NR426 DT R03 JANUARY 2025

CONSTRUCTION SURVEY OF STEEL STRUCTURES OF OFFSHORE UNITS AND INSTALLATIONS

NR426 – JANUARY 2025

RULE NOTE

BUREAU VERITAS

BUREAU VERITAS
RULES, RULE NOTES AND GUIDANCE NOTES

NR426 DT R02 January 2025 takes precedence over previous revision.

The PDF electronic version of this document available on the Bureau Veritas Marine & Offshore website https://marine-offshore.bureauveritas.com/ is the official version and shall prevail if there are any inconsistencies between the PDF version and any other available version.

These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

© **2025 BUREAU VERITAS** - All rights reserved

© PHOTO ADOBESTOCK.COM

NR426

CONSTRUCTION SURVEY OF STEEL STRUCTURES OF OFFSHORE UNITS AND INSTALLATIONS

January 2025

Table of Content

Table of Content

Section 1 General

1 General requirements

1.1

1.1.1 This Rule Note gives the requirements for the construction of steel structure of mobile offshore units or fixed offshore installations surveyed by the Society for classification or certification purpose.

1.1.2 This Rule Note is to be used as specified by the applicable Rules for the Classification of the concerned unit or as specified by an agreed scope of certification. Attention is drawn to the fact that these documents may contain or refer to specific requirements which are applicable and not included in this Rule Note.

1.1.3 As soon as a contract to build a structure to be surveyed by the Society as per [1.1.1] has been awarded to the Builder, it is the responsibility of the Builder to contact the Society and to provide all information needed to carry out the survey process.

In case of subcontracting for the construction of a part of the structure, it is the responsibility of the Builder to specify the requirements of this Rule Note to his subcontractor.

1.1.4 As a general rule, the fabrication documentation is to be submitted to the Society for review before starting the construction. The documentation to be submitted includes:

- quality control plans
- fabrication drawings
- fabrication procedures, such as:
  - builder fabrication standards
  - welding procedure specifications and existing welding procedure qualification test reports
  - welding sequences
  - existing welders certification
  - procedures for welding consumables handling and storage
  - forming procedures and existing qualifications
  - straightening procedures
  - heat treatment procedures.
- testing procedures, such as:
  - NDT procedures
  - hydraulic testing procedures
  - functional testing procedures.
- material certificates,

1.1.5 As a general rule, the construction and the necessary qualifications, inspections and tests carried out by the Builder are surveyed by the Society to the satisfaction of the attending Surveyor. They include:

- additional qualification tests of steel welders and operators
- additional qualification tests of welding procedures
- additional qualification tests of forming procedures
- inspections during fabrication
- materials inspections
- final tests and trials.

1.1.6 The requirements defined in this Rule Note are corresponding to steel structure design and construction of normal practice. Where appropriate, the Society reserves the right to specify additional requirements.

1.1.7 The requirements of the present Rule Note may, at the discretion of the Society, be alleviated in the case of successive units or installations built under the Society's survey which are of one design or undergo only minor alterations. In this case, the party applying for classification is to give all necessary information about these alterations of design or construction conditions in due time.

1.1.8 The present Rule Note specifies requirements for construction in C-Mn steel.

1.1.9 Materials used such as steel plates, sections, seamless and welded pipes, forgings, castings, welding consumables, are to comply with the requirements of NR216 Rules on materials and welding for the classification of marine unit.

2 Symbols and abbreviations

2.1 Symbols

2.1.1 The following symbols are used in this Rule Note:

a : Throat thickness, in mm, of a fillet weld

D : Outside diameter

t : Plate or pipe thickness, in mm; for butt welds of elements having different thicknesses, "t" stands for the thickness of the thinner one

R_{eH} : Specified minimum yield strength, in N/mm^2

R_m : Specified minimum tensile strength in N/mm^2

S : Weld root spacing between the edges to be welded, in mm.

2.2 Abbreviations

2.2.1 The following abbreviations are used in this Rule Note:

CTOD : Crack tip opening displacement

CVN : Charpy V-notch

PT : Dye or penetrant testing

FCAW : Flux-cored arc welding

FL : Fusion line

HAZ : Heat affected zone

KVL : Specified minimum average of Charpy V-Notch impact energy (J) in longitudinal direction

KVT : Specified minimum average of Charpy V-Notch impact energy (J) in transverse direction

MT : Magnetic particle testing

NDT : Non-destructive testing

SAW : Submerged arc welding

PWHT : Postweld heat treatment

pWPS : Preliminary welding procedure specification.

UT : Ultrasonic testing

WPQR : Welding Procedure Qualification Record

WPS : Welding procedure specification.

3 Structural categories

3.1 General

3.1.1 Structural elements in welded steel constructions are classed into three categories: second, first and special categories.

3.1.2 Second category elements are structural elements of minor importance, the failure of which might induce only localized effects.

3.1.3 First category elements are main load carrying elements essential to the overall structural integrity of the unit or installation.

3.1.4 Special category elements are parts of first category elements located in way or at the vicinity of critical load transmission areas and of stress concentration locations.

3.1.5 The Society may, where deemed necessary, upgrade any structural element to account for particular considerations such as novel design features or restrictions regarding access for quality control and in-service inspections.

3.1.6 Structural categories are to be indicated on the drawings submitted to the Society for approval.

3.2 Self-elevating units

3.2.1 The categories of structural members of self-elevating units are given as guidance in NR534, Sec 2, Tab 1.

3.3 Column stabilized units

3.3.1 The categories of structural members of column stabilized units are given as guidance in NR571, Sec 2, Tab 1.

3.4 Tension leg platforms

3.4.1 The categories of structural members of tension leg platforms are given as guidance in NR578, Sec 3, Tab 1.

3.5 Surface units

3.5.1 The following indications are given for guidance only and apply to typical units (refer also to [3.5.5]).

For units with unusual distribution of weights or particular loadings the categories are to be determined in accordance with the intent of [3.1].

3.5.2 Particular locations falling within definition of [3.1.4] are normally to be classed in the special category.

3.5.3 The following structural elements are normally to be classed in the first category:

- bilge, sheerstrake and stringer plates within the whole length of the unit
- deck plating in way of superstructure ends
- deck and bottom platings in midships region or a larger region if necessary on account of unusual weights or loads distribution
- upper and lower strakes of longitudinal bulkheads in midships region or a larger region if necessary on account of unusual weights or loads distribution
- other locations falling within definition of [3.1.3].

3.5.4 Second category elements are structural elements which are classed neither in the special nor in the first categories.

3.5.5 For surface units assigned the structural type notation **offshore ship** or **offshore barge**, the structural categories for offshore areas are given as guidance according to the following:

- for units assigned the service notation **oil storage** or **oil production**: see NR445 Pt D, Ch 1, Sec 3, [1.1.5]
- for units assigned the service notation **liquefied gas storage**, **gas production unit** or **gas liquefaction unit**: see NR542, Sec 2, [1.1.5]
- for units assigned the service notation **drilling**: see NR569, Sec 3 [1.2.1].

3.6 Substructures of fixed platforms (jackets)

3.6.1 The indications given are for guidance only. The actual categories are to be determined in accordance with [3.1] taking into account the actual design of the jacket.

3.6.2 The following structural elements are normally to be classed in the special category:

- all nodes on legs (main legs, skirts, chords of launchways), including cans, brace stubs (if any), ring stiffeners and other reinforcements
- whole legs where no can exists
- complex nodes between bracings of jacket rows
- padeyes for lifting or upending of jacket, including supporting cans, ring stiffeners and other reinforcements
- leg to pile connection pieces.

3.6.3 The following structural elements are normally to be classed in the first category, except parts classed in special category:

- legs (main legs, skirts, chords of launchways)
- all foundation piles
- bracings of rows and levels
- external or internal stiffening of legs
- framing or members supporting conductors, risers and essential caissons
- any attachment pieces onto special category elements.

3.6.4 The following structural elements are normally to be classed in the second category:

- mudmats
- additional temporary bracings for mudmats or launchways
- minor attachment pieces onto first category elements.

3.7 Topsides of fixed platforms

3.7.1 The indications given are for guidance only. The actual categories are to be determined in accordance with [3.1] taking into account the actual design of the topsides.

3.7.2 The following structural elements are normally to be classed in the special category, in the same conditions than in [3.6.2]:

- nodes of deck legs
- padeyes and adjacent structures.

3.7.3 The following structural elements are normally to be classed in the first category, except parts classed in the special category:

- deck legs
- heavily loaded elements forming main truss or frames of integrated decks, support frames or heavy modules
- structure supporting crane pedestals, large flare towers or long span bridges
- helideck frames
- primary framing of large flare towers or long span bridges
- all parts of nodes in above constructions
- connecting parts of important elements to legs.

3.7.4 Second category elements are structural elements which are classed neither in the special nor in the first categories.

3.8 Particulars items

3.8.1 The indications given are for guidance only. The actual categories are to be determined in accordance with [3.1] taking into account the actual design of the unit or installation.

3.8.2 The following structural elements are normally to be classed in the special category:

- padeyes and adjacent parts when used for essential operations
- connecting parts of crane pedestals to main structure.

3.8.3 The following structural elements are normally to be classed in the first category:

- legs and main beams of drill floor substructure of surface and column-stabilized units
- cantilever beams and substructure of drill floor (legs and main beams) of self-elevating units
- crane pedestals.

3.8.4 A weld joint is to be classed in the same category as the category of the element to be welded. In case of a weld joint between two elements classed in different categories, the weld joint is to be classed in the category of the element with highest class.

Section 2 Forming Process

1 Cold forming

1.1 General

1.1.1 Cold forming means forming at temperature not exceeding 250°C in general.

1.1.2 Usual cold forming processes are cold rolling or cold pressing of plates into cylindrical forms, cold bending of pipes and cold forming of plates into spherical shapes.

1.1.3 The cold forming process is to be such as not to impair the material properties. The effect of work hardening is to be considered and suitable heat treatment is to be applied as far as necessary.

1.2 Forming procedure

1.2.1 Cold forming is to result in a deformation within the range recommended by the steel manufacturer for the concerned products.

For extra high strength steel with a specified minimum yield strength R_{eH} up to 690 N/mm², the cold forming deformation of special and primary structural elements is to less than 5%, unless otherwise agreed and qualified. For yield strength 890 N/mm² and 960 N/mm², the cold forming deformation is to be agreed with the steel manufacturer.

Prior to start the fabrication, the Builder has to submit the cold forming procedure to the Society for approval.

The deformation is to be calculated using a formula adapted to the product and the forming process and is to be submitted to the Society.

For cold rolling of plates, the deformation "A" is to be calculated using the following formula where R_i is the inner forming radius, or an equivalent formula accepted by the Society:

$$A = 100\frac{t}{2R_i + t}$$

For values of deformation above the limit recommended by the steel manufacturer or 5%, whichever is the less, a heat treatment is to be performed after cold forming.

The heat treatment may be omitted if strain ageing tests are performed with satisfactory results in accordance with [2.2.2].

1.2.2 Where applicable strain ageing tests are to be performed according to the following procedure:

a) A sample is cold formed under the same conditions as those used for fabrication or is permanently strained to the expected permanent deformation used in fabrication.

b) The sample is then subjected to an artificial ageing at 250°C for 1 hour.

c) One set of three Charpy V-notch test specimens is taken in the strained sample artificially aged. The notch is to be located in the plastically strained area, in the part of the cross section with the highest strain. The longitudinal axis of the specimen is to be located in such way to test in the same direction as required by the base material specification.

d) The impact testing temperature and the minimum average energy required are to be in accordance with the base material specification.

e) One cylindrical tensile test specimen is to be taken and tested in order to check the tensile properties in the strained zone.

If the test results do not satisfy the base material specification, a suitable heat treatment procedure is to be qualified by tests agreed with the Society.

1.2.3 The cold bending of plates using a press for free bending is to be made using a punch with a sufficient radius in order to avoid excessive localized deformation in the outer side of the plate.

Welding in the bent area of plates intended for special category element is to be avoided. In other cases, such welding is subject to qualification tests on a representative sample.

1.2.4 Weld joints shall not be cold formed unless otherwise agreed with the Society.

If welding is applied in areas cold formed with a deformation higher than 5%, NDT inspection is to be performed in accordance with [3.2].

2 Hot forming

2.1 General

2.1.1 Hot forming means forming at temperature exceeding 250°C in general.

2.1.2 The hot forming process is to be such as not to impair the material properties.

2.2 Hot forming procedure

2.2.1 Hot forming conditions of steel plates are to be described in a procedure prepared by the Builder with sufficent details and submitted to the Society.

2.2.2 Hot forming is to be in accordance with the recommendations of the steel manufacturer for the concerned products. Particular attention is to be paid to products rolled using thermomechanical controlled process (TM or TMCP).

2.2.3 If forming temperature is higher than 500°C, a suitable heat treatment is to be carried out after forming.

2.2.4 The forming procedure, together with subsequent heat treatment as applicable, is to be subject to qualification test on sample reproducing the hot forming production conditions. The qualification tests are to include a set of three Charpy V-notch impact tests and one cylindrical tensile test. The results are to be in accordance with the base material specification.

2.2.5 In each case, when hot forming is subsequent to heat treatment, the Builder is to demonstrate to the Society that forming process and operating conditions are such as not to impair the material properties.

2.2.6 Hot forming of quenched and tempered (QT) steels is to be avoided.

3 Post operation on formed plates

3.1 Straightening of plates

3.1.1 Straightening of distorted structural elements by local heating and flame shrinkage is to be kept to a minimum and is to be subject to an exceptional procedure, in particular in the case of high tensile steels, due to possible drop of mechanical characteristics.

3.1.2 Straightening by local heating or flame shrinkage is to be carried out in accordance with a procedure qualified by tests and submitted to the Society for acceptance.

3.1.3 As a general rule, heating temperature is not to exceed 600°C; after heating, a slow temperature decrease is to be applied; otherwise a heat treatment is to be carried out.

3.2 NDT of formed rolled steel products

3.2.1 Non destructive testing is to be carried out after cold forming, cold bending, hot forming, straightening or welding of steel products.

3.2.2 Where deformation of formed, bent or straightened pieces is equal to 5% or higher, formed areas are to be dye-penetrant or magnetic particle tested after heat treatment, if any.

