Tasneef®
Life Environmentally Optimized

Guide for Welding

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GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorized to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

(i) Rules for the Classification of Ships or other special units;
(ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
(iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
(iv) Guides to carry out particular activities connected with Services;
(v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules;
(ii) publishes the Register of Ships;
(iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
(i) in the selection of its Surveyors
(ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of the specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as part of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificate on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaworthiness,

structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certification or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any statutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the

right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.
In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the right to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorization of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of class, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.
Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's clients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.
In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

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GUIDE FOR WELDING

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Appendix **1**

CHAPTER 1 GENERAL

CHAPTER 2 TYPE OF CONNECTIONS AND PREPARATION

CHAPTER 3 SPECIFIC WELD CONNECTIONS

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CHAPTER 5 MODIFICATIONS AND REPAIRS DURING CONSTRUCTION - REPAIRS ON SHIPS IN SERVICE

CHAPTER 6 INSPECTIONS AND CHECKS

CHAPTER 1 GENERAL

1 Scope and field of application

1.1 Scope

1.1.1 The aim of this Guide is to provide indications for welding construction, modifications and repairs on new and existing ships.

It also intends to provide additional clarifications of the requirements set out in Part B, Ch 12, Sec 1, "Welding and weld connections" of the Rules for the classification of ships (hereafter referred to as the "Rules").

In this Guide reference has been made to IACS Rec. No. 47 "Ship building and Repair Quality Standard", the complete text of which has been introduced for ready reference in Appendix 1.

Provisions of equivalent recognised standards may be accepted at Tasneef's discretion.

1.2 Field of application

1.2.1 This Guide applies to welding construction, modifi-cations and repairs on new and existing ships.

2 Base material

2.1 General

2.1.1 In the case of steel plates, sections and bars, refer-ence is to be made to the requirements in Part D, Ch 2, Sec 1, [2] of the Rules.

In the case of aluminium alloys, reference is to be made to Part D, Ch 3, Sec 1 of the Rules.

The test certificates of materials are to be submitted to the Surveyor. Spot checks to verify the correspondence between certificates and material are, in general, performed by the Surveyor.

The Surveyor should verify, by means of checks, as deemed necessary, that the shipyard adopts adequate procedures to ensure that only material tested as required by the Rules is employed.

Moreover, it is to be ensured that plates are marked and identified as appropriate at the time of the supply to the workshop in order to avoid confusion between steel grades.

As far as surface conditions are concerned, the visual exam-ination performed after blasting may reveal surface imper-fections/defects which may not always be easily detected beforehand.

Minor imperfections within the limit of Appendix 1, IACS Rec. No. 47, Part A, Table 1, [4.3.2] are allowed and may be left unrepaired.

Rectification of defects by welding is to be made according to the requirements given in Part D, Ch 2, Sec 1, [2] of the Rules.

In the case of forgings and casting, the repair criteria are given in Part D, Ch. 2, Sec 3, [1] and Part D Ch. 2 Sec 4 [1] of the Rules.

3 Welding consumables and proce-dures

3.1 General

3.1.1 When welding higher strength steels to normal strength steels, due consideration is to be given to the use of welding procedures adequate to the higher strength steels (preheating etc) .

In the case of welding of stainless steels, the selection of consumables and base metals which can be welded is indi-cated in Part D, Ch.5, Sec 4, [3] of the Rules.

In the case of welding aluminium alloys, the selection is to be made on the basis of corrosion resistance and strength as indicated in Part D, Ch.5, Sec 4, [5] of the Rules.

The approved welding procedure specification (WPS) is to be accompanied by a certificate of approval or authorisa-tion for the use of the welding process giving limits and conditions for the application of the process as appropriate.

3.1.2 For higher strength steels and quenched and tem-pered steels, the welding consumables and/or processes may be required to be approved for the individual specifica-tion of the higher strength steel to be used. This depends on the properties of the steel and particularly applies in the case of special high heat input welding processes, such as one side submerged arc, electrogas and electroslag pro-cesses or, when specially required by Tasneef, for steels man-ufactured by thermo-mechanical controlled rolling processes.

4 Personnel and equipment

4.1 Welding operators

4.1.1 Personnel manning automatic equipment are to be fully aware of the operating conditions and parameters of the welding process employed; furthermore, depending on the applications such personnel may be required to be spe-cially certified by Tasneef.

4.2 Organisation

4.2.1 When welding activity is subcontracted, the shipyard organisation is responsible for the correct application of the requirements also as regards the subcontractors; to this end it is to perform the appropriate quality inspections.

4.3 NDE operators

4.3.1 procedures and the main standards, such as EN 473, ASNT- TC-1A are based on three levels of certifica-tion 1- 2 - 3 of increasing duties.

Certification equivalence between the various standards is to be examined on a case-by-case basis.

Only operators certified to at least level 2 may be authorised to interpret the results of tests performed.

Certificates of operators are to be available upon request.

In the case of particular applications, additional tests may be required with or without the attendance of the Surveyor.

4.4 Technical equipment and facilities

4.4.1

a) Calibration

Calibration of welding equipment is a normal duty; checks may be required in particular where the quality of the weld is very dependent upon the reliable setting of welding parameters (current, voltage, speed gas flow etc). It follows from this that while, in general, calibration is important for special (automatic and semiautomatic) welding processes, for manual metal arc welding the welders do not generally need the help of measuring instruments, unless there are specific requirements for heat input control essential for the properties of the welded joint (note that heat input control may also be carried out with the control of the run length).

Note 1: Heat input (Hi: energy input for unit length of weld in Joules/cm) applied during welding is given by the following formula:

$$Hi = \frac{V \times I \times 60}{s}$$

where:

V = voltage, in volts,

I = welding corrent, in ampères

s = welding speed in, cm/1'.

b) Heating equipment

The Manufacturer should submit to the Surveyor the list of heating equipment - torch, gas heaters, gas or electrical strip heaters - and the temperature control and recording devices.

The list of drying ovens and equipment is to include at least:

- facilities for the storage of consumables at appropriate temperature and humidity (humidity lower than 40%, temperature not less than 10°C (recommended 15°C)
- ovens for drying and for the conservation of fluxes and electrodes at the required temperatures, portable heating equipment for electrodes etc
- ·provisions for handling and conservation of consumables are given in [4.2.2].

5 Documentation to be submitted

5.1 General

5.1.1 It is recommended that in addition to the plans of shell and main decks, the plans of other main parts indicate the structures for which grades of steels higher than grade A /AH are fitted.

In particular for structures made of higher strength steel, the plans should provide indications relative to specific working conditions, welding processes used and preheating, where employed.

As far as welding procedures and details are concerned, the information relevant to welding details and welding specification should be usefully collected in a welding book, which should then be submitted to the Surveyor for his ready reference.

Each type of welding represented in the welding book is to contain the reference to the welding procedure specification (WPS) applied and to the relevant procedure qualification report (PQR).

The welding book enables the Surveyor to:

a) identify each important weld with edge preparation, process, welding parameter treatments and controls (WPS)

b) identify the need for a welding procedure qualification test (WPQT) to be performed in order to cover the types of welds proposed

c) identify problems that may arise in the execution

d) verify whether the proposed welds will conform to the design requirements or to the Rules before execution.

The welding book, when required, is to be submitted by the Manufacturer to the local office for review.

As a rule, the welding book should be submitted at least in the following cases:

- normal strength steels for thicknesses > 30 mm
- high strength hull steels with yield strength up to 390N/mm^2 or equivalent for thickness > 15 mm
- high strength steels with yield strength > 390 N/mm^2 for all thicknesses.

The fillet welds are quoted by their throat thickness or by the leg length of the weld fillet.

The type of quoting is to be clearly understandable in the drawings.

5.1.2 Mention of the alterations made to the approved plans, if relevant together with the reasons, will be made by the Surveyor in the final report.

6 Design considerations

6.1 General

6.1.1 Some typical occurrences and relevant provisions are listed in the following items a) to e).

a) Crossing of welded joints

Unless otherwise agreed with in special cases, stiffening members of shell and deck plating (frames, beams and longitudinals) or more in general structuram-embers welded to plating, where crossing a butt-joint of that plating, are to be provided with scallops in way of welded joints of the plating; alternatively, welding sequences and procedures are to be adopted such as to ensure the proper execution and adequate continuity of the welded joint of the plating to the satisfaction of the Surveyor. Similar scallops are generally to be provided in way of the ends of butt-joints of stiffening members (frames, beams or longitudinals.

In the case of members connected by T- or corner joints, suitable means are to be adopted to ensure the possibility of welding with continuity and soundness the butt-joint of each of the said members at the point of crossing/meeting of the T/corner joint assembling the two members.

Wherever possible, therefore, slots of sufficient radius (preferably circular and, in any case, with rounded edges) are to be provided at such points. Where this is not practicable, a suggestion is to:

- to chamfer (at least locally) at the T/corner connection, the member representing the web
- to weld first the butt-joint in the web-member (the back welding would be easier at the crossing point due to the presence of the chamfer in the web edge)
- to complete the T/corner connection in way of the crossing by a local full penetration T weld.

In the case of butt-joints between composite elements of structures having a T or double T section, when the slots (mentioned above) at the ends of the butt-joint representing the web element are not practicable, the joint of the web element should be staggered with respect to the joints of the face element and an adequate welding sequence followed (longitudinal seam as the last).

b) Weld interferences

It is always recommended and in the case of highly stressed structures or items of outfitting (for instance, with connections for cargo handling attachments) it may be required that interference should be avoided between two welds of reasonable size (i.e., one weld should not be deposited over the other).

c) Connection of structural members

The floor webs are to be welded with a T-joint to the continuous longitudinal bottom girder.

In ships not fitted with a double bottom, the continuous face plate of such girders is generally to overlap the face plate of the floors and be welded to it by fillet welds; when face plates of floors and girders are arranged on the same plane, their connections are to be by butt-joints, back welded on the reverse side. Brackets and diamond plates may be required in such cases.

The same requirements are applicable to the ordinary and primary supporting members of the deck.

Frames, vertical stiffeners and beams are generally to be welded to the associated plating by web, i.e. in case of angles not by lap welding the flange to the plating.

The size of welds is to be in accordance with the applicable requirements of Part B, Ch 12 of the Rules.

Connection of members to end brackets is to be in accordance with the applicable requirements of Part B of the Rules.

In the case of built-up members, the face plates are preferably to be continued over the edge of end brackets and welded to form their face plates.

For single bottom ships, the floors are to be suitably connected at the end with the frame bracket; the detail of the welded connection between the flanges or face plates of the floor and the frame bracket is potentially critical; it is to be carefully designed and fabricated minimising notches.

d) Primary supporting members

For primary supporting members forming ring systems, it is recommended that face plates (rather than flanges) should be adopted to be carried over end brackets. The butts of the web and those of the face plates are to be staggered.

The detail of such crossing is potentially critical; therefore, in particular when flanged members are adopted, the details at the corners are to be carefully designed and fabricated minimising notches.

e) slots

Slots through floors and other primary supporting members for the passage of ordinary members such as beams and longitudinals are to be well rounded and of suitable shape; the ordinary members passing through such slots are to be welded to the primary members directly or by means of lugs or brackets as required (see Part B of the Rules).

6.2 Plate orientation

6.2.1 In order to ensure compliance with the requirement for orientation, for example, in the case of insert plates at the corner of openings, it may be necessary to adopt provisions for the identification of the direction of rolling after the inserts are cut from the original plates.

6.3 Overall arrangement

6.3.1 Particular consideration is to be given to the following items a) to h):

a) The overall arrangement and structural details of highly stressed parts (such as structures contributing to the longitudinal strength of the hull girder for an adequate extension about amidships - in general, for not less than 0,6 L amidships - and zones where structural discontinuities are present, such as the ends of superstructures) are to be designed so as to avoid structural notches. Particular attention is to be paid to the structures in the

upper part of the hull, likely to be exposed to low climatic temperatures.

b) The details of structures or outfitting items connected to the sheerstrake or strength deck are to be designed, fabricated and inspected so to avoid possible points of crack initiation.

c) It is recommended that bulwarks, as well as outfitting items for 0,6 L amidships, should not be welded directly to the sheerstrake.

d) Tapered plates at the ends of superstructures, when welded directly to the upper edge of the sheerstrake, are to be accurately faired and realised in compliance with (b) above.

e) The ends of longitudinal members welded to the shell and deck are to be properly faired and reasonably free from undercuts or other surface defects around the end of the weld; as an improvement, the adoption of a local length of full penetration weld may be considered in some cases.

f) Where members contributing to the longitudinal strength of the hull need to be wholly or partially interrupted or their continuity is established through transverse members by welds other than direct full penetration butt-welds, the details of such interruptions and the relevant fabrication procedure are to be approved.

g) The toes of the bracket ends should not be positioned on unstiffened plating.

h) At the ends of scallops, brackets and stiffeners, wrap around fillet welds should be used, with accurate shaping in order to avoid stress concentration.

In addition to the above-mentioned items the following is to be considered, in particular when higher strength steels are used in details subject to fatigue:

- intermittent fillet and scalloping are generally to be avoided
- fillet welds with concave profile reduce stress concentration at the weld toe and the risk of undercuts (of course the required fillet size is to be complied with)
- care is to be given to the execution of small attachments and fittings which are required to be welded with adequate preheat and heat input; large diameter electrodes providing adequate heat input may be suitable.

6.4 Distances between welds

6.4.1 It is recommended that welds running close and parallel or almost parallel should be kept a sufficient distance apart depending on dimension and thickness (generally not less than 200 mm, preferably 300 mm when both joints are butt-joints and not less than 80 mm when one of the welds is a fillet weld). For secondary members or small thicknesses, lower distances are acceptable. See also Appendix 1, IACS Rec. No. 47, Part A, Table 8.7.

6.5 Doublers

6.5.1 In the case of permitted doublers welded along the edges and having a width in relation to their thickness also requiring internal connection with the overlapped plating (see Part B Ch 12, [2] of the Rules), such connection will be made by means of slots welded all around (not filled with welding). See also Appendix 1, IACS Rec. No. 47, Part B, [6.3].

In lieu of doublers in way of openings, or at corners of openings in plating of primary importance, insert plates of a thickness suitably increased to compensate the opening are generally preferred (however, doublers may be preferred where the compensation requires insert plates having thickness in excess of 45 mm).

CHAPTER 2 TYPE OF CONNECTIONS AND PREPARATION

1 General

1.1

1.1.1 Indications as regards the appropriate geometry of the joint preparations, the surface standards of the cut edges, and the tolerances may be found in Appendix 1, IACS Rec. No. 47.

2 Butt welding

2.1 Plating

2.1.1 It is always recommended that X (double-V) edge preparations, when applied to butt-welds of primary plating, should be of the non-symmetrical type, namely with the depth of the two bevels equal to 2/3 and 1/3 of the thickness, respectively, the shallower bevel preferably having a wider enclosed angle (for instance 90° instead of 60°).

The side with the deeper bevel (with the enclosed angle 60°) should be welded first, so the back gouging at the root is facilitated by the wider enclosed angle of the bevel and a more balanced welding thereby results.

The side with the deeper bevel (with the enclosed angle 60°) should be welded first, so the back gouging at the root is facilitated by the wider enclosed angle of the bevel and a more balanced welding thereby results.

Preparations on one edge only (half-V and K preparations) are generally to be avoided due to their tendency to develop defects such as lack of fusion in the right edge.

For joints of minor importance when welding on the reverse side is impracticable, a single V edge preparation is to be adopted and the welding procedure is to be suitable to obtain a satisfactory full penetration at the root as agreed with the Surveyor.

When in particular cases the Y preparation is converted to X preparation by gouging the reverse side before re-welding, suitable non-destructive examinations are to be carried out to check the satisfactory mutual penetration of the passes.

In the case of butt-joints of particular importance and/or of considerable thickness, it is recommended and may be required that the joint should be provided with extensions, so that the welding may be started and ended beyond the actual joint; such extensions are then to be suitably removed.

2.2 Root gap

2.2.1 Where the gap between the edges of two parts to be welded exceeds the limits of normal good welding practice for the specific type of joint, welding process and welding position, suitable corrective measures are to be adopted to avoid the creation of excessive residual stresses (see 5.2.1).

2.3 Butt welding on permanent backing

2.3.1 This type of joint is in general to be avoided on the strength deck.

2.4 Sections, bulbs and flat bars

2.4.1

The edge preparation of abutted sections (i.e. angles and bulbs) is to be suitable so as to attain even in the zone of variable thickness and at the ends of the joint the full penetration and soundness of the weld.

Particular care is required for the welding of butt-joints of ordinary members having an L section, due to the difficult access for chipping at the inside of the L-angle; it may be convenient, when the joint is accessible from both sides, to resort to an X edge preparation and weld from the inside first; the joint is then to be completed by root gouging and welding from the outside.

Where the L sections are already welded to the plating, with consequent restricted accessibility to the inside of the angle, it may be convenient to use a single-V edge preparation with a backing strip on the inside of the angle; the bevel should preferably be without root face and, in any case, the gap sufficient to ensure complete penetration.

In general, in the case of butt-welds of L- or T-angles or bulb plates, a hole or suitably shaped scallop should be provided, whenever possible, in the web - flange (or bulb) fairing zone, in order to avoid welding difficulties at such locations (where possible, such joints may be combined with end brackets).

Depending on the importance of the members in the case of butt-joints of bulb angles or small flat bars (i.e. of a depth up to 100 mm), suitable doublers fitted as shown in Figures 1, 2 and 3 may be required in way of the joint.

The cross-sectional area of the doubler in way of the joint should not be less than about 75% of the cross-sectional area of the flat bar, face plate, flange or bulb joined; in the case of bulbs, to avoid welding difficulties in the area of the bulb, the latter may be suitably tapered in way of the joint and the butt-joint restricted to the web (see Figure 2).

Figure 1

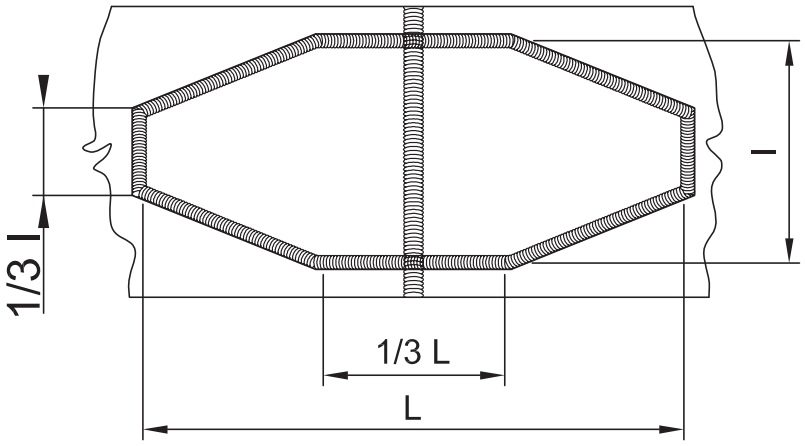


Figure 2

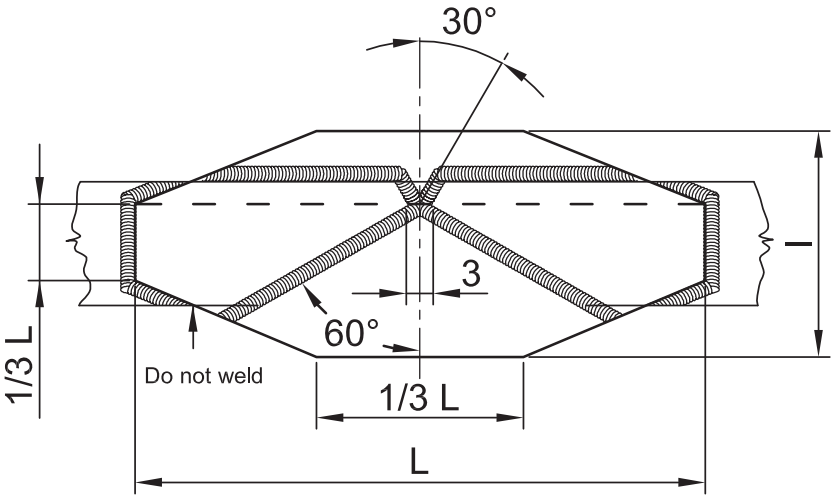
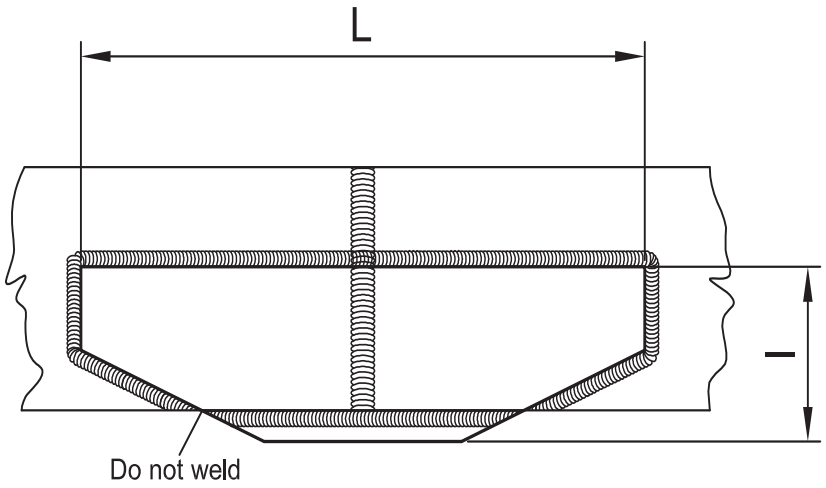


Figure 3



In the case of T-sections that are composite by welding, the butt-joints of the web and face plate are to be preferably staggered and a scallop provided at the end of the web joint; doublers are generally not required.

