INTERNATIONAL STANDARD

ISO 12215-6

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Small craft — Hull construction and scantlings —

Part 6: Structural arrangements and details

Petits navires — Construction de coques et échantillonnages —
Partie 6: Dispositions et détails de construction

Reference number
ISO 12215-6:2008(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12215-6 was prepared by Technical Committee ISO/TC 188, *Small craft*.

ISO 12215 consists of the following parts, under the general title *Small craft — Hull construction and scantlings*:

— *Part 1: Materials: Thermosetting resins, glass-fibre reinforcement, reference laminate*

— *Part 2: Materials: Core materials for sandwich construction, embedded materials*

— *Part 3: Materials: Steel, aluminium alloys, wood, other materials*

— *Part 4: Workshop and manufacturing*

— *Part 5: Design pressures for monohulls, design stresses, scantlings determination*

— *Part 6: Structural arrangements and details*

— *Part 7: Scantling determination of multihulls*

— *Part 8: Rudders*

— *Part 9: Sailing boats — Appendages and rig attachments*

Introduction

The underlying reason for preparing this part of ISO 12215 is that standards and recommended practices for loads on the hull and the dimensioning of small craft differ considerably, thus limiting the general worldwide acceptability of boats.

The objective of this part of ISO 12215 is to achieve an overall structural strength that ensures the watertight and weathertight integrity of the craft.

This part of ISO 12215 is considered to have been developed with the application of current practice and sound engineering principles.

Considering future development in technology and boat types, as well as small craft currently outside the scope of this part of ISO 12215, and provided that methods supported by appropriate technology exist, consideration may be given to their use so long as equivalent strength to this part of ISO 12215 is achieved.

Dimensioning in accordance with this part of ISO 12215 is regarded as reflecting current practice, provided that the craft is correctly handled in the sense of good seamanship and that it is equipped and operated at a speed appropriate to the prevailing sea state.

Small craft — Hull construction and scantlings —

Part 6:
Structural arrangements and details

1 Scope

This part of ISO 12215 concerns structural details and structural components not explicitly included in ISO 12215-5, ISO 12215-7, ISO 12215-8 and ISO 12215-9. It applies to monohull and multihull small craft constructed from fibre reinforced plastics (FRP), aluminium or steel alloys, wood or other suitable boat building material, with a hull length, in accordance with ISO 8666, of up to 24 m.

This part of ISO 12215 fulfils two functions. Firstly, it supports ISO 12215-5 by providing further explanations and calculation procedures and formulae. Secondly, it gives a number of examples of arrangements and structural details which illustrate principles of good practice. These principles provide a standard against which alternative arrangements and structural details can be benchmarked, using the equivalence criteria specified in this part of ISO 12215.

NOTE Scantlings derived from this part of ISO 12215 are primarily intended to apply to recreational craft including recreational charter vessels and might not be suitable for performance racing craft.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8666, *Small craft — Principal data*

ISO 12215-5:2008, *Small craft — Hull construction and scantlings — Part 5: Design pressures for monohulls, design stresses, scantlings determination*

ISO 12215-7, *Small craft — Hull construction and scantlings — Part 7: Scantling determination of multihulls*

ISO 12215-8, *Small craft — Hull construction and scantlings — Part 8: Rudders*

ISO 12215-9, *Small craft — Hull construction and scantlings — Part 9: Appendages and rig attachment*

ISO 12216, *Small craft — Windows, portlights, hatches, deadlights and doors — Strength and watertightness requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
loaded displacement mass
m_{LDC}
mass of the craft, including all appendages, when in the fully-loaded ready-for-use condition, as defined in ISO 8666

3.2
sailing craft
craft for which the primary means of propulsion is by wind power, and for which $A_S > 0{,}07(m_{LDC})^{2/3}$ where

A_S is the total profile area of all sails that can be set at one time when sailing closed hauled, as defined in ISO 8666, expressed in m^2;

m_{LDC} is the loaded displacement, as defined in ISO 8666, expressed in kg.

NOTE In this part of ISO 12215, non-sailing craft are referred to as motor craft.