Section 3 Welding of Steel Structures

1 General

1.1 Scope

1.1.1 Welding operations on offshore units and installations are to comply with the requirements of the present Sec 3.

1.1.2 Welding procedures are to be qualified and approved in accordance with the requirements of Sec 4 unless otherwise agreed with the Society.

1.1.3 Welders and welding operators are to be qualified in accordance with the requirements of Sec 4 unless otherwise agreed with the Society.

1.1.4 The selection of welding procedure specification (WPS) parameters, such as selection of filler metals, edge preparations, current and speed parameters, etc., as well as the use of the WPS within the limits of the range qualified and the conditions stated at the time of the approval are the responsibility of the Builder irrespective of the inspections made by the Society's surveyors.

1.2 Fabrication documentation

1.2.1 The fabrication documentation, including the fabrication drawings and the fabrication specifications, is to be submitted to the Society.

1.2.2 Each fabrication drawing is to bear a reference and a revision number, and include an item list or a bill of materials, the structural categories and steel grades, the reference to particular procedures if any, the marking of welds with reference to the welding documentation.

The fabrication drawings are to show the types, dimensions and locations of the welds. The symbols used are to comply with a recognized international standard like ISO 2553:2019.

The drawings are to show the location of prefabrication joints welded in the workshop and of assembly joints for prefabricated elements welded on the building site.

Joints categories are to be specified on the drawings in terms of element categories.

1.2.3 Fabrication specifications, including all fabrication and building conditions such as forming, welding, heat treatment and inspection, are to be submitted by the Builder.

The welding documentation included in the fabrication specifications is to include the welding procedure specifications showing all welding parameters.

1.3 Parent metal and filler materials

1.3.1 The parent metals used in the welded construction are to be in accordance with the requirements of the applicable Rules for Classification and of NR216 Rules on Materials of Welding for the Classification of Marine Units.

1.3.2 Welding consumables are to be type approved in accordance with the requirements of NR216 Rules on Materials and Welding for the Classification of Marine Units, unless otherwise agreed with the Society.

1.3.3 For welding of higher or extra high strength steels (R_{eH} equal to or higher 300 N/mm^2), welding consumable with hydrogen-controlled grade H10 (HH) or lower are to be used. Covered electrodes for welding of extra high strength steel (R_{eH} equal or higher than 420 N/mm^2) are to be with hydrogen-controlled grade H5 (HHH).

Welding consumables with hydrogen-controlled grade H5 (HHH) are to be used for welding of special or first category members.

1.3.4 In case of welded connections between two different grades as regards strength or Charpy V-notch impact properties, welding consumables selected for the higher grade are to be used.

1.3.5 The Builder is to make all necessary arrangements to check the consistent quality (by example, the hydrogen contents and the mechanical characteristics) of each batch of the electrodes delivered to him and to ensure their proper conservation and, in particular, their storage in a controlled temperature dry place. The Surveyor may require the relevant test reports to be submitted.

1.3.6 Before use, the electrodes are to be properly dried by the Builder, as applicable, according to the Manufacturer's instructions.

The procedure for handling and storage of electrodes is to include storage conditions before opening of containers, temperature to maintain after opening of containers and methods to overhaul electrodes which have been exposed to atmospheric conditions during more than two hours successively.

Methods to handle, store and overhaul low-hydrogen electrodes are to take into account recommendations, in particular drying temperature specified by the manufacturer of filler products.

Electrodes having had a direct contact with moisture, oil, grease, rust or other contaminants are to be discarded unless properly reconditioned.

1.3.7 A clear and practical procedure to identify wires and electrodes is to be prepared by the Builder.

1.3.8 For submerged automatic arc welding details are to be given concerning conditioning method of solid flux and procedures implemented to ensure drying before use, recovery of flux after use, elimination by sieving of foreign material and molten flux, and storage of flux to prevent from pollution or condensation, according to Manufacturer's recommendations.

Recycling of fluxes for SAW shall be performed in accordance with flux Manufacturer's recommendations.

2 Weld types - weld preparation

2.1 General

2.1.1 The Builder is to submit to the Society a welding programme for approval. This welding programme is to include the welding procedure specifications to be used for the construction and their supporting qualification test reports.

2.1.2 Parts to be welded are to be maintained in position by means of bolted or welded assemblies or by any other procedure ensuring adequate tightening and accurate setting, whilst leaving shrinkage as free as possible.

Where brackets, yokes or welded fasteners are used, the weld operation is to give satisfactory results in conformity with the Rules or the construction specifications. After removing such brackets, the plate is to be smooth ground and examined to be crack free by liquid penetrant or magnetic particle testing (special and first categories).

2.1.3 The arrangements made for the design of the joints, the setting of the components, the nature and sequence of the welds are to be such as to avoid angular deformations likely to cause buckling of elements in operation, and avoiding the stress concentration points due to a sharp change of area, or any other defect capable of causing fractures or excessive distortions.

2.1.4 Welding operations are not permitted on post weld heat treated fabrications, except for temporary and non-structural attachments where prior approval of the Society has been obtained and provided that the thickness of the attachment does not exceed one third of the plate thickness at point of attachment, and the attachment weld is not closer than 100 mm from a structural weld.

2.2 Edge preparation

2.2.1 The edges of elements to be welded are generally to be prepared by machining, or by flame cutting followed by grinding to bright metal, in accordance with the welding procedure specification.

2.2.2 The surfaces to be welded are to be dry, clean and free from laminations, cracks, loose scale, slag, grease, paint etc. The presence of a protective primer coating may be permitted where prior tests have been carried out to the satisfaction of the Surveyor.

2.2.3 For extra high strength steels with R_{eH} equal to or higher than 420 N/mm^2, edges of elements in special and first categories are to be examined by liquid penetrant or magnetic particle testing prior to welding.

2.2.4 For plates thicker than 25 mm, the area which will lie under a T-joint with full penetration is to be examined using ultrasonic testing on the full length with a width of at least 100 mm. Where plates manufactured to Z grade are used, this examination is not required.

2.3 Tack welding

2.3.1 Tack welds used for assembly of the fabrication are to be of a minimum length of 3 times the thickness of the thinner material of the joint or 100 mm, whichever is the less.

Tack welds are to be carried out according to the qualified welding procedures and by qualified welders.

Tack welds may form part of the completed welds provided that they are made with consumables meeting the requirements for the base metal to be welded and free from defects. Tack welds intended to form part of the root run are to be tapered at the extremities to ensure complete root fusion.

2.4 Distance between welds

2.4.1 Plates

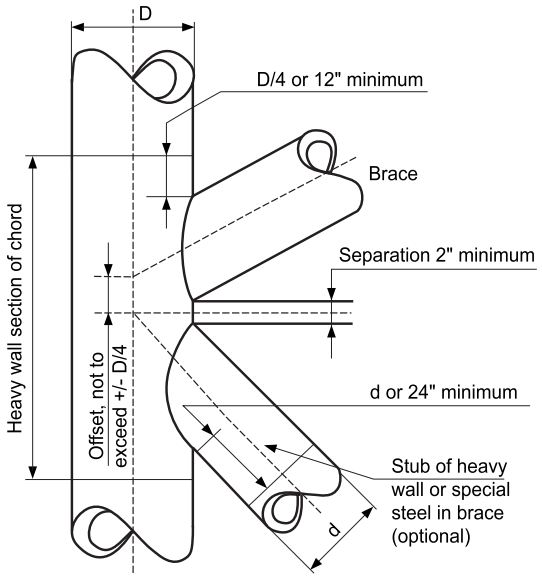
The distance between two butt welded joints on the same plate or element is to be at least equal to 300 mm or ten times the thickness, whichever is the greater.

Close vicinity of two fillet welds or of fillet weld with butt weld is to be avoided as far as possible (brackets subject of [2.1.4] are to be avoided closer than 50 mm from a structural weld).

2.4.2 Tubular and branch connections

Distances between welds are to be at least equal to the minimum ones shown on Fig 1.

Figure 1 : Minimum distance between welds in branch and tubular joint



where two values are given on the Figure, the greater one is to be considered.

2.5 Butt weld assembly

2.5.1 For butt weld assembly of plates of the same thickness, edge preparation and gap G prior to welding, are to be as per the approved welding procedure specification.

2.5.2 Typical preparations are shown on Tab 1.

2.5.3 Where products of the same thickness "t" are assembled, the products are to be correctly aligned; a slight misalignment d is however acceptable on part of the joint length if it cannot be reduced by the usual means, provided that:

$d \leq 0,15t$ but maximum 4 mm.

2.5.4 Where products of different thicknesses are butt welded, the difference in thickness is not to exceed 1/10th of the greater thickness, without tapering the thicker edge.

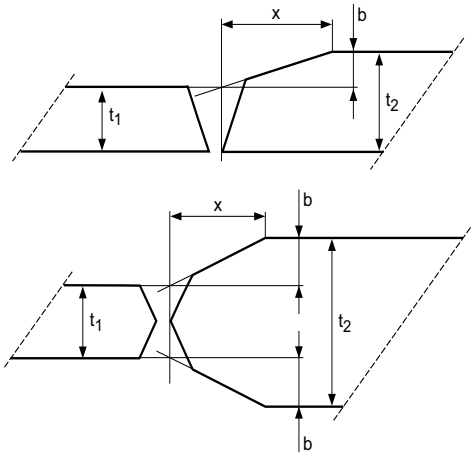
The external profile of welding is to give a maximum slope of 1/4.

If the difference in thicknesses exceeds 1/10th of the greater thickness, a tapering of the edge of the thicker product is to be carried out, with a maximum slope of 1/4 for special category and 1/3 for other categories, as shown on Fig 2.

2.5.5 Welding on a permanent backing flat bar is not authorized in special category and is subject to approval for other categories particularly in case of possible corrosion and in case of cyclic loadings.

2.5.6 Welding on a non permanent backing is subject to previous approval by the Society of the welding procedure and of the backing material.

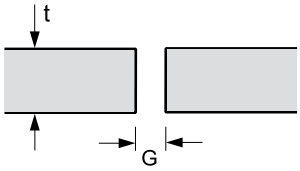
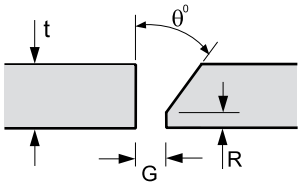
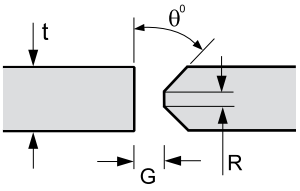
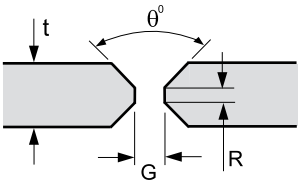
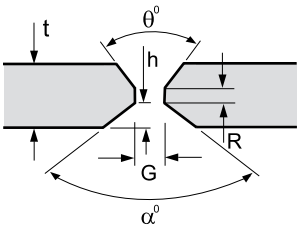
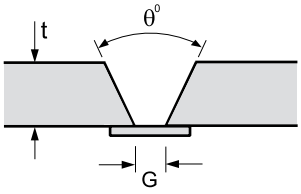
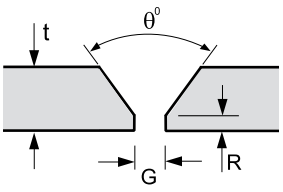
Figure 2 : Plate tapering



$x \geq 4b$ for special category

$t \geq 3b$ for other categories.

Table 1 : Typical butt weld plate edge preparation (manual welding) - See Note 1

Detail	Dimensions	Detail	Dimensions
Square butt 	t ≤ 5 mm G = 3 mm		
Single bevel butt 	t > 5 mm G ≤ 3 mm R ≤ 3 mm 50° ≤ θ ≤ 70°	**Double bevel butt** 	t > 19 mm G ≤ 3 mm R ≤ 3 mm 50° ≤ θ ≤ 70°
Double vee butt, uniform bevels 	G ≤ 3 mm R ≤ 3 mm 50° ≤ θ ≤ 70°	**Double vee butt, non-uniform bevels** 	G ≤ 3 mm R ≤ 3 mm 6 ≤ h ≤ t/3 mm θ = 50° α = 90°
Single vee butt, one side welding with backing strip (temporary or permanent) 	3 ≤ G ≤ 9 mm 30° ≤ θ ≤ 45°	**Single vee butt** 	G ≤ 3 mm 50° ≤ θ ≤ 70° R ≤ 3 mm
Note 1: Different plate edge preparation may be accepted by the Society on the basis of an appropriate welding procedure specification.			

2.6 Full penetration T joints

2.6.1 Full penetration T joints are required when assembling highly stressed elements, playing an important part in the structure and in which fatigue phenomena are likely to occur. This case may occur in particular for elements of special and first categories.

2.6.2 For highly stressed assemblies, corresponding to a special category or a first category element, lamellar tearing risks may be lowered following recommendations given in Article [3].

2.6.3 For very thick assemblies subject to high restraint and essential to the structural safety of the unit or installation, a postweld heat treatment may be required, as specified in [4.6].

2.6.4 For special category elements submitted to fatigue cycles, the surface condition of the weld, in particular its connection with plates, is to be taken care of and inspected. In certain cases, grinding of weld connection with plate may be required.

2.7 Welding of thick parts

2.7.1 When thick parts are intended to be either butt welded or full penetration T-welded, special precautions are to be taken for welding, concerning the preparation of the edges to be welded and the welding operations (welding sequences aiming at limiting distortions, protection under temporary cover for open air welding, etc.).

2.7.2 Depending upon the steel grade, upon the thickness of the elements to be assembled and upon the clamping of the assembly, preheating may be required, as per [4.4].

2.7.3 A postweld heat treatment may be required for the assembly, as mentioned in [4.6].

2.8 Connections of pipes

2.8.1 Where several pipes are connected, proper preparation of joints before welding is necessary, in particular for special and first category elements.

2.8.2 For special and first category elements, all the welds are to be full penetration welds. The surface of the external weld is to present a continuous and regular profile, blending without discontinuity and gradually with the surface of the two pipes.

2.8.3 All the edges are to be chamfered before welding, the tolerance on the groove angle being $\pm 10°$.

2.8.4 All details about preparation of the edges to be welded and welding conditions are to be submitted to the Society's approval within the welding programme.

