



Hull in Aluminium Alloys, Design Principles, Construction and Surveys



Hull in Aluminium Alloys, Design Principles, Construction and Survey

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**Rule Note
NR 561 DT R02 E**

Marine & Offshore
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**BUREAU
VERITAS**

MARINE & OFFSHORE - GENERAL CONDITIONS

1. INDEPENDENCY OF THE SOCIETY AND APPLICABLE TERMS

- 1.1. The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.
- 1.2. The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not, in any circumstances, involve monitoring or exhaustive verification.
- 1.3. The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of them above listed being relieved of any of their expressed or implied obligations as a result of the interventions of the Society.
- 1.4. The Services are carried out by the Society according to the applicable Rules and to the Bureau Veritas Code of Ethics. The Society only is qualified to apply and interpret its Rules.
- 1.5. The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.
- 1.6. Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the rules applicable at the time of the Services' performance and contract's execution.
- 1.7. The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

- 2.1. "Certificate(s)" means class certificates, attestations and reports following the Society's intervention. The Certificates are an appraisal given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules or to the documents of reference for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.
- 2.2. "Certification" means the activity of certification in application of national and international regulations or standards, in particular by delegation from different governments that can result in the issuance of a certificate.
- 2.3. "Classification" means the classification of a Unit that can result or not in the issuance of a class certificate with reference to the Rules.
- 2.4. "Client" means the Party and/or its representative requesting the Services.
- 2.5. "Conditions" means the terms and conditions set out in the present document.
- 2.6. "Industry Practice" means International Maritime and/or Offshore industry practices.
- 2.7. "Intellectual Property" means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.
- 2.8. "Parties" means the Society and Client together.
- 2.9. "Party" means the Society or the Client.
- 2.10. "Register" means the register published annually by the Society.
- 2.11. "Rules" means the Society's classification rules, guidance notes and other documents. The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.
- 2.12. "Services" means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.
- 2.13. "Society" means the classification society 'Bureau Veritas Marine & Offshore SAS', a company organized and existing under the laws of France, registered in Nanterre under the number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.
- 2.14. "Unit" means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

- 3.1. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

3.2. Subject to the Services performance and always by reference to the Rules, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enters the Unit's class in the Society's Register;
- survey the Unit periodically in service to note that the requirements for the maintenance of class are met. The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

- 4.1. The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit after surveys; (iii) present the Unit for surveys; and (iv) inform the Society in due course of any circumstances that may affect the given appraisal of the Unit or cause to modify the scope of the Services.
- 4.2. Certificates referring to the Society's Rules are only valid if issued by the Society.
- 4.3. The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

5. ACCESS AND SAFETY

- 5.1. The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawings, etc. required for the performance of the Services must be made available in due time.
- 5.2. The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

- 6.1. The provision of the Services by the Society, whether complete or not, involve, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.
- 6.2. Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold certificates and other documents and/or to suspend or revoke the validity of certificates.
- 6.3. In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to solve the dispute.

7. LIABILITY

- 7.1. The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:
 - Indirect or consequential loss;
 - Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

- 7.2. In any case, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cents (150%) of the price paid by the Client to the Society for the performance of the Services. This limit applies regardless of fault by the Society, including breach of contract, breach of warranty, tort, strict liability, breach of statute.
- 7.3. All claims shall be presented to the Society in writing within three (3) months of the Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

- 8.1. The Client agrees to release, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services except for those claims caused solely and completely by the negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

- 9.1. The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2. In such a case, the class granted to the concerned Unit and the previously issued certificates shall remain valid until the date of effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.

10. FORCE MAJEURE

10.1. Neither Party shall be responsible for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2. For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts

11. CONFIDENTIALITY

11.1. The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:

- is already known by the receiving Party from another source and is properly and lawfully in the possession of the receiving Party prior to the date that it is disclosed;
- is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
- is acquired independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).