3.3
grid
grillage
set of transverse stiffeners that intersect a set of longitudinal stiffeners

3.4
secondary stiffener
stiffening element that directly supports the plating

NOTE In a stiffener grillage, secondary stiffeners usually correspond to stiffeners having the lower second moment of area, e.g. stringers, frames, partial bulkheads. The spacing of secondary stiffeners generally corresponds to the shortest unsupported span of the attached plating. In the case of stiffeners with a substantial base width (i.e. top hat stiffeners), the stiffener spacing will be the unsupported panel span plus this base width.

3.5
primary stiffener
stiffening element that supports the secondary stiffening element

NOTE 1 In a stiffener grillage, primary stiffeners usually correspond to stiffeners which have the higher second moment of area, e.g. structural bulkheads, girders, web frames. The spacing of primary stiffeners generally corresponds to the span of secondary stiffeners.

NOTE 2 Some stiffeners, such as bulkheads, deep girders or web frames, may also contribute to resisting global loads.

3.6
stringer
longitudinal stiffener, generally designated a **secondary stiffener** (3.4), which supports the shell plating

3.7
frame
transverse stiffener, generally designated a **secondary stiffener** (3.4), which supports the shell plating

3.8
beam
transverse stiffener, generally designated a **secondary stiffener** (3.4), which supports the deck plating

3.9
web frame
substantial transverse stiffener, generally designated a **primary stiffener** (3.5), which supports stringers and less substantial girders and is usually connected with substantial deck beams

NOTE The spacing of web frames is usually greater than (or some multiple of) the frame or beam spacing.

3.10
floor
substantial transverse bottom stiffener, which may be used to link frames and may also be a partial bulkhead

NOTE Floors are often used to support a cabin sole, so the upper edge is generally horizontal. On sailing craft, floors are traditionally used to support ballast keels.

3.11
girder
substantial longitudinal stiffening element, generally designated a primary member, which supports bottom transverse frames or floors, other frames and beams

NOTE Bottom girders are sometimes called keelsons.

3.12
bracket
stiffening element, usually of triangular shape, used to reinforce the connection of two stiffeners and to reduce their span

NOTE Brackets are also used to transmit local loads.

4 Symbols

Unless specifically otherwise defined, the symbols and units used in this part of ISO 12215 are given in Table 1.

NOTE Symbols and units used only in the annexes are not included in Table 1.

Table 1 — Symbols

Symbol	Designation	Unit
A_D	Design area of plating/stiffener	mm^2
b	Spacing between stiffeners	mm
b_w	Width of bonding flange	mm
B_H	Beam of hull, in accordance with ISO 8666	m
D_{max}	Maximum depth of the boat, in accordance with ISO 8666	m
E	Elastic modulus of stiffener	N/mm^2
f_1	Mechanical property coefficient for FRP and aluminium alloys	1
f_{1w}	Mechanical property coefficient for wood	1
I	Second moment of stiffener	cm^4
$k_0, \ldots, k_2$	Coefficients for reinforcing thickness calculation	1
k_j, k_{jmin}	Glue width coefficient	1
l_u	Span of stiffeners	mm
L_H	Length of hull, in accordance with ISO 8666	m
L_{WL}	Length of waterline, in accordance with ISO 8666	m
m_{LDC}	Loaded displacement mass, in accordance with ISO 8666	kg
m_T	Trailering mass, in accordance with ISO 8666	kg
P	Maximum engine power	kW
t_b	Bottom plating thickness	mm
t_{BHD}	Thickness of plywood bulkhead	mm
t_w	Total thickness of top hat web	mm
V_{max}	Boat maximum speed in calm water	knot
σ_d	Design direct stress	N/mm^2
σ_u	Ultimate direct strength	N/mm^2
τ_d	Design shear stress	N/mm^2
τ_u	Ultimate shear strength	N/mm^2
Ψ	Glass content by mass	1

5 General

Where the load and scantling determination have been accomplished for craft with a hull length, L_H, of between 2,5 m and 24 m in accordance with

— ISO 12215-5 for design pressure for monohulls and scantlings determination,

— ISO 12215-7 for multihulls,

— ISO 12215-8 for rudders, and

— ISO 12215-9 for appendages and rig attachment,

structural arrangements and details shall comply with Clauses 6 to 11.