2.8.5 Weld preparation (groove angle, root opening, pipe connection angle) is to comply with welded tubular connection details given in figure 11.1.3 of API RP2A-WSD, the selection of the weld profile control, if necessary, being made in accordance with paragraph 11.1.3.d of the same API Standard.

Alternatively, the "Details for welded tubular joints in T-, Y-, and K-connections made from one side without backing" in Section 10-13 of ANSI/AWS D1-1, may be used, the selection of the profile types having been carried out at the design stage, depending upon the fatigue level of the structure.

2.8.6 When, after positioning prior to welding, the gap G, as defined on Tab 1, is too narrow to allow a good penetration at the weld root, this gap is to be increased by mechanical gouging or by means of the arc-air procedure to reach the appropriate gap.

For special and first category elements, when gap G before welding is too important, local building up by welding may be required.

2.8.7 For special category and first category highly stressed nodes constituted with thick pipes, the design of the connection is to be, as far as possible, such as the weld connecting braces with chord may be made with sealing runs, with access possible for the welder from both sides of the joints.

Design of nodes and their welding procedures are to be presented to the examination of the Society at the design stage, under the form of a welding programme, according to [1.2.3].

2.8.8 For highly stressed special category or first category nodes, lamellar tearing risks on the chord pipe of the node may be lowered following recommendations given in Article [3].

2.8.9 For special category and first category elements, ultrasonic inspection is to be carried out along a pipe strip 100 mm wide, which receives the weld on its surface. This 100 mm strip is to be centred on the weld axis.

2.9 Fillet weld assembly

2.9.1 Fillet welds are related to connections of stiffeners to plates, securing brackets, etc.

2.9.2 The value of the throat thickness "a" as defined in Sec 1, [2.1], of a double continuous line of welding is determined in terms of the thinnest plate (the thickness of which being noted t_{min}) of the assembly under consideration and in terms of minimum welding heat input necessary to obtain required hardness values.

Except otherwise stated, the throat thickness for double fillet welds does not need to exceed:

$a = 0,45\ t$

with "t" as defined in Sec 1, [2.1].

Besides, the throat thickness is to be equal or higher than:

a) In the general case of continuous or discontinuous welding:

$a = 3,5$ mm

b) For high strength steel assemblies:

- where $t_{min} \leq 8$ mm:

  $a = 3,5$ mm
- where $8 \text{ mm} < t_{min} \leq 12$ mm:

  $a = 4$ mm
- where $t_{min} > 12$ mm:

  $a = 5$ mm

Besides complying with these maximum and minimum values, throat thickness is to be large enough to satisfy the strength purposes.

Where a deep penetration automatic welding procedure is used, the throat thickness may be reduced according to the actual throat of the weld, measured on the macrography of the qualification test.

However, this reduction is not to exceed 15% of the throat thickness.

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

2.9.3 The plates are to be correctly adjusted without spacing. A slight spacing S is however acceptable over part of the joint length where it does not exceed:

- for $t_{min} \leq 6$ mm:

  S = 2 mm

- for $t_{min} > 6$ mm:

  S = 3 mm

- for fillet welds in the overhead position:

  S = 2 mm

where t_{min} as defined in [2.9.2].

Where there is a spacing between plates, the throat thickness of lines of welding is to be increased by one-half of the clearance between the elements to be assembled.

2.9.4 Where the spacing S exceeds the values specified in [2.9.3], a re-welding procedure is to be prepared by the Builder in agreement with the Surveyor according to the clearance and size of the elements to be assembled.

3 Recommendations to reduce the risks of lamellar tearing

3.1 Factors influencing lamellar tearing

3.1.1 Lamellar tearing may occur mainly on T joints. Lamellar tearing is dependent on multiple parameters like shrinkage stresses during cooling due to assembly stiffness, clamping of the structure close to the joint, material thickness, material inclusions level, distribution and size of weld runs.

3.2 Means to reduce the risks of lamellar tearing

3.2.1 The following precautions are recommended to be taken:

a) At the initial stage of the project, too high service stresses on strongly clamped cruciform assemblies are to be avoided; furthermore, the structure design is to be simplified with a view to rendering it less sensitive to clamping during welding

b) Ultrasonic testing of the plate on which the weld is to be deposited is to be carried out along a strip of 100 mm in width centred on the weld axis to detect any possible lamination of the plate located below the weld.

c) Proper preparation, welding sequence and parameters are to be selected (e.g. welding techniques by alternate symmetrical runs: balanced welding).

d) The plate grade on which the weld is to be carried out is to be also specially selected. Plates manufactured as Z grade in accordance with NR216 are limiting the risks of lamellar tearing.

   The use of Z grade plates does not dispense to take appropriate measures for welding operations.

e) Buttering technique is to be used, in new building as well as in repairing.

4 Welding operations

4.1 Execution of the welds

4.1.1 The welding operations are to be carried out under shelter from rain, snow or wind. It is recommended to carry out welding on as many elements as possible under cover.

Work is to be interrupted when the temperature on the welding site drops below a minimum value determined during the qualification of the welding process.

When the steel temperature is equal to or lower than -5°C for normal strength steels A, B, D or E, preheating temperature is to be 20°C or a higher temperature as specified by the WPS.

When the steel temperature is equal to or lower than 0°C for higher strength steels with minimum specified yield strength of 315N/mm² or higher, preheating temperature is to be 20°C or a higher temperature as specified by the WPS.

4.1.2 The zone to be preheated is to comply with the requirements of [4.4.3].

4.1.3 After each run, slag is to be eliminated and the weld is to be cleaned; the same precaution is to be taken when resuming an interrupted weld or connecting two welds.

As far as possible, welds are to be carried out from both sides (mechanical gouging or arc-air gouging of the root pass being recommended).

4.1.4 Interpass temperature is to be kept between the preheating temperature as defined in [4.1.1] and the maximum interpass temperature measured during the welding qualifications.

In general the maximum interpass temperature is 250°C, and in any case is to be as specified by the WPS.

4.1.5 No new run is to be undertaken if the previous one is not finished.

4.1.6 Runs are not to begin or end at the same point as the previous one.

4.1.7 For all butt welds and particularly in case of automatic butt welding, it is recommended to start and end the joints on appendages to be fixed at the ends. When an interrupted weld is resumed manually or by machine, the joint end is to be carefully cleaned and grinded. This operation is to be carried out as soon as practicable after the interruption.

4.1.8 Proper operation of the machines is to be frequently checked by the welder and the Builder's staff during welding.

4.2 Identification of welders

4.2.1 Any welder is to receive a number or an identification symbol that he is to use to identify all welds performed by him. Marking is to be made with a weather resistant crayon or paint.

When a punch is used, it is to create only spherical or rounded marks.

Welds which are not definitely identified may be rejected by the Surveyor.

4.2.2 A welder is not to change in any case the symbol which is assigned to him during a construction. If a welder quits, the symbol which has been assigned to him is not to be used by another welder.

4.3 Welding sequence

4.3.1 As a general rule, assembly and welding sequences of the different parts of structure are to be carefully defined such as to reduce to a minimum distortions and accumulation of residual stresses in any part of the structure. Adequate heat treatments are to be carried out after welding when excessive residual stresses in the joint cannot be avoided.

4.3.2 The Builder is to plan and have made all the necessary surveys to make sure that contemplated welding sequences are complied with.

4.3.3 The Builder is to keep the Surveyor informed of any major modification of the welding sequence of an assembly as compared with the sequence contemplated in the welding programme.

4.4 Preheating during welding

4.4.1 Assembly preheating is to be considered depending on:

- the thickness of the elements to be welded
- the chemical composition of the parent material and weld metal
- the hydrogen content of the weld metal
- the welding process and associated parameters
- the temperature of the welded object
- the clamping conditions of the assembly.

Preheating temperature is to be maintained during the welding operations.

4.4.2 The preheating conditions are to be defined by the Builder and validated during the qualification tests of the welding procedure.

4.4.3 The required preheat temperature is to be achieved in the zone encompassing the weld and parent material for at least 75mm or 3 t, whichever is the greater, from the weld centreline on each side of the weld.

4.4.4 For steels with R_{eH} equal to or higher than 300 N/mm², the preheating temperature defined during the welding procedure qualifications is to be increased and the WPS modified accordingly (the procedure being requalified if necessary), if the carbon equivalent C_{EQ} of the parent metal to be welded exceeds the carbon equivalent of the WPQR test samples by more than 0,03. Consequently, the welding procedure remains valid only for:

$C_{EQ(Parent\ metal)} \leq C_{EQ(WPQR)} + 0,03$

The carbon equivalent is given by the formula:

$$C_E = C + \frac{Mn}{6} + \frac{C_r + Mo + V}{5} + \frac{Ni + Cu}{15}$$

where all components are expressed in percentages from ladle analysis.

4.5 Post-heating immediately after welding

4.5.1 The post-heating after welding is to be defined at the stage of welding specification and qualification procedure.

4.5.2 Post-heating is defined by its temperature and duration and is performed immediately after welding.

4.6 Post weld heat treatment (PWHT)

4.6.1 As a general rule, PWHT is normally used in case of weld thicknesses equal to or higher than 60mm. The Society may require to witness the PWHT operations.

When PWHT is applied, the Builder is to provide a procedure specification including the following operating conditions:

- heating and cooling rates
- temperature gradients
- soaking temperature range and minimum holding time
- heating facilities
- insulation
- control devices
- recording equipment.

Heat treatment records shall be kept throughout the heat treatment process.

4.6.2 Notwithstanding [4.6.1], PWHT may be waived by the Builder with the agreement of the Society. In this case, fracture mechanics tests, such as CTOD tests, are to be performed during corresponding welding procedure qualification and fracture mechanics analysis (Engineering Criticality Assessment) and CTOD test results are to be submitted to the Society.

4.6.3 PWHT conditions are to be defined in accordance with the steel maker recommendations. Soaking temperature and time shall be defined taking into account recommendations for the welding consumables and steel grade. Conditions of post weld heat treatment (PWHT) for carbon non-alloyed or micro-alloyed steels with $R_{eH} < 420$ N/mm^2, may be the following ones:

- heating to 560°C ± 20°C
- holding time at treatment temperature T (in minutes), calculated in relation to the thickness e (in mm) of the thickest weld, as follows:
  - T = 2e when e ≤ 60 with a minimum of one hour
  - T = 120 + 0,5 (e – 60) when e > 60.

The holding time is measured from the moment when the ambient temperature in the oven reaches the value foreseen for the treatment; in the case of a local treatment with heating strips, it is the temperature of the part to be PWHT which is taken into account.

The heating rate and cooling rate are to be sufficiently slow to limit the residual stresses and deformations.

As a general rule, this rate is not to exceed:

- heating rate 80°C/h
- cooling rate 100°C/h.

For extra high strength steels ($R_{eH} \geq 420$ N/mm2), conditions of PWHT are to be defined in agreement with the Society and according to the steel maker recommendations or specific advice.

4.6.4 Heating, soaking and cooling shall be carried out in a controlled manner that prevents cracking or distortions outside the dimensional tolerances.

4.6.5 The heat-treatment cycle and the actual metal temperature shall be recorded using thermocouples equally spaced externally, and whenever possible internally, throughout the heated region. The heat treatment temperature cycle charts shall be available for verification if requested.

4.6.6 Where a complex prefabricated element is concerned, e.g. a node, only the global heat treatment in a special oven may be foreseen so as to ensure that the treatment applies to the whole part.

4.6.7 In the case of an isolated circular weld, located on a continuous element, such as pipe joining, a local heat treatment may be accepted. In such case, requirements given in [4.6.5] are applicable.

4.6.8 After the final treatment of a welded part, any repair of a welding defect that may have occurred after this treatment is to be submitted to the surveyor for approval, in particular as regards the possibility of a second treatment of the part after the repair.

4.7 Temperature control

4.7.1 Methods are to be established for all operations requiring a control during temperatures of preheating, between runs, during post heating or during post weld heat treatment.

4.7.2 Hardness test after PWHT may be required by the Surveyor.

Section 4 Approval of Steel Welding Procedures and Welders

1 General

1.1 Scope

1.1.1 General

The requirements relevant to materials not covered herein are agreed on a case-by-case basis following, as far as applicable, the criteria specified in this Section.

1.1.2 Other standards and specifications

Other recognised standards or specifications for similar structural applications may be accepted by the Society on case-by-case basis.

1.2 Welding procedure

1.2.1 Welding processes

Qualification tests are, as a rule, required for the manual or semiautomatic or automatic processes indicated below together with their relevant numbering according to ISO 4063:2009:

- Manual metal arc welding: 111
- Submerged Arc Welding with wire electrode (SAW): 12
- Flux-Cored wire metal Arc Welding without gas shield (FCAW): 114
- Metal arc Inert Gas welding (MIG welding): 131
- Metal arc Active Gas welding (MAG welding): 135
- Flux-Cored wire metal Arc Welding with active gas shield: 136
- Flux-Cored wire metal Arc Welding with inert gas shield: 132
- Tungsten Inert Gas arc welding (TIG welding): 141
- Plasma Arc Welding: 15.

1.2.2 Welding consumables

Consumables approved in accordance with the requirements of NR216 are to be used within the limits of their approval.

When non-approved welding consumables are used, the requirements relevant to the qualification of the welding procedures are established on a case-by-case basis and in general tests on a deposited metal sample are required.

1.2.3 Preliminary welding procedure specification

A welding procedure specification is to be prepared by the Builder or yard which intends to perform the qualification tests. This document is also referred to as a preliminary welding procedure specification (pWPS) and is to be submitted to the Society for review prior to the tests.

This pWPS may be modified and amended during the procedure tests as deemed necessary however it shall define all relevant variables as mentioned in the welding procedure specification (refer to [1.2.4]).

In case that the test pieces welded according to the pWPS show unacceptable results, the pWPS is to be adjusted by the Builder. The new pWPS is to be prepared and the test pieces welded in accordance with the new pWPS.

In general, the qualification tests is to reflect fabrication conditions in respect to welding equipment, inside or outside fabrication, weld preparation, preheating and any post-weld heat treatment. It is to the manufacturer's responsibility to establish and document whether a procedure is suitable for the particular application.

