.-\sqrt{\left(P_C\left(\frac{1}{A_e}+\frac{y_p}{I_e}\left(w_s+\frac{5\ell^4 s|p|}{384\times10^3 EI_e}\right)\right)+\sigma_Y-\frac{p\ell^2 s}{8\times10^3}\frac{y_p}{I_e}\right)^2-4\left(\sigma_Y-\frac{p\ell^2 s}{8\times10^3}\frac{y_p}{I_e}\right)\frac{P_C}{A_e}}\right\}$$

$$\sigma_{SI}=\frac{A_e}{2A}\left\{P_C\left(\frac{1}{A_e}+\frac{y_s}{I_e}\left(w_s+\frac{\ell^4 s|p|}{384\times10^3 EI_e}\right)\right)+\sigma_Y+\frac{p\ell^2 s}{24\times10^3}\frac{y_s}{I_e}\right.$$
$$\left.-\sqrt{\left(P_C\left(\frac{1}{A_e}+\frac{y_s}{I_e}\left(w_s+\frac{\ell^4 s|p|}{384\times10^3 EI_e}\right)\right)+\sigma_Y+\frac{p\ell^2 s}{24\times10^3}\frac{y_s}{I_e}\right)^2-4\left(\sigma_Y+\frac{p\ell^2 s}{24\times10^3}\frac{y_s}{I_e}\right)\frac{P_C}{A_e}}\right\}$$

(b) In case $p \geq p_{cr}$ or $p \leq -p_{cr}$:

$$\sigma_{Uxp}=\sigma_{HI}$$

$$\sigma_{HI}=-\frac{\sigma*_{HI}}{p_{st}-p_{cr}}\left(|p|-p_{cr}\right)+\sigma*_{HI}$$

$$\sigma*_{HI}=\min[\sigma_{PI(p=pcr)},\sigma_{SI(p=pcr)}]$$

Following definitions are applied to the symbols used in preceding **(a)** and **(b)**.

p : Pressure acting on the stiffener considered, as specified in the preceding **(2)**

p_{cr} : Plastic collapse load of attached plating considered, which is obtained from the following formula:

$$p_{cr}=\frac{12}{\ell^2 s}\frac{I}{y_{s0}}\sigma_Y\times10^3 \quad (kN/m^2)$$

p_{st} : Plastic collapse load of stiffener considered, which is obtained from the following formula:

$$p_{st}=\frac{16}{\ell^2 s}Z_p\sigma_Y\times10^3 \quad (kN/m^2)$$

P_C : Euler's buckling load, as obtained from following formula:

$$P_C=\frac{\pi^2 EI_e}{\ell^2} \quad (N)$$

I : Moment of inertia of stiffener including attached plating with full width (mm^4)

I_e : Moment of inertia of stiffener including attached plating with effective width (mm^4)

Z_p : Plastic section modulus of stiffener including attached plating (mm^3)

y_p : Vertical distance from neutral axis of stiffener including attached plating to the mid point of thickness of attached plating (*mm*)

y_s : Vertical distance from neutral axis of stiffener including attached plating with effective width to the outer surface of the face plate (*mm*)

y_{s0} : Vertical distance from neutral axis of stiffener including attached plating with full width to the outer surface of the face plate (*mm*)

σ_Y : Yield stress of stiffener including attached plating, obtained from following formula:

$$\sigma_Y=\left\{st_p\sigma_{Yp}+\left((h_w-t_f)t_w+b_f t_f\right)\sigma_{Ys}\right\}/A \quad (N/mm^2)$$

σ_{Yp} : Yield stress of material of attached plating under consideration (N/mm^2)

σ_{Ys} : Yield stress of material of stiffener under consideration (N/mm^2)

ℓ : Span of stiffener (*mm*). Where , however, suitable end brackets are fitted, span of the stiffener which is used in the formulae except that of α_p, m_1 and P_C

may be corrected as specified in following **i)** or **ii)** depending on the type of end bracket (See **Fig. C31A.6.2-3**)

i) In case of bracket where the face plate is not carried continuously around the edge of the bracket, the span is taken between points where the depth of the bracket is equal to half the depth of the web

ii) In case of curved brackets where the face plate is continuous along the face of the bracket, the span is taken between points where the depth of the bracket is equal to one quarter the depth of the web

A: Cross sectional area of stiffeners including attached plating with full width (mm^2), which is given by the following formula:

$$A = st_p + (h_w - t_f)t_w + b_f t_f$$

A_e: Cross sectional area of stiffeners including attached plating with effective width (mm^2), which is given by the following formulae:

$A_e = s_e t_p + (h_w - t_f)t_w + b_f t_f$ for angles and T-sections

$A_e = s_e t_p + (h_w - t_f)t_e$ for flat bars

s: Spacing of stiffeners (mm)

t_p: Plate thickness of attached plating (mm)

h_w: Web height (mm)

t_w: Web thickness (mm)

b_f: Width of face plate (mm)

t_f: Thickness of face plate (mm). For bulb sections, the mean thickness of the bulb is to be used.

t_e: Effective thickness of attached plating (mm), obtained from the following formula.

$$t_e = t_w\left(1 - \frac{2\pi^2}{3}\left(\frac{h_w}{s}\right)^2\left(1 - \frac{s_e}{s}\right)\right)$$

s_e: Effective width of attached plating (mm), obtained from the following formula.

$$s_e = \left(\frac{\sigma_{crx}}{\sigma_{Yp}}(1 - \alpha_p) + \alpha_p\right)s$$

$$\frac{\sigma_{crx}}{\sigma_{Yp}} = \frac{1}{2}\left(\frac{\sigma_{crex}}{\sigma_{Yp}} + 1 - \sqrt{\left(\frac{\sigma_{crex}}{\sigma_{Yp}} - 1\right)^2 + 0.01}\right)$$

$$\sigma_{crex} = \kappa_x \sigma_{crex(p)}$$

$$\sigma_{crex(p)} = \frac{E\pi^2}{3(1 - \nu^2)}\left(\frac{t_p}{s}\right)^2$$

$$\kappa_x = c_x\left(\frac{t_w}{t_p}\right)^3 + 1$$

c_x: Coefficient according to the type of stiffeners, which is given by the followings:

$c_x = 0.07$ for angles and T-sections

$c_x = 0.02$ for flat bars

$$\alpha_p = \frac{1+(\ell / m_1 s)^4}{3+(\ell / m_1 s)^4}$$

m_1: Integer which satisfies the following formula:

$$\sqrt{(m_1 - 1)m_1} \le \ell / s \le \sqrt{m_1 (m_1 + 1)}$$

w_s : Assumed imperfection of stiffeners (*mm*). The value of $\ell / 1000$ may be used as standard.

E : Modulus of elasticity for material:
2.06×10^5 for steel (*N/mm*^{2})

Table C31.6.2-4 Standard deduction

Structure	Standard Deduction (*mm*)	Limit Value (*mm*)	
		Minimum	Maximum
1. Compartments carrying dry bulk cargos and void spaces 2. One side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than 25° to the horizontal line 3. Hatch side coaming	0.05*t*	0.5	1.0
1. One side exposure to ballast and/or liquid cargo Horizontal surfaces and surfaces sloped at an angle less than 25° to the horizontal line 2. Two side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than 25° to the horizontal line	0.10*t*	2.0	3.0
1. Two side exposure to ballast and/or liquid cargo Horizontal surfaces and surfaces sloped at an angle less than 25° to the horizontal line	0.15*t*	2.0	4.0

(Note) t : Thickness of structural members under consideration (*mm*)

Fig.C31A.6.2-3 Span of stiffeners

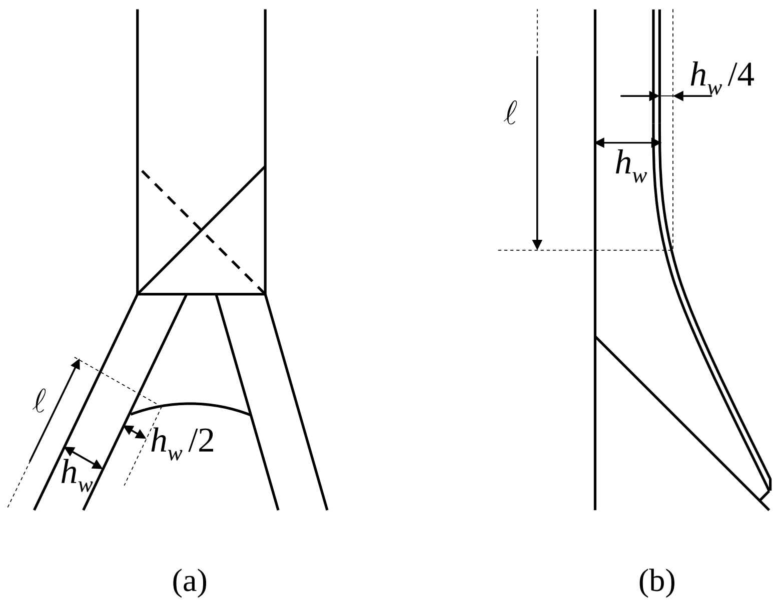
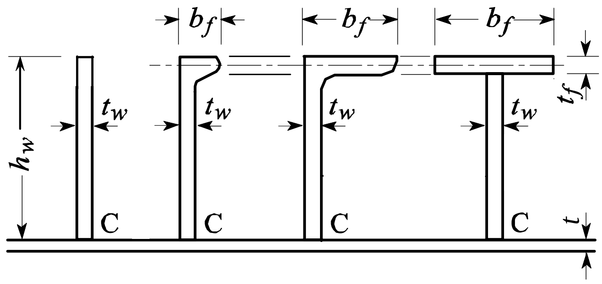


