

S 31 Renewal Criteria for Side Shell Frames and Brackets in Single Side Skin Bulk Carriers and Single Side Skin OBO Carriers not Built in accordance with UR S12 Rev.1 or subsequent revisions

(Nov. 2002)
 (Rev.1 June 2003)
 (Corr.1 July 2003)
 (Corr.2 Nov. 2003)
 Corr.3 Jan 2004)
 (Rev.2 July 2004)
 (Rev.3 Nov. 2005)
 (Rev.4 Apr 2007)

S31.1 Application and definitions

These requirements apply to the side shell frames and brackets of cargo holds bounded by the single side shell of bulk carriers constructed with single deck, topside tanks and hopper tanks in cargo spaces intended primarily to carry dry cargo in bulk, which were not built in accordance with UR S12 Rev. 1 or subsequent revisions.

In addition, these requirements also apply to the side shell frames and brackets of cargo holds bounded by the single side shell of Oil/Bulk/Ore(OBO) carriers, as defined in UR Z11 but of single side skin construction.

In the case a vessel as defined above does not satisfy above definition in one or more holds, the requirements in UR S31 do not apply to these individual holds.

For the purpose of this UR, "ships" means both "bulk carriers" and "OBO carriers" as defined above, unless otherwise specified.

Bulk Carriers subject to these requirements are to be assessed for compliance with the requirements of this UR and steel renewal, reinforcement or coating, where required in accordance with this UR, is to be carried out in accordance with the following schedule and at subsequent intermediate and special surveys.

- i. For bulk carriers which will be 15 years of age or more on 1 January 2004 by the due date of the first intermediate or special survey after that date;
- ii. For bulk carriers which will be 10 years of age or more on 1 January 2004 by the due date of the first special survey after that date;
- iii. For bulk carriers which will be less than 10 years of age on 1 January 2004 by the date on which the ship reaches 10 years of age.

Completion prior to 1 January 2004 of an intermediate or special survey with a due date after 1 January 2004 cannot be used to postpone compliance. However, completion prior to 1 January 2004 of an intermediate survey the window for which straddles 1 January 2004 can be accepted.

Note:

1. This UR is to be applied to bulk carriers and OBO carriers of single side skin construction, as defined above, in conjunction with UR Z10.2 (Rev.15, 2003 and Corr.1, 2004). Z10.2.1.1.5 refers.
2. The changes introduced in Rev.3 are to be applied by IACS Members and Associates not later than on assessments for compliance commenced on or after 1 July 2006.
3. The changes introduced in Rev.4 are to be applied by IACS Members and Associates not later than on assessments for compliance commenced on or after 1 July 2008.

OBO carriers subject to these requirements are to be assessed for compliance with the requirements of this UR and steel renewal, reinforcement or coating, where required in accordance with this UR, is to be carried out in accordance with the following schedule and at subsequent intermediate and special surveys.

- i. For OBO carriers which will be 15 years of age or more on 1 July 2005 by the due date of the first intermediate or special survey after that date;
- ii. For OBO carriers which will be 10 years of age or more on 1 July 2005 by the due date of the first special survey after that date;
- iii. For OBO carriers which will be less than 10 years of age on 1 July 2005 by the date on which the ship reaches 10 years of age.

Completion prior to 1 July 2005 of an intermediate or special survey with a due date after 1 July 2005 cannot be used to postpone compliance. However, completion prior to 1 July 2005 of an intermediate survey the window for which straddles 1 July 2005 can be accepted.

These requirements define steel renewal criteria or other measures to be taken for the webs and flanges of side shell frames and brackets as per S31.2.

Reinforcing measures of side frames are also defined as per S31.2.3.

Finite element or other numerical analysis or direct calculation procedures cannot be used as an alternative to compliance with the requirements of this UR, except in cases of unusual side structure arrangements or framing to which the requirements of this UR cannot be directly applied. In such cases, the analysis criteria and the strength check criteria are to be in accordance with each Society's Rules.

S31.1.1 Ice strengthened ships

S31.1.1.1 Where ships are reinforced to comply with an ice class notation, the intermediate frames are not to be included when considering compliance with S31.

S31.1.1.2 The renewal thicknesses for the additional structure required to meet the ice strengthening notation are to be based on the class society's requirements.

S31.1.1.3 If the ice class notation is requested to be withdrawn, the additional ice strengthening structure, with the exception of tripping brackets (see S31.2.1.2.1.b and S31.2.3), is not to be considered to contribute to compliance with S31.