The test pieces are to be chosen so as to cover all the production welds in accordance with the approval range of parameters.

1.2.4 Approval of welding procedure specification

The qualification tests when required, welding of test pieces according to the proposed pWPS and testing of test specimens, are to be witnessed by the Surveyor.

Upon satisfactory completion of the tests, the Society may approve the pWPS as a welding procedure specification.

In its final version, the welding procedure specification (WPS) is to include all the parameters characterising the welding process; in particular, as applicable:

a) Type of welding process and equipment, as appropriate

b) Type of joint, preparation and backing material, if any

c) Base metal, thickness range, pipe diameter etc.

d) Filler metal

e) Welding position

f) Minimum preheat, minimum and maximum interpass temperature

g) Post-weld heat treatment if applicable

h) Shielding gas as applicable

i) Welding parameters

j) Other information relevant to the welding techniques as applicable.

The actual parameters used for welding the approval test pieces and the results of the inspections and tests carried out are to be recorded in the welding procedure qualification record (WPQR) also referred to as welding procedure approval record (WPAR).

The WPQR is generally prepared by the Builder and endorsed by the attending Surveyor.

1.2.5 Inspections

Inspections and control tests may be periodically and randomly required as deemed necessary by the Society and are to yield satisfactory results in order to maintain the validity of the approval.

The results of any suitable control performed during production may be accepted, to the Surveyor's satisfaction.

1.2.6 Responsibilities of the users

The qualification tests are intended to verify that a manufacturer is adequately qualified to perform welding operations using a particular procedure.

Irrespective of the inspections carried out by the Surveyor, the user is responsible for the use of the approved procedures, within the limits of the range qualified and the conditions stated at the time of the approval.

Compliance with the above is essential for the validity of the approval.

2 Welding procedure qualification tests

2.1 Butt joints in plates with full penetration

2.1.1 Assembly of test pieces

Preparation and welding are to be in accordance with the pWPS and under the general condition of production welding which it represents.

If tack welds and / or start and stop points are a condition of the weld process, they are to be fused into the joint and are to be included in the test pieces.

The test assembly is to be of a size sufficient to ensure a reasonable heat distribution and is to have the minimum following dimensions (see Fig 1):

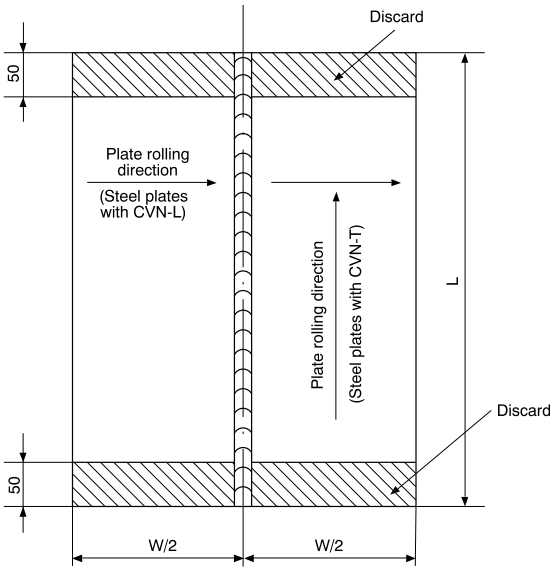
a) Manual or semiautomatic welding:
   - length L = 6 t, min. 350 mm
   - width W with W/2 = 3 t, min. 150 mm.

b) Automatic welding:
   - length L = min. 1000 mm
   - width W with W/2 = 4 t, min. 200 mm.

In the case of steel plates impact tested in the longitudinal direction (CVN-L), the butt weld of the test piece is perpendicular to the rolling direction of the two plates.

In the case of steel plates impact tested in the transversal direction (CVN-T), the butt weld of the test piece is parallel to the rolling direction of the two plates.

Figure 1 : Test assembly for plate butt weld



2.1.2 Examinations and tests

Non-destructive examinations and destructive tests required according to Tab 1 are to be carried out, while the location of the test specimens is to be in accordance with Fig 2.

Table 1 : Examinations and tests for butt joints in plates

Type of examination or test	Extent of examination or test
Visual examination	100%
Surface crack detection **(1)**	100%
Radiographic or ultrasonic examination	100%
Transverse tensile test	2 specimens
Transverse bend tests **(2)**	2 root and 2 face specimens
Charpy V-notch impact tests **(3)**	3 sets
Macro examination	on 1 section
Hardness test **(4)**	on 1 section
Longitudinal tensile test **(5)**	1 specimen

(1) Dye penetrant according to ISO 3452:2021 (or an other recognised standard accepted by the Society) or magnetic particle testing; for non-magnetic materials, dye penetrant only.

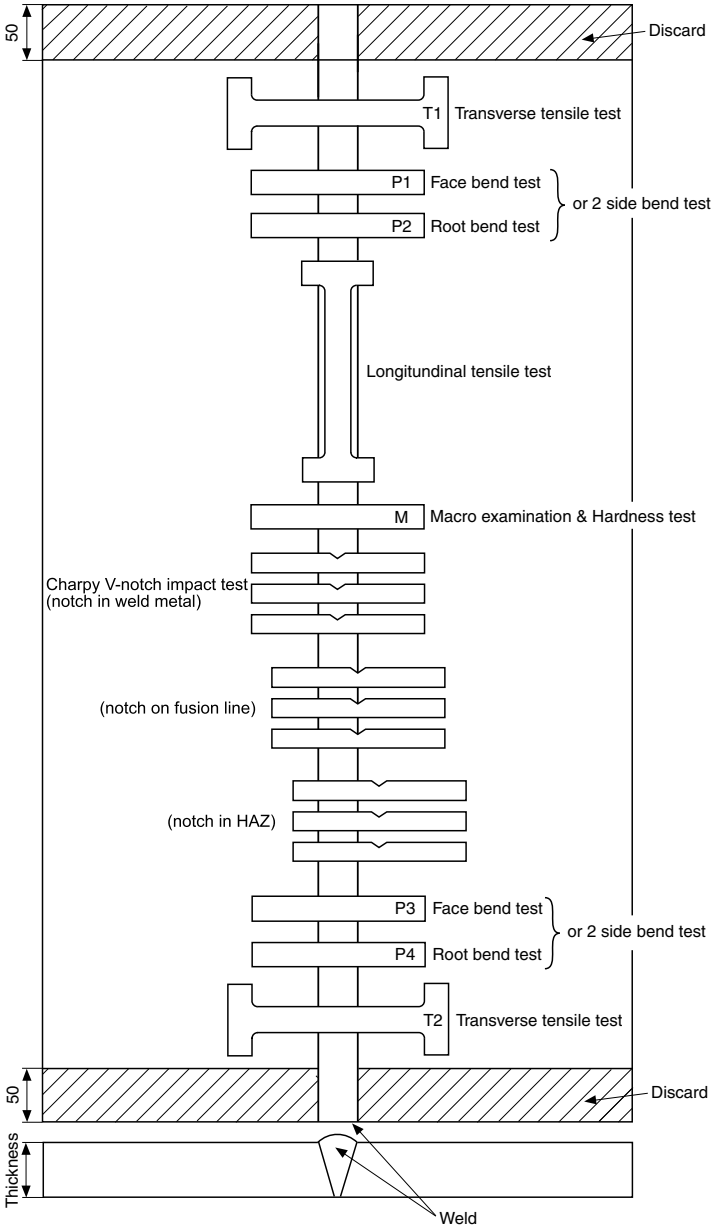
(2) For $t \geq 12$ mm, the face and root bends are preferably to be replaced by 4 side bends.

(3) 3 sets each of 3 specimens as per [2.1.7].

(4) Only required for high strength steels with minimum specified yield strength equal to or greater than 355 N/mm^2.

(5) Required only when the use of non-approved filler metal has been accepted (see [1.2.2]).

Figure 2 : Location of test specimens



2.1.3 Non-destructive examinations

Non-destructive examinations are to be carried out after any required or specified post-weld heat treatment and prior to the cutting of test specimens. For extra high strength steels, NDT is not to be carried out before 48 hours after completion of welding. For steel with specified minimum yield greater than 690 N/mm2, NDT is not to be carried out before 72 hours after completion of welding.

Imperfections detected by visual or non-destructive testing are to be assessed in accordance with ISO 5817:2023 class B, except for the following imperfections for which the level C applies:

- excess weld metal or convexity
- excess throat thickness, and
- excess of penetration.

2.1.4 Transverse tensile tests

Specimens for transverse tensile tests are to be in accordance with NR216.

The tensile strength recorded for each specimen is to be not less than the minimum required for the parent metal; the location of the fracture is to be reported.

When butt welds are made between plates of different grades, the tensile strength to be obtained on the welded assembly is to be in accordance with the requirement of the grade having lower strength.

2.1.5 Tensile tests on cylindrical specimens

When required (see Tab 1), a round tensile specimen is to be cut along the weld axis to the dimension given in NR216, Ch 2, Sec 2, Fig 3, in the all weld metal.

Where the size of the deposited metal is too small, a 6 mm diameter specimen may be taken or a deposited weld metal test is to be carried out in accordance with the requirements of NR216, Chapter 11.

The tensile properties recorded (yield stress R_{eH}, tensile strength R_m and elongation A_5) are to be not less than the minimum required for the approval of the appropriate grade of consumables.

When more than one welding process or type of consumable has been used to make the test weld, test specimens are to be removed from the area of the weld where each was used with the exception of those processes or consumables used to make the first weld run or root deposit.

2.1.6 Bend tests

Transverse root bend, face bend and side bend specimens are to be machined to the dimensions given in NR216, Ch 2, Sec 3, [1.1].

For dissimilar or heterogeneous butt-joints, one longitudinal bend test may be used instead of transverse bend tests.

The test specimens are to be bent on a mandrel having a diameter equal to 4 times the thickness of the specimen; the bending angle is to be 180°.

After testing, the test specimens are not to reveal any open defect, in any direction, greater than 3 mm. Defects appearing at the corners of the test specimen during testing are to be investigated case-by-case.

When butt welds are made between plates of different grades, face and root longitudinal bend test specimens may be used instead of the transverse bend test specimens.

2.1.7 Impact tests

Dimensions and testing of Charpy V-notch impact test specimens are to be in accordance with NR216, Ch 2, Sec 4.

Charpy V-notch impact test specimens in accordance with NR216, Ch 2, Sec 4 are to be sampled from 1 to 2 mm below the surface of the parent material, transverse to the weld and on the side containing the last run.

The Charpy V-notch specimens are located in the butt-welded joint as indicated in Fig 3 and Fig 4, and the V-notch is to be cut perpendicular to the surface of the weld.

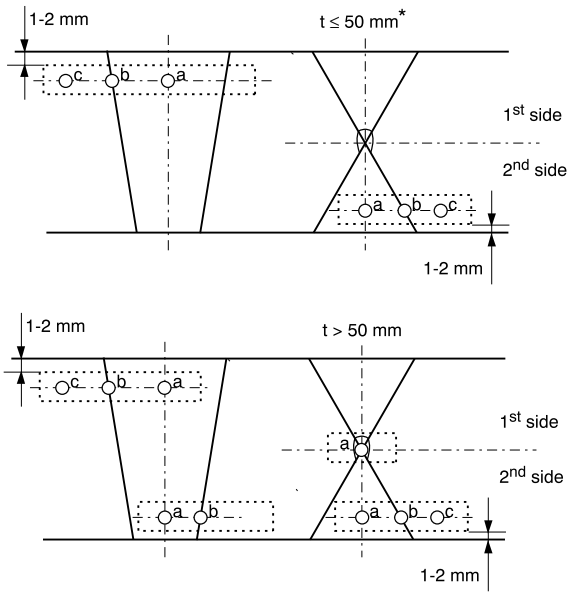
The test temperature and absorbed energy are to be in accordance with the requirements of the base material.

When butt welds are made between different steel grades/types, the test specimens are to be taken from the side of the joint with steel of lower toughness level. Temperature and absorbed energy results are to be in accordance with the minimum value required for the steel of lower toughness level.

Where more than one welding process or consumable has been used to make the test weld, impact test specimens are to be removed from the respective areas where each was employed. This should not apply to the process or consumables used solely to make the first weld run or root deposit.

When cast or forged material with specified impact values is to be welded, test temperature and absorbed energy are to be in accordance with the requirements of the base material.

Figure 3 : Location of V-notch for normal heat input ≤ 50 kJ/cm



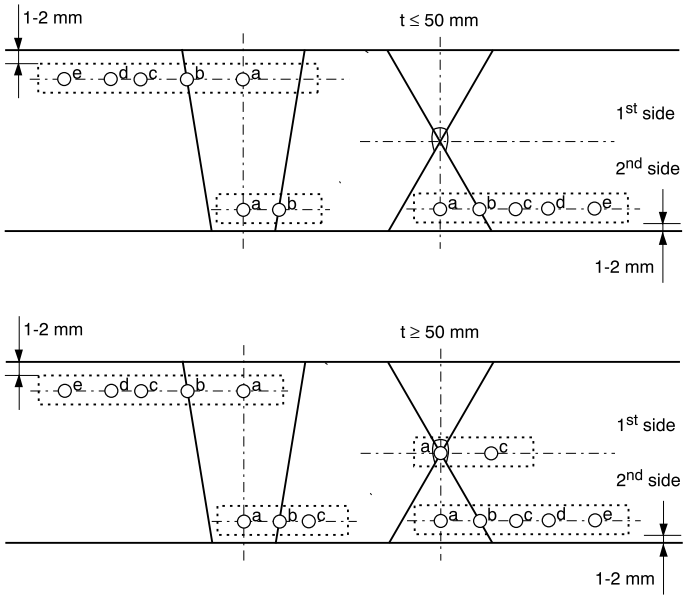
a : Centre of weld "WM"

b : On fusion line "FL"

c : In HAZ, 2 mm from fusion line

* : For one side pass welding over 20 mm "WM" FL and HAZ, 2mm from fusion line to be added on root side.