11.2. The Society and the Client shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3. Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4. The Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

- 12.1. Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.
- 12.2. The Intellectual Property developed for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain exclusive property of the Society.

13. ASSIGNMENT

- 13.1. The contract resulting from these Conditions cannot be assigned or transferred by any means by a Party to a third party without the prior written consent of the other Party.
- 13.2. The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1. Invalidity of one or more provisions does not affect the remaining provisions.

14.2. Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3. In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

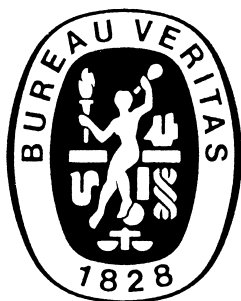
15.1. The Conditions shall be construed and governed by the laws of England and Wales.

15.2. The Society and the Client shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a written notice of such a dispute.

15.3. Failing that, the dispute shall finally be settled by arbitration under the LCIA rules, which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be London (UK).

16. PROFESSIONAL ETHICS

- 16.1. Each Party shall conduct all activities in compliance with all laws, statutes, rules, and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption. Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.
- 16.2. In addition, the Client shall act consistently with the Society's Code of Ethics of Bureau Veritas, <http://www.bureauveritas.com/home/about-us/ethics-and-compliance>



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SECTION 1

GENERAL REQUIREMENTS

1 General

1.1 Application

1.1.1 General scope of application

The requirements of this Rule Note are applicable to ships having their hull and superstructure totally made of aluminium alloy.

The purpose of this Rule Note is to define the general requirements for hull scantling and arrangements, with respect to:

- material
- hull structure and welding calculation approach
- classification and /or certification process.

1.1.2 Other applicable Rules

The requirements of this Rule Note apply in addition to the following Society Rules for the classification and/or certification of ships, in particular the requirements concerning:

- a) Classification:
 - NR467, Part A: Rules for the Classification of Steel Ships, Classification and Surveys
- b) Loading cases, permissible stresses and/or safety coefficients, as applicable:
 - NR600: Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m
 - NR500: Rules for the Classification and the Certification of Yachts.
- c) Subdivision, compartment and access arrangements and arrangement of hull openings, as applicable:
 - NR600: Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m, or
 - NR566: Hull arrangement, Stability and Systems for Ships less than 500 GT
 - NR500: Rules for the Classification and the Certification of Yachts.

Other Rule Notes may be considered by the Society on a case by case basis in accordance with the service notations and additional service features considered for the classification (see NR467, Part A).

1.1.3 Structural scopes not covered by Rules

The following structural aspects are not covered by the present Rules:

- structure deflection under loads
- structural response to vibrations induced by engines, propeller blades or water jet.

The scantling of superstructures built in aluminium alloy and fitted on board a steel ship are to be checked according to NR467 Rules for Steel Ships.

1.2 Exceptions

1.2.1 Ships with unusual design, speed or service, or intended to carry special cargoes not provided by the Rules, are examined on a case-by-case basis.

1.3 Drawings and documents to be submitted

1.3.1 As a rule, the drawings and documents to be submitted for hull structure review are listed in the Society Rules for the classification and/or certification of ships (see [1.1.2]).

Weld and welding booklets as requested in Sec 3, [1.2] are also to be submitted for review.

1.3.2 Builder's quality systems checking the general production fabrication and process are to be submitted for review (see Sec 9).

1.4 Working process and inspection at works

1.4.1 Inspections needed by the Society during ship hull construction within the scope of the classification and/or certification of ships built in unit production or in mass production are defined in Sec 9.

SECTION 2 MATERIALS

Symbols

- E : Young’s modulus of aluminium, equal to 70000 N/mm²
- v : Poisson ratio of aluminium, equal to 0,33
- R_m : Tensile strength, in N/mm², of the parent metal in delivery condition, as specified
- R_{p0,2} : Proof stress (yield strength), in N/mm², of the parent metal in delivery condition, as specified
- R’_m : Tensile strength, in N/mm², of the parent metal in as-welded condition, as defined in [2.1.3] or [2.1.4]
- R’_{p0,2} : Proof stress (yield strength), in N/mm², of the parent metal in as-welded condition, as defined in Article [2].