Where one of the two following methods prescribed in ISO 12215-5 have been used, the craft need only comply with the requirements of Annex A:

a) for sailing craft with a length, L_H, of between 2,5 m and 9 m of design categories C and D, where ISO 12215-5:2008, Annex A, has been used;

b) for craft with a length, L_H, of between 2,5 m and 6 m and of single skin FRP bottom construction, where ISO 12215-5:2008, Annex B, has been used.

6 Structural arrangement

6.1 Stiffening

6.1.1 General

The hull, deck and deckhouse plating shall be stiffened as necessary to comply with ISO 12215-5, by any combination of longitudinal and transverse conventional stiffeners, structural bulkheads, internal furniture such as berths and shelves, and internal tray mouldings, providing these may be considered as “load bearing”. The arrangement is usually made with stiffeners supported by deeper and stronger stiffeners, crossing perpendicularly.

NOTE For small boats, “natural stiffeners” (i.e. elements that add stiffness, even if not dedicated for the purpose; see ISO 12215-5:2008, 9.14), e.g. deck edge, round bilges, hard chines, keel, can define panels that need no further stiffening.

Figures 1, 2 and 3 illustrate characteristic arrangements that comply with good practice. These figures apply to both sailing and non-sailing craft, and combinations of arrangement within a single craft are acceptable. Small boats (generally those of hull length less than about 9 m in length) employ natural stiffeners such as deck edge, round bilges, hard chines, keel, etc. to define panels and then need no further stiffening. Larger craft generally need to make greater use of the stiffener types described in 3.3 to 3.12.

6.1.2 Equivalence criteria

Other arrangements are possible, but these shall follow good practice principles (as illustrated by Figures 1, 2 and 3) of effective and smooth transmission of stresses due to pressure loads and concentrated loads (mast, keel, rudder, etc) from the load point into the supporting structure (see 6.3 and 6.4).

6.1.3 Longitudinally framed boat

In the example in Figure 1, the hull shell is stiffened by longitudinal secondary stiffeners supported by transverse primary stiffeners, such as web frames, bulkheads and deep floors. The example given is typical for an FRP boat.

6.1.4 Transversally framed boat

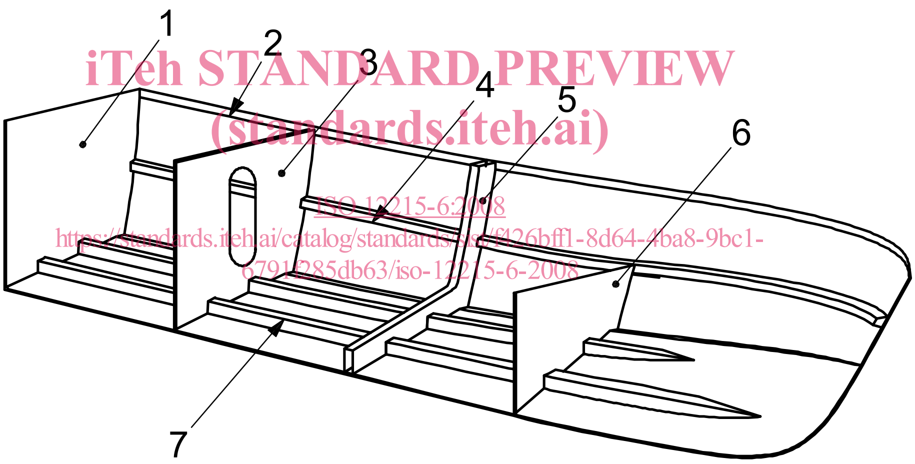
In the example in Figure 2, the hull shell is stiffened by transverse frames (secondary stiffeners) that are typically supported at the centreline, at the chines or turn of bilge and at deck level. In larger boats, girders (primary stiffeners) may be fitted, which support these frames and also assist in carrying hull girder loads.