3 Fillet welding

3.1 Size requirements for deep penetration welding

3.1.1 Deep penetration means important fusion of the parent metal, particularly in automatic and semiautomatic welding.

Deep penetration is measured, and is to be found satisfactory, during the welding procedure qualification tests (see Part D, Ch 5, Sec 4, [2.3] of the Rules).

During the procedure tests, it is to be demonstrated that, due to the greater penetration, the proposed process and welding conditions systematically produce a fillet weld having a throat thickness not less than 0,7 times the normal leg length required for manual welding.

The Surveyor may require a check of the regularity of deep penetration fillet welding on macrographic sections made on production check samples.

4 Partial and full T penetration welding

4.1 General

4.1.1 The use of partial/full penetration T welds is generally required for members over 12 mm thick constituting the whole or part of engine seating.

In any case, partial penetration T-joints are subject to acceptance by , as detailed in the relevant approved drawings.

The use of a bevelled edge may also be necessary in specific cases where the web and face plate forming the T are inclined (in general, at an angle of 90° ± 20°).

As a rule, welding on a bevelled edge is to be continuous and back welded on the reverse side, except when welding on one side only is permitted, as in the event of inaccessibility.

4.2 Lamellar tearing

4.2.1 To prevent or minimise the phenomenon, it is advisable in critical cases to take adequate precautions concerning the quality of the steel employed (Z quality type as per Part D, Ch.2, Sec 1, [9] of the Rules) and/or use fabrication techniques suitable both to prevent cold cracking (such as preheating, sufficient heat input, and softening welding passes) and to reduce through thickness stresses (such as downhand welding with few and large passes and buttering, either as a preliminary operation or consequent to welding sequences).

With particularly susceptible base materials, this defect may also appear on thickness lower than 20 mm.

5 Lap-joint welding

5.1 General

5.1.1 The main application of lap welded joints is the connection of doublers.

Otherwise, lap welded joints may be permitted for structures of secondary importance (members subject to moderate stress).

In the case of structures contributing to the longitudinal strength of the hull, Tasneef may consider the acceptance of lap welded joints on a case-by-case basis.

For the above structures, as well as for doublers around openings in the shell and strength deck, the fillets are to be of the elongated type (leg length of the base approximately 1,5 times the other leg length) for a sufficient length of the periphery of the doublers in the fore-and-aft direction.

The fillet is to provide a sectional area equivalent either to the cross-sectional area of the joined elements or to the sectional area of the doublers.

In the case of doublers having a cross-sectional area considerably in excess of the area necessary to compensate the opening, the size of fillet welds may be based on the cross-sectional area of the plating lost as a consequence of the opening.

In specific instances this type of joint may be permitted for the seams of unstressed plating.

5.2 Gap

5.2.1 The surfaces of lap-joints are to be in sufficiently close contact; alignment is to be within 2 mm; for higher values up to 5 mm, weld leg length is to be increased by the same amount as the increase in the gap.

For higher values, members are to be realigned (see Appendix 1, IACS Rec. No. 47, Part A, Table 9.1).

5.3 Dimensions

5.3.1 General guidelines for lap welded connections provided that minimum applicable sizing is satisfied:

a) When the connection is subject mainly to shear stresses, the requirements for T connection apply in accordance with Part B, Ch 12, Sec 1, [2.3] of the Rules;

b) For connections of webs in primary members subject to bending stresses, the size and shape of fillet welds are established case by case. The fillet welds are to be made continuous on the edges of the overlapping elements, on both sides of the overlap. The leg length of the weld on the edge of the overlapping element is to be not greater than the thickness of the same element reduced by 0,5 - 1,0 mm.

c) For butts of members subject to tensile or compressive stresses along the edge transverse or inclined to the direction of the main stress, fillet welds having unequal leg lengths are preferably to be used, the greater leg being that deposited on the overlapped member; the minor leg length "l" of the fillet is generally to be as fol-

lows, depending on the thickness s of the thinner of the members to be joined:

- for t = 10 mm: l = t - 1 mm
- for t > 10 mm:l = t - 2 mm.

d) Welding along edges of doublers for compensation of openings.

The leg length of the fillet welds is in general to be not less than 0,65 times the thickness of the doubler.

Along the edges of doublers which are transverse to or form a certain angle with the fore-and-aft direction, fillet welds having unequal legs are to be used; in this case the value of 0,65 times the doubler thickness refers to the lesser leg length, i.e. to the leg on the side of the doubler's edge.

On the edges of both sides of doublers having two sides parallel to the fore-and-aft aft direction, fillet welds may be adopted having leg length equal to 50% of the doubler thickness but in no case less than 6 mm.

Fillet welds of a different size from that specified above and based on direct calculation of the area of weld (obtained by multiplying the length by the throat thick-ness) will be specially considered by Tasneef; in this regard, the length of the weld included as deemed appropriate in an angle between 90° and 120° to the fore-and-aft direction is to be considered.

6 Slot welding

6.1 General

6.1.1 Slot welding on immersed structures (such as that used to connect closing plates of rudder plating to internal rudder structures) is generally permitted provided the slots are not completely filled with deposited metal but only fillet welded around the slot; for this purpose, the edges of structural members to which the slotted plating is to be connected will be provided, where necessary, with a strip of suitable width, T-welded to the same edges.

6.2 Dimensions

6.2.1 If possible, the slots are to be aligned in the preferential direction of the stresses.

The size of the weld fillet to be deposited around the edge of the slot is to be determined in each case, depending also on the thicknesses of the parts to be connected.

Reference may also be made to shape and dimensions as shown in Appendix 1, IACS Rec. No. 47, Part A, Table 8.6.

Should the slots on the doublers be fitted in more than one row, they are preferably to be staggered. Unless otherwise specified in the individual cases, the slot welds are normally to be fitted so that the distance from the centre of the slots to the edge of the doubler, and from centre to centre of two adjacent slots, in any direction, is not greater than approximately 15 times the doubler thickness or 500 mm, whichever is the lesser.

7 Plug welding

7.1 General

7.1.1 Where possible, a slot is preferably to be adopted as an alternative to a plug.

If possible, the plugs are to be aligned in the preferential direction of the stresses.

7.1.2 In the case of plug welding of thick plates, it is preferable not to completely fill in the hole with filler metal. It can be filled in with polyester resin or neoprene type coating.

The shape and dimensions of plug welds are shown in Appendix 1, IACS Rec. No. 47, Part A, Table 8.6.

For thickness t > 25mm, the shape of the plug weld is to be specially agreed with Tasneef.

The distance L between two consecutive plug welds is to be not greater than a maximum which is to be defined on the basis of:

- the distance between two adjacent plug weld lines
- the importance of the stress
- the structure located below the plate.

CHAPTER 3 SPECIFIC WELD CONNECTIONS

1 Corner joint welding

1.1 General

1.1.1 Corner joints are, as a rule, not recommended. It is preferable to use the ordinary T-joints obtained by protruding one of the two elements beyond the edge of the other by an amount sufficient to accommodate a fillet weld on both sides of the joint.

When corner joints are accepted, it is advisable to adopt some increase in size for the inside fillet to compensate for possible deficiencies of the outside fillet due to inaccurate assembly.

1.1.2 In the case of structural arrangements where the inside corner is not accessible, full penetration welding on bevelled edges will be substituted for ordinary fillet welds.

However, in such cases the use of a single fillet joint may still be permitted, depending on the stresses and subject to strict assembly tolerances, to ensure the possibility of depositing an external fillet weld of adequate size.

CHAPTER 4 WORKMANSHIP

1 Forming of the plates

1.1 Cold forming

1.1.1 Cold bending, depending on bend radius, may produce severe and localised deformation in the bent area and due to the ageing effect, depending also on the grade of steel, may lead to a consistent diminution of impact properties.

The mandrel radius determines the deformation rate in the bend (therefore, the greatest possible radius should be adopted in order to distribute the steel deformation over the greatest area).

Guidance for the minimum bending radius that should be guaranteed by Manufacturers for structural steels is given in Table 1 for transverse (T) and longitudinal (L) bending, i.e. respectively parallel and longitudinal to the rolling direction.

Table 1 : Permissible bending radius (according to EN 10025 Standard)

Steel grade	Bending direction **(1)**	Minimum permissible bending radius for steel plates having thickness t (mm)								
		> 5 ≤ 6	> 6 ≤ 7	> 7 ≤ 8	> 8 ≤ 10	> 10 ≤ 12	> 12 ≤ 14	> 14 ≤ 16	> 16 ≤ 18	> 18 ≤ 20
Normal strength	T	10	12	16	20	25	28	32	40	45
	L	12	16	20	25	32	36	40	45	50
Higher strength	T	10	12	16	20	25	32	36	45	50
	L	12	16	20	25	32	36	40	50	63
(1) T = transverse; L = longitudinal										

Up to thickness 12 mm the bending radius is the same for normal and higher strength steels.

For thickness higher than 20 mm the minimum bending radius is defined on a case-by-case basis (in general 5 times the plate thickness).

In order to avoid the ageing effect (i.e. resulting sometimes in the event of heating after work hardening), it is recommended as far as possible that all welding should be avoided near the bent area (the distance between the bent area and any weld is to be at least 5 times the plate thickness); the use of killed and fine grain steel grade is also recommended and is required if welding on the bent zone cannot be avoided.

Welding on cold formed steel having permanent deformation greater than 5% should be evaluated on a case-by-case basis.

The permanent deformation (deformation of the outer fibre (A%)) is determined with the following formula: 50 t /Rm, where t is the thickness and Rm the radius at mid-thickness.

1.2 Hot forming and line heating

1.2.1 Hot forming may be used when cold forming cannot be performed (due to great thickness and/or small forming radius).

Particular attention is to be given to the hot forming temperatures and to the procedures for temperature control.

For line heating, indications on maximum heating temperatures on the plating surface are given in Appendix 1, IACS Rec. No. 47, Part A, Table 6.5.

2 Welding procedures and consumables

2.1 General

2.1.1 Indications relevant to the use of the manual welding process with covered electrodes, automatic welding processes, one side welding, and inert gas welding of alloys steels and aluminium alloys are given in [4.2.2] to [4.2.6].

2.2 Manual welding processes with electrodes

2.2.1

a) Type of consumables

Low hydrogen electrodes (basic coating) are required to be used among other applications, in particular on butt-joints on mild and low alloy carbon manganese steels.

Basic electrodes are used in Direct current electrode positive (DCEP) unless use also with alternating current is specified by the Manufacturer.

The basic electrodes are characterised by good impact properties at low temperatures and resistance to hot cracking.

Due to their hygroscopic coating, basic electrodes are very sensitive to moisture and must be properly stocked and, if applicable, dried before use.

Non-basic electrodes may be used when permitted by the Rules (see Part B, Ch 12, Sez 1, [1.3]).

In the case of welding of stainless steels which require good resistance to corrosion in service, careful finishing of welded surfaces is always required.

The ease in handling the electrodes plays an important role.

Such ease depends on the type of coating and decreases from rutile coating to rutile-basic coating to basic coating.

Rutile basic electrodes are, in general, used for welding stainless steels since they are not affected by the same metallurgical problems (cold cracks) as hull structural steels.

b) Storage and preservation conditions

The following provisions apply to the storage and conservation of electrodes.

Drying of low hydrogen electrodes at 300-350°C for at least 2 hours is generally required for welding of higher tensile steels and high thickness (>25 mm) unless electrodes are purchased in hermetically sealed containers.

Electrodes are to be dried before use if the hermetically sealed container shows evidence of damage.

The electrodes are then to be stocked in conservation ovens at 120-200°C; each welder is to be provided with portable heating equipment to maintain the electrodes at about 80°C.

Electrodes from their original containers may be used without particular treatment for welding normal structural steels (while for high strength steels, the stocking of the electrodes in conservation ovens at approximately 120-200°C is generally required).

The Manufacturers' instructions for drying of electrodes should be followed in all cases.

The handling of consumables and return of unused electrodes are to be supervised by the organisation of the Yard

c) Welding procedure

The type of current and amperage are to be appropriate to the particular electrode, size and welding position.

Electrodes are to be used according to the limits of size, welding position and welding conditions indicated at the time of their approval.

The back gouging at the root of the joint before back welding is to be well centred and extended, in general, for a depth of not less than 3 mm and, in any case, such as to reach sound metal. Suitable tools are to be used and the resulting bevel is to be well rounded and free of notches, in order to avoid any subsequent defects during back welding.

For the first pass of butt- and T-joints, where carried out other than in the flat and flat-horizontal position, electrodes of diameter of 3,25 mm are recommended; this size is compulsory for butt-joints welded with basic covered electrodes.

The completion of the joint is then made with larger electrode diameters and by weaving or straight technique depending on the position and in accordance with the procedure specification.

When weaving technique is adopted, it is recommended and may be required that the weave should not be wider than 4 times the diameter of the electrode; this prevents slag getting trapped in the weld and reduces the heat input

As a rule, welds in the vertical position are to be carried out upwards, except where electrodes specially approved for the downward technique are employed.

In particular, the downward technique may be used for circumferential joints of pipes with cellulosic electrodes specially approved for such technique.

2.3 Semiautomatic welding process

2.3.1 The semiautomatic welding process (i.e. the welder holds the gun through which the wire is fed automatically) is generally used under gas shield; in the case of particular flux cored wires, the shielding is assured directly by the flux and the gas may not be required.

CO_2 or Argon/CO_2 mixture is generally used as the shielding gas for mild and low alloy steels.

Depending on the welding parameters (ampere and volts), two welding techniques are used: short-circuiting or dip transfer (low voltage 18-22V and low current) and spray technique, which is used downhand due to the difficulties in controlling the weld pool in position welding.

The spray arc technique is characterised by high current density (in general >150A/mm^2).

The typical current range for short arc technique with 1,2 mm wire diameter is 100-180A.

Particular attention is to be paid to the possibility of welding defects, such as lack of fusion, especially when the joint is welded in a position other than flat with too low current.

One side welding may also be performed with semiautomatic gas metal arc welding; welders performing one side welding on refractory backing (ceramic) are, in general, to be certified for this particular technique.

2.4 Submerged arc welding

2.4.1

a) Type of consumables

The flux plays the same role of protection of the weld pool as the coating of the electrodes and, as for coated electrodes, fluxes may be basic, neutral or acid.

Fluxes are classified in two categories:

1) melted

2) agglomerated.

Melted fluxes generally have a vitrified shining appearance, are practically insensitive to humidity and may be kept without particular precautions in their original packages.

Agglomerated fluxes have the appearance of a granulated blend of bright colour; they are sensitive to humidity and must be kept in dry places.

b) Preservation

Drying of fluxes, unless otherwise indicated by the Manufacturer, is generally performed at a temperature of 300-400°C for agglomerated fluxes and 200-400°C for melted fluxes, for 2-10 hours.

c) Automatic welding

Submerged arc welding is generally used for welding on both sides with multi-run or two run technique; one side welding on back support is also used on panel lines.

Higher impact properties in butt-joints are more likely to be obtained with multi-run technique than with two run technique.

When two run technique is used, particular care is to be taken to ensure accurate fit up, with setting of correct welding parameters assuring penetration between the opposite passes without a burn through of the first one.

When the fit up is not accurate (gap higher than 0,5mm), proper repair may be allowed by manual welding to obtain good backing for the first pass.

The influence of the parameters on welding is given as a general indication in Table 2.

Table 2

Welding parameters	Increase	Decrease
Voltage V	to get a wider bead	to get higher penetration to avoid undercuts
Welding current I	to get higher penetration	to get a flatter bead to avoid undercuts
Welding speed v		to get higher penetration

d) One side welding

With one side automatic welding processes, edge preparations are to be within the tolerance limits stated in their approval, and back supports are to be carefully positioned and kept tight to the joint by appropriate means (compressed air tube, magnetic flask, etc.) such as to avoid breaking through or irregular shape on the back of the joint.

For one side technique and for the first pass in multi-run technique, where cracks are possible at the end of the joint due to the so-called "scissor effect", the weld should be stopped approximately 1 m before the end, then the crater defects removed, the bevel suitably prepared and the weld completed proceeding in the opposite direction; alternatively, it may be advisable to perform a preliminary manual weld of the final length of the joint in order to have a supplementary restraint.

Unless otherwise stated, initial and final lengths are generally to be submitted to systematic radiographic or ultrasonic examination for adequate repair of any defects.

e) Automatic welding processes; run-off pieces

Care is to be taken to avoid defects in the start and stop parts of the joint or in the case of restarts. To this end, at the ends of butt-joints, and in line with them, suitable pieces to start and end the weld outside the joint (having a thickness corresponding to that of the joint to be welded and a sufficient length, with respect to the welding procedure and parameters) should generally be fitted so the terminal crater may be brought well beyond the end of the joint.

The welding equipment is to be set in advance to the required parameters; only minor adjustments to achieve the required parameters should be performed, within the starting end piece.

In automatic submerged arc processes, when it is practically impossible to fit end pieces, as for instance in the case of circumferential joints of vessel shells, the welding equipment is to be preliminarily adjusted to the correct welding parameters before welding; the end run is to overlap as necessary the existing part and the crater and the overthickness are to be subsequently removed; this also applies, generally, to multiple-run welding.

2.5 Inert gas welding of stainless steels and aluminium alloys

2.5.1 When using inert gas processes for welding stainless steels and aluminium alloys, it is essential that the parts to be welded, including backing strips when used, and the wire are free of dirt or other substances in view of the deleterious effects on the soundness of the finished weld with respect to porosity. Welding surfaces are to be carefully cleaned with strong stainless steel brushes just prior to starting the welding; in general, the parts to be welded are to be subjected to an initial cleaning by means of suitable chemical agents (in particular in the case of aluminium alloys).

The surface of the welding wire is to have been suitably protected by the Manufacturer using special treatments and the wire is to be supplied under conditions such as to exclude the possibility of contact with foreign matter and mishandling; it is then to be properly stored so as to maintain such conditions.

In order to avoid the presence of oxide inclusions in the finished weld, butt-joints are to be carefully gouged out at the root using proper means before back welding; gouging may not be required, however, where a correct root pass is carried out, as may be the case when backing strips are used or when welding is satisfactorily performed with non-fusible electrodes (TIG).

The arc stops are to be performed by techniques aimed at filling the end crater.

Except for particular applications for which TIG welding (the non-fusible electrode process) is specially intended (such as the first pass of pipe welding), general preference is

to be given to MIG welding (the fusible continuous wire process); other than the aforesaid cases, TIG welding is suitable for joints which, due to their position and/or the complex shape and variable thickness of the pieces to be joined, are not suitable for the fusible continuous wire process.