1 General

1.1 Application

1.1.1 As a rule, the aluminium alloys used for the construction of aluminium ships are as follows:

- For rolled or extruded products:
 - series 5000: aluminium-magnesium alloy
 - series 6000: aluminium-magnesium-silicon alloy
- For cast products:
 - aluminium-magnesium alloy
 - aluminium-silicon alloy
 - aluminium-magnesium-silicon alloy.

In the early stages of the project, the shipyard is to submit to the Society the characteristics of the materials they intend to use for the construction of the hull and of the structures. In particular, the temper of parent metal is to be indicated.

1.1.2 Manufacture, inspection and certification

The general requirements relevant to the manufacture, inspection and certification of aluminium alloy products entering in the hull construction are given in NR216 Rules on Materials and Welding for the Classification of Marine Units.

1.1.3 Aluminium alloy characteristics

The characteristics of aluminium alloy to be used in the construction are to comply with the applicable requirements of NR216 Materials and Welding, Ch 3, Sec 2.

Materials with different characteristics may be considered provided their specification (manufacture, chemical composition, mechanical properties, welding, etc.) is submitted to the Society for approval.

1.1.4 In the case of structures subjected to low service temperatures or intended for other specific applications, the alloys to be employed are to be agreed by the Society.

2 Aluminium structure

2.1 Influence of welding on mechanical characteristics

2.1.1 Welding heat input lowers locally the mechanical characteristics R_{p0,2} and R_m of aluminium alloys hardened by work hardening (series 5000 other than condition O) or by heat treatment (series 6000).

2.1.2 Consequently, where necessary, a drop in the mechanical characteristics of welded structures, with respect to those of the parent material, is to be considered for the structure calculation.

As a general rule, the heat affected zone (HAZ) is to be taken extending over 25 mm on each side of the weld axis.

2.1.3 Aluminium alloys of series 5000 (rolled and extruded)

Aluminium alloys of series 5000 in O condition (annealed) are not subject to a drop in mechanical strength in the welded areas.

Aluminium alloys of series 5000 other than condition O are subject to a drop in mechanical strength in the welded areas. The mechanical characteristics to be considered are normally those of condition O.

Note 1: Higher mechanical characteristics may be taken into account, provided they are duly justified.

2.1.4 Aluminium alloys of series 6000

Aluminium alloys of series 6000 are subject to a drop in mechanical strength in the vicinity of the welded areas.

The mechanical characteristics to be considered in this HAZ are normally indicated by the supplier.

When no information is provided by the supplier, the values given in Tab 1 may be used.

Note 1: Higher mechanical characteristics may be taken into account, provided they are duly justified.

2.1.5 Hardened aluminium alloys

For welded constructions in hardened aluminium alloys (series 5000 other than condition O and series 6000), higher characteristics than those in welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or as-welded condition.

2.1.6 Young’s modulus and Poisson ratio

Unless otherwise specified, the Young’s modulus and the Poisson ratio are to be taken, for aluminium alloy, respectively equal to 70000 N/mm² and 0,33.

Table 1 : Aluminium alloys
As welded mechanical characteristics

Aluminium alloy	Temper condition	R'p0,2	R'm
5000 series	0	Rp0,2	Rm
5000 series	other	values of 0 condition	
6005 A (open sections)	T5 or T6	0,45 Rp0,2	0,6 Rm
6005 A (closed sections)	T5 or T6	0,50 Rp0,2	0,6 Rm
6060 (sections) (1)	T5	0,43 Rp0,2	0,5 Rm
6061 (sections)	T6	0,53 Rp0,2	0,6 Rm
6082 (sections)	T6	0,45 Rp0,2	0,6 Rm
6106 (sections)	T5	0,33 Rp0,2	0,54 Rm
(1) 6060 alloy is not to be used for structural members sustaining dynamic loads (slamming and impact loads). The use of 6106 alloy is recommended in that case.			