S31.2 Renewal or other measures

S31.2.1 Criteria for renewal or other measures

S31.2.1.1 Symbols used in S31.2.1

t_M	= thickness as measured, in mm
t_{REN}	= thickness at which renewal is required. See S31.2.1.2
$t_{REN,d/t}$	= thickness criteria based on d/t ratio. See S31.2.1.2.1
$t_{REN,S}$	= thickness criteria based on strength. See S31.2.1.2.2
t_{COAT}	= $0.75 t_{S12}$
t_{S12}	= thickness in mm as required by UR S12 (Rev.3) in S12.3 for frame webs and in S12.4 for upper and lower bracket webs
t_{AB}	= thickness as built, in mm
t_C	= See Table 1 below

Table 1 - t_c values, in mm

Ship's length L, in m	Holds other than No. 1		Hold No. 1	
	Span and upper brackets	Lower brackets	Span and upper brackets	Lower brackets
≤100	2.0	2.5	2.0	3.0
150	2.0	3.0	3.0	3.5
≥ 200	2.0	3.0	3.0	4.0

Note: For intermediate ship lengths, t_c is obtained by linear interpolation between the above values.

S31.2.1.2 Criteria for webs (Shear and other checks)

The webs of side shell frames and brackets are to be renewed when the measured thickness (t_M) is equal to or less than the thickness (t_{REN}) as defined below:

t_{REN} is the greatest of:

- (a) $t_{COAT} - t_c$
- (b) $0.75 t_{AB}$
- (c) $t_{REN,d/t}$ (applicable to Zone A and B only)
- (d) $t_{REN,S}$ (where required by S31.2.1.2.2)

S31.2.1.2.1 Thickness criteria based on d/t ratio

Subject to b) and c) below, $t_{REN,d/t}$ is given by the following equation:

$$t_{REN,d/t} = (\text{web depth in mm})/R$$

where:

$$R = \begin{array}{ll} \text{for frames} & \\ 65 k^{0.5} & \text{for symmetrically flanged frames} \\ 55 k^{0.5} & \text{for asymmetrically flanged frames} \end{array}$$

for lower brackets (see a) below):

$$\begin{array}{ll} 87 k^{0.5} & \text{for symmetrically flanged frames} \\ 73 k^{0.5} & \text{for asymmetrically flanged frames} \end{array}$$

$$k = \begin{array}{l} 1.0 \text{ for ordinary hull structural steel and according to UR S4 for higher} \\ \text{tensile steel.} \end{array}$$

In no instance is $t_{REN,d/t}$ for lower integral brackets to be taken as less than $t_{REN,d/t}$ for the frames they support.

a) Lower brackets

Lower brackets are to be flanged or face plate is to be fitted, ref. S31.2.1.3.

In calculating the web depth of the lower brackets, the following will apply:

- The web depth of lower bracket may be measured from the intersection of the sloped bulkhead of the hopper tank and the side shell plate, perpendicularly to the face plate of the lower bracket (see Figure 3).
- Where stiffeners are fitted on the lower bracket plate, the web depth may be taken as the distance between the side shell and the stiffener, between the stiffeners or between the outermost stiffener and the face plate of the brackets, whichever is the greatest.

b) Tripping bracket alternative

When t_M is less than $t_{REN,d/t}$ at section b of the side frames, tripping brackets in accordance with S31.2.3 may be fitted as an alternative to the requirements for the web depth to thickness ratio of side frames, in which case $t_{REN,d/t}$ may be disregarded in the determination of t_{REN} in accordance with S31.2.1.2. The value of t_M is to be based on zone B according to UR Z10.2, ANNEX V, see Figure 1.

c) Immediately abaft collision bulkhead

For the side frames, including the lower bracket, located immediately abaft the collision bulkheads, whose scantlings are increased in order that their moment of inertia is such to avoid undesirable flexibility of the side shell, when their web as built thickness t_{AB} is greater than $1.65 \cdot t_{REN,S}$, the thickness $t_{REN,d/t}$ may be taken as the value $t'_{REN,d/t}$ obtained from the following equation:

$$t'_{REN,d/t} = \sqrt[3]{t_{REN,d/t}^2 t_{REN,S}}$$

where $t_{REN,S}$ is obtained from S31.3.3

S31.2.1.2.2 Thickness criteria based on shear strength check

Where t_M in the lower part of side frames, as defined in Figure 1, is equal to or less than t_{COAT} , $t_{REN,S}$ is to be determined in accordance with S31.3.3.