2.6 Electroslag welding

2.6.1 In electroslag welding processes with consumable insert, the latter is to be centred with respect to the edges before the second sliding block is arranged.

Any accidental interruptions to welding are always be marked on the piece, which is to be subsequently subjected to suitable non-destructive examinations.

Where it is practically impossible to fit end pieces (e.g. butt-joints of web girders or vertical joints of shell plating), the welding equipment is to be adjusted to the correct welding parameters before welding. In such cases the initial and final lengths of the joint are to be carefully examined after welding and, if necessary, removed and properly restored with manual welding; in some cases systematic removal may be required. The same applies in the case of incidental restarts. Auxiliary pieces may be fitted at the ends of joints with particular procedures, and are then to be removed.

In the particular application of electroslag welding (ES process) for butt-joints of webs of longitudinals, care is to be taken in the execution of the last part of the joint in way of the horizontal element (e.g. in way of the deck or face plate joint); the applicable procedure, including the tests and examinations, is to be approved for the individual shipbuilders.

The welding techniques specified in the following items (a) and (b) were found suitable:

a)

- the vertical ES weld is stopped just below the horizontal element;
- the end of the joint is subsequently removed by a slot; and
- the welding of the horizontal element is completed by a local smooth groove, filled by welding and back re-welded.

b)

- the vertical ES weld process is continued above the thickness of the horizontal element by means of an auxiliary piece suitable to retain the molten metal exceeding the joint;
- the excess metal is removed down to the sound material;
- the length of the joint in way of the horizontal element is locally removed by a smooth groove; and
- the butt-joint of the horizontal element is then completed, filling the groove by welding and back re-welding as necessary, with the usual precautions.

In all cases adequate tests, to the satisfaction of Tasneef, are to be carried out at the facilities of the individual users; the production joints are then to be subjected to appropriate non-destructive examinations.

3 Welding operations

3.1 Weather conditions

3.1.1 When welding is performed in the open, it is advisable to dry welding edges by heating in the case of unfavourable weather conditions and in cold weather (below about 5°C) to avoid condensation.

See also the provisions for preheating in [4.3.8].

3.2 Butt connection edge preparation

3.2.1 The following methods of edge preparation may be adopted:

a) cutting by shearing

b) gas cutting (manual and mechanised)

c) plasma cutting

d) laser beam cutting

In the case of cutting by shearing, grinding of sheared edges is always recommended and may be required. It is to be verified that plate edges are free from cracks or flaws.

For gas and plasma arc cutting, recommendations relevant to the slope and roughness of cut edges and provisions for deviations are given in Appendix 1, IACS Rec. No. 47, Part A, [5.1].

All edges to be welded are to be visually inspected by the yard and at random by the Surveyor to detect possible defects, such as in particular:

a) oxycutting or grinding defects

b) cracks, laminations or segregations at mid-thickness.

When required, a check of the soundness of the edges is to be made by a penetrant or magnetic particle test (supplemented if necessary by an ultrasonic inspection in longitudinal waves).

As far as the bevel forms are concerned, typical edge preparations for ordinary manual welding and for automatic arc welding are given in Appendix 1, IACS Rec. No. 47.

Consideration is also to be given to the following:

- excessive gaps and angles are to be avoided (an excessive volume of deposited metal, consequent heating and shrinkage may be the cause of deformation and cracks)
- gaps and angles which are too closed may produce lack of penetration or cracking
- correct edge preparation has great influence on the success of the welding.

Therefore, the Surveyor will verify by checks as necessary that the Manufacturer employs adequate procedures to ensure correct execution.

3.3 Surface condition

3.3.1 Shot blasting is generally used for surface cleaning of the plates.

In the absence of a shot blasting machine, cleaning may be carried out by sandblasting or flame descaling followed by scrubbing using a rotative scrubber.

Particular care is to be taken to remove the rust by suitable means in the assembly for fillet T-joints.

Painting with protective primers should be usefully performed directly when plates are removed from the shot blasting machine.

Primers may contain components (e.g. zinc aluminium oxides) liable to cause defects, particularly porosity in welded joints. This is first checked in the approval of primers.

In particular, zinc primers are more likely to produce porosity than iron oxide primers.

The porosity in the weld depends on the gas developed by the primer due to the welding heat.

The possibility that gas has to escape from the welding pool is affected by different parameters such as joint configuration, welding process and heat input.

Porosity generally affects more fillet than butt-welding; in double fillet welding the second fillet is, in general, more sensitive to porosity.

High heat input, with consequent lower cooling rate, may as a rule be favourable giving gases the possibility to escape.

3.4 Assembling

3.4.1 Tack welds in way of bevels are to be avoided or, when permitted, are to be removed as the welding proceeds, unless the submerged arc welding process is used.

When tack welds are not removed they are to be performed with the same grades of consumables used for the welding of the joints, and deposited in sufficient length (i.e. at least 75mm) by qualified welders.

When not removed, tack welds are to be visually inspected for freedom from defects; when they are removed, the removal is not to damage the material.

Tack welds intended to be removed are preferably to be carried out with lower strength consumables, in particular in the case of high restraint conditions.

In the case of stainless steels, tack welding at closer spacing than for mild steel should generally be adopted.

Tacking by Tee welded auxiliary pieces bridging the joint and scalloped in way are in general preferably used and they should be arranged across the joint at 45° to its axis.

Their removal after welding is to be carried out by chipping or cutting without damaging the material surface; hammering is not permitted. The same applies to temporary lifting lugs or attachments.

For important structures the remaining plate surface should be ground smooth and is to be checked for freedom from defects.

Where post-weld heat treatment is applied, the removal of attachments and rectification of scars by welding are to be carried out before the heat treatment.

Adjustment of the various members during assembly is to be made properly such as to avoid inducing high stresses or damage.

The acceptance of butt-joints to be completed after assembling may be subject to the outcome of suitable non-destructive examinations.

3.5 Gap in fillet weld T connections

3.5.1 When the gap g is higher than the maximum allowed (up to 5 mm), the required leg length is to be increased to: leg length + (g-2mm). When the gap is higher than 5 mm, the repair provisions in [5.2.2] apply.

3.6 Plate misalignment in butt connections

3.6.1 When the misalignment exceeds the admitted tolerances, members are to be released and adjusted.

3.7 Misalignment in cruciform connections

3.7.1 The value of misalignment on cruciform joints of primary structures (strength members) should be limited to t/3 (where t is the minimum thickness of the abutting member).

3.8 Preheating and interpass temperature

3.8.1 Rapid cooling and shrinkage, due to condition of restraint, may cause cracks in the weld metal and cold cracks in the heat affected zone.

Cold cracks in the heat affected plate thickness mainly depend on:

a) cooling rate (heat input, thickness)

b) steel chemical composition (Ceq and max carbon content)

c) restraint conditions

d) diffusible hydrogen of the welding consumables and environmental conditions (moisture).

Preheating, retarding the cooling rate, reduces the risk of cracks in the heat affected zone and weld metal and promotes metallurgical structure less likely to have hard zones.

Moreover, by removing moisture from the plate surface it allows lower hydrogen content in the weld area, and by reducing the cooling rate after welding it allows better removal of hydrogen by diffusion.

In the welding of thick wall and/or complex and restrained components, in addition to proper preheat and interpass temperature, the following methods are advisable to prevent cold cracks:

- slow (or delayed) cooling after welding
- holding at 250 °C for a convenient time prior to cooling
- heat treatment immediately after welding without intermediate cooling.

Preheating is to be applied uniformly over a distance of about four times the plate thickness (but not more than 100 mm) on both sides of the weld; localised overheating is to be avoided.

In cold weather conditions (ambient temperature below approximately 5°C), when welding with low heat input or in the case of thick components and restraint, preheating is recommended or may be required depending on the type of steel.

In addition to the type of steel and its chemical composition, the necessity and amount of preheating are also dependent on the thickness and the conditions of restraint, the hydrogen content of the consumables, the heat input, the importance of the structure and the climatic conditions. This also applies to welding of auxiliary pieces and to tack welds in bevels. Dryness of the welding zone is to be ensured in all cases.

Wherever possible, no welding should be performed at ambient temperature below -10°C.

Unless otherwise specified on the approved drawing, the recommended minimum preheat temperature for manual metal arc welding of butt-joints between ferritic steels using low hydrogen electrodes is given in Table 3.

For automatic welding processes utilising higher heat input (such as submerged arc welding), a reduction of up to 50°C of the prescribed preheat temperature may be considered.

Table 3 : Recommended minimum preheat temperature for manual metal arc welding of butt-joints between ferritic steels

Steel	Grade or Ceq		Recommended minimum preheat temperature in °C for thickness t mm **(3)**		
			≤ 25	25 < t ≤ 35	t > 35
Normal strength hull structural steel	All grades **(1)**		-	-	-
Higher strength hull structural steels **(2)**	Ceq.	< 0,43	-	50	100
		< 0,45	50	100	125
		< 0,47	100	125	150
		< 0,50	125	150	175
High temperature steels C- Mn steels	510		-	100	
Cr- Mo steels	0,3 Mo 1Cr 0,5 Mo		150	200	
	2,25 Cr1 Mo		200	250	
Low temperature Ni steels	0,5 Ni- 1,5 Ni			100	
	3,5 Ni- 5 Ni			100	
	9 Ni			100	

(1) In particular when welding at temperature lower than 5° C, preheating may be recommended for thickness > 25 mm or under condition of restraint or in order to eliminate moisture and/or condensation.

(2) High strength structural steels are generally to be preheated if the temperature of the work piece is lower than 5° C.

(3) In the case of T fillet welding or cruciform joints, the value of 't' to be entered in the table is to be calculated, respectively, by the following formulae: $t= t_1+t_2/2$ or $t= t_1+t_2/2 +t_3/2$, where t_1 is the thickness of the continuous plate and t_2 and t_3 are the thickness of the abutting plates.

The temperature during welding is to be not higher than the interpass temperature adopted in the welding procedure approval or lower than the required preheat temperature.

Special consideration is to be given in the welding of quenched and tempered steels, where accurate control of preheating and interpass temperature is always required.

As a related recommendation, a multi-run weld should not be left incomplete when only the first run is completed; at least one third of the thickness should be welded before any interruption.

Any completed weld is to be left to cool naturally, without accelerating its cooling rate; moreover, it should not be submitted to stresses or vibrations.

Any restrained or very thick weld should be carried out practically without interrupting the welding and cooled slowly as under isolating glass wool.

3.9 Welding sequences

3.9.1

Assembling and welding sequences are to be carefully planned. In order to limit welding shrinkage stresses, welding should proceed to free edges; where possible, welding is to commence from the centre of the joint or the centre of

an assembly and proceed outwards towards the perimeter to give each part freedom to move.

Provisions to limit welding shrinkage or deformation and to facilitate the various operations may include in particular: disconnecting adjacent structures, use of straight joints, possible avoidance of interlocking connections, adoption of pre-deformations.

In particular, stiffening members which cross unwelded butt-joints of the respective plating are to be disconnected, as far as practicable, for a convenient length across the butt-joint.

Butt-joints of major importance should be welded without interruption, as far as possible; when of considerable length they should preferably be welded simultaneously by various welders at different locations.

When two butt-joints cross, one being continuous and the other having its end at the cross, the continuous joint is to be left unwelded at least locally for a length of about 300 mm before the cross, the other joint is to be completed down to the bevel of the first and the welding of the latter is then to be completed, after restoring the bevel at the crossing.

The same applies when butt-joints cross in a cruciform pattern; the first joint is to be left unwelded (or is to be disconnected) to a distance of about 200 mm from the crossing, then the second joint is welded and, after restoring the bevel, the weld of the first joint is completed.

In the case of automatic welding on panel lines, in order to limit the handling and turning over of the unstiffened panels, the welding of the butt-joints may be carried out on the upper side only and then the stiffeners fitted and welded.

The welding of such butt-joints will then be completed on the second side either in the workshop or even in the dry dock, of course always taking care when handling.

If this method is used, care should be taken to ensure that the fit up and welding of stiffeners do not create heavy stresses in the first run on the second side.

Transverse cracks in particular may occur in these welds at the crossing (their junction) with a stiffener welded on the opposite side and also in the case of defective fit up of stiffening components.

The Surveyor should therefore randomly check the chipped surface of this root run before the weld on the second side of the panel is carried out.

When panels made of one length plates are to be turned over before their completion, the turning should be done on an axis perpendicular to the weld lines.

When abutting panels have the respective butt-joint shifted at the crossing joint, it is recommended that the longitudinal joints should be left unwelded for a length of 100-200 mm depending on the plate thickness.

At the connection of abutting panels, the fillet welds at the extremity of stiffeners in way of their butt-joints must be left unwelded for a length of about 100 mm to be then welded after completion of the butt-joint between the panel plates; it is also advisable to increase the above length up to 500-700 mm in order to facilitate the correction of possible misalignment.

3.10 Interpass and final cleaning; bead sequences

3.10.1

a) Cleaning

Crater cracks are to be avoided by appropriate welding technique or, if present, removed.

The welder at the arc extinction should take care to feed the bead properly by slowing down the electrode in a back motion.

Weld spatter is to be removed with a scraper or chipping hammer or by grinding as appropriate.

In the case of welding on stainless steels, spatter impairs the pitting corrosion resistance due to local breakdown of the passivity film.

Provisions are to be taken, by anti-spatter products, to avoid the adhesion of spatter to the surface or to clean the surfaces by grinding as necessary.

Appropriate grinding wheels and steel brushes are to be employed, taking care that they have not been previously used on carbon steel.

b) Bead sequence

In the case of welding of higher strength steels, the bead sequence is to be appropriate to minimise hardening in the heat-affected zone.

To this end a suggested technique for the V butt-joints is to deposit the beads alternately on opposite sides of the bevel in order to temper the parent metal hardened by the previous bead. Final additional beads are to be deposited on the weld metal of the last beads at the sides without touching the base metal.

In the case of T fillet welds made by three beads, the last bead should be deposited in the centre bridging the previous two.

Welding technique (string bead or weaving) is to be in accordance with indications given in the WPS.

Unless otherwise required, weld beads are not to be too widely weaved (in general the maximum is four times the diameter of the electrodes).

3.11 Stress relieving

3.11.1

a) Carbon and carbon manganese steels

Post-weld heat treatment relieves the stresses due to welding and softens the structure in way of HAZ. Any stress relieving heat treatment is to comply with the indications of the relevant specification; as a rule, the following indications apply.

After being kept at the prescribed temperature for the required holding time (in general 2 minutes/mm), the material is to be slow cooled to 300°C in the furnace or in heat treatment devices, and then in still air.

Lower heat treatment temperatures and increased holding time may be recommended in order to avoid distortion during cooling.

The stress relieving is preferably to be carried out in the furnace.

An accurate control of the temperature is always required and the temperature recording curve is to be supplied to the Surveyor.

The temperature of loading and unloading (300°C maximum), the heating and cooling rate (maximum 5500°C divided by the thickness in mm per hour with min 55°C /hour and max 220°C/ hour), and the holding temperature at 550-620°C and time, 1 hour per 25mm with a minimum of one hour, are to be registered and verified.

The range of holding temperatures may be required to be further restricted to a maximum of 580°C where strength properties of the steel may be impaired by higher temperature (for instance, TM steels).

The temperature within the heated piece must be uniform (recommended maximum difference from one point to another of 40°C).

The registered temperature, indicated by the heat treatment curve, is to be that of the piece and not that of the furnace; to this end the locations of thermocouples on the heat treated piece are to be verified.

The cooling of the piece after its removal from the oven is to be in still air.

When, due to the dimensions of the components, treatment in the furnace is not possible, local heat treatment (by gas burners, heating coils or electrical resistance heaters) may be considered on a case-by-case basis taking into account the geometry of the part involved. Post-weld heat treatment with a hand torch is not permitted.

b) Austenitic and austeno-ferritic stainless steels

For austenitic and austeno-ferritic stainless steels, stress relieving is generally not required or recommended.

CHAPTER 5 MODIFICATIONS AND REPAIRS DURING CONSTRUCTION - REPAIRS ON SHIPS IN SERVICE

1 General

1.1

1.1.1 Some guidelines in addition to possible requirements on a case-by-case basis are given in following articles. The recommendations of Appendix 1, IACS Rec. No. 47 are also to be taken into account.

2 Gap and weld deformations

2.1 Butt-joints

2.1.1 When the gap exceeds the required limits by no more than one and half times the plate thickness or 25 mm, whichever is the lesser, a building up by welding on one or both sides for a thickness not exceeding half the plate thickness (with use of a backing strip or other adequate technique, as necessary), may generally be allowed. The bevel edges are to be restored by chipping and grinding before completing the welding of the joint.

When the gap exceeds the above allowances, repair with an insert plate is required (see Appendix 1, IACS Rec. No. 47, Part A, Tables 9.4 and 9.5.)Metodo di prova.

2.2 Fillet weld T-joints

2.2.1 When an excessive gap occurs in a fillet welded T-joint (up to 16 mm), the edge of the non-continuous element of the T is generally to be chamfered for penetration welding; a backing strip will be used at the root, as appropriate.

If the gap is too wide for such kind of repair, depending on the structure at the Surveyor's discretion, the fitting in the gap of a flat bar as a doubler of the plating or face plate may be allowed. Such flat is to have adequate thickness; in general, the thickness is to be not less than that of the lesser of the two parts to be joined and the width is not to exceed the minimum necessary to accommodate the fillet welds on the two sides of the web; the flat bar is to be connected to the plate by fillet welds along the edges. In the case of cross-joints subject to tension rather than shear stresses, where such kind of repair is still considered permissible, a flat bar is to be arranged on the two sides of the cross-joint such as to avoid the creation of secondary bending stresses in the joint.

In any event, the fitting of the above kind of doublers is generally not allowed in cargo areas or in the case of tensile stress perpendicular to the flat bar.

As an alternative to the above or for higher values of the gap, a new plate of minimum 300 mm width is to be inserted in the web of the T-joint (see Appendix 1, IACS Rec. No. 47, Part A, Tables 9.6 and 9.7).

2.3 Weld deformations

2.3.1 Excessive welding deformations in way of butt-joints of plates of major importance, such as outer shell and strength deck plates, is to be eliminated or restricted within acceptable limits.

In order to reduce the deformations, an appropriate procedure is, in general, to apply uniform heating over a suitably large area, in association with progressive straightening. The internal structures in way of the area affected by the heating may be required to be disconnected. In some cases, it may be advisable to remove the weld reinforcements from the butt welds in way of the heated zone.

Caution is to be used in the case of higher strength steels; in particular, it is to be ensured that the base metal and welded joint do not suffer from prejudicial deterioration (excessive work hardening, decrease of toughness, etc).

For hot straightening by means of flame with or without mechanical help the following applies:

a) it is never to exceed 650°C
b) accelerated cooling by compressed air or water should be avoided on high strength steels susceptible to hardening
c) hot straightening is not allowed on quenched and tempered steels.

Flame straightening is not allowed on stainless steels as there is a significant risk of precipitation of chromium carbide at the temperature to be reached for efficient straightening (600-650°C).

Cold straightening by means of a press or jack is tolerated only on ordinary steel of low thickness; visual examination and non-destructive examination may be required.

Any large deformations are to be repaired by cutting the joints, straightening the plates and re-welding the joint with a suitable procedure.

After straightening operations of an appreciable extent, the plating and associated structures affected are to be thoroughly inspected.

In general, precautions to avoid distortions include the following.

For a given assembly the less the amount of welding the lower the strain; moreover, it is advisable to use automatic processes in view of the lower number of passes, the more homogeneous distribution of stresses due to heating and the deeper penetration which limits the asymmetry of the heat-affected zone on both faces of the plate.

The low heat input welding method may be useful in order to reduce the effect of the heat and consequent deformation; the back step method may also be useful to reduce deformation.

Deformations and distortions are more difficult to control in the case of stainless steels than in the case of mild steel.

In the case of aluminium alloy, in order to keep possible deformations of plating resulting from welding operations within acceptable limits, local heating and hammering by means of plastic covered mallets may be used, with the usual precautions. Local heating for straightening purposes is to be applied by means of suitable torches and propane gas. The temperature of the material is preferably to be confined to 250 ÷ 280°C; in no case is the temperature to exceed 350°C.