Figure 4 : Location of V-notch for high heat input > 50 kJ/cm



a : Centre of weld "WM"

b : On fusion line "FL"

c : In HAZ, 2 mm from fusion line

d : In HAZ, 5 mm from fusion line

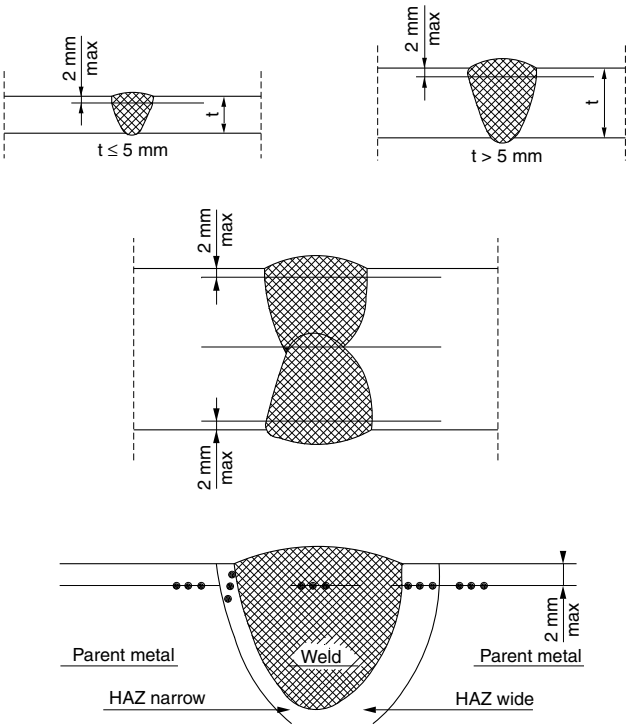
e : In HAZ, 10 mm from fusion line in case of heat input > 200 kJ/cm.

2.1.8 Macro examinations

The test specimens are to be prepared and etched using suitable agent on one side to clearly reveal the weld metal, fusion line, the heat affected zone (HAZ) and about 10 mm of unaffected parent metal.

The examination shall reveal a regular weld profile, through fusion between adjacent layers of weld and base metal and the absence of defects such as cracks, lack of fusion etc.

Figure 5 : Examples of hardness indentations



2.1.9 Hardness tests

Hardness testing is required for steels with minimum specified yield strength equal to or greater than 355N/mm². Unless otherwise agreed, the Vickers method HV10 is to be used.

The indentations are to be made in the weld, heat affected zones, and the parent metals measuring and recording the hardness values. Two rows of indentations are to be carried out in accordance with Fig 5.

For each row of indentations, there is to be a minimum of 3 individual indentations in the weld, the heat affected zones (both sides) and the parent metals (both sides).

The distance between the indentations may vary from 0,5 to 2 mm depending on the zone tested.

Typical example of hardness indentations are given in Fig 5.

The results of hardness tests are not to exceed 350 HV for steels with a specified minimum yield strength less than or equal to 420 N/mm².

2.2 T butt joints in plates

2.2.1 General

Where this type of joints is predominant in production, qualification tests are to be performed on T butt joint assembly in addition to the equivalent qualification on butt joint.

The same principle applies when changes occur in the geometry of the bevel which may significantly affect the penetration or fusion.

2.2.2 Assembly and welding

Preparation and welding are to be in accordance with the pWPS and under the general condition of production welding which it represents.

If tack welds are a condition of the weld process, they are to be fused into the joint and are to be included in the test pieces.

The test assembly is to be of a size sufficient to ensure a reasonable heat distribution and is to have the minimum following dimensions (reference can be made to Fig 6):

a) Manual or semiautomatic welding:

- length L = 6 t, min. 350 mm
- width W = 3 t, min. 150 mm.

b) Automatic welding:

- length L = min. 1000 mm
- width W = 3 t, min. 150 mm.

2.2.3 Examinations and tests

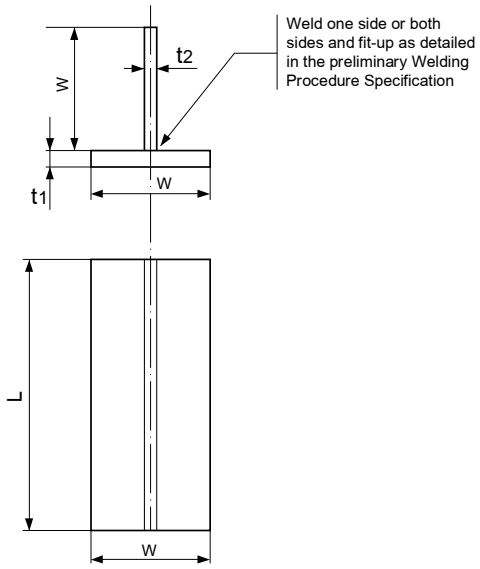
Non-destructive examinations and destructive tests are required according to Tab 2; a discard of 50 mm from both edges is permitted.

Table 2 : Examinations and tests for T butt joints in plates

Type of examination or test	Extent of examination or test
Visual examination	100%
Surface crack detection **(1)**	100%
Ultrasonic examination **(4)**	100%
Macro examination	on 1 section
Hardness test **(2)**	on 1 section
Longitudinal tensile test **(3)**	1 specimen

(1) Dye penetrant according to ISO 3452 (or an other recognised standard accepted by the Society) or magnetic particle testing; for non-magnetic materials, dye penetrant only.
(2) Only required for high strength steels with minimum specified yield strength equal to or greater than 355 N/mm².
(3) Required for thickness above 50 mm or when the use of non-approved filler metal has been accepted (see [1.2.2]).
(4) Applicable to full penetration weld or to verify the extent of penetration in partial penetration welds

Figure 6 : T butt joint in plates



2.2.4 Non-destructive examination

Reference is made to [2.1.3].

2.2.5 Tensile tests on cylindrical specimens

Reference is made to [2.1.5].

2.2.6 Macro examination

Reference is made to [2.1.8].

2.2.7 Hardness test

Hardness testing is required for steels with minimum specified yield strength equal to or greater than 355 N/mm². Unless otherwise agreed, the Vickers method HV10 is to be used.

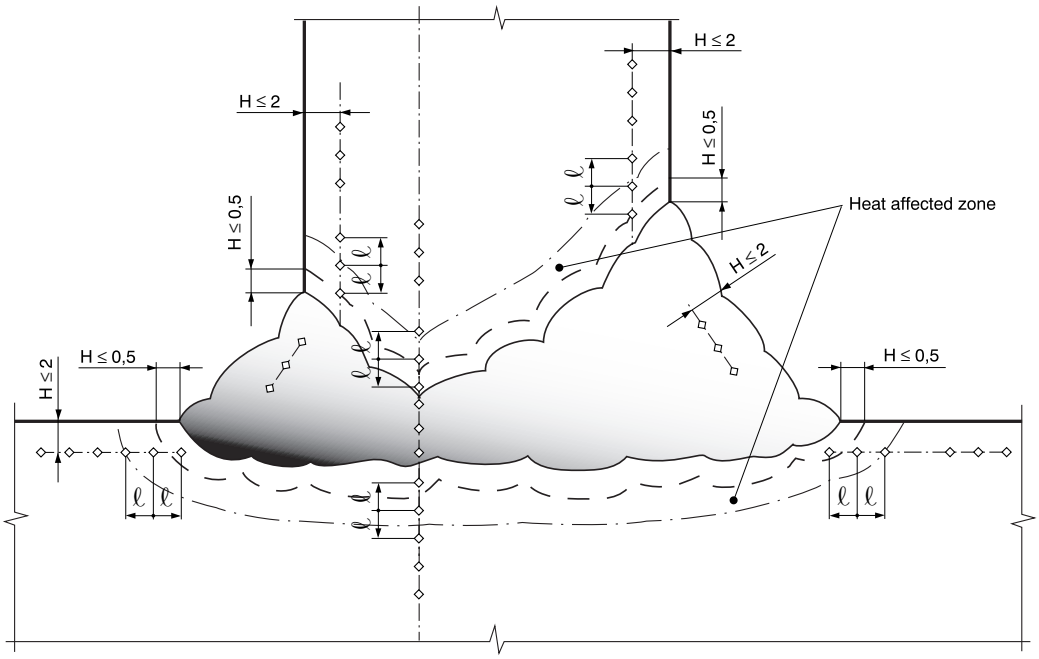
The indentations are to be made in the weld, heat affected zones, and the parent metals measuring and recording the hardness values.

Rows of indentations are to be carried out in accordance with Fig 7.

For each row of indentations, there is to be a minimum of 3 individual indentations in the weld, the heat affected zones (both sides) and the parent metals (both sides).

The results of hardness tests are not to exceed 350 HV for steels with a specified minimum yield strength less than or equal to 420 N/mm².

Figure 7 : Hardness indentations



With H, dimension in mm

2.3 Fillet weld on plates

2.3.1 General

Where this type of joints is predominant in production, qualification tests are to be performed on a fillet weld assembly in addition to the equivalent qualification on butt joint.

2.3.2 Assembly and welding

Preparation and welding are to be in accordance with the pWPS and under the general condition of production welding which it represents.

If tack welds are a condition of the weld process, they are to be fused into the joint and are to be included in the test pieces.

The test assembly is welded on one side only. For single pass manual and semi-automatic welding, a stop/restart is to be included in the test length and its position is to be clearly marked for subsequent examination.

The test assembly is to be of a size sufficient to ensure a reasonable heat distribution and is to have the minimum following dimensions (see Fig 8):

a) Manual or semiautomatic welding:
- length L = 6t, min. 350 mm
- width W = 3 t, min. 150 mm.

b) Automatic welding:
- length L = min. 1000 mm;
- width W = 3 t, min. 150 mm.

2.3.3 Examinations and tests

Non-destructive examinations and destructive tests are required according to Tab 3; a discard of 50 mm from both edges is permitted.

Figure 8 : Fillet weld on plates

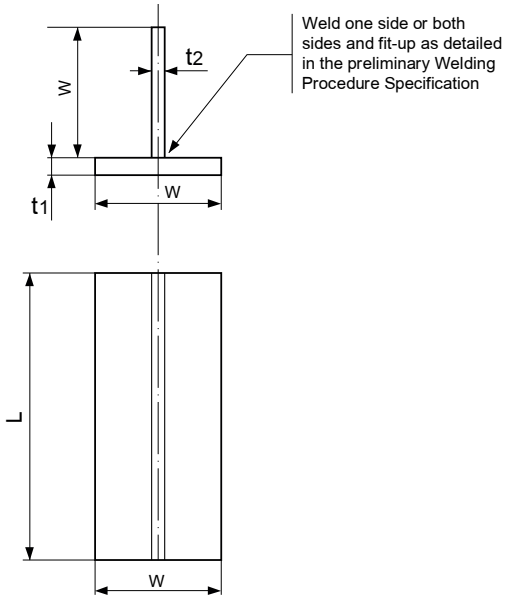


Table 3 : Examinations and tests for fillet welds on plates

Type of examination or test	Extent of examination or test
Visual examination	100%
Surface crack detection **(1)**	100%
Macro examination **(2)**	2 sections
Hardness test **(3)**	on 1section
Fracture test	1 test

(1) Dye penetrant according to ISO 3452 (or equivalent accepted standard) or magnetic particle testing; for non-magnetic materials, dye penetrant only.

(2) One of the macro sections is to be taken at the position of the stop/restart; see [2.3.2].

(3) Only required for high strength steels having:
$R_{eH} \geq 355$ N/mm^2

2.3.4 Visual examination and surface crack detection

Non-destructive examinations are to be carried out after any required or specified post-weld heat treatment and prior to the cutting of test specimens.

Imperfections detected are to be assessed in accordance with [2.1.3].

2.3.5 Macro examination

The test specimen is to be prepared and etched on one side to clearly reveal the weld metal, fusion line, root penetration, the heat affected zone and about 10 mm of unaffected base material.

The examination is to reveal a regular weld profile, through fusion between adjacent layers of weld and base metal and the absence of defects such as cracks, lack of fusion etc.

The dimensions of leg size, throat and penetration are to be reported.

2.3.6 Fracture test

The fracture test is to be performed by folding the upright plate onto the through plate. Evaluation is to be concentrated on cracks, porosity and pores, inclusions, lack of fusion and incomplete penetration. Imperfections that are detected shall be assessed in accordance with ISO 5817 Class B.

2.3.7 Hardness test

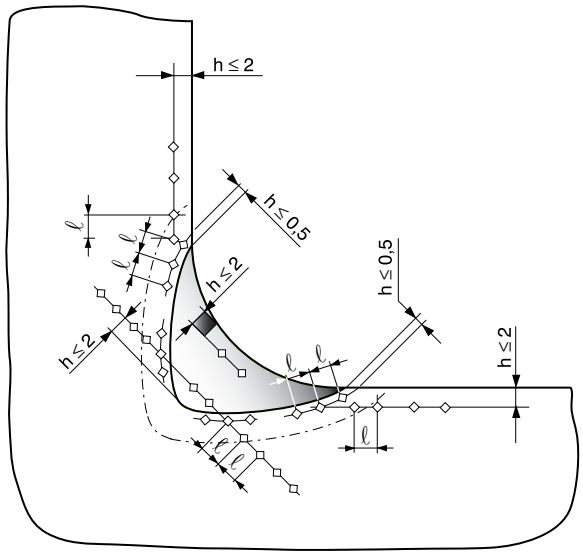
Hardness testing is required for steels with minimum specified yield strength equal to or greater than 355 N/mm². Unless otherwise agreed, the Vickers method HV10 is to be used.

The indentations are to be made in the weld, heat affected zones, and the parent metals measuring and recording the hardness values. Two rows of indentations are to be carried out in accordance with Fig 9.

For each row of indentations, there is to be a minimum of 3 individual indentations in the weld, the heat affected zones (both sides) and the parent metals (both sides).

The results of hardness tests are not to exceed 350 HV for steels with a specified minimum yield strength less than or equal to 420 N/mm².