S31.2.1.2.3 Thickness of renewed webs of frames and lower brackets

Where steel renewal is required, the renewed webs are to be of a thickness not less than t_{AB} , $1.2t_{COAT}$ or $1.2t_{REN}$, whichever is the greatest.

S31.2.1.2.4 Criteria for other measures

When $t_{REN} < t_M \leq t_{COAT}$, measures are to be taken, consisting of all the following:

- a) Sand blasting, or equivalent, and coating (see S31.2.2).
- b) Fitting tripping brackets (see S31.2.3), when the above condition occurs for any of the side frame zones A, B, C and D, shown in Figure 1. Tripping brackets not connected to flanges are to have soft toe, and the distance between the bracket toe and the frame flange is not to be greater than about 50 mm, see Figure 4.
- c) Maintaining the coating in "as-new" condition (i.e. without breakdown or rusting) at Special and Intermediate Surveys.

The above measures may be waived if the structural members show no thickness diminution with respect to the as built thicknesses and coating is in "as-new" condition (i.e. without breakdown or rusting).

When the measured frame webs thickness t_M is such that $t_{REN} < t_M \leq t_{COAT}$ and the coating is in GOOD condition, sand blasting and coating as required in a) above may be waived even if not found in "as-new" condition, as defined above, provided that tripping brackets are fitted and the coating damaged in way of the tripping bracket welding is repaired.

S31.2.1.3 Criteria for frames and brackets (Bending check)

When lower end brackets were not fitted with flanges at the design stage, flanges are to be fitted so as to meet the bending strength requirements in S31.3.4. The full width of the bracket flange is to extend up beyond the point at which the frame flange reaches full width. Adequate back-up structure in the hopper is to be ensured, and the bracket is to be aligned with the back-up structure.

Where the length or depth of the lower bracket does not meet the requirements in S12(Rev.3), a bending strength check in accordance with S31.3.4 is to be carried out and renewals or reinforcements of frames and/or brackets effected as required therein.

The bending check needs not to be carried out in the case the bracket geometry is modified so as to comply with S12(Rev.3) requirements.

S31.2.2 Thickness measurements, steel renewal, sand blasting and coating

For the purpose of steel renewal, sand blasting and coating, four zones A, B, C and D are defined, as shown in Figure 1. When renewal is to be carried out, surface preparation and coating are required for the renewed structures as given in UR Z9 for cargo holds of new buildings.

Representative thickness measurements are to be taken for each zone and are to be assessed against the criteria in S31.2.1.

When zone B is made up of different plate thicknesses, the lesser thickness is to be used for the application of the requirements in S31.

In case of integral brackets, when the criteria in S31.2.1 are not satisfied for zone A or B, steel renewal, sand blasting and coating, as applicable, are to be done for both zones A and B.

In case of separate brackets, when the criteria in S31.2.1 are not satisfied for zone A or B, steel renewal, sand blasting and coating is to be done for each one of these zones, as applicable.

When steel renewal is required for zone C according to S31.2.1, it is to be done for both zones B and C. When sand blasting and coating is required for zone C according to S31.2.1, it is to be done for zones B, C and D.

When steel renewal is required for zone D according to S31.2.1, it needs only to be done for this zone. When sand blasting and coating is required for zone D according to S31.2.1, it is to be done for both zones C and D.

Special consideration may be given by the Society to zones previously renewed or re-coated, if found in "as-new" condition (i.e., without breakdown or rusting).

When adopted, on the basis of the renewal thickness criteria in S31.2.1, in general coating is to be applied in compliance with the requirements of UR Z9, as applicable.

Where, according to the requirements in S31.2.1, a limited number of side frames and brackets are shown to require coating over part of their length, the following criteria apply.

- a) The part to be coated includes:
 - the web and the face plate of the side frames and brackets,
 - the hold surface of side shell, hopper tank and topside tank plating, as applicable, over a width not less than 100 mm from the web of the side frame.
- b) Epoxy coating or equivalent is to be applied.

In all cases, all the surfaces to be coated are to be sand blasted prior to coating application.

When flanges of frames or brackets are to be renewed according to S31, the outstanding breadth to thickness ratio is to comply with the requirements in UR S12.5.