2.2 Extruded plating

2.2.1 Extrusions with built-in plating and stiffeners, referred to as extruded plating, may be used.

In general, the application is limited to decks, bulkheads, superstructures and deckhouses. Other uses may be considered by the Society, on a case-by-case basis.

2.2.2 Extruded plating is preferably to be oriented so that the stiffeners are parallel to the direction of main stresses.

2.2.3 The structure continuity of plates and stiffeners is to be ensured in way of weld end extruded panels. The end weld preparation and joints of extruded plating ends are to be submitted for examination.

The crossing of extruded plating stiffeners with transverse primary structure is to be submitted for examination, in particular the connection of the secondary stiffeners to the primary web transverse, and the connection of the primary web transverse to the extruded plating.

2.3 Minimum yield stress for scantling criteria of hull structure

2.3.1 The minimum yield stress of aluminium Ry, in N/mm², used for the scantling criteria of the hull structure is to be taken, unless otherwise specified, equal to:

Ry = R'lim

where:

R'lim : Minimum yield stress of the aluminium alloys considered, to be taken equal to the minimum value, in welded condition, between R'p0,2 (proof stress) and 0,7 R'm (tensile strength).

2.4 Material factor k

2.4.1 To take into account the minimum yield stress of the aluminium alloy in welded condition, the material factor k used in the scantling formulae is to be taken equal to:

k = 100 / R'lim

2.4.2 In the case of welding of two different aluminium alloys, the material factor k to be considered for the scantlings is the greater material factor of the aluminium alloys of the assembly.

2.5 Aluminium properties

2.5.1 Mechanical properties of aluminium alloys are to comply with the applicable requirements of NR216 Materials and Welding.

For information only, these properties are reminded in App 1.

SECTION 3

JOINT DESIGN, WELD AND RIVETING SCANTLING

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the scantling and joint design of welded connections or riveting connections in aluminium alloy hull structures.

Other equivalent standards may be accepted by the Society, on a case-by-case basis.

Note 1: Welding processes and inspection are dealt with in Sec 9.

1.1.2 Welding of various types of aluminium alloys is to be carried out by means of welding procedures approved for the purpose.

1.1.3 The requirements of this Section apply also to heterogeneous connection of aluminium alloy members with steel members by riveting, bi-metallic transition joints or other means.

1.1.4 Weld connections are to be executed according to:

- the approved hull construction plans, and
- the weld and welding booklets submitted to the Society.

Any details not specifically represented in the plans are, in any case, to comply with the applicable requirements of the Society.

1.1.5 The method used to prepare the parts to be welded is left to the discretion of each shipbuilder, according to its own technology and experience.

These methods are to be reviewed during the qualification of welding procedure, as defined in [1.2.2].

1.2 Weld and welding booklets

1.2.1 Weld booklet

A weld booklet, including the weld scantling such as throat thickness, pitch, design of joints, is to be submitted to the Society for examination.

The weld booklet is not required if the structure drawings submitted to the Society contain the necessary relevant data defining the weld scantling.

1.2.2 Welding booklet

A welding booklet including the welding procedures and the criteria for the acceptance of weld imperfections is to be submitted to the Surveyor for examination (see Sec 9).

2 Scantling of welds

2.1 Butt welds

2.1.1 As a rule, butt welding is to be used for plate and stiffener butts and is mandatory for heavily stressed butts such as those of the bottom, keel, side shell, sheerstrake and strength deck plating, and bulkheads (in particular bulkheads located in areas where vibrations occur).