6.1.5 Small, slow boat stiffened by keel, gunwale stringer, structural sole and thwarts

It is common for small craft (i.e. those of hull length less than 6 m) to have no specific stiffeners. However, components not primarily intended to be stiffeners, such as internal partitions may act as such. These components may need to be reinforced for this other role as “stiffeners”. In Figure 3, the thwarts, front and aft locker, cockpit sole and gunwale are used in this way.

6.1.6 Load bearing elements

To be considered as “load bearing”, the supporting member shall be effectively attached to the plating by any combination of welding (continuous or intermittent), bonding with structural quality adhesive (e.g. use of epoxy fillets) or fibre reinforced bonding angles or other methods appropriate to the materials. In addition, the member in question shall be constructed of material acceptable for hull construction in accordance with ISO 12215-5, and shall be able to carry the forces and moments associated with the effective support assumption as defined there.

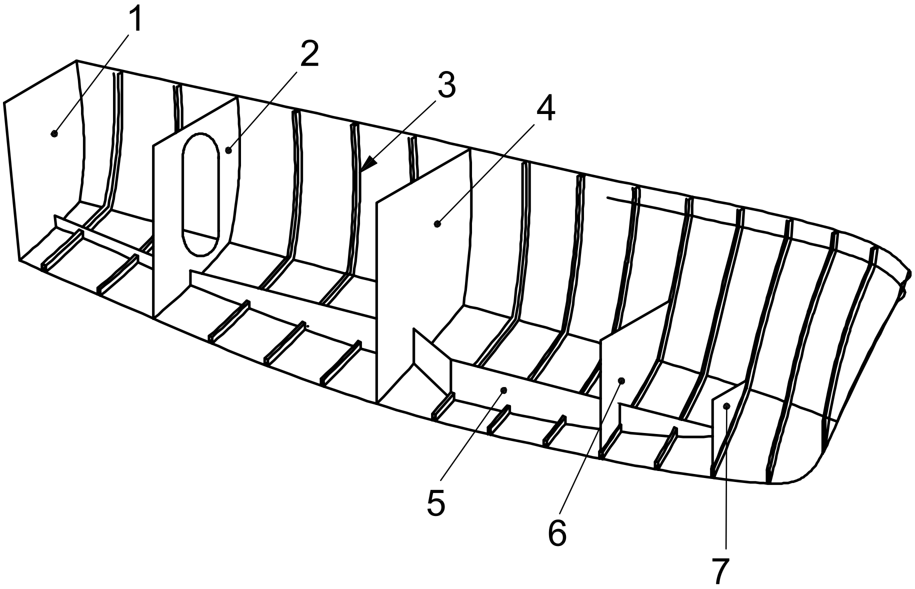


Key

1 transom
2 gunwale stringer
3 bulkhead
4 side longitudinal stiffener (stringer)
5 web frame
6 deep floor
7 bottom longitudinal stiffener (girder or stringer); good practice is to have ends in accordance with Figure 4 a) or 4 c)

NOTE 1, 3, 5 and 6 are primary stiffeners; 2, 4 and 7 are secondary stiffeners.