S31.2.3 Reinforcing measures

Reinforcing measures are constituted by tripping brackets, located at the lower part and at midspan of side frames (see Figure 4). Tripping brackets may be located at every two frames, but lower and midspan brackets are to be fitted in line between alternate pairs of frames.

The thickness of the tripping brackets is to be not less than the as-built thickness of the side frame webs to which they are connected.

Double continuous welding is to be adopted for the connections of tripping brackets to the side shell frames and shell plating.

Where side frames and side shell are made of Higher Strength Steel (HSS), Normal Strength Steel (NSS) tripping brackets may be accepted, provided the electrodes used for welding are those required for the particular HSS grade, and the thickness of the tripping brackets is equal to the frame web thickness, regardless of the frame web material.

S31.2.4 Weld throat thickness

In case of steel renewal the welded connections are to comply with UR S12.7 of UR S12(Rev.3).

S31.2.5 Pitting and grooving

If pitting intensity is higher than 15% in area (see Figure 5), thickness measurement is to be taken to check pitting corrosion.

The minimum acceptable remaining thickness in pits or grooves is equal to:

- 75% of the as built thickness, for pitting or grooving in the frame and brackets webs and flanges
- 70% of the as built thickness, for pitting or grooving in the side shell, hopper tank and topside tank plating attached to the side frame, over a width up to 30 mm from each side of it.

S31.2.6 Renewal of all frames in one or more cargo holds

When all frames in one or more holds are required to be renewed according to UR S31, the compliance with the requirements in URS 12 (Rev. 1) may be accepted in lieu of the compliance with the requirements in UR S31, provided that:

- It is applied at least to all the frames of the hold(s)
- The coating requirements for side frames of “new ships” are complied with
- The section modulus of side frames is calculated according to the Classification Society Rules.

S31.2.7 Renewal of damaged frames

In case of renewal of a damaged frame already complying with S31, the following requirements apply:

- The conditions accepted in compliance with S31 are to be restored as a minimum.
- For localised damages, the extension of the renewal is to be carried out according to the standard practice of each Classification Society.

S31.3 Strength check criteria

In general, loads are to be calculated and strength checks are to be carried out for the aft, middle and forward frames of each hold. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the above frames.

When scantlings of side frames vary within a hold, the required scantlings are also to be calculated for the mid frame of each group of frames having the same scantlings. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the calculated frames.

S31.3.1 Load model

The following loading conditions are to be considered:

- Homogeneous heavy cargo (density greater than 1,78 t/m³)
- Homogeneous light cargo (density less than 1,78 t/m³)
- Non homogeneous heavy cargo, if allowed
- Multi port loading/unloading conditions need not be considered.

S31.3.1.1 Forces

The forces $P_{fr,a}$ and $P_{fr,b}$, in kN, to be considered for the strength checks at sections a) and b) of side frames (specified in Figure 2; in the case of separate lower brackets, section b) is at the top of the lower bracket), are given by:

$$P_{fr,a} = P_s + \max(P_1, P_2)$$

$$P_{fr,b} = P_{fr,a} \frac{h - 2h_B}{h}$$

where:

$$P_s = \text{still water force, in kN}$$

$$= s h \left(\frac{P_{S,U} + P_{S,L}}{2} \right) \quad \text{when the upper end of the side frame span } h \text{ (see Figure 1) is below the load water line}$$

$$= s h' \left(\frac{P_{S,L}}{2} \right) \quad \text{when the upper end of the side frame span } h \text{ (see Figure 1) is at or above the load water line}$$

P_1 = wave force, in kN, in head sea

$$= \text{sh} \left(\frac{p_{1,U} + p_{1,L}}{2} \right)$$

P_2 = wave force, in kN, in beam sea

$$= \text{sh} \left(\frac{p_{2,U} + p_{2,L}}{2} \right)$$

h, h_B = side frame span and lower bracket length, in m, defined in Figures 1 and 2, respectively

h' = distance, in m, between the lower end of side frame span h (see Figure 1) and the load water line

s = frame spacing, in m

$p_{s,U}, p_{s,L}$ = still water pressure, in kN/m^2 , at the upper and lower end of the side frame span h (see Figure 1), respectively

$p_{1,U}, p_{1,L}$ = wave pressure, in kN/m^2 , as defined in S31.3.1.2.1) below for the upper and lower end of the side frame span h , respectively

$p_{2,U}, p_{2,L}$ = wave pressure, in kN/m^2 , as defined in S31.3.1.2.2) below for the upper and lower end of the side frame span h , respectively