3 Defects

3.1 General

3.1.1 In the case of serious or systematic defects, Tasneef is to be informed, also indicating the presumed causes.

In cases of particular gravity the proposed repairs are to be submitted, also in order to give Tasneef the time and opportu-nity to establish any measures conditioning their accept-ance.

3.2 Surface defects of plating

3.2.1 Surface defects introduced by the removal of auxiliary pieces when not removable by grinding or similar methods are to be repaired by welding, with prior adequate surface preparation and subsequent careful grinding.

Defects of this type are usually due to improper tack welding of such pieces; therefore, suitable means are to be provided to prevent their occurrence or to limit it only to occasional cases.

Similar kinds of repair may be adopted in the case of undue occurrence in major plates of surface defects due to arc strikes adjacent to a welded joint; also in this case, of course, prevention is better than cure.

3.3 Defects in the welds

3.3.1 Welds found defective to an unacceptable extent according to the Tasneef requirements are to be carefully removed and the zone suitably prepared for subsequent repair by welding; to this end the groove is to be prepared with an adequate taper to the sound material. Contiguous welds are to be suitably examined to exclude the continuity of defects.

Depending on the extent of the repair, adjacent structures may be required to be disconnected so that the shrinkage due to welding may be absorbed by a sufficiently wide zone.

The welding is to be performed as deemed appropriate in each case, such as by means of the use of basic coated electrodes and preheating when necessary.

Contiguous defects on the same joint are generally to be included in the same repair.

3.4 Cracks and fractures

3.4.1 When non-random cracks are found in welds, the causes are to be investigated and provisions taken as far as possible to avoid their recurrence.

When fractures in plates are found during construction, the causes are to be carefully investigated. Tasneef is to be informed as necessary or advisable.

3.5 Repair criteria

3.5.1 In the cases in {5.3.4} the type of repair is to be decided in relation to the presumed cause of the cracks as follows:

- When the quality of material is involved, the defective plate or piece is to be totally removed and replaced.
- If the material quality is not open to question, the defective plate or piece is to be replaced at least locally.
- In minor cases and where no doubts exist as to the quality and actual condition of the material, to the Surveyor's satisfaction, the defect may be allowed to be repaired, without replacing the defective part, by chipping the crack, suitably preparing the edges of the chipped length and welding at full penetration; in such cases, it may be advisable to drill a hole at the ends of the cracks before welding and, if applicable, to disconnect the adjacent structures.
- Where cracks or fractures are clearly due to the presence of structural notches or local hard spots, these should be eliminated as far as possible by suitable means, such as tapering or modification of details so as to distribute the local stresses over a wider area.

4 Repairs on structures already welded

4.1 Welding of inserted elements

4.1.1 Some indications are given in the following items 1) and 2) and in Appendix 1, IACS Rec. No. 47, Part B.

a) Welding of plates

When a welded plate is to be removed, the cut may follow either:

1) the centreline of the original welded joints, or

2) a line parallel, located on the side of the plating which remains in place.

In case (1), when the cut reaches one of the corners of the plate it is to be extended in thesame direction for a length equal to approximately 5 plating thicknesses or 100 mm, whichever is the greater; the cut is then to be

restarted on the plate along the removal line (see Appendix 1, IACS Rec. No. 47, Part B, [6.2]).

In case (2), the line of the cut is to be gradually moved to join the welded joint before proceeding as stated for case (1) .

Any other cutting operation on plating is to be performed along a line having well rounded corners.

When the removal concerns hull primary plating, the distance between two consecutive transverse butt-joints in the same strake is, as a rule, to be not less than two frame spaces, while the distance in the longitudinal direction between the butt-joints of two adjacent strakes is to be not less than one frame space, the seam between the two strakes then being welded after completion of the butts.

This means that cross-joints with butts and seams to be welded at the same time should if possible be avoided; otherwise, they are to be subjected to non-destructive examinations.

The above sequences may be recommended more generally, also in cases other than primary hull plating.

When the plating is to be removed with its stiffening members, the butt-joints of the latter and the peripheral joints of plating are to be staggered whenever possible.

b) Welding of stiffeners

When renewal of internal stiffeners is required, reference should be made to the welding sequences suggested in Appendix 1, IACS Rec. No. 47, Part B, [6.4].

4.2 Plugging of openings

4.2.1 When openings in the plating are to be closed by butt-welded insert plates, the diameter or minimum dimension of the insert is, in general, to be not less than 20 times the thickness of the plating with a minimum of 200 mm; rectangular insert plates are to have well rounded corners, in general with a radius not less than 5 times the thickness of the plating (see Appendix 1, IACS Rec. No. 47, Part B, [6.2]).

For circular inserts the minimum diameter is 200 mm.

Particular care is recommended in the fit up of the inserts. The first run should be made with the electrode of maximum diameter compatible with good penetration in order to avoid cracking.

The use of mild steel electrodes giving a deposited metal having high deformation properties may also be considered on a case-by-case basis.

The closing of openings by means of welded overlapped plugs is generally allowed only in structures of secondary importance.

CHAPTER 6 INSPECTIONS AND CHECKS

1 General

1.1

1.1.1 When starting fabrication of a welded structure and in the course of fabrication itself, it is to be checked that:

a) the materials used are of the required type, have been duly tested and are of dimensions complying with the approved plans;

b) the welding consumables and the welding processes/procedures have been duly approved and are used in accordance with the relevant approvals;

c) the welders are qualified and employed in accordance with their qualification with satisfactory results;

d) the welding consumables are taken from original containers;

e) the welding equipment and plants are operating regularly and their measuring instruments have been calibrated, as required;

f) the joint preparations and back gouging are of the due shape and the prepared surfaces are satisfactory with regard to cutting and gouging;

g) the assembling, alignment, tacking and cleanliness are satisfactory, giving special attention to the connection of prefabricated parts;

h) the welding sequences are correct and, where relevant, in accordance with the approved plans;

i) the welding and workmanship are in accordance with the applicable requirements and normal good practice.

Supervision during construction is to be extended as far as possible. Inspections (and NDE) will be intensified, as found necessary, at the beginning of the main phases of a specific construction (shop work, prefabrication, erection and assembly, welding of important prefabricated parts or major structures in general) and at the beginning of production involving the use of welding processes or techniques with which the yard has no previous experience or in other similar cases, such as when doubts arise concerning the results of a welded application.

Applications involving the use of new welding processes and techniques will be specially monitored in the initial stages, by means of radiographic/ultrasonic examinations, so that corrective measures may be promptly adopted, where necessary.

Careful attention is also to be paid to edge preparation, alignment of the pieces, tack welding procedures and welding sequences.

The edge preparation and the back chipping (or similar) groove of the butt-joints of large prefabricated panels of hull structures should be inspected by the Surveyors as far as appropriate at their discretion.

The above inspection may be wholly or partly replaced by non-destructive examinations additional to the systematic checks required by the Rules.

It is recommended that radiographic and ultrasonic examinations should not be limited to the minimum required by the Rules, but extended as necessary to ascertain the satisfactory quality of the production.

To increase their significance these NDEs should be carried out at random, to check for example the application of various welding processes, edge preparation, welding positions, back chipping and welders.

Furthermore, it is also recommended that, where possible, welders associated with welding of the main structural joints should be identified for reference purposes when examining the results of non-destructive tests.

The Surveyors may also require that random weld tests are performed in order to ascertain whether the welding procedure complies with the requirements verified at the time of approval.

In the case of important welding details of complex design, preliminary verification of the suitability of the welding procedure may be required. For this purpose, representative samples of the detail and welding conditions may be required and subjected to appropriate tests.

1.1.2 When the work produced by a welder raises doubts as to his level of training, additional confirmation tests may be required, either in part or wholly, irrespective of the expiry date of his qualification.

The welding processes proposed by the Manufacturer, their limitations, operating conditions, applications and associated welding equipment are to be clearly identifiable in detail.

The welding processes and filler metals are to be approved for the particular applications and operating conditions employed by the individual Manufacturers.

1.1.3 The internal organisation, production facilities and control procedures of the builder are to be suitable for the expected duties.

In the case of serious doubts concerning the capacity of the Manufacturer's organisation to fulfil the required tasks, Tasneef may increase its surveys as deemed necessary or even refuse to proceed with the requested services.

The Manufacturer's quality control organisation and the Surveyors are to check that fabrication activity is carried out satisfactorily.

2 Visual and non-destructive examinations

2.1 General

2.1.1 Welds in carbon manganese and alloy steels are in general not to be finally inspected until at least 48 hours after completion of the welding. The final inspection for acceptance is to be made after the final heat treatment, if any.

In general the parts/compartments are to be submitted to inspection by the Surveyors when already found acceptable by the Manufacturer.

The yard is to submit to the Surveyor all the inspection reports related to the welds (visual, radiographic, magnetic, dimensional, watertightness, strength test etc, as appropriate).

Films of radiographic examinations are to be submitted to the Surveyor. The Surveyor may require that the examinations are carried out in his presence.

In particular the Surveyors are to:

a) provide for the inspections and witness the tests as required by the Rules and applicable drawings and instructions; in particular as regards the hull welds, they are to carry out adequate visual examinations

b) verify the certification of the NDE operators

c) indicate the locations of the random NDEs performed

d) draw/sign the relevant reports as appropriate.

When, due to the occurrence of defects, there are grounds for reasonable doubts suggesting that such defects may continue or recur in similar joints, additional examinations may be required, to an extent as deemed necessary by the Surveyor.

Where, in welds or base metal, defects related to the properties of the materials used are detected, special checks, including destructive tests, may be required by the Surveyor.

2.1.2 As far as concerns non-destructive examinations of welded joints, the following guidelines may be applied to the Surveyor's satisfaction:

a) Magnetic particle examinations may be required on highly stressed joints (usually T-joints) not subjected to radiographic examination or where the aim is to ensure the absence of surface cracks.

b) As regards ultrasonic examination, in addition to its application as a substitute, where admitted or necessary, for radiographic or gamma-ray examinations, it may also be required as an additional examination in specific cases where the presence of possible defects which are difficult to detect by radiographic examinations is suspected. For instance, an ultrasonic examination will be required, as a rule, for joints on important plating welded with processes using bare or cored wires or similar methods, with or without shielding gas, particularly in positions other than flat; if incorrectly applied, such processes may lead to lack of fusion, which generally escapes detection in radiographic examinations. In particular, an ultrasonic examination will be required in the first stage of application of the processes, or when new welders or special edge preparations presenting special difficulties are used.

Ultrasonic and magnetic particle examinations may be also required in specific cases to verify the quality of the base material.

Irrespective of the requirements of the applicable Rules and approved plans, the Surveyor may require, as deemed necessary, that non-destructive tests are carried out in the following or similar cases:

a) for important joints, especially if they are dynamically stressed or connecting members of considerable thickness;

b) for details presenting difficulties in the welding;

c) in the initial stage of the application of a welding process;

d) for special welding processes in general, where an adequate inspection of fabrication procedures during welding has not been performed;

e) in the event of suspected serious defects.

2.1.3 The requirements relevant to non-destructive examinations are given in the Rules for carrying out non-destructive examinations of welding.

APPENDIX 1 IACS REC. NO. 47 "SHIP BUILDING AND REPAIR QUALITY STANDARD"

No.47 Shipbuilding and Repair Quality Standard

(1996)
(Rev. 1, 1999)
(Rev.2, Dec. 2004)
(Rev.3, Nov. 2006)
(Rev.4, Aug. 2008)
(Rev.5, Oct. 2010)
(Rev.6, May 2012)
(Rev.7, June 2013)

Part A Shipbuilding and Remedial Quality Standard for New Construction

Part B Repair Quality Standard for Existing Ships

PART A - SHIPBUILDING AND REMEDIAL QUALITY STANDARDS FOR NEW CONSTRUCTION

REFERENCES

1. IACS "Bulk Carriers - Guidelines for Surveys, Assessment and Repair of Hull Structure"
2. TSCF "Guidelines for the inspection and maintenance of double hull tanker structures"
3. TSCF "Guidance manual for the inspection and condition assessment of tanker structures"
4. IACS UR W7 "Hull and machinery steel forgings"
5. IACS UR W8 "Hull and machinery steel castings"
6. IACS UR W11 "Normal and higher strength hull structural steel"
7. IACS UR W13 "Thickness tolerances of steel plates and wide flats"
8. IACS UR W14 "Steel plates and wide flats with specified minimum through thickness properties ("Z" quality)"
9. IACS UR W17 "Approval of consumables for welding normal and higher strength hull structural steels"
10. IACS UR W28 "Welding procedure qualification tests of steels for hull construction and marine structures"
11. IACS UR Z10.1 "Hull surveys of oil tankers" and Z10.2 "Hull surveys of bulk carriers" Annex I
12. IACS UR Z23 "Hull survey for new construction"
13. IACS Recommendation No. 12 "Guidelines for surface finish of hot rolled plates and wide flats"
14. IACS Recommendation No. 20 "Non-destructive testing of ship hull steel welds"

1. Scope

It is intended that these standards provide guidance where established and recognized shipbuilding or national standards accepted by the Classification Society do not exist.

1.1 This standard provides guidance on shipbuilding quality standards for the hull structure during new construction and the remedial standard where the quality standard is not met.

Whereas the standard generally applies to
- conventional merchant ship types,
- parts of hull covered by the rules of the Classification Society,
- hull structures constructed from normal and higher strength hull structural steel,

the applicability of the standard is in each case to be agreed upon by the Classification Society.

The standard does generally not apply to the new construction of
- special types of ships as e.g. gas tankers
- structures fabricated from stainless steel or other, special types or grades of steel

1.2 In this standard, both a "Standard" range and a "Limit" range are listed. The "Standard" range represents the target range expected to be met in regular work under normal circumstances. The "Limit" range represents the maximum allowable deviation from the "Standard" range. Work beyond the "Standard" range but within the "Limit" range is acceptable. In cases where no 'limit' value is specified, the value beyond the 'standard' range may be accepted subject to the consideration of the Classification Society.

1.3 The standard covers typical construction methods and gives guidance on quality standards for the most important aspects of such construction. Unless explicitly stated elsewhere in the standard, the level of workmanship reflected herein will in principle be acceptable for primary and secondary structure of conventional designs. A more stringent standard may however be required for critical and highly stressed areas of the hull, and this is to be agreed with the Classification Society in each case. In assessing the criticality of hull structure and structural components, reference is made to ref. 1, 2 and 3.

1.4 Details relevant to structures or fabrication procedures not covered by this standard are to be approved by the Classification Society on the basis of procedure qualifications and/or recognized national standards.

1.5 For use of this standard, fabrication fit-ups, deflections and similar quality attributes are intended to be uniformly distributed about the nominal values. The shipyard is to take corrective action to improve work processes that produce measurements where a skew distribution is evident. Relying upon remedial steps that truncate a skewed distribution of the quality attribute is unacceptable.

2. General requirements for new construction

2.1 In general, the work is to be carried out in accordance with the Classification Society rules and under the supervision of the Surveyor to the Classification Society

2.2 Welding operations are to be carried out in accordance with work instructions accepted by the Classification Society.

2.3 Welding of hull structures is to be carried out by qualified welders, according to approved and qualified welding procedures and with welding consumables approved by the Classification Society, see Section 3. Welding operations are to be carried out under proper supervision by the shipbuilder. The working conditions for welding are to be monitored by the Classification Society in accordance with UR Z23.

3. Qualification of personnel and procedures

3.1 Qualification of welders

3.1.1 Welders are to be qualified in accordance with the procedures of the Classification Society or to a recognized national or international standard. Recognition of other standards is subject to submission to the

Classification Society for evaluation. Subcontractors are to keep records of welders qualification and, when required, furnish valid approval test certificates.

3.1.2 Welding operators using fully mechanized or fully automatic processes need generally not pass approval testing provided that the production welds made by the operators are of the required quality. However, operators are to receive adequate training in setting or programming and operating the equipment. Records of training and operation experience shall be maintained on individual operator's files and records, and be made available to the Classification Society for inspection when requested.

3.2 Qualification of welding procedures

Welding procedures are to be qualified in accordance with URW28 or other recognized standard accepted by the Classification Society.

3.3 Qualification of NDE operators

Personnel performing non-destructive examination for the purpose of assessing quality of welds in connection with new construction covered by this standard, are to be qualified in accordance with Classification Society rules or to a recognized international or national qualification scheme. Records of operators and their current certificates are to be kept and made available to the Surveyor for inspection.

4. Materials

4.1 Materials for Structural Members

All materials, including weld consumables, to be used for the structural members are to be approved by the Classification Society as per the approved construction drawings and meet the respective IACS Unified Requirements. Additional recommendations are contained in the following paragraphs.

All materials used should be manufactured at a works approved by the Classification Society for the type and grade supplied.

4.2 Surface Conditions

4.2.1 Definitions

Minor Imperfections:	Pitting, rolled-in scale, indentations, roll marks, scratches and grooves
Defects:	Cracks, shells, sand patches, sharp edged seams and minor imperfections exceeding the limits of table 1
Depth of Imperfections or defects:	The depth is to be measured from the surface of the product

4.2.2 Acceptance without remedies

Minor imperfections, in accordance with the nominal thickness (t) of the product and the limits described in Table 1, are permissible and may be left as they are.

Imperfection surface area Ratio(%)	15～20%	5～15%	0～5%
t < 20 mm	0.2 mm	0.4 mm	0.5 mm
20 mm ≤ t < 50 mm	0.2 mm	0.6 mm	0.7 mm
50 mm ≤ t	0.2 mm	0.7 mm	0.9 mm

Table 1 Limits for depth of minor imperfection, for acceptance without remedies

Imperfection surface area Ratio (%) is obtained as influenced area / area under consideration (i.e. plate surface area) x 100%.
For isolated surface discontinuities, influenced area is obtained by drawing a continuous line which follows the circumference of the discontinuity at a distance of 20 mm. (Figure 1)
For surface discontinuities appearing in a cluster, influenced area is obtained by drawing a continuous line which follows the circumference of the cluster at a distance of 20 mm. (Figure 2)

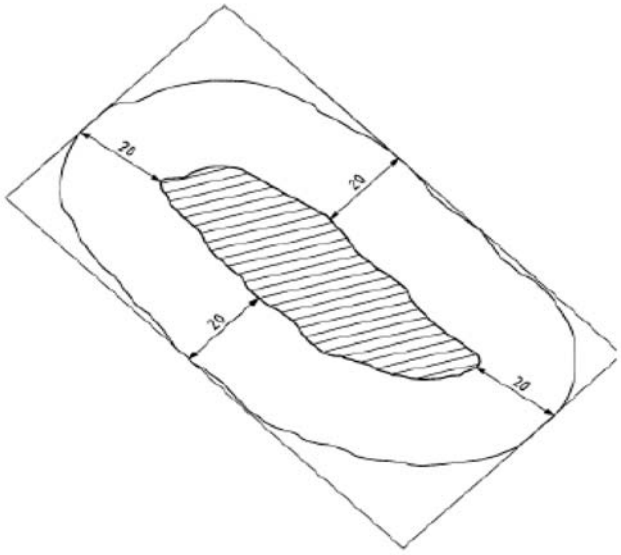


Figure 1 - Determination of the area influenced by an isolated discontinuity
(Ref. Nr. EN 10163-1:2004+AC:2007 E)

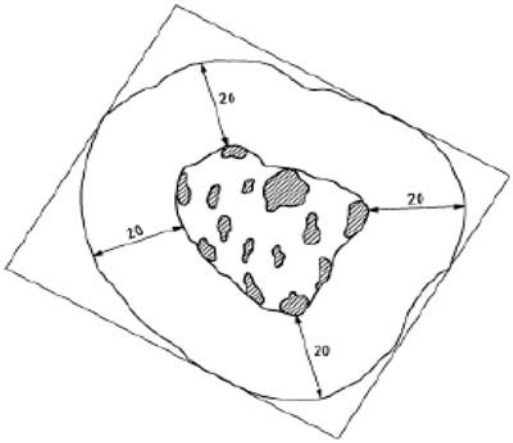


Figure 2 - Determination of the area influenced by clustered discontinuities
(Ref. Nr. EN 10163-1:2004+AC:2007 E)

4.2.3 Remedial of Defects

Defects are to be remedied by grinding and/or welding in accordance with IACS Rec.12.