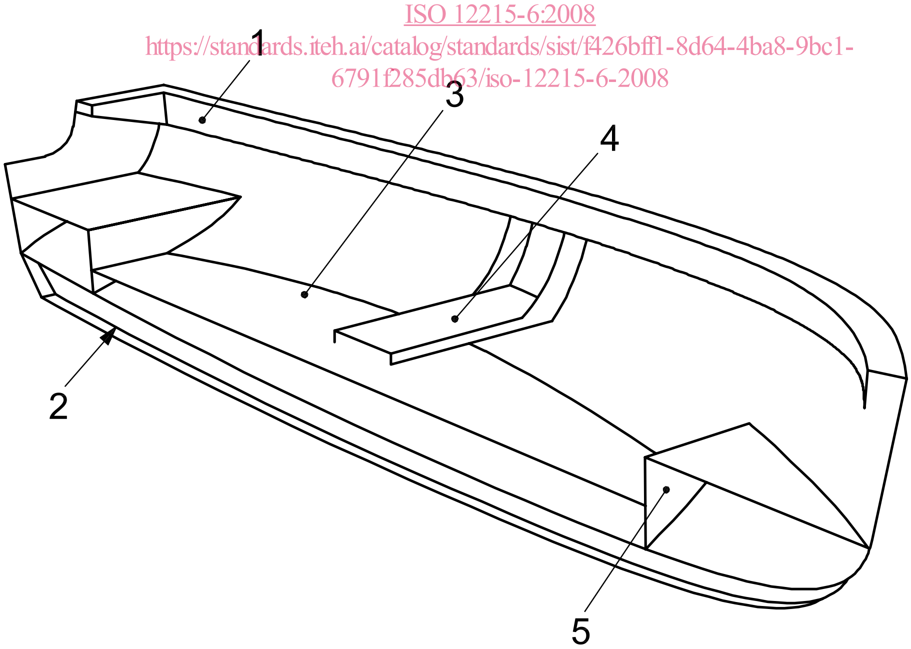
Figure 1 — Longitudinally framed boat



Key

1 transom
2 bulkhead
3 frame
4 bulkhead
5 bottom girder
6 deep floor
7 deep floor

Figure 2 — Transversally framed boat



Key

1 gunwale stringer
2 keel
3 structural sole
4 thwarts
5 deep floor

Figure 3 — Small, slow boat stiffened by keel, gunwale stringer, structural sole and thwarts

6.2 Hull girder strength

ISO 12215-5 is based on the assumption that hull and deck scantlings are governed by local loads, which is usually the case for craft of normal proportions and is especially so for longitudinally framed craft.

For the following craft, an explicit longitudinal strength and buckling assessment is recommended:

— transversely framed motor craft where $\frac{V_{\text{max}}}{\sqrt{L_{\text{WL}}}} > 6$;

— transversely framed sailboats experiencing large rig loads;

— craft with large deck openings or craft with $\frac{L_{\text{H}}}{D_{\text{max}}} > 12$.

Annex D gives recommendations for the assessments to be made.

6.3 Load transfer

6.3.1 General

The structural geometry shall be so arranged and detailed as to ensure a smooth transfer of loads throughout the structure. Concentrated loads (e.g. mast step for a keel stepped mast, mast pillar for a deck stepped mast) shall be transmitted into the surrounding structure by a series of stiff supporting members. In no case shall concentrated load points be landed on unsupported plating. In general, concentrated loads shall be introduced into the adjacent structural elements by shear load carrying brackets, flanges or floors. Knife edge load crossing shall be avoided (see 6.3.5).

6.3.2 gives examples of good practice load transfer arrangements. Other arrangements need to be specifically engineered.

6.3.2 Examples of good practice load transfer arrangements

The list below gives examples of good practice load transfer arrangements.

— Stiffeners (generally angle bar, tee section, top hats or flat bars, etc.) and girders (including engine girders) do not terminate abruptly, but are suitably terminated to develop their bending strength and shear strength at the supporting member, with brackets or without brackets, but with structurally effective attachment of web and flange to the supporting member (see Figure 4). Where stiffeners are lightly loaded, they may have tapered (sniped) ends, provided the slope of the taper is at least 30 % and that the plating between the end of the stiffener and the supporting structure is designed or able to transmit the shear force and bending moment of the tapered stiffener [see Figure 4 c)].

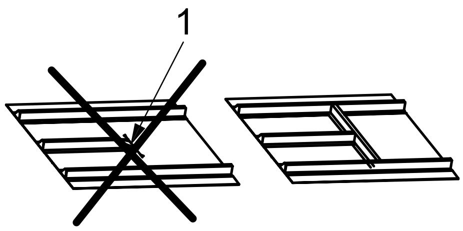
— Floors smoothly taper in depth towards that of the attached transverse frame. Where no transverse frames are fitted, the floor is attached to the side shell over a sufficient length to ensure that the shear force (due to keel moment or bottom pressure) can be adequately transferred to the side shell (see Figure 5). The ends of floors or transverse stiffeners for sailboat ballast keel are in accordance with the requirements of ISO 12215-9.