S31.3.1.2 Wave Pressure

1) Wave pressure p_1

- The wave pressure p_1 , in kN/m^2 , at and below the waterline is given by:

$$p_1 = 1.50 \left[p_{11} + 135 \frac{B}{2(B+75)} - 1,2(T-z) \right]$$

$$p_{11} = 3k_s C + k_f$$

- The wave pressure p_1 , in kN/m^2 , above the water line is given by:

$$p_1 = p_{1wl} - 7.50 (z - T)$$

2) Wave pressure p_2

- The wave pressure p_2 , in kN/m^2 , at and below the waterline is given by

$$p_2 = 13.0 \left[0.5B \frac{50c_r}{2(B+75)} + C_B \frac{0.5B + k_f}{14} \left(0.7 + 2 \frac{z}{T} \right) \right]$$

- The wave pressure p_2 , in kN/m^2 , above the water line is given by:

$$p_2 = p_{2wl} - 5.0 (z - T)$$

where:

p_{1wl}	=	p_1 wave sea pressure at the waterline
p_{2wl}	=	p_2 wave sea pressure at the waterline
L	=	Rule length, in m, as defined in UR S2
B	=	greatest moulded breadth, in m
C_B	=	block coefficient, as defined in UR S2, but not to be taken less than 0.6
T	=	maximum design draught, in m
C	=	coefficient
	=	$10.75 - \left(\frac{300 - L}{100} \right)^{1.5}$ for $90 \leq L \leq 300$ m
	=	10.75 for $300 \text{ m} < L$
C_r	=	$(1.25 - 0.025 \frac{2k_r}{\sqrt{GM}}) k$
k	=	1.2 for ships without bilge keel
	=	1.0 for ships with bilge keel
k_r	=	roll radius of gyration. If the actual value of k_r is not available
	=	0.39 B for ships with even distribution of mass in transverse section (e.g. alternate heavy cargo loading or homogeneous light cargo loading)
	=	0.25 B for ships with uneven distribution of mass in transverse section (e.g. homogeneous heavy cargo distribution)
GM	=	0.12 B if the actual value of GM is not available
z	=	vertical distance, in m, from the baseline to the load point
k_s	=	$C_B + \frac{0.83}{\sqrt{C_B}}$ at aft end of L
	=	C_B between 0.2 L and 0.6 L from aft end of L
	=	$C_B + \frac{1.33}{C_B}$ at forward end of L
		Between the above specified points, k_s is to be interpolated linearly.
k_f	=	0.8 C

S31.3.2 Allowable stresses

The allowable normal and shear stresses σ_a and τ_a , in N/mm^2 , in the side shell frames and brackets are given by:

$$\begin{aligned}\sigma_a &= 0.90 \sigma_F \\ \tau_a &= 0.40 \sigma_F\end{aligned}$$

where σ_F is the minimum upper yield stress, in N/mm^2 , of the material.

S31.3.3 Shear strength check

Where t_M in the lower part of side frames, as defined in Figure 1, is equal to or less than t_{COAT} , shear strength check is to be carried out in accordance with the following.

The thickness $t_{\text{REN,S}}$, in mm, is the greater of the thicknesses $t_{\text{REN,Sa}}$ and $t_{\text{REN,Sb}}$ obtained from the shear strength check at sections a) and b) (see Figure 2 and S31.3.1) given by the following, but need not be taken in excess of $0.75t_{\text{S12}}$.

$$\text{- at section a): } t_{\text{REN,Sa}} = \frac{1000 k_S P_{\text{fr,a}}}{d_a \sin\phi \tau_a}$$

$$\text{- at section b): } t_{\text{REN,Sb}} = \frac{1000 k_S P_{\text{fr,b}}}{d_b \sin\phi \tau_a}$$

where:

k_S	=	shear force distribution factor, to be taken equal to 0.6
$P_{\text{fr,a}}, P_{\text{fr,b}}$	=	pressures forces defined in S31.3.1.1
d_a, d_b	=	bracket and frame web depth, in mm, at sections a) and b), respectively (see Figure 2); in case of separate (non integral) brackets, d_b is to be taken as the minimum web depth deducing possible scallops
ϕ	=	angle between frame web and shell plate
τ_a	=	allowable shear stress, in N/mm^2 , defined in S31.3.2.