Fig.C31A.6.2-4 Dimensions of stiffeners



(5) Buckling Strength Criteria

The buckling strength of stiffeners specified in preceding **(1)** is to comply with the following formula:

$$\frac{\sigma_{Uxp}}{\sigma_{ref}} \geq 1.15$$

σ_{ref} : Reference stress of the stiffener considered, as specified in preceding **(3)** (N/mm^2)

σ_{Uxp} : Buckling stress of the stiffener considered, as specified in preceding **(4)** (N/mm^2)

EFFECTIVE DATE AND APPLICATION (Amendment 4-1)

1. The effective date of the amendments is 1 July 2006.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to ships the keels of which were laid or which were at *a similar stage of construction* before the effective date.

(Note) The term "*a similar stage of construction*" means the stage at which the construction identifiable with a specific ship begins and the assembly of that ship has commenced comprising at least 50 *tonnes* or 1% of the estimated mass of all structural material, whichever is the less.

Amendment 4-2

C31A ADDITIONAL REQUIREMENTS FOR NEW BUKL CARRIERS

C31A.6 Double-side Skin Construction and Cargo Hold Construction

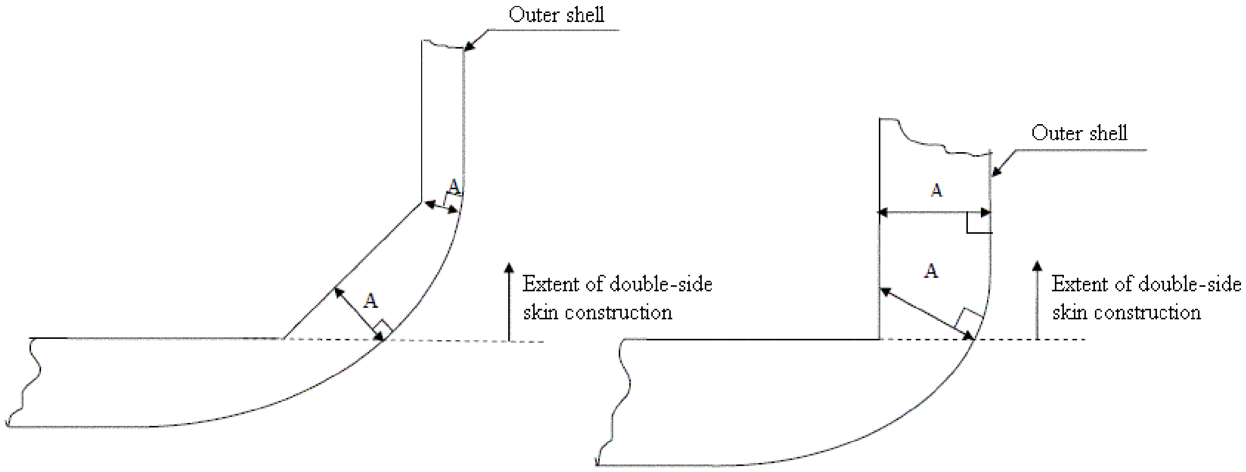
C31A.6.1 Double-side Skin Construction

Existing text has been numbered to sub-paragraph -2, and sub-paragraph -1 has been added as follows.

1 The distance between the outer shell and the inner shell as specified in **31A.6.1-1(2), Part C of the Rules** is to be measured in accordance with **Fig. C31A.6.1-1**.

Fig. C31A.6.1-1 has been added as follows.

Fig. C31A.6.1-1 Width of Double-side Skin Construction



EFFECTIVE DATE AND APPLICATION (Amendment 4-2)

1. The effective date of the amendments is 30 November 2006.