4.2.4 Further Defects

4.2.4.1 Lamination

Investigation to be carried out at the steelmill into the cause and extent of the detected laminations. Severe lamination is to be remedied by local insert plates. The minimum breadth or length of the plate to be replaced is to be:

- 1600 mm for shell and strength deck plating in way of cruciform or T-joints,
- 800 mm for shell, strength deck plating and other primary members,
- 300 mm for other structural members.

Local limited lamination may be remedied by chipping and/or grinding followed by welding in accordance with sketch (a). In case where the local limited lamination is near the plate surface, the remedial may be carried out as shown in sketch (b). For limitations see paragraph 4.2.2.

4.2.4.2 Weld Spatters

Loose weld spatters are to be removed by grinding or other measures to clean metal surface (see Table 9.13), as required by the paint system, on:

- shell plating
- deck plating on exposed decks
- in tanks for chemical cargoes
- in tanks for fresh water and for drinking water
- in tanks for lubricating oil, hydraulic oil, including service tanks

5. Gas Cutting

The roughness of the cut edges is to meet the following requirements:

Free Edges:

	Standard	Limit
Strength Members	150 μm	300 μm
Others	500 μm	1000 μm

Welding Edges:

	Standard	Limit
Strength Members	400 μm	800 μm
Others	800 μm	1500 μm

6. Fabrication and fairness

6.1 Flanged longitudinals and flanged brackets (see Table 6.1)
6.2 Built-up sections (see Table 6.2)

6.3 Corrugated bulkheads (see Table 6.3)
6.4 Pillars, brackets and stiffeners (see Table 6.4)
6.5 Maximum heating temperature on surface for line heating (see Table 6.5)
6.6 Block assembly (see Table 6.6)
6.7 Special sub-assembly (see Table 6.7)
6.8 Shape (see Table 6.8 and 6.9)
6.9 Fairness of plating between frames (see Table 6.10)
6.10 Fairness of plating with frames (see Table 6.11)
6.11 Preheating for welding hull steels at low temperature (See Table 6.12)

7. Alignment

The quality standards for alignment of hull structural components during new construction are shown in Tables 7.1, 7.2 and 7.3. The Classification Society may require a closer construction tolerance in areas requiring special attention, as follows:

- Regions exposed to high stress concentrations
- Fatigue prone areas
- Detail design block erection joints
- High tensile steel regions

8. Welding Joint Details

Edge preparation is to be qualified in accordance with URW28 or other recognized standard accepted by the Classification Society.

Some typical edge preparations are shown in Table 8.1, 8.2, 8.3, 8.4 and 8.6 for reference.

8.1 Typical butt weld plate edge preparation (manual and semi-automatic welding) for reference - see Table 8.1 and 8.2
8.2 Typical fillet weld plate edge preparation (manual and semi-automatic welding) for reference - see Table 8.3 and 8.4
8.3 Butt and fillet weld profile (manual and semi-automatic welding) - see Table 8.5
8.4 Typical butt weld plate edge preparation (Automatic welding) for reference - see Table 8.6
8.5 Distance between welds - see Table 8.7

9. Remedial

All the major remedial work is subject to reporting by shipbuilder to the Classification Society for approval in accordance with their work instruction for new building.

Some typical remedial works are shown in Tables 9.1 to 9.13.

9.1 Typical misalignment remedial - see Tables 9.1 to 9.3
9.2 Typical butt weld plate edge preparation remedial (manual and semi-automatic welding) - see Table 9.4 and 9.5
9.3 Typical fillet weld plate edge preparation remedial (manual and semi-automatic welding) - see Tables 9.6 to 9.8
9.4 Typical fillet and butt weld profile remedial (manual and semi-automatic welding) - see Table 9.9
9.5 Distance between welds remedial - see Table 9.10
9.6 Erroneous hole remedial - see Table 9.11
9.7 Remedial by insert plate - see Table 9.12
9.8 Weld surface remedial - see Table 9.13
9.9 Weld remedial (short bead) - see Table 9.14

TABLE 6.1 – Flanged Longitudinals and Flanged Brackets

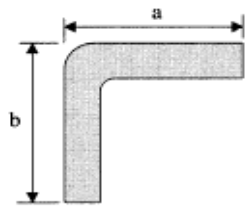
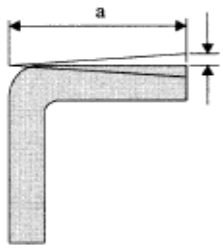
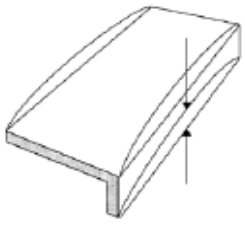
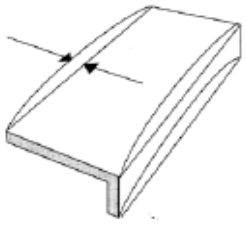
Detail	Standard	Limit	Remarks
Breadth of flange  compared to correct size	± 3 mm	± 5 mm	
Angle between flange and web  compared to template	± 3 mm	± 5 mm	per 100 mm of a
Straightness in plane of flange and web  	± 10 mm	± 25 mm	per 10 m

TABLE 6.2 – Built Up Sections

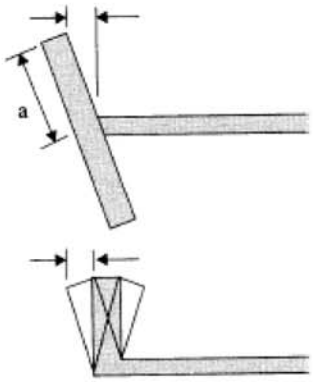
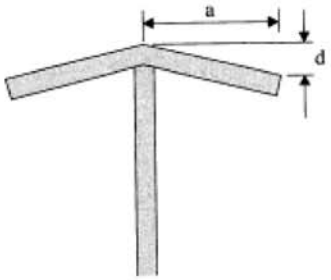
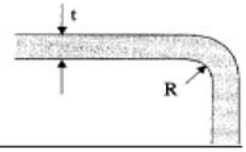
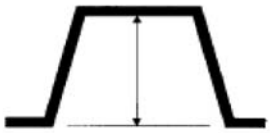
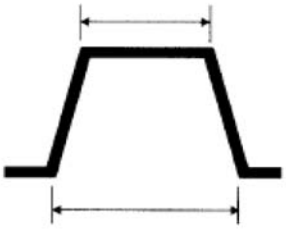
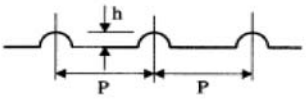
Detail	Standard	Limit	Remarks
Frames and longitudinal 	± 1.5 mm	± 3 mm	per 100 mm of a
Distortion of face plate 	d ≤ 3 + a/100 mm	d ≤ 5 + a/100 mm	
Distortion in plane of web and flange of built up longitudinal frame, transverse frame, girder and transverse web. 	± 10 mm	± 25 mm	per 10 m in length

TABLE 6.3 – Corrugated Bulkheads

Detail	Standard	Limit	Remarks
Mechanical bending 	R ≥ 3t mm R ≥ 4.5t mm for CSR ships [Note 1]	2t mm [Note 2]	Material to be suitable for cold flanging (forming) and welding in way of radius
Depth of corrugation 	± 3 mm	± 6 mm	
Breadth of corrugation 	± 3 mm	± 6 mm	
Pitch and depth of swedged corrugated bulkhead compared with correct value 	h : ± 2.5 mm Where it is not aligned with other bulkheads P : ± 6 mm Where it is aligned with other bulkheads P : ± 2 mm	h : ± 5 mm Where it is not aligned with other bulkheads P : ± 9 mm Where it is aligned with other bulkheads P : ± 3 mm	

Notes:
1. For CSR Bulk Carriers built under the "Common Structural Rules for Bulk Carriers" with the effective dates of 1 July 2010 and 1 July 2012, the standard is R≥2t mm.
2. For CSR ships, the allowable inside bending radius of cold formed plating may be reduced provided the following requirements are complied with.

When the inside bending radius is reduced below 4.5 times the as-built plate thickness, supporting data is to be provided. The bending radius is in no case to be less than 2 times the as-built plate thickness. As a minimum, the following additional requirements are to be complied with:

a) For all bent plates:

- 100% visual inspection of the bent area is to be carried out.
- Random checks by magnetic particle testing are to be carried out.

b) In addition to a), for corrugated bulkheads subject to lateral liquid pressure:

- The steel is to be of Grade D/DH or higher.

The material is impact tested in the strain-aged condition and satisfies the requirements stated herein. The deformation is to be equal to the maximum deformation to be applied during production, calculated by the formula $t_{as\text{-}built}/(2r_{bdg} + t_{as\text{-}built})$, where $t_{as\text{-}built}$ is the as-built thickness of the plate material and r_{bdg} is the bending radius. One sample is to be plastically strained at the calculated deformation or 5%, whichever is greater and then artificially aged at 250°C for one hour then subject to Charpy V-notch testing. The average impact energy after strain ageing is to meet the impact requirements specified for the grade of steel used.

TABLE 6.4 – Pillars, Brackets and Stiffeners

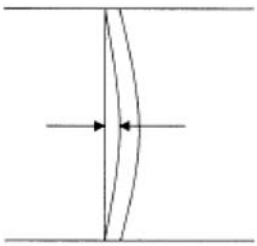
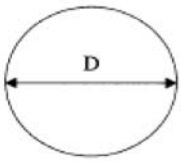
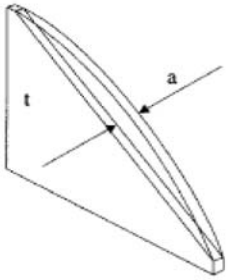
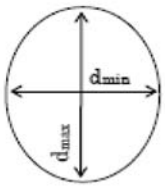
Detail	Standard	Limit	Remarks
Pillar (between decks) 	4 mm	6 mm	
Cylindrical structure diameter (pillars, masts, posts, etc.) 	± D/200 mm max. + 5 mm	± D/150 mm max. 7.5 mm	
Tripping bracket and small stiffener, distortion at the part of free edge 	a ≤ t/2 mm	t	
Ovality of cylindrical structure 		$d_{max} - d_{min} \leq 0.02 \times d_{max}$	

TABLE 6.5 – Maximum Heating Temperature on Surface for Line Heating

Item		Standard	Limit	Remarks
Conventional Process AH32-EH32 & AH36-EH36	Water cooling just after heating	Under 650°C		
TMCP type AH36-EH36 (Ceq.>0.38%)	Air cooling after heating	Under 900°C		
	Air cooling and subsequent water cooling after heating	Under 900°C (starting temperature of water cooling to be under 500°C)		
TMCP type AH32-DH32 & AH36-DH36 (Ceq. ≤ 0.38%)	Water cooling just after heating or air cooling	Under 1000°C		
TMCP type EH32 & EH36 (Ceq. ≤ 0.38%)	Water cooling just after heating or air cooling	Under 900°C		

NOTE:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} (\%)$$

TABLE 6.6 – Block Assembly

Item	Standard	Limit	Remarks
Flat Plate Assembly			
Length and Breadth	± 4 mm	± 6 mm	
Distortion	± 10 mm	±20mm	
Squareness	± 5 mm	±10mm	
Deviation of interior members from plate	5 mm	10mm	
Curved plate assembly			
Length and Breadth	± 4 mm	± 8 mm	measured along the girth
Distortion	± 10 mm	± 20 mm	
Squareness	± 10 mm	± 15 mm	
Deviation of interior members from plate	5 mm	10 mm	
Flat cubic assembly			
Length and Breadth	± 4 mm	± 6 mm	
Distortion	± 10 mm	± 20 mm	
Squareness	± 5 mm	± 10 mm	
Deviation of interior members from plate	5 mm	10 mm	
Twist	± 10 mm	± 20 mm	
Deviation between upper and lower plate	± 5 mm	± 10 mm	
Curved cubic assembly			
Length and Breadth	± 4 mm	± 8 mm	measured along with girth
Distortion	± 10 mm	± 20 mm	
Squareness	± 10 mm	± 15 mm	
Deviation of interior members from plate	± 5 mm	± 10 mm	
Twist	± 15 mm	± 25 mm	
Deviation between upper and lower plate	± 7 mm	± 15 mm	

TABLE 6.7 – Special Sub-Assembly

Item	Standard	Limit	Remarks
Distance between upper/lower gudgeon	± 5 mm	± 10 mm	
Distance between aft edge of boss and aft peak bulkhead	± 5 mm	± 10 mm	
Twist of sub-assembly of stern frame	5 mm	10 mm	
Deviation of rudder from shaft center line	4 mm	8 mm	
Twist of rudder plate	6 mm	10 mm	
Flatness of top plate of main engine bed	5 mm	10 mm	
Breadth and length of top plate of main engine bed	± 4 mm	± 6 mm	

NOTE:

Dimensions and tolerances have to fulfill engine and equipment manufacturers' requirements, if any.

TABLE 6.8 – Shape

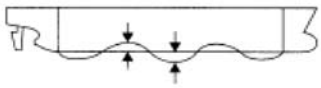
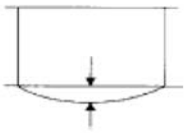
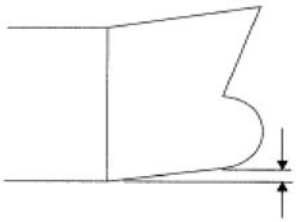
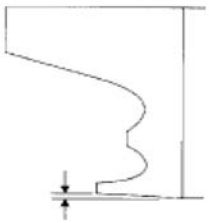
Detail	Standard	Limit	Remarks
Deformation for the whole length 	± 50 mm		per 100 m against the line of keel sighting
Deformation for the distance between two adjacent bulkheads 	± 15 mm		
Cocking-up of fore body 	± 30 mm		The deviation is to be measured from the design line.
Cocking-up of aft-body 	± 20 mm		
Rise of floor amidships 	± 15 mm		The deviation is to be measured from the design line.

TABLE 6.9 – Shape

Item	Standard	Limit	Remarks
Length between perpendiculars	±L/1000 mm where L is in mm		Applied to ships of 100 metre length and above. For the convenience of the measurement the point where the keel is connected to the curve of the stem may be substituted for the fore perpendicular in the measurement of the length.
Moulded breadth at midship	±B/1000 mm where B is in mm		Applied to ships of 15 metre breadth and above, measured on the upper deck.
Moulded depth at midship	±D/1000 mm where D is in mm		Applied to ships of 10 metre depth and above, measured up to the upper deck.

TABLE 6.10 – Fairness of Plating Between Frames

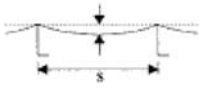
Item		Standard	Limit	Remarks
Shell plate	Parallel part (side & bottom shell)	4 mm	8 mm	
	Fore and aft part	5 mm		
Tank top plate		4 mm		
Bulkhead	Longl. Bulkhead Trans. Bulkhead Swash Bulkhead	6 mm		
Strength deck	Parallel part	4 mm	8 mm	
	Fore and aft part	6 mm	9 mm	
	Covered part	7 mm	9 mm	
Second deck	Bare part	6 mm	8 mm	
	Covered part	7 mm	9 mm	
Forecastle deck poop deck	Bare part	4 mm	8 mm	
	Covered part	6 mm	9 mm	
Super structure deck	Bare part	4 mm	6 mm	
	Covered part	7 mm	9 mm	
House wall	Outside wall	4 mm	6 mm	
	Inside wall	6 mm	8 mm	
	Covered part	7 mm	9 mm	
Interior member (web of girder, etc)		5 mm	7 mm	
Floor and girder in double bottom		5 mm	8 mm	

TABLE 6.11 – Fairness of Plating with Frames

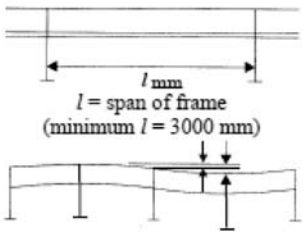
Item		Standard	Limit	Remarks
Shell plate	Parallel part	±2 *l* /1000 mm	±3 *l* /1000 mm	*l* = span of frame (mm) To be measured between on trans. space (min. *l* = 3000 mm)
	Fore and aft part	±3 *l* /1000 mm	±4 *l* /1000 mm	
Strength deck (excluding cross deck) and top plate of double bottom	-	±3 *l* /1000 mm	±4 *l* /1000 mm	
Bulkhead	-		±5 *l* /1000 mm	
Accommodation above the strength deck and others	-	±5 *l* /1000 mm	±6 *l* /1000 mm	
 To be measured between one trans. space.				

TABLE 6.12 – Preheating for welding hull steels at low temperature

Item		Standard		Limit	Remarks
		Base metal temperature needed preheating	Minimum preheating temperature		
Normal strength steels	A, B, D, E	Below -5 °C	20 °C [1)]		
Higher strength steels (TMCP type)	AH32 – EH32 AH36 – EH36	Below 0 °C			
Higher strength steels (Conventional type)		Below 0 °C			

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

TABLE 7.1 – Alignment

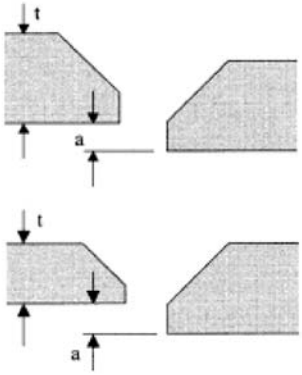
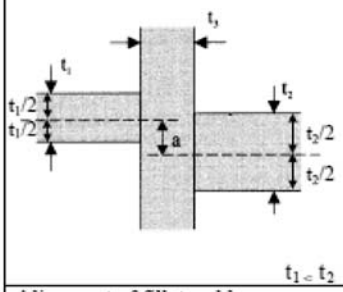
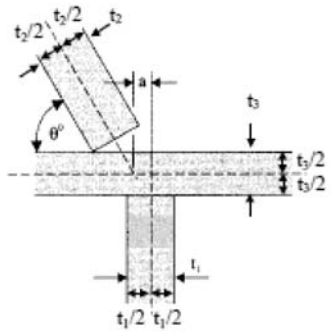
Detail	Standard	Limit	Remarks
Alignment of butt welds 		a ≤ 0.15t strength member a ≤ 0.2t other but maximum 4.0 mm	t is the lesser plate thickness
Alignment of fillet welds 		Strength member and higher stress member: $a \le t_1/3$ Other: $a \le t_1/2$	Alternatively, heel line can be used to check the alignment. Where t_3 is less than t_1, then t_3 should be substituted for t_1 in the standard.
Alignment of fillet welds 		Strength member and higher stress member: $a \le t_1/3$ Other: $a \le t_1/2$	Alternatively, heel line can be used to check the alignment. Where t_3 is less than t_1, then t_3 should be substitute for t_1 in the standard.