S31.3.4 Bending strength check

Where the lower bracket length or depth does not meet the requirements in UR S12(Rev.3), the actual section modulus, in cm^3 , of the brackets and side frames at sections a) and b) is to be not less than:

- at section a):

$$Z_a = \frac{1000 P_{\text{fr,a}} h}{m_a \sigma_a}$$

- at section b)

$$Z_b = \frac{1000 P_{fr,a} h}{m_b \sigma_a}$$

where:

$P_{fr,a}$	=	pressures force defined in S31.3.1.1
h	=	side frame span, in m, defined in Figure 1
σ_a	=	allowable normal stress, in N/mm^2 , defined in S31.3.2
m_a, m_b	=	bending moment coefficients defined in Table 2

The actual section modulus of the brackets and side frames is to be calculated about an axis parallel to the attached plate, based on the measured thicknesses. For pre-calculations, alternative thickness values may be used, provided they are not less than:

- t_{REN} , for the web thickness
- the minimum thicknesses allowed by the Society renewal criteria for flange and attached plating.

The attached plate breadth is equal to the frame spacing, measured along the shell at midspan of h .

If the actual section moduli at sections a) and b) are less than the values Z_a and Z_b , the frames and brackets are to be renewed or reinforced in order to obtain actual section moduli not less than $1.2 Z_a$ and $1.2 Z_b$, respectively.

In such a case, renewal or reinforcements of the flange are to be extended over the lower part of side frames, as defined in Figure 1.

Table 2 – Bending moment coefficients m_a and m_b

	m_a	m_b		
		$h_B \leq 0.08h$	$h_B = 0.1h$	$h_B \geq 0.125h$
Empty holds of ships approved to operate in non homogeneous loading conditions	10	17	19	22
Other cases	12	20	22	26

Note 1: Non homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, exceeds 1.20 corrected for different cargo densities.

Note 2: For intermediate values of the bracket length h_B , the coefficient m_b is obtained by linear interpolation between the table values.

Figure 1 – Lower part and zones of side frames

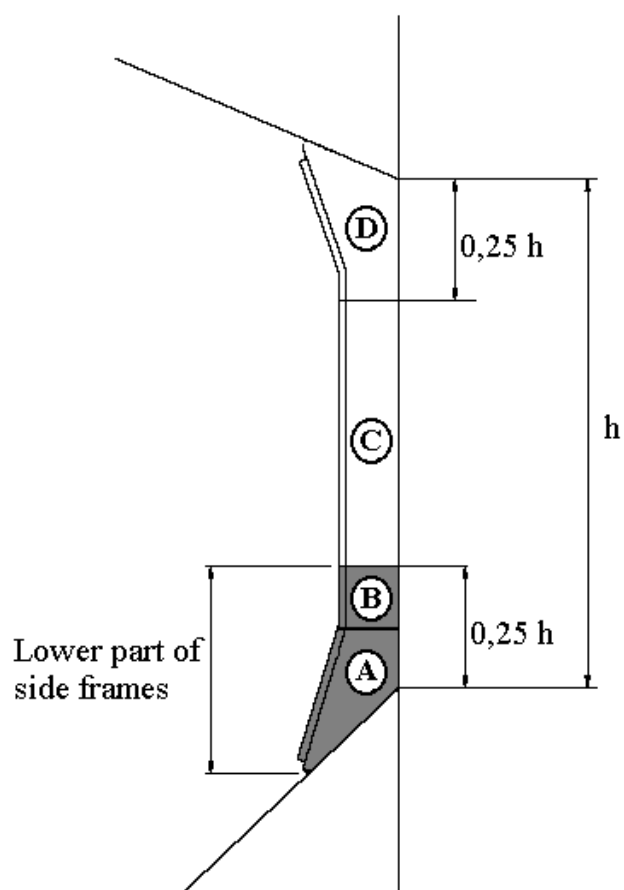


Figure 2 – Sections a) and b)