Figure 9 : Hardness indentations



2.4 Pipes butt weld with full penetration

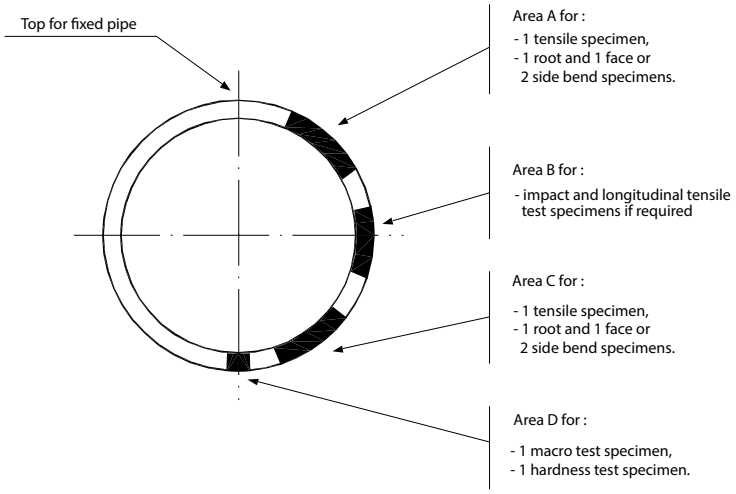
2.4.1 Assembly and welding

Preparation and welding are to be in accordance with the pWPS and under the general condition of production welding which it represents.

If tack welds are a condition of the weld process, they are to be fused into the joint and are to be included in the test pieces.

The test assembly is to be in accordance with Fig 11.

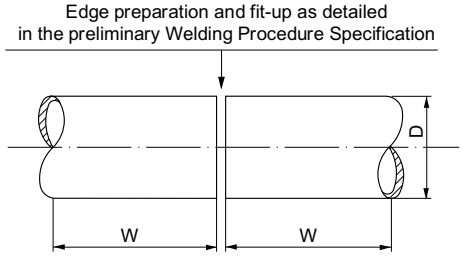
Figure 10 : Location of the test specimens



2.4.2 Examinations and tests

Non-destructive examinations and destructive tests required are given in Tab 1. The location of the test specimens is to be in accordance with Fig 11.

Figure 11 : Butt joint in pipes test assembly



W: Minimum value = 150 mm

D: Outside diameter.

2.4.3 Results

The results are to comply with the requirements for plate butt weld in [2.1].

2.5 Branch connection in pipes

2.5.1 General

Where this type of joints is predominant in production, qualification tests are to be performed on branch connection assembly in addition to the equivalent qualification on butt joint.

The same principle applies when changes occur in the geometry of the bevel may significantly affect the penetration or fusion.

2.5.2 Assembly and welding

Preparation and welding are to be in accordance with the pWPS and under the general condition of production welding which it represents.

If tack welds are a condition of the weld process, they are to be fused into the joint and are to be included in the test pieces.

The test assembly is to be in accordance with Fig 12.

2.5.3 Examinations and tests

Non-destructive examinations and destructive tests are required according to Tab 4. The location of the test specimens is to be in accordance with Fig 13.

2.5.4 Visual examination and surface crack detection

Reference is made to [2.1.3].

2.5.5 Macro examination

Reference is made to [2.1.8].

2.5.6 Hardness test

Hardness testing is required for steels with minimum specified yield strength equal to or greater than 355 N/mm². Unless otherwise agreed, the Vickers method HV10 is to be used.

The indentations are to be made in the weld, heat affected zones, and the parent metals measuring and recording the hardness values.

Rows of indentations are to be carried out in accordance with Fig 7.

For each row of indentations, there is to be a minimum of 3 individual indentations in the weld, the heat affected zones (both sides) and the parent metals (both sides).

The results of hardness tests are not to exceed 350 HV for steels with a specified minimum yield strength less than or equal to 420 N/mm².

Figure 12 : Test assembly for branch connection in pipes

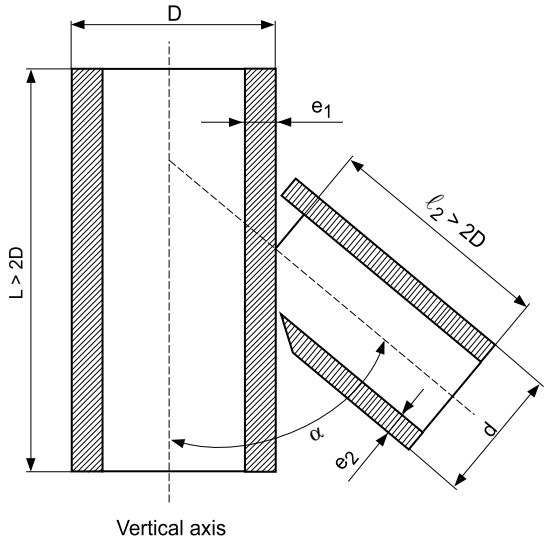
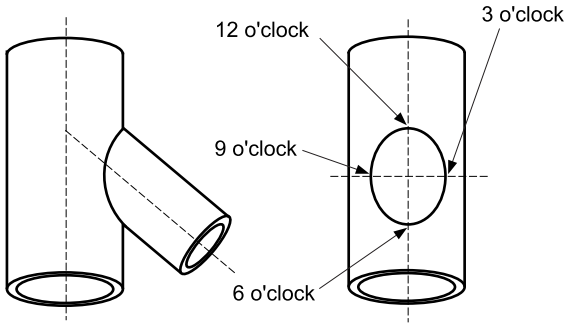


Figure 13 : Location of test specimen for branch connection in pipes



Area 6 o'clock for macrographic examination and hardness tests.

Areas 3 or 9 o'clock for macrographic examination.

Table 4 : Examinations and tests for branch connection in pipes

Type of examination or test	Extent of examination or test
Visual examination	100%
Surface crack detection **(1)**	100%
Ultrasonic examination **(4)**	100%
Macro examination	on 1 section
Hardness test **(2)**	on 1 section
Longitudinal tensile test **(3)**	1 specimen

(1) Dye penetrant according to ISO 3452 (or equivalent accepted standard) or magnetic particle testing; for non-magnetic materials, dye penetrant only.

(2) Only required for high strength steels with minimum specified yield strength equal to or greater than 355 N/mm².

(3) Required for thickness above 50 mm or when the use of non-approved filler metal has been accepted (see [1.2.2]).

(4) Applicable to full penetration weld or to verify the extent of penetration in partial penetration welds

2.6 Re-testing

2.6.1 If the test piece fails to comply with any of the requirements for visual or non-destructive testing, one further test piece is to be welded and subjected to the same examination.

If this additional test piece does not comply with the relevant requirements, the pWPS is to be regarded as not capable of complying with the requirements without modification.

2.6.2 If any test specimens fails to comply with the relevant requirements for destructive testing due to weld imperfection only, two further test specimens shall be obtained for each one that failed. These specimens can be taken from the same test piece if there is sufficient material available or from a new test piece, and is to be subjected to the same test. If either of these additional test specimens does not comply with the relevant requirements, the pWPS is to be regarded as not capable of complying with the requirements without modification.

2.6.3 If a tensile test specimen fails to meet the requirements, the re-testing is to be in accordance with NR216, Ch 2, Sec 2, [1.3].

2.6.4 If there is a single hardness value above the maximum values allowed, additional hardness tests shall be carried out (on the reverse of the specimen or after sufficient grinding of the tested surface). None of the additional hardness values is to exceed the maximum hardness values required.

2.6.5 The re-testing of Charpy V-notch impact test specimens are to be carried out in accordance with NR216, Ch 2, Sec 4, [1.4].

2.6.6 Where there is not sufficient material remaining in the test piece to provide the additional test specimens, a further assembly shall be welded using the same procedure to provide the additional specimens.

2.7 Range of approval

2.7.1 General

The approval of a WPS obtained by a yard or Manufacturer is valid for welding in workshops under the same technical and quality management, to the Society's satisfaction.

The welding procedure is to be used within the range of the parameters indicated below; changes outside the range specified of one or more of these parameters require a new qualification test.

2.7.2 Parent metal

For steels with R_{eH} equal to or higher than 300 N/mm², the welding procedure remains valid only for:

$C_{EQ(Parent\ metal)} \leq C_{EQ(WPQR)} + 0,03$

For hull structural steel grades A to FH40 as defined in NR216, Ch 3, Sec 2, the following applies:

a) For each strength level, welding procedures are considered applicable to the same and lower toughness grades as that tested;

b) For each toughness grade, welding procedures are considered applicable to the same and two lower strength levels as that tested;

c) For applying the above a) and b) to high heat input processes above 50 kJ/cm, e.g. the two-run technique with either submerged arc or gas shielded metal arc welding, electroslag and electrogas welding, welding procedure is applicable that toughness grade tested and one strength level below.

Where steels used for construction are supplied from different delivery conditions from those tested, the Society may require additional tests.

For weldable C and C-Mn hull steel forgings as defined in NR216, Ch 5, Sec 2, the following applies:

a) Welding procedures are considered applicable to the same and lower strength level as that tested

b) Qualification tests on quenched and tempered hull structural steel forgings do not qualify other delivery condition and vice-versa.

For weldable C and C-Mn hull steel castings as defined in NR216, Ch 6, Sec 2, the following applies:

a) Welding procedures are considered applicable to the same and lower strength level as that tested

b) Qualification tests on quenched and tempered hull structural steel forgings do not qualify other delivery condition and vice-versa.

2.7.3 Thickness

The qualification of a WPS carried out on a welded assembly of thickness t is valid for the thickness range given in Tab 5.

In addition to the requirements of Tab 5, the range of approval for fillet welds shall be as follows:

a) Single pass fillet welds; for throat thickness "a" as defined in Sec 1, [2.1].: the range of approval is from 0,75 a to 1,5 a.

b) Multipass fillet welds; for throat thickness "a" the range of approval is as for multipass butt welds (i.e. a = t).

For the vertical-down welding, the test piece thickness t is always taken as the upper limit of the range of application.

For unequal plate thickness of butt welds, the lesser thickness is the ruling dimension.

Notwithstanding the above, the approval of maximum base material thickness for any technique is restricted to the test assembly thickness if three of the hardness values in the heat affected zone are found to be within 25 HV of the maximum permitted, as stated in [2.1.9] and [2.3.7].

Table 5 : Approved thickness range

Thickness t of test piece (mm) **(1)**	Range of approval	
	Single run or single run from both sides, Butt and T-joints	Multi-run welding, Butt, T-joint and fillet welds **(2)**
3 < t ≤ 12	0,7 t to 1,1 t	3 mm to 2 t **(2)**
12 < t ≤ 100	0,7 t to 1,1 t **(3)**	0,5 t to 2 t (max.150) **(3)**

(1) For multi process procedures, the recorded thickness contribution of each process is to be used as a basis for the range of approval for the individual welding process.

(2) For fillet welds, the range of approval is to be applied to both parent materials.

(3) For high heat input process over 50 kJ/cm, the upper limit of range of approval is to be 1,0 t.

Table 6 : Approved diameter range

Diameter of the test piece (mm)	Range of approval **(1)**
D ≤ 25	0,5 D to 2 D
D > 25	≥ 0,5 D (25 mm min.)

(1) Qualification for plates also covers pipes with outside diameter > 500 mm.

2.7.4 Pipe diameter

Qualification tests on an assembly of pipes of diameter D is valid for diameters in the range given in Tab 6.

2.7.5 Welding position

Standard positions are given in Fig 14 for plates and pipes.

Approval for a test made in any position is restricted to that position.

To qualify all positions, test assemblies are to be welded for highest and lowest heat input position and all applicable tests are to be made on those assemblies.

For plates butt welds with full penetration, the highest heat input position is normally the vertical upwards position and the lowest heat input position is normally the horizontal-vertical position.

Vertical downwards techniques are to be qualified separately.

2.7.6 Welding process

The approval is only valid for the welding process(es) used in the qualification tests. It is not permitted to change from a multi-run to a single run.

For multi-process procedures the welding procedure approval may be carried out with separate qualification tests for each welding process. It is also accepted to make the qualification test as a multi-process procedure test. The approval of such a test is only valid for the process sequence carried out during the multi-process procedure test.

For the manual metal arc welding process (111) and semi-automatic welding process with flux cored wire without shielding gas (114), the approval obtained is valid for the diameter of the electrode used in the welding procedure test plus or minus one electrode diameter size for each run, except for the root run of the one side welded assembly without backing strip, for which no size change is allowed.

For the gas metal arc welding processes (131, 135, 136), the approval obtained for face and/or back shielding gas is restricted to the type of gas (nominal composition) used during the procedure test. The approval is restricted to the wire system used in the approval test (e.g. single wire or multi-wire) and, in the case of automatic welding, to the relevant welding technique.

For the submerged arc processes (12), the approval obtained is restricted to the wire system used in the approval test (e.g. single wire or multi-wire) and relevant welding technique (T, M, U). Change in the flux trade mark requires new welding procedure approval tests.

2.7.7 Welding consumables

Except high heat input process (over 50 KJ/cm), welding consumables tested cover other approved welding consumables having the same grade mark including all suffixes specified in NR216, Chapter 11 with that tested.