2.1.2 All structural butt joints are to be full penetration welds completed by a backing run weld.

2.2 Butt welds on permanent backing

2.2.1 Butt weld on permanent backing may be accepted where a backing run is not feasible.

In this case, the type of bevel and the gap between the members to be assembled are to be such as to ensure a proper penetration of the weld on its backing.

2.3 Fillet welds in a lap joint

2.3.1 Fillet weld in a lap joint may be used only for members submitted to moderate stresses, taking into account the throat thicknesses as defined in Fig 1 or Fig 2.

Figure 1 : Fillet weld in lap joint

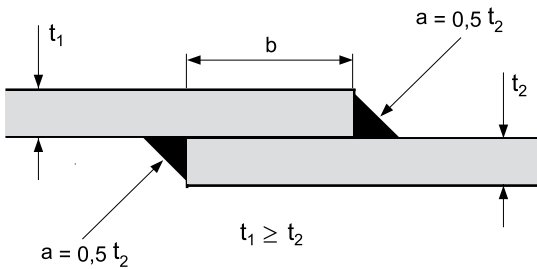
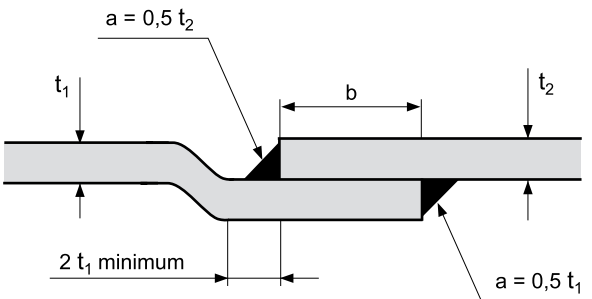


Figure 2 : Fillet weld in joggled lap joint



2.3.2 The width b , in mm, of overlapping is to be such that:
 $b \geq 1,5 (t_1 + t_2) + 20$

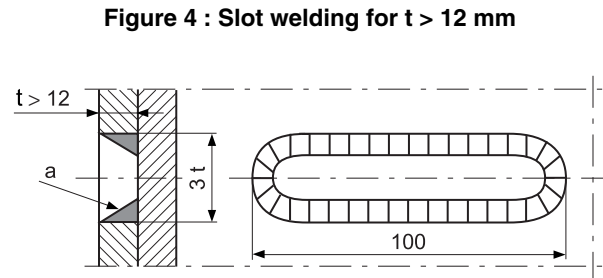
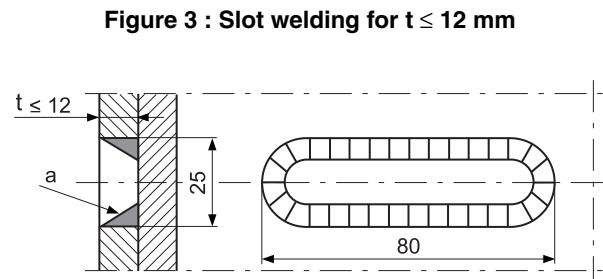
2.3.3 The ends are to be watertight, as far as practicable.

2.3.4 The weld closest to the shoulder may be intermittent except in liquid compartments and exposed areas.

2.4 Slot welds

2.4.1 Slot welding may be used where fillet welding is not possible. The shape is shown in Fig 3 and Fig 4, depending on the plate thickness.

Slot welds are to be, as far as practicable, parallel to the direction of main stresses.



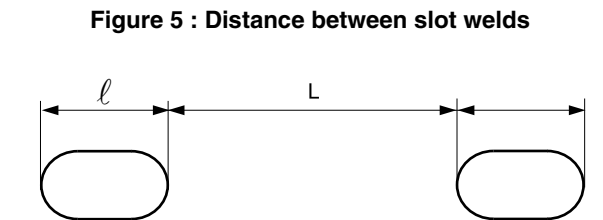
2.4.2 Slot welding is not to be completely filled by the weld, and the width of the opening is to be such as to allow easy fillet weld along its perimeter.