— Cut-outs and sharp corners are avoided in load-carrying structures such as shell, deck, primary and secondary stiffening members. Where cut-outs cannot be avoided, the depth of any cut-out does not exceed 50 % of the depth of the web of the member, and the length of the cut-out does not exceed 75 % of the depth of the web of the member, unless effectively engineered. Cut-outs shall have radius corners not less than 12 % of the cut-out depth or 30 mm, whichever is the greater. Cut-outs are avoided within 20 % of the span from the support points and by way of concentrated loads on the member.

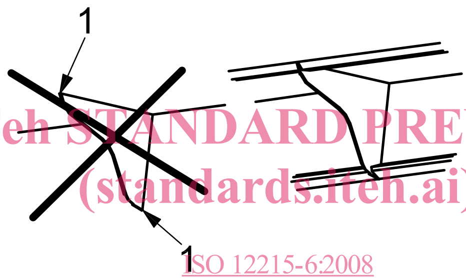
6.3.3 Openings in deck and shell according to good practise

Openings in decks and shell have radius corners not less than 12 % of the width of opening, but need not exceed 300 mm and are not less than 50 mm. This does not apply where the edges are reinforced by a structural flat bar or equivalent (see Figure 6).

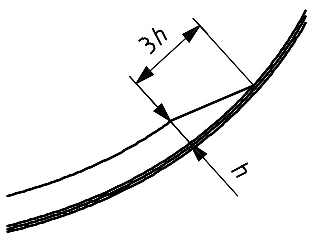
It is also good practice to minimize sharp cut-outs in structurally loaded panels and stiffeners, unless accordingly reinforced.



a) Stiffener ending in panel, poor practice and good practice solution



b) Bracket, poor practice and good practice solution



c) Tapered ends acceptable provided the vertical load can be taken by the shell

Key

1 risk of crack

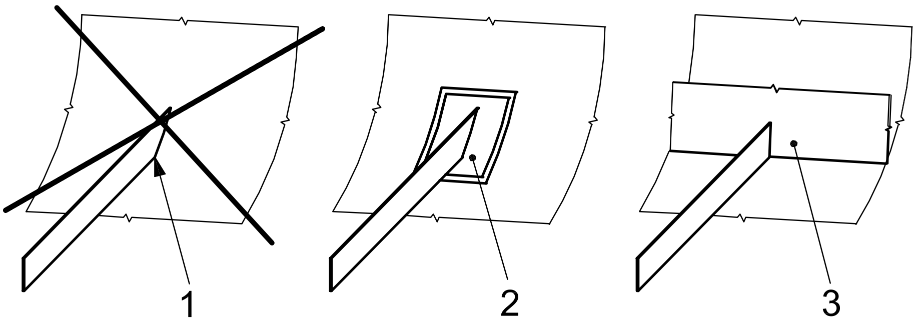
h height of stiffener

Figure 4 — Detail of stringer and bracket end

6.3.4 Floating frame systems

Floating frame systems (see Figure 7) are those where one set of stiffeners (the “floated” stiffeners) effectively sits on top of another set without being directly attached to the hull plating. Only the second set (the “attached” stiffener) is directly attached to the plating. When analysing such floating frames using ISO 12215-5, the effective plating of the floating frame is to be taken as zero.

For all materials, particular metal boats or wooden boats that use plywood frames, these “floating” frames are normally I beams “attached” to a T, L or U stringer. Attention shall be given to the strength of the weld or glued area between the “floating” frame and stringer, torsional (tripping) or shear buckling of the stringer and the frame transverse web and knife edge load crossing (see 6.3.5), which requires explicit calculation. By way of guidance, the weld or glue area shall generally not be less than the stiffener web area, A_W, given by ISO 12215-5:2008, Equation (48).



a) Stiffener ending in shell, poor practice and good practice

b) Deep floor/partial bulkhead

Key

1 hard spot, risk of crack, poor practice

2 reinforced plating, acceptable practice

3 transverse floor or bulkhead, good practice

4 no longitudinal structure at top end of deep floor, acceptable practice

5 cabin sole, deck or longitudinal stiffener on top of floor, good practice

Figure 5 — Detail of stiffener ending on the plating