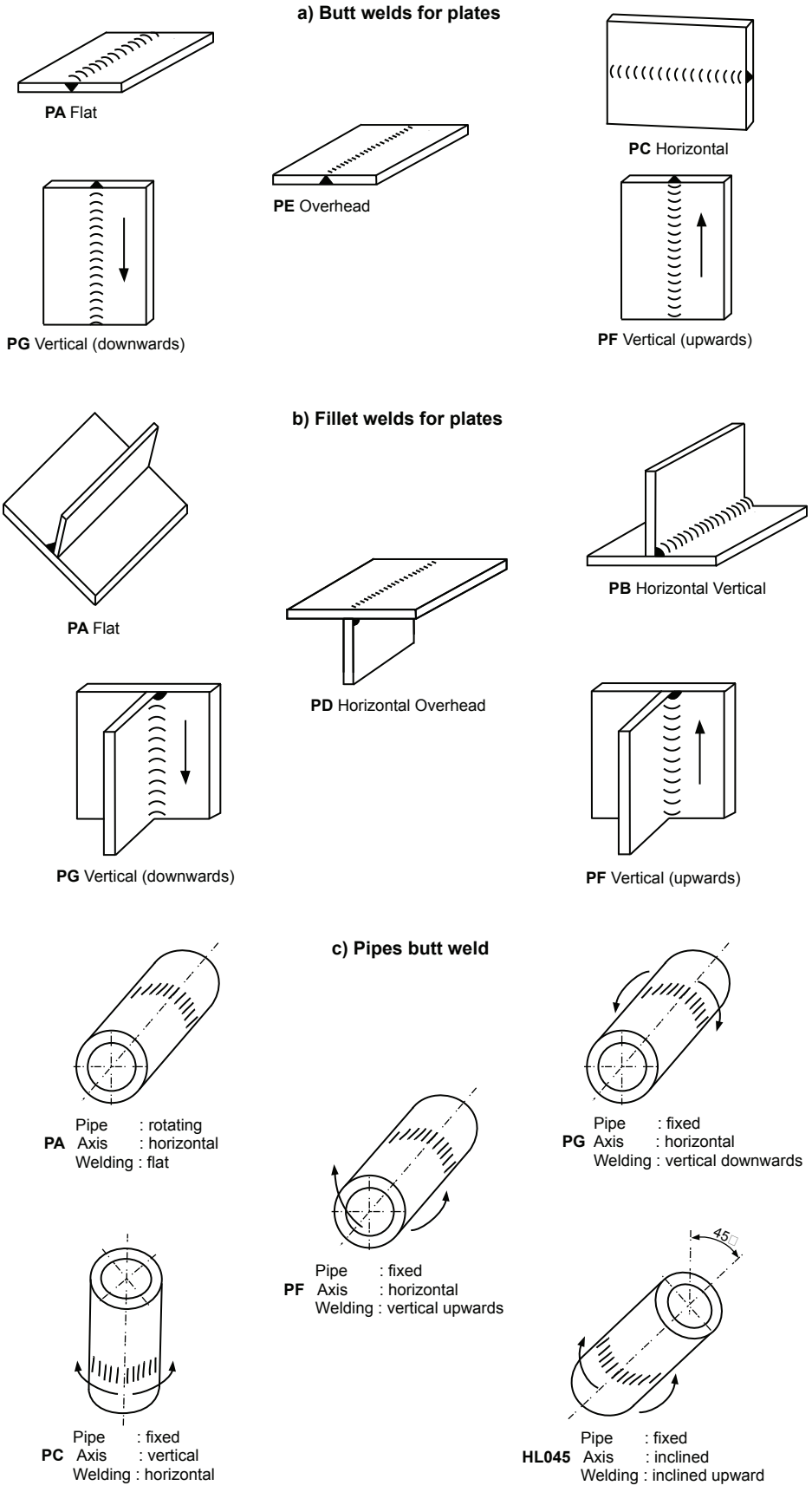
Change in the trade name of filler metal requires new welding procedure approval tests when Charpy V-notch impact tests are required at temperature strictly below –20°C.

2.7.8 Heat input

The upper limit of heat input approved is 25% greater than that used in welding the test piece or 50 KJ/cm whichever is smaller, except that the upper limit is 10% greater than that for high heat input processes over 50 KJ/cm.

The lower limit of heat input approved is 25% lower than that used in welding the test piece.

Figure 14 : Welding positions according to ISO Standard



2.7.9 Preheat and interpass temperature

The minimum preheat temperature is not to be less than that used in the qualification test.

The minimum interpass temperature is not to be less than the specified preheat temperature.

The maximum interpass temperature is not to be higher than that used in the qualification test.

2.7.10 Post-weld heat treatment

The heat treatment used in the qualification test is to be maintained during manufacture. Holding time may be adjusted as a function of thickness.

2.7.11 Type of joint

The range of approval depending on type of welded joint for test assembly is given in Tab 7, Tab 8 and Tab 9.

New qualification tests may be required by the Surveyor when changes occur in the geometry of the bevel which may significantly affect the penetration or fusion.

Table 7 : Range of approval for butt joints and fillet welds on plates

Type of welded joint for test assembly			Range of approval				
			Butt joints in plates with full or partial penetration				Fillet welds on plates
			Welded from one side		Welded from both sides		
			With backing	No backing	With gouging	No gouging	
Butt joint in plates with full penetration **(1)**	One side	With backing	◊	–	x	–	x
		No backing	x	◊	x	x	x
	Both sides	With gouging	–	–	◊	–	x
		No gouging	–	–	x	◊	x
Fillet weld on plates **(2)**	–	–	–	–	–	–	◊

Note 1:
◊: Indicates the type of assembly of qualification test.
x: Indicates on the same line as the symbol ◊ those welds for which the WPS is also approved.
–: Indicates on the same line as the symbol ◊ those welds for which the WPS is not approved.
(1) Butt joint in plate qualifies butt joints in pipes having diameter > 500mm within the limitations of the table.
(2) In addition to the equivalent qualification on butt joint and where production works include predominantly fillet welding

Table 8 : Range of approval for T butt joints in plates

Type of welded joint for test assembly			Range of approval			
			Butt joints in plates with full or partial penetration			
			Welded from one side		Welded from both sides	
			With backing	No backing	With gouging	No gouging
T butt joint in plates with full penetration **(1)**	One side	With backing	◊	–	x	–
		No backing	x	◊	x	x
	Both sides	With gouging	–	–	◊	–
		No gouging	–	–	x	◊

Note 1:
◊: Indicates the type of assembly of qualification test.
x: Indicates on the same line as the symbol ◊ those welds for which the WPS is also approved.
–: Indicates on the same line as the symbol ◊ those welds for which the WPS is not approved.
(1) In addition to the equivalent qualification on butt joint and where production works include predominantly this type of joint or when changes occur in the geometry of the bevel which may significantly affect the penetration or fusion.

Table 9 : Range of approval for type of joint between pipes

Type of welded joint for test assembly			Range of approval			
			Butt joints in pipes with full or partial penetration		Branch connection with full or partial penetration	Fillet welds on pipes
			Welded from one side			
			With backing	No backing		
Full penetration butt joint in pipes **(1)**	One side	With backing	◊	–	–	x
		No backing	x	◊	x	x
Branch connection with full penetration weld **(2) (3)**	–	–	–	–	◊	x
Fillet welds on pipes **(2) (3)**	–	–	–	–	–	◊

Note 1:

◊: Indicates the type of assembly of qualification test.

x: Indicates on the same line as the symbol ◊ those welds for which the WPS is also approved.

–: Indicates on the same line as the symbol ◊ those welds for which the WPS is not approved.

(1) Butt joint in pipe qualifies all branch connections with angle in the range [60°, 90°]

(2) In addition to the equivalent qualification on butt joint and where angle α is lower than 60°. Branch connection with angle α qualifies all branch connections with angle in the range [min. α, 90°]

(3) In addition to the equivalent qualification on butt joint and where production works include predominantly this type of joint or when changes occur in the geometry of the bevel which may significantly affect the penetration or fusion.

3 Approval of stud welding

3.1 General

3.1.1 Stud welding to elements in special and first category is to be qualified by tests which shall include as a minimum macro-examination and hardness tests to check that there are no detrimental effects on the base material.

4 Approval of welders

4.1 General

4.1.1 Reference is made to the Rule Note NR476 “Approval testing of Welders”.

Section 5 Weld Joints Examination and Tests

1 General

1.1 Scope

1.1.1 This Section applies to fusion welds made in normal and higher strength hull structural steels, extra high strength steels for welded structure, connection welds with hull steel forgings and castings in accordance with NR216. Base metals other than the above may be considered by the Society.

1.1.2 This Section applies to fusion welds made using manual metal arc welding (shielded metal arc welding, 111), gas-shielded metal arc welding (gas metal arc welding, including flux cored arc welding, 13x), gas-shielded arc welding with non-consumable tungsten electrode (gas tungsten arc welding, 14x), submerged arc welding (12x), electro-slag welding (72x) and electro-gas welding processes (73).

Note 1: Terms and numbers according to ISO 4063:2009 ("x" indicates that relevant subgroups are included).

1.1.3 This Section may also be applied to welding processes other than the above at the discretion of the Society.

1.1.4 This Section applies to butt welds with full penetration, tee, corner and cruciform joints with or without full penetration, and fillet welds.

1.1.5 This Section covers conventional NDT methods. As far as advanced non-destructive testing (ANDT) methods are concerned, reference is made to NR216, Chapter 14. ANDT methods are typically phased array ultrasonic testing (PAUT), time of flight diffraction (TOFD), digital radiography (RT-D), radioscopic testing (RT-S), and computed radiography (RT-CR).

1.1.6 The weld joints examinations and tests includes:

- production tests, if required
- visual inspection of all welds over their full length
- non-destructive testing (magnetic particle testing, dye-penetrant testing, ultrasonic testing, radiographic testing or other methods).

1.2 Production tests

1.2.1 During construction, the Builder is to check that welding is carried out satisfactorily and in accordance with the approved welding procedure specifications. Production tests (destructive testing) may be required by the Society, especially in the case of modification of the welding procedures during construction. In such case the frequency and types of tests are to be defined in agreement with the Society.

2 Non-destructive testing

2.1 General

2.1.1 This Section gives requirements on the methods and quality levels that are to be adopted for the non-destructive testing (NDT) of structural elements in welded steel constructions during new building.

2.1.2 Structural elements in welded steel constructions and associated structural categories are defined in Sec 1, [3].

2.1.3 The quality levels given in this Section refer to production quality and not to fitness for-purpose of the welds examined.

2.1.4 The NDT is normally to be performed by the Builder or its subcontractors in accordance with the requirements of this Section. The Surveyor may require witnessing of the testing.

2.1.5 It is the Builder's responsibility to assure that testing specifications and procedures are adhered to during the construction and the reports are made available to the Society on the findings made by the NDT.

2.1.6 The following terms and definitions apply:

MT : Magnetic Particle Testing

NDT : Non-Destructive Testing: the development and application of technical methods to examine materials or components in ways that do not impair their future usefulness and serviceability, in order to measure geometrical characteristics and to detect, locate, measure and evaluate flaws. NDT is also known as non-destructive examination (NDE), non-destructive inspection (NDI) and non-destructive evaluation (NDE).

PT : Dye or Liquid Penetrant Testing

PWHT : Post Weld Heat Treatment

RT : Radiographic Testing
UT : Ultrasonic Testing
VT : Visual Testing.

2.2 Requirements for the entity carrying out NDT

2.2.1 In case of non-destructive testing carried out by an independent company from the manufacturer of shipyard, such company has to comply with the requirements for the independent NDT service supplier as set out in NR669 Requirements for non-destructive testing suppliers

2.2.2 In case of non-destructive testing carried out directly by the shipyard or manufacturer, the requirements for the internal NDT department as set out in NR669 Requirements for non-destructive testing suppliers are to be complied with.

2.3 NDT plan and extent of examination

2.3.1 For each construction, the Builder is to submit a plan for review by the Society, specifying the areas to be examined, the extent of testing and the acceptance levels as specified in Article [4], with reference to the NDT procedures to be used. Particular attention is to be paid to inspecting welds in highly stressed areas and welds in primary and special category structural members indicated in Sec 1, [3]. The plan is only to be released to the personnel in charge of the NDT and its supervision.

2.3.2 The extent of non destructive testing is to be defined according to the category of the element to be welded and to the weld type. Tab 1 gives minimum extent of NDT to be performed by the Builder. The testing volume is to be the zone which includes the weld and parent material for at least 10 mm each side of the weld, or the width of the heat affected zone (HAZ), whichever is greater. In all cases inspection is to cover the whole testing volume. As far as practicable, PT or MT are to be used when investigating the outer surface of welds, checking the intermediate weld passes and back-gouged joints prior to subsequent passes deposition. MT is to be performed in ferromagnetic materials welds unless otherwise agreed with the Society. Surface inspection of important tee or corner joints, using an approved MT or PT method, is to be conducted to the satisfaction of the Surveyor. As given in Tab 1, UT or RT or a combination of UT and RT may be used for testing of butt welds with full penetration of 8 mm or greater. Methods to be used are to be agreed with the Society. The method used is to be suited for the detection of particular types and orientations of discontinuities. RT and UT are used for detection of internal discontinuities, and in essence they supplement and complement each other. RT is generally most effective in detecting volumetric discontinuities (e.g. porosity and slag) whilst UT is more effective for detecting planar discontinuities (e.g. laminations, lack of fusion and cracks).

2.3.3 Other extent of NDT may be considered by the Society where justified in writing by the organization of the Builder.

2.3.4 In selecting checkpoints, emphasis is to be given to the following inspection locations:

- welds in high stressed areas
- fatigue sensitive areas
- welds which are inaccessible or very difficult to inspect in service
- field erected welds
- suspected problem areas.

Block construction welds performed in the yards, or at subcontracted yards/facilities, are to be considered in selecting checkpoints.

2.3.5 If an unacceptable level of indications is found the NDT extent is to be increased.

2.4 Realisation of NDT

2.4.1 The NDT is to be performed by the Builder or its subcontractors in accordance with the requirements of this Section. The Surveyor may require witnessing of the testing.

2.4.2 It is the Builder's responsibility to assure that testing specifications and procedures are adhered to during the construction and the reports are made available to the Society on the findings made by the NDT.

2.4.3 NDT is to be conducted after welds have cooled to ambient temperature and after post weld heat treatment where applicable.

2.4.4 For high strength steels for welded structure with specified minimum yield stress in the range of 420 N/mm^2 to 690 N/mm^2, NDT is not to be carried out before 48 hours after completion of welding and cooling down to ambient temperature. For steel with specified minimum yield greater than 690 N/mm^2, NDT is not to be carried out before 72 hours after completion of welding and cooling down to ambient temperature. Regardless of yield strength, consideration is to be given to requiring a delayed inspection where evidence of delayed cracking has been observed in production welds.

A longer interval and/or additional random inspection at a later time may be required at the discretion of the Surveyor (e.g. in the case of very thick welds).

The 72 hours interval may be reduced to 48 hours for RT or UT inspection, provided there is no indication of delayed cracking, and the 100% visual and random MT or PT inspection are carried out to the satisfaction of the Surveyor 72 hours after welds have been completed and cooled to ambient temperature.

Where PWHT is carried out, the requirement for testing after a delay period may be relaxed, at the discretion of the Surveyor.

2.4.5 The methods mentioned in this Section for detection of surface imperfections are VT, PT and MT. The methods mentioned for detection of internal imperfections are UT and RT.