2.4.3 The distance L between extremities of two consecutive slot welds, as shown in Fig 5, is to be such that:

$$10 t \leq L \leq 200$$

where “ t ” is the plate thickness, in mm.

The maximum distance of L depends on the stresses of the members.



2.5 Plug welding

2.5.1 Plug welding is to be used exceptionally, as a substitute to slot welding.

Plug welding is to be completely filled by the welding.

2.6 Fillet weld

2.6.1 Double continuous fillet weld location

As a general rule, double continuous fillet weld is to be required in the following locations, as appropriate:

- a) watertight and oiltight connections
- b) main engine and auxiliary machinery seatings
- c) bottom structure of high speed ship in way of jet room spaces
- d) structure in way of bilge keel, stabiliser, bow thruster, cranes, etc.
- e) bottom structure in the vicinity of propeller blade
- f) primary and secondary stiffeners in way of end supports (crosstie, pillars, brackets) and knees on a length extending over the depth of the stiffener and at least equal to 50 mm for:
 - web stiffener connection with the attached plating
 - flange stiffener with web of built-up stiffeners.

Note 1: Where direct calculation according to [2.6.4] or equivalent are carried out, discontinuous fillet weld may be considered on a case-by-case basis.

- g) secondary stiffeners of deck plating subjected to wheel loads.

Continuous fillet weld may also be adopted in lieu of intermittent welding wherever deemed suitable, and is recommended where the length p , defined according to [2.6.5], is low.

2.6.2 Intermittent fillet weld

Where intermittent fillet welds are provided in area subjected to high dynamic loads of vibrations, staggered welds may be accepted with overlap in compliance with Tab 2 case 2.

2.6.3 Efficient length of fillet weld

The efficient length, in mm, of the lines of welding is given by:

$$d_e = d - 20$$

where:

d : Actual length, in mm, of the line of welding.

Table 1 : Welding factor w_F for the various hull structural connections

Hull area	Connection			w _F (1)
	of	to		
General, unless otherwise specified in the Table	watertight plates	boundaries		0,35
	non-tight plates	boundaries		0,20
	strength decks	side shell		0,45
	webs of ordinary stiffeners	plating		0,13
		plating at ends (2)		0,20
		web of primary stiffener		see [2.7]
	web of primary stiffeners	plating and flange		0,20
		plating and flange at ends (2)		0,30 (3)
		bottom and inner bottom (in way of transversal and/or longitudinal bulkhead supported on tank top)		0,45
		deck (for cantilever deck beam)		0,45
		web of primary stiffeners		0,35 (3)
Structures located abaft 0,25 L from the fore end	ordinary stiffeners	bottom and side shell plating		0,20
	primary stiffeners	bottom, inner bottom and side shell plating		0,25
Structures located in bottom slamming area or in the first third of underside of cross deck of catamaran	ordinary stiffeners	bottom plating		0,20
	primary stiffeners	bottom plating		0,25
Machinery space	girders	bottom and inner bottom plating	in way of main engine foundations	0,45
			in way of seating of auxiliary machinery	0,35
			elsewhere	0,25
	floors (except in way of main engine foundations)	bottom and inner bottom plating	in way of seating of auxiliary machinery	0,35
			elsewhere	0,25
	floors in way of main engine foundations	bottom plating		0,35
		foundation plates		0,45
	floors	centre girder	single bottom	0,45
double bottom			0,25	
Superstructures and deckhouses	external bulkheads	deck		0,35
	internal bulkheads	deck		0,13
	ordinary stiffeners	external and internal bulkhead plating		0,13
Pillars	pillars	deck	pillars in compression	0,35
			pillars in tension	full penetration welding
Rudders	primary element directly connected to solid parts or rudder stock	solid part or rudder stock		0,45
	other webs	each other		0,20
	webs	plating	in general	0,20
			top and bottom plates of rudder plating	0,35

(1) For connections where w_F ≥ 0,35, continuous fillet welding is to be adopted. See also [2.6.1].