TABLE 7.2 – Alignment

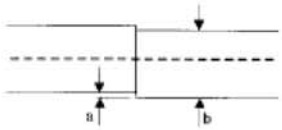
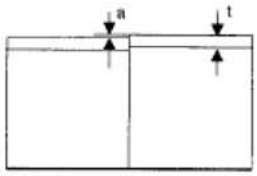
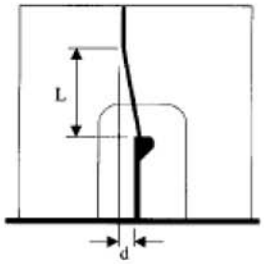
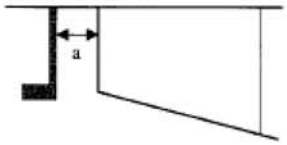
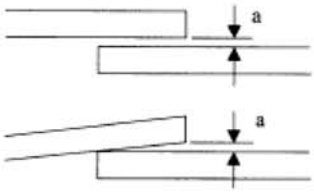
Detail	Standard	Limit	Remarks
Alignment of flange of T-longitudinal  b (mm)	Strength member a ≤ 0.04b (mm)	a = 8.0 mm	
Alignment of height of T-bar, L-angle bar or bulb  	Strength member a ≤ 0.15t Other a ≤ 0.20t	a = 3.0 mm	
Alignment of panel stiffener  	d ≤ L/50		
Gap between bracket/intercostal and stiffener  	a ≤ 2.0 mm	a = 3.0 mm	
Alignment of lap welds  	a ≤ 2.0 mm	a = 3.0 mm	

TABLE 7.3 – Alignment

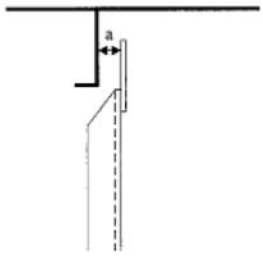
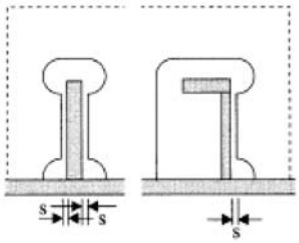
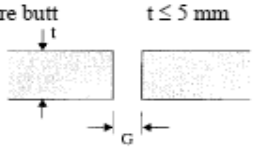
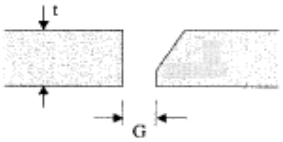
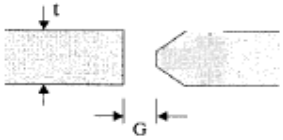
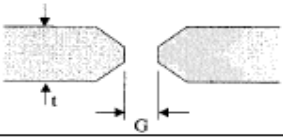
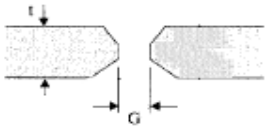
Detail	Standard	Limit	Remarks
Gap between beam and frame 	a ≤ 2.0 mm	a = 5.0 mm	
Gap around stiffener cut-out 	s ≤ 2.0 mm	s = 3.0 mm	

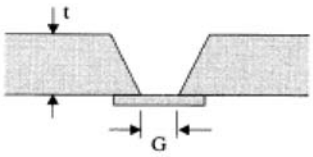
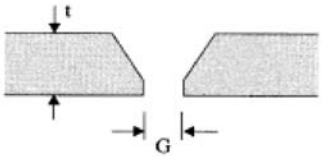
TABLE 8.1 – Typical Butt Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

Detail	Standard	Limit	Remarks
Square butt $t \leq 5$ mm 	G ≤ 3 mm	G = 5 mm	see Note 1
Single bevel butt $t > 5$ mm 	G ≤ 3 mm	G = 5 mm	see Note 1
Double bevel butt $t > 19$ mm 	G ≤ 3 mm	G = 5 mm	see Note 1
Double vee butt, uniform bevels 	G ≤ 3 mm	G = 5 mm	see Note 1
Double vee butt, non-uniform bevel 	G ≤ 3 mm	G = 5 mm	see Note 1

NOTE 1

Different plate edge preparation may be accepted or approved by the Classification Society in accordance with URW28 or other recognized standard accepted by the Classification Society.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of weld procedures.

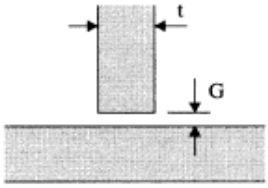
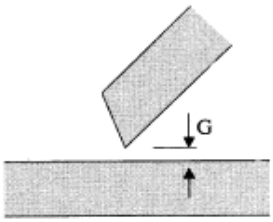
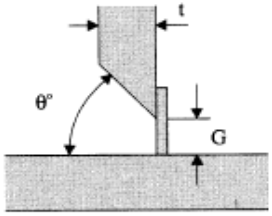
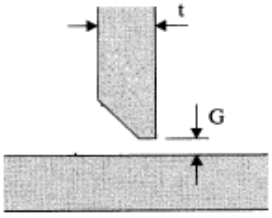
TABLE 8.2 – Typical Butt Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

Detail	Standard	Limit	Remarks
Single Vee butt, one side welding with backing strip (temporary or permanent) 	G = 3 to 9 mm	G = 16 mm	see Note 1
Single vee butt 	G ≤ 3 mm	G = 5 mm	see Note 1

NOTE 1

Different plate edge preparation may be accepted or approved by the Classification Society in accordance with URW28 or other recognized standard accepted by the Classification Society.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

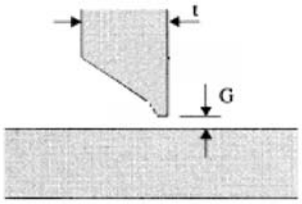
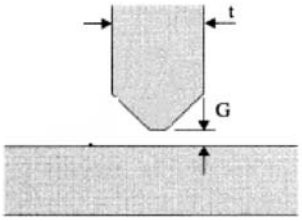
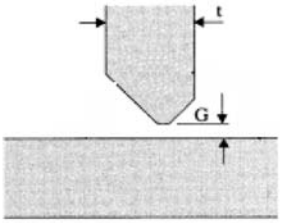
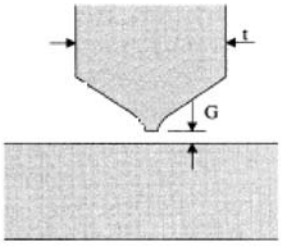
Table 8.3 – Typical Fillet Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

Detail	Standard	Limit	Remarks
Tee Fillet 	G ≤ 2 mm	G = 3 mm	see Note 1
Inclined fillet 	G ≤ 2 mm	G = 3 mm	see Note 1
Single bevel tee with permanent backing 	G ≤ 4 to 6 mm θ° = 30° to 45°	G = 16 mm	Not normally for strength member also see Note 1
Single bevel tee 	G ≤ 3 mm		see Note 1

NOTE 1

Different plate edge preparation may be accepted or approved by the Classification Society in accordance with URW28 or other recognized standard accepted by the Classification Society.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.4 – Typical Fillet Weld Plate Edge Preparation (Manual Welding and Semi-Automatic Welding) for Reference

Detail	Standard	Limit	Remarks
Single 'J' bevel tee 	G = 2.5 to 4 mm		see Note 1
Double bevel tee symmetrical t > 19 mm 	G ≤ 3 mm		see Note 1
Double bevel tee asymmetrical t > 19 mm 	G ≤ 3 mm		see Note 1
Double 'J' bevel tee symmetrical 	G = 2.5 to 4 mm		see Note 1

NOTE 1
Different plate edge preparation may be accepted or approved by the Classification Society in accordance with URW28 or other recognized standard accepted by the Classification Society.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.5 – Butt And Fillet Weld Profile (Manual Welding and Semi-Automatic Welding)

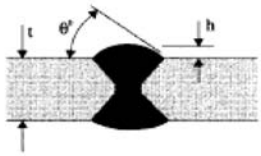
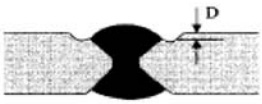
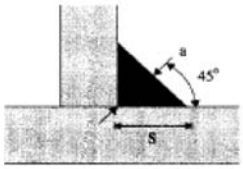
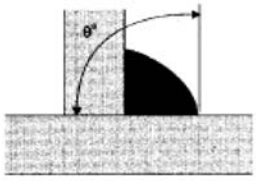
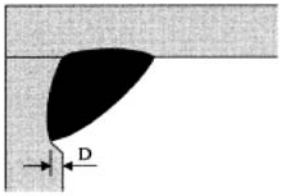
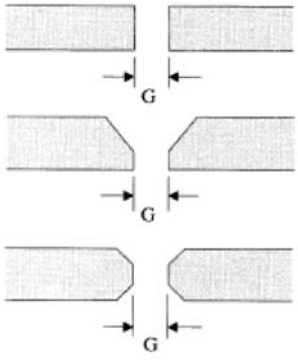
Detail	Standard	Limit	Remarks
Butt weld toe angle 	$\theta \leq 60°$ $h \leq 6$ mm	$\theta \leq 90°$	
Butt weld undercut 		$D \leq 0.5$ mm for strength member $D \leq 0.8$ mm for other	
Fillet weld leg length  s = leg length; a = throat thickness		$s \geq 0.9s_d$ $a \geq 0.9a_d$ over short weld lengths	s_d = design s a_d = design a
Fillet weld toe angle 		$\theta \leq 90°$	In areas of stress concentration and fatigue, the Classification Society may require a lesser angle.
Fillet weld undercut 		$D \leq 0.8$ mm	

Table 8.6 – Typical Butt Weld Plate Edge Preparation (Automatic welding) for Reference

Detail	Standard	Limit	Remarks
Submerged Arc Welding (SAW)  	$0 \le G \le 0.8$ mm	G = 2 mm	See Note 1.

NOTE 1

Different plate edge preparation may be accepted or approved by the Classification Society in accordance with URW28 or other recognized standard accepted by the Classification Society.
For welding procedures other than manual welding, see paragraph 3.2 Qualification of welding procedures.

Table 8.7 – Distance Between Welds

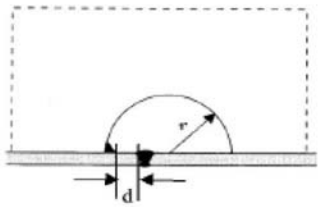
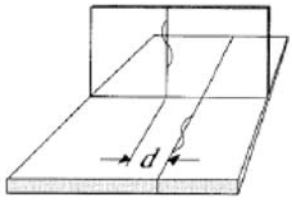
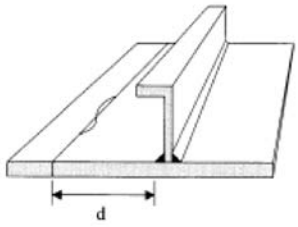
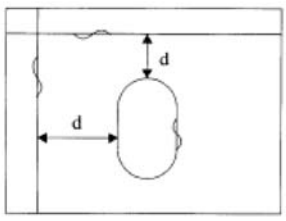
Detail	Standard	Limit	Remarks
Scallops over weld seams 		for strength member d ≥ 5mm for other d ≥ 0mm	The "d" is to be measured from the toe of the fillet weld to the toe of the butt weld.
Distance between two butt welds 		d ≥ 0 mm	
Distance between butt weld and fillet weld 		for strength member d ≥ 10 mm for other d ≥ 0 mm	The "d" is to be measured from the toe of the fillet weld to the toe of the butt weld.
Distance between butt welds 	for cut-outs d ≥ 30 mm		
	for margin plates d ≥ 300 mm	150 mm	

Table 9.1 – Typical Misalignment Remedial

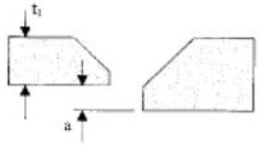
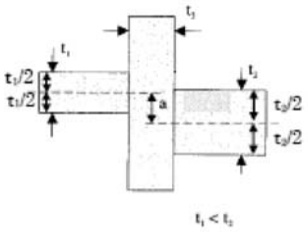
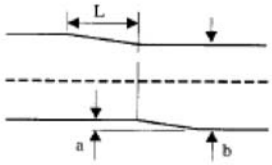
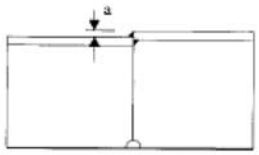
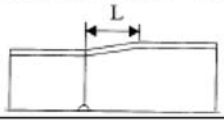
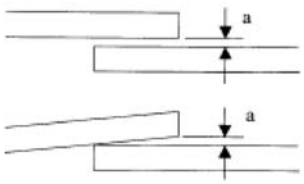
Detail	Remedial Standard	Remarks
Alignment of butt joints 	Strength member $a > 0.15t_1$ or $a > 4$ mm release and adjust Other $a > 0.2t_1$ or $a > 4$ mm release and adjust	t_1 is lesser plate thickness
Alignment of fillet welds 	Strength member and higher stress member $t_1/3 < a \leq t_1/2$ - generally increase weld throat by 10% $a > t_1/2$ - release and adjust over a minimum of 50a Other $a > t_1/2$ - release and adjust over a minimum of 30a	Alternatively, heel line can be used to check the alignment. Where t_3 is less than t_1 then t_3 should be substituted for t_1 in standard
Alignment of flange of T-longitudinal 	When $0.04b < a \leq 0.08b$, max 8 mm: grind corners to smooth taper over a minimum distance L = 3a When $a > 0.08b$ or 8 mm: release and adjust over a minimum distance L = 50a	
Alignment of height of T-bar, L-angle bar or bulb 	When 3 mm < a ≤ 6 mm: build up by welding When a > 6 mm: release and adjust over minimum L = 50a for strength member and L = 30a for other 	
Alignment of lap welds 	3 mm < a ≤ 5 mm: weld leg length to be increased by the same amount as increase in gap in excess of 3 mm a > 5 mm: members to be re-aligned	

Table 9.2 – Typical Misalignment Remedial

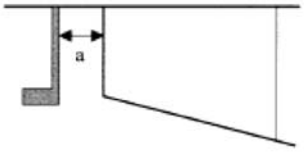
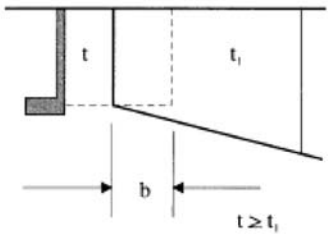
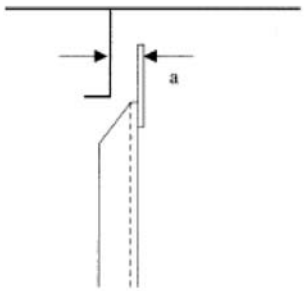
Detail	Remedial Standard	Remarks
Gap between bracket/intercostal and stiffener 	When 3 mm < a ≤ 5 mm: weld leg length to be increased by increase in gap in excess of 3 mm	
	When 5mm < a ≤ 10 mm: chamfer 30° to 40° and build up by welding with backing	
	When a > 10 mm: increase gap to about 50 mm and fit collar plate  b = (2t + 25) mm, min. 50 mm	
Gap between beam and frame 	3 mm < a ≤ 5 mm: weld leg length to be increased by the same amount as increase in gap in excess of 3 mm a > 5 mm release and adjust	

TABLE 9.3 – Misalignment Remedial

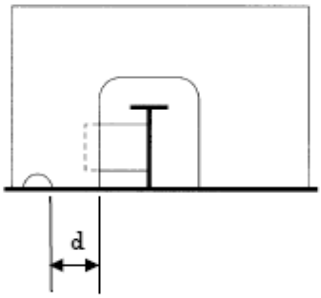
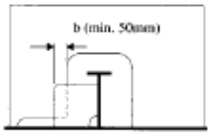
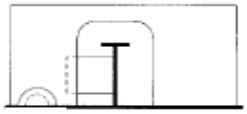
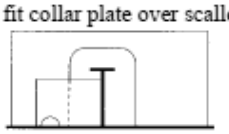
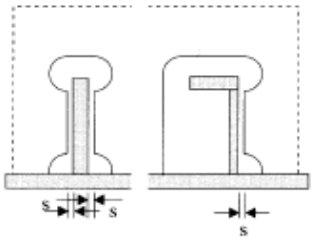
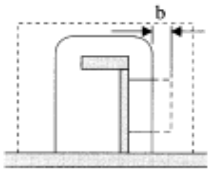
Detail	Remedial standard	Remarks
Position of scallop 	When d < 75 mm web plate to be cut between scallop and slot, and collar plate to be fitted  Or fit small collar over scallop  Or fit collar plate over scallop 	
Gap around stiffener cut-out 	When 3 mm < s ≤ 5 mm weld leg length to be increased by the same amount as increase in gap in excess of 2 mm	
	When 5 mm < s ≤ 10 mm nib to be chamfered and built up by welding	
	When s > 10 mm cut off nib and fit collar plate of same height as nib  20 mm ≤ b ≤ 50 mm	

TABLE 9.4 – Typical Butt Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

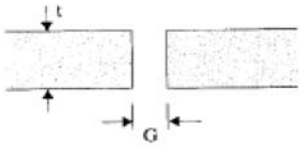
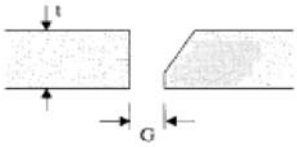
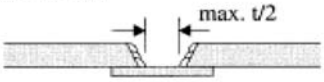
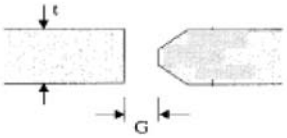
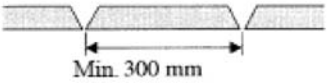
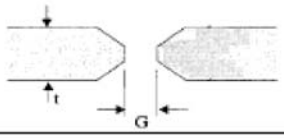
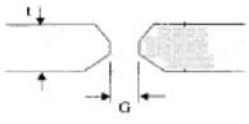
Detail	Remedial standard	Remarks
Square butt 	When G ≤ 10 mm chamfer to 45° and build up by welding When G > 10mm build up with backing strip; remove, back gouge and seal weld; or, insert plate, min. width 300 mm	
Single bevel butt 	When 5 mm < G ≤ 1.5t (maximum 25 mm) build up gap with welding on one or both edges to maximum of 0.5t, using backing strip, if necessary. Where a backing strip is used, the backing strip is to be removed, the weld back gouged, and a sealing weld made. 	
Double bevel butt 	Different welding arrangement by using backing material approved by the Classification Society may be accepted on the basis of an appropriate welding procedure specification. When G > 25 mm or 1.5t, whichever is smaller, use insert plate, of minimum width 300 mm 	
Double vee butt, uniform bevels 		
Double vee butt, non-uniform bevel 		

TABLE 9.5 – Typical Butt Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

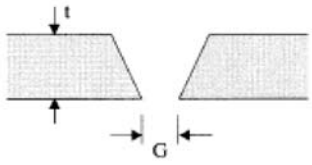
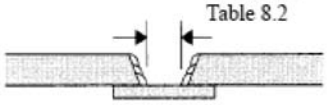
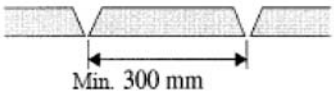
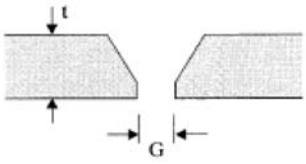
Detail	Remedial Standard	Remarks
Single vee butt, one side welding  	When 5 mm < G ≤ 1.5t mm (maximum 25 mm), build up gap with welding on one or both edges, to "Limit" gap size preferably to "Standard" gap size as described in Table 8.2. Where a backing strip is used, the backing strip is to be removed, the weld back gouged, and a sealing weld made. Different welding arrangement by using backing material approved by the Classification Society may be accepted on the basis of an appropriate welding procedure specification. Limits see Table 8.2  When G > 25 mm or 1.5t, whichever is smaller, use insert plate of minimum width 300 mm.  	
Single vee butt  		

TABLE 9.6 – Typical Fillet Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

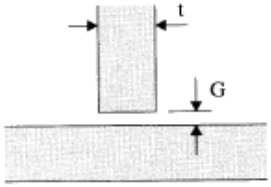
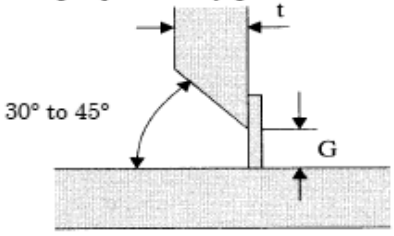
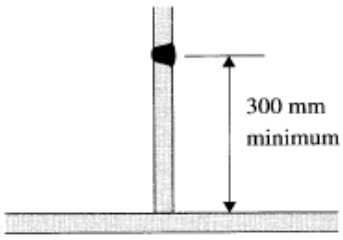
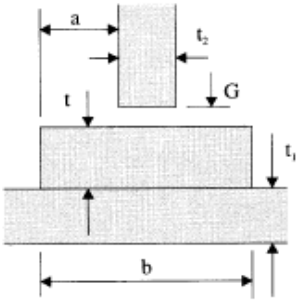
Detail	Remedial standard	Remarks
Tee Fillet 	3 mm < G ≤ 5 mm – leg length increased to Rule leg + (G-2)	
	5 mm < G ≤ 16 mm or G ≤ 1.5t - chamfer by 30° to 45°, build up with welding, on one side, with backing strip if necessary, grind and weld. 	
	G > 16 mm or G > 1.5t use insert plate of minimum width 300 mm 	
Liner treatment 	$t_2 \le t \le t_1$ G ≤ 2 mm a = 5 mm + fillet leg length	Not to be used in cargo area or areas of tensile stress through the thickness of the liner