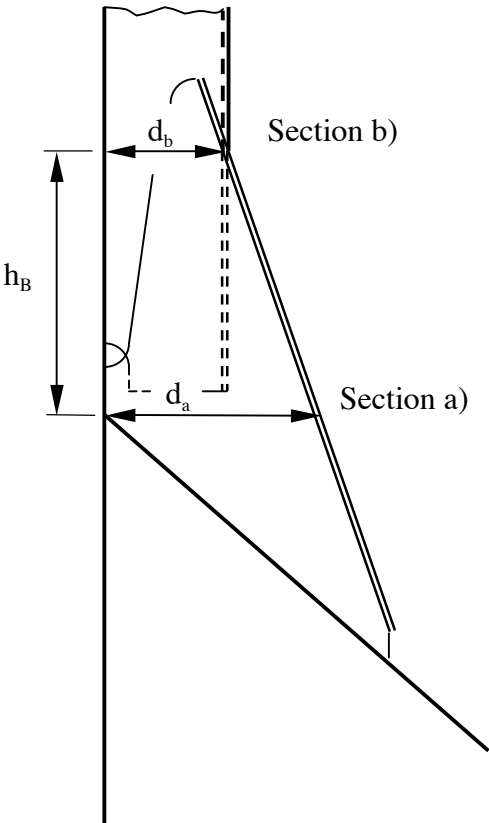
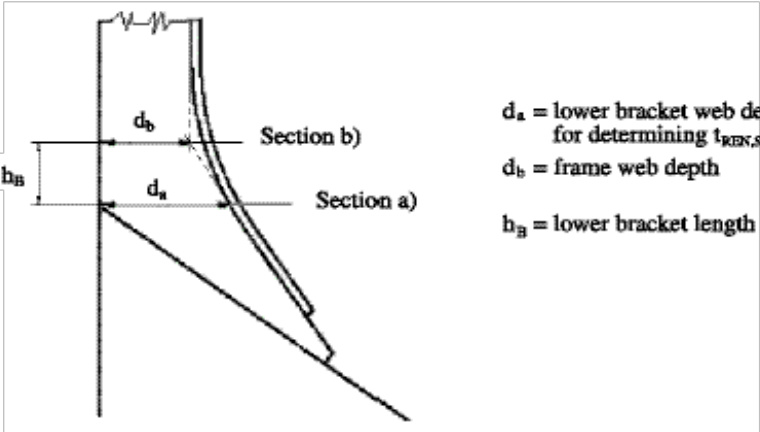


Figure 3 – Definition of the lower bracket web depth for determining $t_{REN, d/t}$