(2) See [2.6.1], f) .

(3) Full penetration welding may be required, depending on the structural design and loads.

2.6.4 Throat thickness of double continuous fillet weld

a) General:

The minimum throat thickness t_T of a double continuous fillet weld, in mm, is to be obtained from the following formula:

$t_T = w_F \cdot t$

where:

w_F : Welding factor for the various hull structural connections, defined in Tab 1

t : Actual thickness, in mm, of the thinner plate of the assembly.

b) Particular cases:

The throat thickness t_T may be increased when deemed necessary in high stress level areas.

In case of automatic welding with deep penetration, or in case of TIG welding, a reduction in the throat t_T may be accepted, subject to qualification of the welding procedure.

c) Specific requirements:

- The welding procedures and welders are to be specially qualified for welding having throat thickness less than 4 mm.
- The maximum throat thickness is not to be greater than 1,5 t to limit the welding energy content and to avoid the deterioration of the elements to weld.

2.6.5 Direct calculation of double continuous fillet weld

Where deemed necessary, the minimum throat thickness t_T of a double continuous fillet weld between stiffener web and associated plating and/or flange, in mm, may be determined as follows:

$t_T \geq \frac{T \cdot m}{2 \cdot I \cdot \tau}$

where:

T : Shear force, in N, in the considered section of the stiffener

I : Inertia, in mm⁴, of the stiffener

τ : Permissible shear stress, in N/mm², as defined in the Society Rules for the classification and/or certification of ships (see Sec 1, [1.1.2])

m : Value, in mm³, calculated as follows (see Fig 6):

- for weld between flange and web:
 $m = t_f \cdot b_f \cdot v_f$
- for weld between associated plate and web:
 $m = t_p \cdot b_p \cdot v_p$

2.6.6 Throat thickness of intermittent weld

The throat thickness t_{iT} , in mm, of intermittent welds is to be not less than:

$t_{iT} = t_T \frac{p}{d_e} \leq 1,5t$

where:

t_T : Throat, in mm, of the double continuous fillet weld, obtained as defined in [2.6.4] or [2.6.5]

p : Pitch, in mm, of the fillet welds positioned on the same side, measured as indicated in Tab 2

d_e : Efficient length, in mm, of the fillet welds, as defined in [2.6.3]

t : Actual thickness, in mm, of the thinner plate of the assembly.

Figure 6 : Direct calculation of double continuous fillet weld

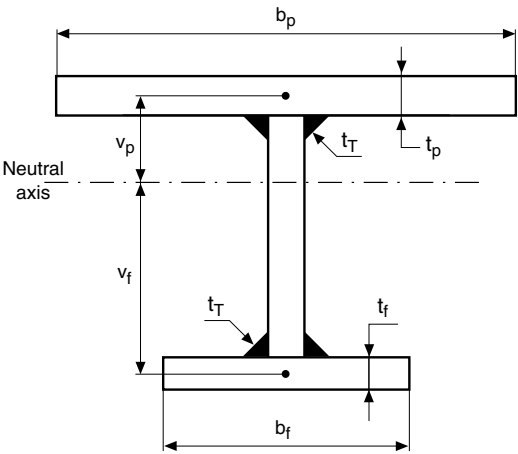


Table 2 : Pitch on intermittent fillet weld

Type of intermittent fillet weld	Pitch requirements
Case 1: Staggered welds 	$d \geq 75 \text{ mm}$ (1) $p \leq 3 d$
Case 2: Staggered welds subjected to dynamic loads 	$d \geq 75 \text{ mm}$ $r \geq 20 \text{ mm}$ $p \leq 3 d$
Case 3: Chain welds 	$d \geq 75 \text{ mm}$ $p - d \leq 200 \text{ mm}$
(1) To reduce deformations, it is recommended to choose the values of d according to the thickness.	