TABLE 9.7 – Typical Fillet Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

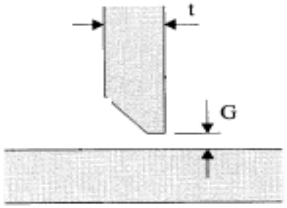
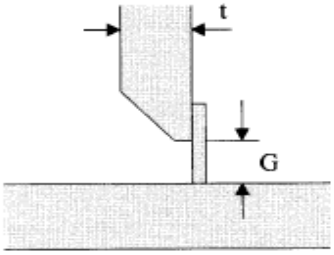
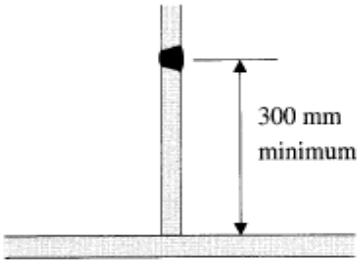
Detail	Remedial standard	Remarks
Single bevel tee 	3 mm < G ≤ 5 mm build up weld	
	5 mm < G ≤ 16 mm - build up with welding, with backing strip if necessary, remove backing strip if used, back gouge and back weld. 	
	G > 16 mm new plate to be inserted of minimum width 300 mm 	

TABLE 9.8 – Typical Fillet Weld Plate Edge Preparation Remedial (Manual Welding and Semi-Automatic Welding)

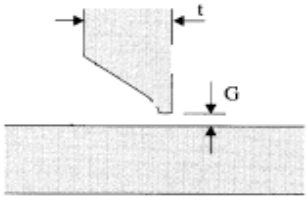
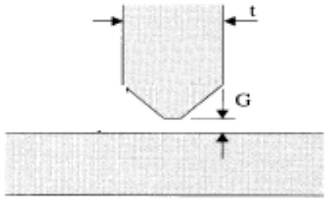
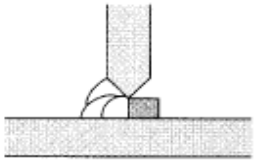
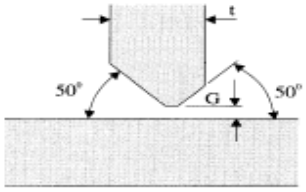
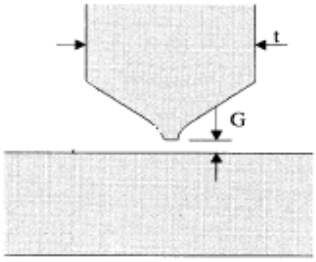
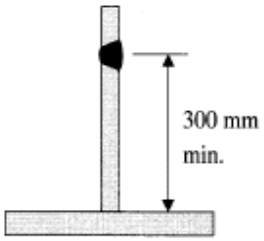
Detail	Remedial standard	Remarks
Single 'J' bevel tee 	as single bevel tee	
Double bevel tee symmetrical 	When 5 mm < G ≤ 16 mm build up with welding using ceramic or other approved backing bar, remove, back gouge and back weld. 	
Double bevel tee asymmetrical 		
Double 'J' bevel symmetrical 	When G > 16 mm-insert plate of minimum height 300 mm to be fitted. 	

TABLE 9.9 – Typical Fillet and Butt Weld Profile Remedial (Manual Welding and Semi-Automatic Welding)

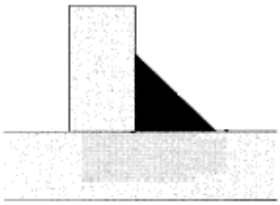
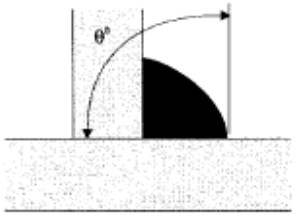
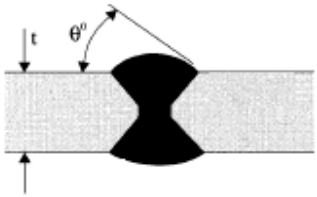
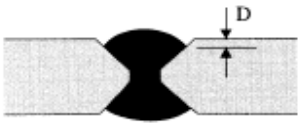
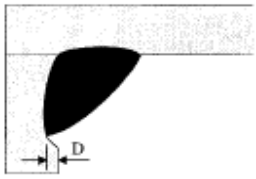
Detail	Remedial standard	Remarks
Fillet weld leg length 	Increase leg or throat by welding over	Minimum short bead to be referred Table 9.14
Fillet weld toe angle 	θ > 90° grinding, and welding, where necessary, to make θ ≤ 90°	
Butt weld toe angle 	θ > 90° grinding, and welding, where necessary, to make θ ≤ 90°	
Butt weld undercut 	For strength member, where 0.5 < D ≤ 1 mm, and for other, where 0.8 < D ≤ 1 mm, undercut to be ground smooth (localized only) or to be filled by welding Where D > 1 mm undercut to be filled by welding	
Fillet weld undercut 	Where 0.8 < D ≤ 1 mm undercut to be ground smooth (localized only) or to be filled by welding Where D > 1 mm undercut to be filled by welding	

TABLE 9.10 – Distance Between Welds Remedial

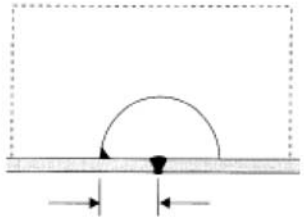
Detail	Remedial standard	Remarks
Scallops over weld seams 	Hole to be cut and ground smooth to obtain distance	

TABLE 9.11 – Erroneous Hole Remedial

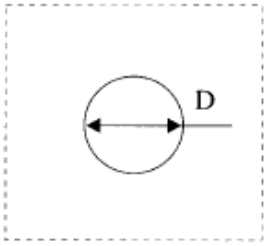
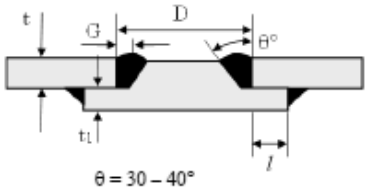
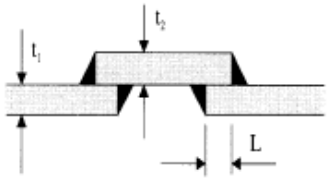
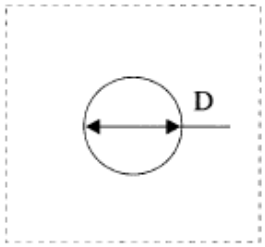
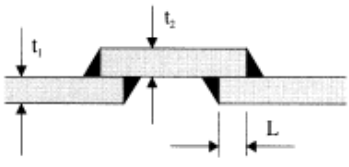
Detail	Remedial standard	Remarks
Holes made erroneously D < 200 mm 	Strength member open hole to minimum 75 mm dia., fit and weld spigot piece  θ = 30 – 40° G = 4 – 6 mm 1/2t ≤ t1 ≤ t l = 50 mm Or open hole to over 300 mm and fit insert plate	Fillet weld to be made after butt weld The fitting of spigot pieces in areas of high stress concentration or fatigue is to be approved by the Classification Society.
	Other open hole to over 300 mm and fit insert plate Or fit lap plate  t1 = t2 L = 50 mm, min	
Holes made erroneously D ≥ 200 mm 	Strength member open hole and fit insert plate	
	Other open hole to over 300 mm and fit insert plate Or fit lap plate  t1 = t2 L = 50 mm, min	

TABLE 9.12 – Remedial by Insert Plate

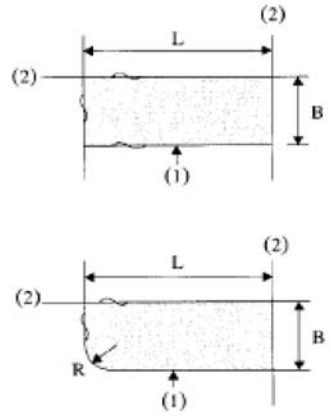
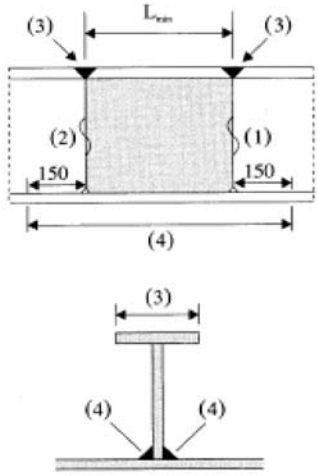
Detail	Remedial standard	Remarks
Remedial by insert plate 	L = 300 mm minimum B = 300 mm minimum R = 5t mm 100mm minimum (1) seam with insert piece is to be welded first (2) original seam is to be released and welded over for a minimum of 100 mm.	
Remedial of built section by insert plate 	$L_{min} \geq 300$ mm Welding sequence (1) →(2) →(3) →(4) Web butt weld scallop to be filled during final pass (4)	

TABLE 9.13 – Weld Surface Remedial

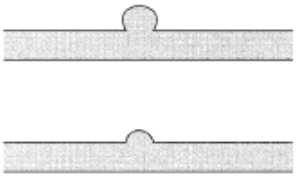
Detail	Remedial standard	Remarks
Weld spatter 	1. Remove spatter observed before blasting with scraper or chipping hammer, etc. 2. For spatter observed after blasting: a) Remove with a chipping hammer, scraper, etc. b) For spatter not easily removed with a chipping hammer, scraper, etc., grind the sharp angle of spatter to make it obtuse.	In principle, no grinding is applied to weld surface.
Arc strike (HT steel, Cast steel, Grade E of mild steel, TMCP type HT steel, Low temp steel)	Remove the hardened zone by grinding or other measures such as overlapped weld bead etc.	Minimum short bead to be referred Table 9.14

TABLE 9.14 – Welding Remedial by Short Bead

Detail	Remedial standard	Remarks
Short bead for remedying scar (scratch)	a) HT steel, Cast steel, TMCP type HT steel (Ceq > 0.36%) and Low temp steel (Ceq > 0.36%) Length of short bead ≥ 50 mm b) Grade E of mild steel Length of short bead ≥ 30 mm c) TMCP type HT steel (Ceq ≤ 0.36%) and Low temp steel (Ceq ≤ 0.36%) Length of short bead ≥ 10 mm	Preheating is necessary at 100 ± 25°C
Remedying weld bead	a) HT steel, Cast steel, TMCP type HT steel (Ceq > 0.36%) and Low temp steel (Ceq > 0.36%) Length of short bead ≥ 50 mm b) Grade E of mild steel Length of short bead ≥ 30 mm c) TMCP type HT steel (Ceq ≤ 0.36%) and Low temp steel (Ceq ≤ 0.36%) Length of short bead ≥ 30 mm	

NOTE:

1. When short bead is made erroneously, remove the bead by grinding.
2. $Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} (\%)$

No. 47 Part B

Repair Quality Standard for Existing Ships

Part B - Shipbuilding and Repair Quality Standard for Existing Ships

CONTENTS:

REFERENCES

1. IACS "Bulk Carriers - Guidelines for Surveys, Assessment and Repair of Hull Structure"
2. TSCF "Guidelines for the inspection and maintenance of double hull tanker structures"
3. TSCF "Guidance manual for the inspection and condition assessment of tanker structures"
4. IACS UR W 11 "Normal and higher strength hull structural steels"
5. IACS UR W 13 "Thickness tolerances of steel plates and wide flats"
6. IACS UR W 17 "Approval of consumables for welding normal and higher strength hull structural steels"
7. IACS Z 10.1 "Hull surveys of oil tankers" and Z 10.2 "Hull surveys of bulk carriers" Table IV
8. IACS UR Z 13 "Voyage repairs and maintenance"
9. IACS Recommendation 12 "Guidelines for surface finish of hot rolled steel plates and wide flats"
10. IACS Recommendation 20 "Non-destructive testing of ship hull steel welds"

1. Scope

1.1 This standard provides guidance on quality of repair of hull structures. The standard covers permanent repairs of existing ships.

Whereas the standard generally applies to

- conventional ship types,
- parts of hull covered by the rules of the Classification Society,
- hull structures constructed from normal and higher strength hull structural steel, the applicability of the standard is in each case to be agreed upon by the Classification Society.

The standard does generally not apply to repair of

- special types of ships as e.g. gas tankers
- structures fabricated from stainless steel or other, special types or grades of steel

1.2 The standard covers typical repair methods and gives guidance on quality standard on the most important aspects of such repairs. Unless explicitly stated elsewhere in the standard, the level of workmanship reflected herein will in principle be acceptable for primary and secondary structure of conventional design. A more stringent standard may however be required for critical and highly stressed areas of the hull, and is to be agreed with the Classification Society in each case. In assessing the criticality of hull structure and structural components, reference is made to ref. 1, 2 and 3.

1.3 Restoration of structure to the original standard may not constitute durable repairs of damages originating from insufficient strength or inadequate detail design. In such cases strengthening or improvements beyond the original design may be required. Such improvements are not covered by this standard, however it is referred to ref. 1, 2 and 3.

2. General requirements for repairs and repairers

2.1 In general, when hull structure covered by classification is to be subjected to repairs, the work is to be carried out under the supervision of the Surveyor to the Classification Society. Such repairs are to be agreed prior to commencement of the work.

2.2 Repairs are to be carried out by workshops, repair yards or personnel who have demonstrated their capability to carry out hull repairs of adequate quality in accordance with the Classification Society's requirements and this standard.

2.3 Repairs are to be carried out under working conditions that facilitate sound repairs. Provisions are to be made for proper accessibility, staging, lighting and ventilation. Welding operations are to be carried out under shelter from rain, snow and wind.

2.4 Welding of hull structures is to be carried out by qualified welders, according to approved and qualified welding procedures and with welding consumables approved by the Classification Society, see Section 3. Welding operations are to be carried out under proper supervision of the repair yard.

2.5 Where repairs to hull which affect or may affect classification are intended to be carried out during a voyage, complete repair procedure including the extent and sequence of repair is to be submitted to and agreed upon by the Surveyor to the Classification Society reasonably in advance of the repairs. See Ref. 8.

3. Qualification of personnel

3.1 Qualification of welders

3.1.1 Welders are to be qualified in accordance with the procedures of the Classification Society or to a recognised national or international standard, e.g. EN 287, ISO 9606, ASME Section IX, ANSI/AWS D1.1. Recognition of other standards is subject to submission to the Classification Society for evaluation. Repair yards and workshops are to keep records of welders qualification and, when required, furnish valid approval test certificates.

3.1.2 Welding operators using fully mechanised of fully automatic processes need generally not pass approval testing, provided that production welds made by the operators are of the required quality. However, operators are to receive adequate training in setting or programming and operating the equipment. Records of training and production test results shall be maintained on individual operator's files and records, and be made available to the Classification Society for inspection when requested.

3.2 Qualification of welding procedures

Welding procedures are to be qualified in accordance with the procedures of the Classification Society or a recognised national or international standard, e.g. EN288, ISO 9956, ASME Section IX, ANSI/AWS D1.1. Recognition of other standards is subject to submission to the Classification Society for evaluation. The welding procedure should be supported by a welding procedure qualification record. The specification is to include the welding process, types of electrodes, weld shape, edge preparation, welding techniques and positions.

3.3 Qualification of NDE operators

3.3.1 Personnel performing non destructive examination for the purpose of assessing quality of welds in connection with repairs covered by this standard, are to be qualified in accordance with the Classification Society rules or to a recognised international or national qualification scheme. Records of operators and their current certificates are to be kept and made available to the Surveyor for inspection.

4. Materials

4.1 General requirements for materials

4.1.1 The requirements for materials used in repairs are in general the same as the requirements for materials specified in the Classification Society's rules for new constructions, (ref. 5).

4.1.2 Replacement material is in general to be of the same grade as the original approved material. Alternatively, material grades complying with recognised national or international standards may be accepted by the Classification Societies provided such standards give equivalence to the requirements of the original grade or are agreed by the Classification Society. For assessment of equivalency between steel grades, the general requirements and guidelines in Section 4.2 apply.

4.1.3 Higher tensile steel is not to be replaced by steel of a lesser strength unless specially approved by the Classification Society.

4.1.4 Normal and higher strength hull structural steels are to be manufactured at works approved by the Classification Society for the type and grade being supplied.

4.1.5 Materials used in repairs are to be certified by the Classification Society applying the procedures and requirements in the rules for new constructions. In special cases, and normally limited to small quantities, materials may be accepted on the basis of alternative procedures for verification of the material's properties. Such procedures are subject to agreement by the Classification Society in each separate case.

4.2 Equivalency of material grades

4.2.1 Assessment of equivalency between material grades should at least include the following aspects;

- heat treatment/delivery condition
- chemical composition
- mechanical properties
- tolerances

4.2.2 When assessing the equivalence between grades of normal or higher strength hull structural steels up to and including grade E40 in thickness limited to 50 mm, the general requirements in Table 4.1 apply.

4.2.3 Guidance on selection of steel grades to certain recognised standards equivalent to hull structural steel grades specified in Classification Societies' rules is given in Table 4.2

Items to be considered	Requirements	Comments
Chemical composition	- C; equal or lower - P and S; equal or lower - Mn; approximately the same but not exceeding 1.6% - Fine grain elements; in same amount - Detoxidation practice	The sum of the elements, e.g. Cu, Ni, Cr and Mo should not exceed 0.8%
Mechanical properties	- Tensile strength; equal or higher Yield strength; equal or higher - Elongation; equal or higher - Impact energy; equal or higher at same or lower temperature, where applicable	Actual yield strength should not exceed Classification Society Rule minimum requirements by more than 80 N/mm^2
Condition of supply	Same or better	Heat treatment in increasing order; - as rolled (AR) - controlled rolled (CR) - normalised (N) - thermo-mechanically rolled (TM)[1)] - quenched and tempered (QT)[1)] [1)] TM- and QT-steels are not suitable for hot forming
Tolerances	- Same or stricter	Permissable under thickness tolerances; - plates: 0.3 mm - sections: according to recognised standards

Table 4.1 Minimum extent and requirements to assessment of equivalency between normal or higher strength hull structual steel grades

Steel grades according to Classification Societies' rules (ref. 5)							Comparable steel grades			
Grade	Yield stress R_{eH} min. N/mm^2	Tensile strength R_m N/mm^2	Elongation A_5 min. %	Average impact energy Temp. °C	J, min. L	T	ISO 630-80 4950/2/3/ 1981	EN EN 10025-93 EN 10113-93	ASTM A 131	JIS G 3106
A	235	400-502	22	+20	-	-	Fe 360B	S235JRG2	A	SM41B
B				0	27	20	Fe 360C	S235J0	B	SM41B
D				-20	27	20	Fe 360D	S235J2G3	D	(SM41C)
E				-40	27	20	-	S275NL/ML	E	-
A 27	265	400-530	22	0			Fe 430C	S275J0G3	-	-
D 27				-20	27	20	Fe 430D	S275N/M	-	-
E 27				-40			-	S275NL/ML	-	-
A 32	315	440-590	22	0			-	-	AH32	SM50B
D 32				-20	31	22	-	-	DH32	(SM50C)
E 32				-40			-	-	EH32	-
A 36	355	490-620	21	0			Fe 510C	S355N/M	AH36	SM53B
D 36				-20	34	24	Fe 510D	S355N/M	DH36	(SM53C)
E 36				-40			E355E	S355NL/ML	EH36	-
A 40	390	510-650	20	0			E390CC	S420N/M	AH40	(SM58)
D 40				-20	41	27	E390DD	S420N/M	DH40	-
E 40				-40			E390E	S420NL/ML	EH40	-

Note: In selecting comparitable steels from this table, attention should be given to the requirements of Table 4.1 and the dimension requirements of the product with respect to Classification Sociey rules.

Table 4.2 Guidance on steel grades comparable to the normal and high strength hull structural steel grades given in Classification Society rules

5. General requirements to welding

5.1 Correlation of welding consumables with hull structural steels

5.1.1 For the different hull structural steel grades welding consumables are to be selected in accordance with IACS UR W17 (see Ref.6).