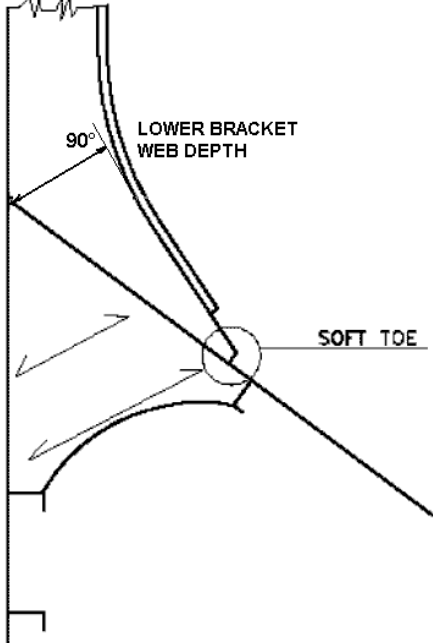


Figure 4 – Tripping brackets

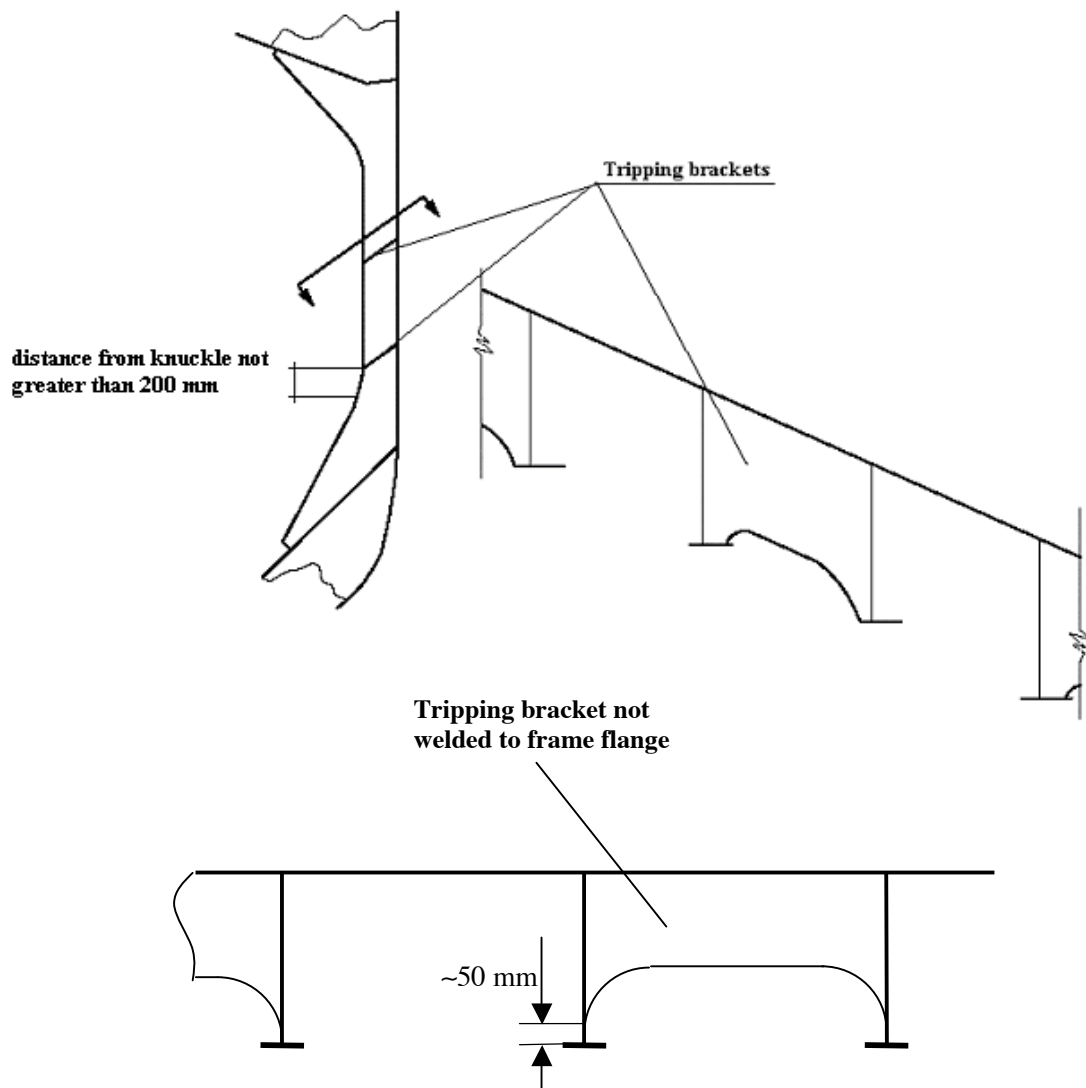
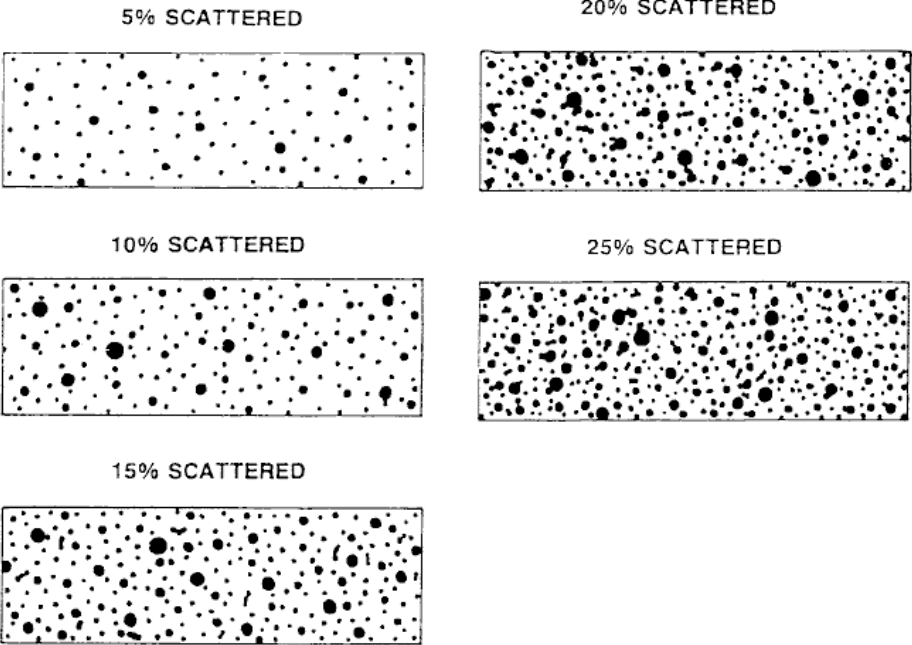


Figure 5 - Pitting intensity diagrams (from 5% to 25% intensity)



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