5.2 General requirements to preheating and drying out

5.2.1 The need for preheating is to be determined based on the chemical composition of the materials, welding process and procedure and degree of joint restraint.

5.2.2 A minimum preheat of 50° C is to be applied when ambient temperature is below 0° C. Dryness of the welding zone is in all cases to be ensured.

5.2.3 Guidance on recommended minimum preheating temperature for higher strength steel is given in Table 5.1. For automatic welding processes utilising higher heat input e.g. submerged arc welding, the temperatures may be reduced by 50° C. For re-welding or repair of welds, the stipulated values are to be increased by 25° C.

Carbon equivalent [1]	Recommended minimum preheat temperature (° C)		
	$t_{comb} \leq 50$ mm [2]	50 mm < $t_{comb} \leq 70$ mm [2]	$t_{comb} > 70$ mm [2]
Ceq ≤ 0.39	- -	50	
Ceq ≤ 0.41	- -	75	
Ceq ≤ 0.43	-	50	100
Ceq ≤ 0.45	50	100	125
Ceq ≤ 0.47	100	125	150
Ceq ≤ 0.50	125	150	175

Table 5.1 Preheating temperature

5.3 Dry welding on hull plating below the waterline of vessels afloat

5.3.1 Welding on hull plating below the waterline of vessels afloat is acceptable only on normal and higher strength steels with specified yield strength not exceeding 355 MPa and only for local repairs. Welding involving other high strength steels or more extensive repairs against water backing is subject to special consideration and approval by the Classification Society of the welding procedure.

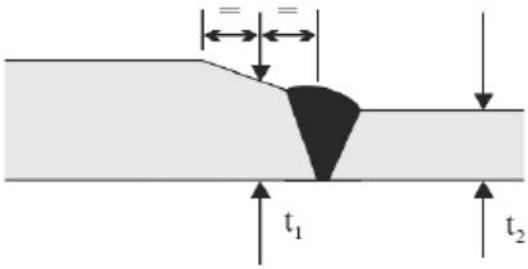
5.3.2 Low-hydrogen electrodes or welding processes are to be used when welding on hull plating against water backing. Coated low-hydrogen electrodes used for manual metal arc welding should be properly conditioned to ensure a minimum of moisture content.

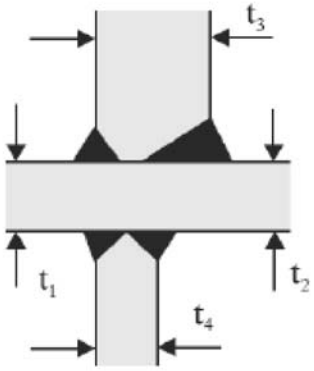
5.3.3 In order to ensure dryness and to reduce the cooling rate, the structure is to be preheated by a torch or similar prior to welding, to a temperature of minimum 5° C or as specified in the welding procedure.

Notes:

1) $$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}(\%)$$

2) Combined thickness $t_{comb} = t_1 + t_2 + t_3 + t_4$, see figure





6. Repair quality standard

6.1 Welding, general

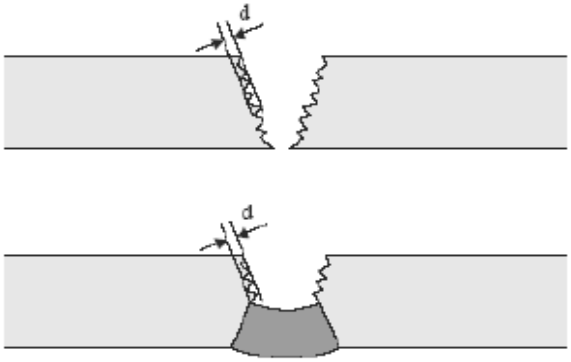


Fig 6.1 Groove roughness

Item	Standard	Limit	Remarks
Material Grade	Same as original or higher		See Section 4
Welding Consumables	IACS UR W17 (ref. 6)	Approval according to equivalent international standard	
Groove / Roughness	See note and Fig 6.1	d < 1.5 mm	Grind smooth
Pre-Heating	See Table 5.1	Steel temperature not lower than 5°C	
Welding with water on the outside	See Section 5.3	Acceptable for normal and high strength steels	- Moisture to be removed by a heating torch
Alignment	As for new construction		
Weld Finish	IACS Recommendation 20 (ref. 10)		
NDE	IACS Recommendation 20 (ref. 10)	At random with extent to be agreed with attending surveyors	

Note:

Slag, grease, loose mill scale, rust and paint, other than primer, to be removed.

6.2 Renewal of plates

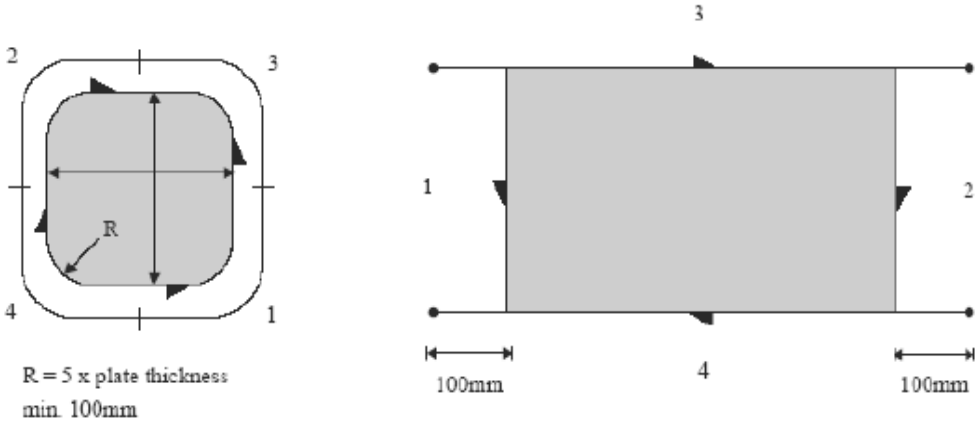


Fig 6.2 Welding sequence for inserts

Item	Standard	Limit	Remarks
Size Insert	Min. 300 x 300 mm R = 5 x thickness Circular inserts: D_{min} = 200 mm	Min. 200 x 200 mm Min R = 100 mm	
Marterial Grade	Same as original or higher		See Section 4.
Edge Preparation	As for new construction		In case of non compliance increase the amount of NDE
Welding Sequence	See Fig 6.2 Weld sequence is 1→ 2 → 3→4		For primary members sequence 1 and 2 transverse to the main stress direction
Alignment	As for new construction		
Weld Finish	IACS Recommendation 20 (ref. 10)		
NDE	IACS Recommendation 20 (ref. 10)		

6.3 Doublers on plating

Local doublers are normally only allowed as temporary repairs, except as original compensation for openings, within the main hull structure.

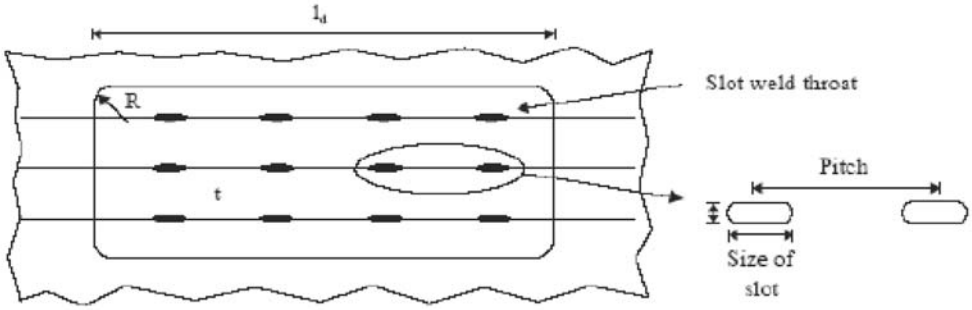


Fig 6.3 Doublers on plates

Item	Standard	Limit	Remarks
Existing Plating		General: t ≥ 5 mm	For areas where existing plating is less than 5 mm plating a permanent repair by insert is to be carried out.
Extent / Size	Rounded off corners.	min 300 x 300 mm R ≥ 50 mm	
Thickness of Doubler (td)	td ≤ tp (tp = original thickness of existing plating)	td > tp/3	
Material Grade	Same as original plate		See Section 4
Edge Preparation	As for [newbuidling] new construction		Doublers welded on primary strength members: (Le: leg length) when t > Le + 5 mm, the edge to be tapered (1:4)
Welding	As for [newbuidling] new construction		Welding sequence similar to insert plates.
Weld Size (throat thicknesss)	Circumferencial and in slots: 0.6 x td		
Slot Welding	Normal size of slot: (80-100) x 2 td Distance from doubler edge and between slots: d ≤ 15 td	Max pitch between slots 200 mm dmax = 500 mm	For doubler extended over several supporting elements, see Figure 6.3
NDE	IACS Recommendation 20 (ref. 10)		

6.4 Renewal of internals/stiffeners

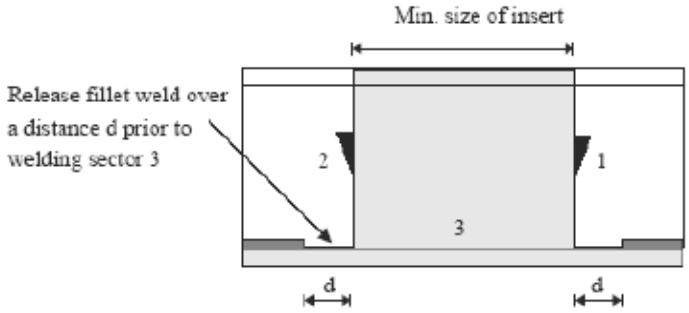


Fig 6.4 Welding sequence for inserts of stiffeners

Item	Standard	Limit	Remarks
Size Insert	Min. 300 mm	Min. 200 mm	
Marterial Grade	Same as original or higher		See Section 4.
Edge Preparation	As for new construction. Fillet weld stiffener web / plate to be released over min. d = 150 mm		
Welding Sequence	See Fig 6.4 Welding sequence is 1→ 2 → 3		
Alignment	As for new construction		
Weld Finish	IACS Recommendation 20 (ref. 10)		
NDE	IACS Recommendation 20 (ref. 10)		

6.5 Renewal of internals/stiffeners – transitions inverted angle/bulb profile

The application of the transition is allowed for secondary structural elements.

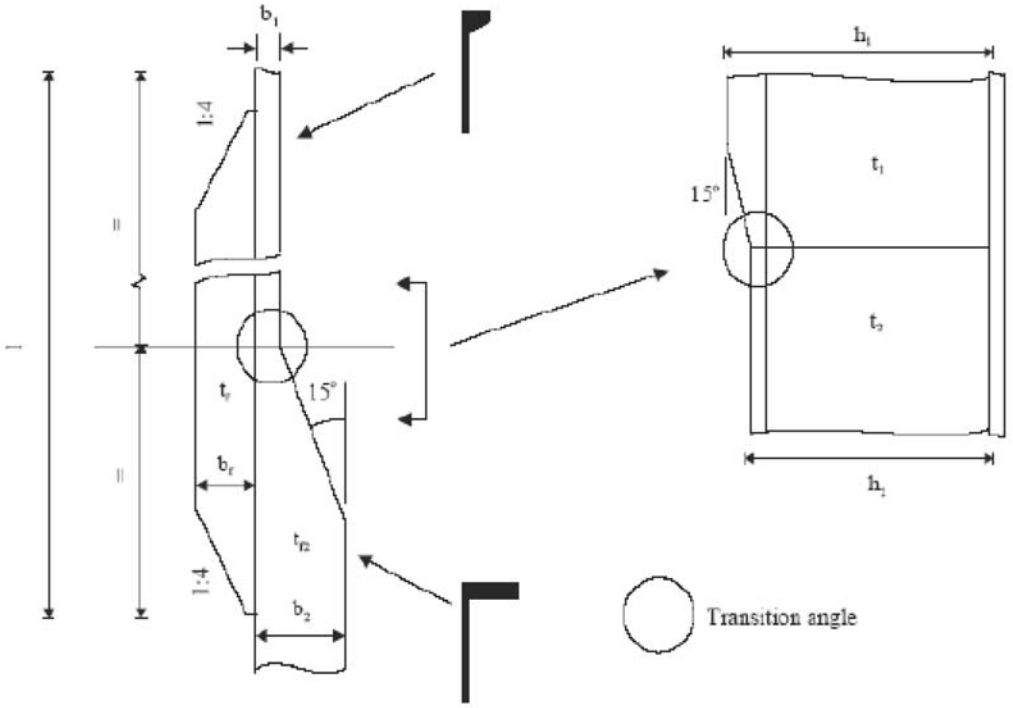


Fig 6.5 Transition between inverted angle and bulb profile

Item	Standard	Limit	Remarks
$(h_1 - h_2)$	≤ 025 x b1		
$\lvert t_1 - t_2 \rvert$	2 mm		Without tapering transition.
Transition Angle	15 degrees		At any arbitrary section
Flanges	$tf = tf_2$ $bf = bf_2$		
Length of Flatbar	4 x h_1		
Material			See Section 4.

6.6 Application of Doubling Straps

In certain instances, doubling straps are used as a means to strengthen and reinforce primary structure. Where this has been agreed and approved, particular attention should be paid to:

- the end termination points of the straps, so that toe support is such that no isolated hard point occurs.
- in the case of application of symmetrical or asymmetrical-ended straps, the corners at the end of the tapering should be properly rounded.
- any butts between lengths of doubling straps, so that there is adequate separation of the butt weld from the primary structure below during welding, and so that a high quality root run under controlled circumstances is completed prior to completing the remainder of the weld. Ultrasonic testing should be carried out on completion to verify full penetration.

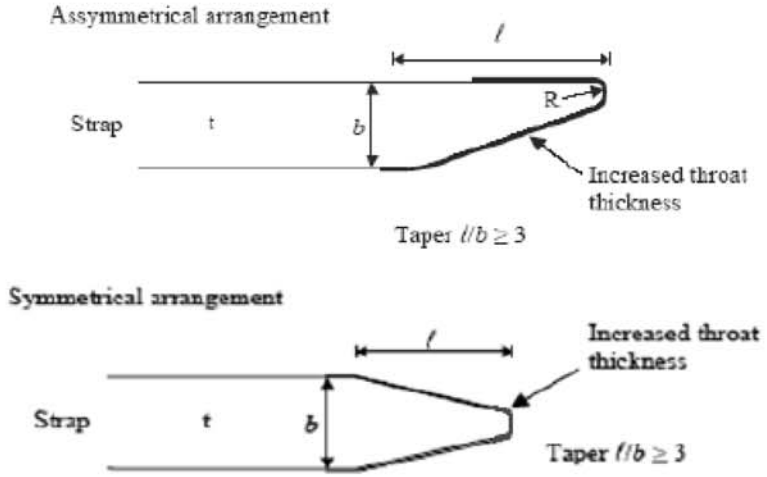


Fig 6.6 Application of Doubling Straps

Item	Standard	Limit	Remarks
Tapering	*l/b>3*		Special consideration to be drawn to design of strap terminations in fatigue sensitive areas.
Radius	0.1 x *b*	min 30 mm	
Material			See paragraph 2.0 General requirement to materials.
Weld Size			Depending on number and function of straps. Throat thickness to be increased 15 % toward ends.
Welding	Welding sequence from middle towards the free ends		See sketch. For welding of lengths > 1000 mm step welding to be applied.

6.7 Welding of pitting corrosion

Notes:

Shallow pits may be filled by applying coating or pit filler. Pits can be defined as shallow when their depth is less that 1/3 of the original plate thickness.

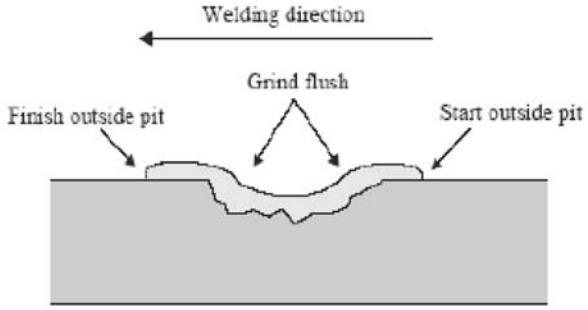


Fig 6.7 Welding of pits

Item	Standard	Limit	Remarks
Extent / Depth	Pits / grooves are to be welded flush with the original surface.	If deep pits or grooves are clustered together or remaining thickness is less than 6 mm, the plates should be renewed.	See also IACS Recommendation 12 (ref. 9)
Cleaning	Heavy rust to be removed		
Pre-Heating	See Table 5.1	Required when ambient temperature < 5°C	Always use propane torch or similar to remove any moisture
Welding Sequence	Reverse direction for each layer		See also IACS Recommendation 12 (ref. 9)
Weld Finish	IACS Recommendation 20 (ref. 10)		
NDE	IACS Recommendation 20 (ref. 10)	Min. 10% extent	Preferably MPI

Reference is made to TSCF Guidelines, Ref. 2 & 3.

6.8 Welding repairs for cracks

In the event that a crack is considered weldable, either as a temporary or permanent repair, the following techniques should be adopted as far as practicable. Run-on and run-off plates should be adopted at all free edges.

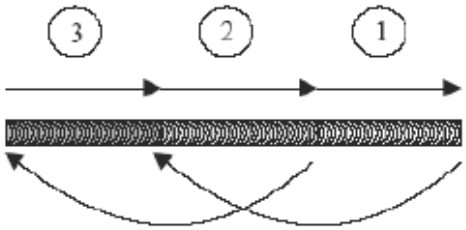


Fig 6.8.a Step back technique

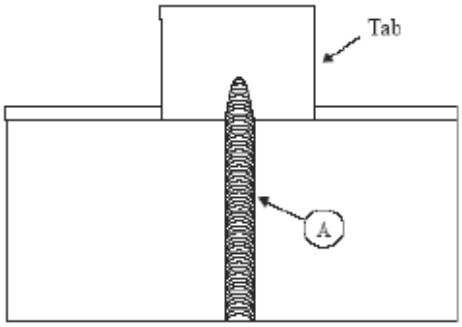


Fig 6.8.b End crack termination

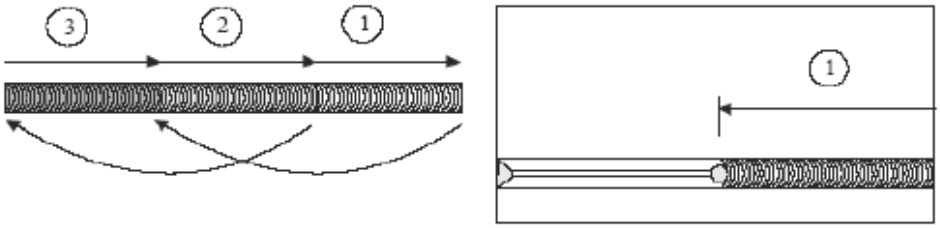


Fig 6.8.c Welding sequence for cracks with length less than 300 mm

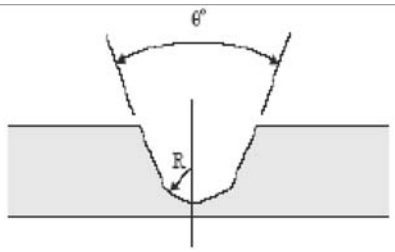


Fig 6.8.d Groove preparation (U-groove left and V-groove right)

Item	Standard	Limit	Remarks
Groove Preparation	θ = 45-60° r = 5 mm		For through plate cracks as for newbuilding. Also see Fig 6.8.d
Termination	Termination to have slope 1:3		For cracks ending on edges weld to be terminated on a tab see Fig 6.8.b
Extent	On plate max. 400 mm length. Vee out 50 mm past end of crack	On plate max 500 mm. Linear crack, not branched	
Welding Sequence	See Fig 6.8.c for sequence and direction	For cracks longer than 300 mm step-back technique should be used Fig 6.8.a	Always use low hydrogen welding consumables
Weld Finish	IACS Recommendation 20 (ref. 10)		
NDE	IACS Recommendation 20 (ref. 10)	100 % MP or PE of groove	100 % surface crack detection + UE or RE for butt joints