2.4.6 Applicable methods for testing of the different types of weld joints are given in Tab 2.

Table 1 : Minimum extent of non destructive testing

Element category **(10) (11)**	Weld type	Testing method			
		Visual	RT **(5)**	UT **(6)**	MT **(9)**
Special	Buttweld	100%	100% of crossings and 10% of welds **(1) (7) (8)**	100% of non RT welds **(1)**	100%
	Full penetration angle weld **(2)**	100%	–	100%	100%
	Limited penetration fillet weld **(3)**	100%	–	–	100%
First	Buttweld	100%	10% of welds including crossings **(1) (7) (8)**	10% of non RT welds **(1) (8)**	20% **(1) (8)**
	Full penetration angle weld **(2)**	100%	–	20% **(1) (8)**	20% **(1) (8)**
	Limited penetration fillet weld **(3)**	100%	–	–	20% **(1) (8)**
Second	Buttweld	100%	at random **(1) (4)**	– **(1)**	at random **(1) (4)**
	Full penetration angle weld **(2)**	100%	–	at random **(1) (4)**	at random **(1) (4)**
	Limited penetration fillet weld **(3)**	100%	–	–	at random **(1) (4)**

(1) These values are minimum values subject to be increased, in case of doubt, by the Surveyor.
(2) If half the thickness of the thinnest plate or more is welded, the weld is considered as full penetrated - Refer to Sec 4.
(3) If less of half the thickness of the thinnest plate is welded, the weld is considered as a limited penetration weld or a fillet weld - Refer to Sec 4.
(4) Testing at random from 0 to 5% of the number of weld joints to the Surveyor's satisfaction.
(5) For thicknesses equal to 50 mm and over, ultrasonic inspection may be used instead of radiographic testing.
(6) Ultrasonic testing is to be carried out for thicknesses exceeding 8 mm. For 8 mm or under, radiographic testing is to be used (butt welds). In all cases, radiographic testing may be used instead of ultrasonic testing.
(7) 100% of beam flanges butt welds are to be inspected.
(8) Locations of welds inspections will be notified by the Surveyor after welding.
(9) Dye-penetrant testing may be used instead of magnetic particle testing (after approval only).
(10) In particular cases, weld category may be different from the structural category. In such case, the weld category is to be indicated on the drawings submitted to the Society for approval.
(11) In case of welds between two different categories, the welds are to be inspected according to the highest category.

Table 2 : Applicable methods for testing of weld joints

Weld joints	Parent material thickness	Applicable test methods
Butt welds with full penetration	thickness < 8 mm **(1)**	VT, PT, MT, RT
	thickness ≥ 8 mm	VT, PT, MT, UT, RT
Tee joints, corner joints and cruciform joints with full penetration	thickness < 8 mm **(1)**	VT, PT, MT, RT **(3)**
	thickness ≥ 8 mm	VT, PT, MT, UT, RT **(3)**
Tee joints, corner joints and cruciform joints without full penetration and fillet welds	All	VT, PT, MT, UT **(2)**, RT **(3)**

(1) In cases of thickness below 8 mm the Society may consider application of an appropriate advanced UT method
(2) UT may be used to check the extent of penetration in tee, corner and cruciform joints. This requirement is to be agreed with the Society
(3) RT may be applied however there will be limitations

2.5 Qualification of personnel involved in NDT

2.5.1 References is made to the requirements of NR669 Requirements for non-destructive testing suppliers.

2.6 Visual inspection

2.6.1 All welds over their full length are to be subject to VT by personnel designated by the Builder, who may be exempted from the qualification requirements defined in [2.2].

The personnel in charge of VT is to confirm that the surface condition is acceptable prior to carrying out the inspection.

VT is to be carried out in accordance with procedure or recognised standards agreed between the Builder and the Society.

2.6.2 A procedure shall define tolerances of weld bead geometry and (un)acceptable weld imperfections.In any cases, the welds are to be free from cracks and significant planar defects.

2.6.3 For welds of special category elements, a check is to be made to ensure that over-thicknesses and under-thicknesses are in accordance with the standard accepted by the Society. In the case of an abnormal over-thickness, the weld is to be ground; in the case of an abnormal under-thickness, building up is to be performed by welding to ensure proper stress continuity, according to an approved procedure.

2.7 Liquid penetrant testing (PT)

2.7.1 PT is to be carried out in accordance to ISO 3452-1:2013 or a recognized standard accepted by the Society.

2.7.2 The extent of PT is to be in accordance to the plans agreed with the attending Surveyor and to the satisfaction of the Surveyor.

2.7.3 The surface to be examined is to be clean and free from scale, oil, grease, dirt or paint so there are not contaminants and entrapped material that may impede penetration of the inspection media.

2.7.4 The temperature of parts examined is to be typically between 5°C and 50°C. Outside this temperature range special low/ high temperature penetrant and reference comparator blocks are to be used.

2.8 Magnetic particle testing (MT)

2.8.1 MT is to be carried out in accordance to ISO 17638:2016 or a recognized standard accepted by the Society.

2.8.2 The extent of MT is to be in accordance to the plans agreed with the attending Surveyor and to the satisfaction of the Surveyor.

2.8.3 The surface to be examined is to be free from scale, weld spatter, oil, grease, dirt or paint and is to be clean and dry. In general, the inside and outside of the welds to be inspected need to be sufficiently free from irregularities that may mask or interfere with interpretation.

2.9 Radiographic testing (RT)

2.9.1 RT is to be carried out in accordance to ISO 17636-1:2013 or a recognized standard accepted by the Society.

2.9.2 The number and location of radiographic photographs are to be determined jointly by the Builder and the Society according to the construction type, service conditions and elements of the structure concerned, on the base of a minimum number of films as specified by Tab 1.

The number of the radiographic photographs may be increased at the request of the Surveyor, mainly when the visual inspection or radiographic or ultrasonic soundings which have been previously carried out show major defects.

2.10 Ultrasonic testing

2.10.1 UT is to be carried out according to procedure based on ISO 17640:2018 (testing procedure), ISO 23279:2017 (characterization) and ISO 11666:2018 (acceptance levels) or recognized standards accepted by the Society.

3 Acceptance Levels (criteria)

3.1 General

3.1.1 Welds are to be free from cracks and planar imperfections like incomplete root penetration and lack of fusion. All significant planar defects are to be removed and repaired.

3.1.2 This Article details the acceptance levels (criteria) followed for the assessment of the NDT results. Techniques include but are not limited to: VT, MT, PT, RT and UT.

3.1.3 As far as necessary, testing techniques are to be combined to facilitate the assessment of indications against the acceptance criteria.

3.1.4 The assessment of indications not covered by this Article is to be made in accordance with a standard agreed with the Society. Alternative acceptance criteria can be agreed with the Society, provided equivalency is established.

The general accepted methods for testing of welds are provided in Tab 3 and Tab 4 for surface and embedded discontinuities respectively (Refer to ISO 17635:2016).

Table 3 : Method for detection of surface discontinuities (All type of welds including fillet welds)

Materials	Testing method
Ferritic steel	VT
	VT, MT
	VT, PT

Table 4 : NDT for detection of embedded discontinuities (for butt and T joints with full penetration)

Materials and type of joint	Nominal thickness (t) of the parent material to be welded (mm)		
	t < 8	8 ≤ t ≤ 40	t > 40
Ferritic butt-joints	RT or UT **(1)**	RT or UT	UT or RT **(2)**
Ferritic T-joints	UT **(1)** or RT **(2)**	UT or RT **(2)**	UT or RT **(2)**
(1) Below 8mm the Society may consider application of an appropriate advanced UT method. **(2)** RT may be applied however there will be limitations.			

3.2 Quality Levels

3.2.1 Testing requirements follow the designation of a particular quality level of imperfections in fusion-welded joints in accordance with ISO 5817:2014. Three quality levels (B, C and D) are specified.

In general, Quality level C is to be applied for Primary and Secondary structural categories.

Quality level B corresponds to the highest requirement on the finished weld, and is generally applied to Special structural category and critical welds.

This standard applies to steel materials with thickness above 0,5 mm.

Note 1: ISO 5817:2014 Table 1 provides the requirements on the limits of imperfections for each quality level. ISO 5817:2014 Annex A also provides examples for the determination of percentage of imperfections (number of pores in surface percent).

All levels (B, C and D) refer to production quality and not to the fitness for purpose (ability of product, process or service to serve a defined purpose under specific conditions). The correlation between the quality levels defined in ISO 5817:2014, testing levels/ techniques and acceptance levels (for each NDT technique) will serve to define the purpose under specific conditions. The acceptance level required for examination shall be agreed with the Society. This will determine the quality level required in accordance with the non-destructive technique selected. Refer to Tab 5 to Tab 10.

3.3 Testing Levels

3.3.1 The testing coverage and thus the probability of detection increases from testing level A to testing level C. The testing level is to be agreed with the Society. Testing level D is intended for special applications, this can only be used when defined by the Builder specification.

Note 1: ISO 17640:2018 Annex A tables A.1 to A.7 provide guidance on the selection of testing levels for all type of joints in relation to the thickness of parent material and inspection requirements.

3.3.2 The testing technique used for the assessment of indications is also to be specified.

3.4 Acceptance Levels

3.4.1 The acceptance levels are specified for each testing technique used for performing the inspection. The criteria applied is to comply with each standard identified in Tab 5 to Tab 10 (or any recognized acceptable standard agreed with the Society.

3.4.2 Probability of detection (POD) indicates the probability that a testing technique will detect a given flaw.

3.5 Visual testing (VT)

3.5.1 The acceptance levels and required quality levels for VT are provided in IACS Recommendation 47, “Shipbuilding and Repair Quality Standard” and Tab 5.

3.6 Penetrant testing (PT)

3.6.1 The acceptance levels and required quality levels for PT are provided in Tab 6.

Table 5 : Visual testing

Quality levels (ISO 5817:2014 applies) **(1)**	Testing techniques/ levels (ISO 17637:2016 applies) **(1)**	Acceptance levels **(2)**
B	Level not specified	B
C		C
D		D
(1) Or any recognized standard agreed with the Society and demonstrated to be acceptable **(2)** The acceptance levels for VT are the same to the quality levels requirements of ISO 5817:2014		

Table 6 : Penetrant testing

Quality levels (ISO 5817:2014 applies) **(1)**	Testing techniques/ levels (ISO 3452-1:2013 applies) **(1)**	Acceptance levels (ISO 23277:2015 applies) **(1)**
B	Level not specified	2X
C		2X
D		3X
(1) Or any recognized standard agreed with the Society and demonstrated to be acceptable		

3.7 Magnetic Particle testing (MT)

3.7.1 The acceptance levels and required quality levels for MT is provided in Tab 7.

Table 7 : Magnetic Particle Testing

Quality levels (ISO 5817:2014 applies) **(1)**	Testing techniques/ levels (ISO 17638:2016 applies) **(1)**	Acceptance levels (ISO 23278:2015 applies) **(1)**
B	Level not specified	2X
C		2X
D		3X
(1) Or any recognized standard agreed with the Society and demonstrated to be acceptable		

3.8 Radiographic testing (RT)

3.8.1 The acceptance levels and required quality levels for RT are provided in Tab 8.

Reference radiographs for the assessment of weld imperfections are to be provided in accordance to ISO 5817:2014 or acceptable recognized standard agreed with the Society.

Table 8 : Radiographic Testing

Quality levels (ISO 5817:2014 applies) **(1)**	Testing techniques/ levels (ISO 17636-1:2013 applies) **(1)**	Acceptance levels (ISO 10675-1:2016 applies) **(1)**
B	B (class)	1
C	B **(2)** (class)	2
D	at least A (class)	3
(1) Or any recognized standard agreed with the Society and demonstrated to be acceptable **(2)** For circumferential weld testing, the minimum number of exposures may correspond to the requirements of ISO 17636-1:2013, class A		

3.9 Ultrasonic testing (UT)

3.9.1 The acceptance levels and required quality levels for UT are provided in Tab 9 and Tab 10.

3.9.2 UT Acceptance Levels apply to the examination of full penetration ferritic steel welds, with thickness from 8 mm to 100 mm. The nominal frequency of probes used is to be between 2 MHz and 5 MHz. Examination procedures for other type of welds, material, thicknesses above 100 mm and examination conditions are to be submitted to the consideration of the Society.

3.9.3 The acceptance levels for UT of welds are to be defined in accordance to ISO 11666:2018 requirements or any recognized acceptable standard agreed with the Society. The standard specifies acceptance level 2 and 3 for full penetration welded joints in ferritic steels, corresponding to quality levels B and C (Refer to Tab 8).

Table 9 : Ultrasonic Testing

Quality levels (ISO 5817:2014 applies) **(1) (2)**	Testing techniques/ levels (ISO 17640:2018 applies) **(1) (2)**	Acceptance levels (ISO 11666:2018 applies) **(1) (2)**
B	at least B	2
C	at least A	3
D	at least A	3 **(3)**

(1) Or any recognized standard agreed with the Society and demonstrated to be acceptable
(2) When characterization of indications is required, ISO 23279:2017 is to be applied
(3) UT is not recommended but can be defined in a specification with same requirement as Quality Level C

Table 10 : Recommended Testing and Quality Levels (ISO 17640)

Testing level **(1) (2) (3)** (ISO 17640:2018 applies)	Quality level (ISO 5817:2014 applies)
A	C, D
B	B
C	By agreement
D	Special application

(1) POD increases from testing level A to C as testing coverage increases
(2) Testing Level D for special application is to be agreed with the Society
(3) Specific requirements for testing levels A to C, are provided for various types of joints in ISO 17460:2018 Annex A

3.9.4 Sensitivity settings and levels. The sensitivity levels are set by the following techniques:

- Technique 1: based on 3 mm diameter side-drilled holes
- Technique 2: based on distance gain size (DGS) curves for flat bottom holes (disk shaped reflectors)
- Technique 3: using a distance-amplitude-corrected (DAC) curve of a rectangular notch of 1 mm depth and 1 mm width
- Technique 4: using the tandem technique with reference to a 6 mm diameter flat bottom hole (disk shaped reflector)

The evaluation levels (reference, evaluative, recording and acceptance) are specified in ISO 11666:2018 Annex A.

4 Reporting

4.1 General

4.1.1 Reports of NDT required are to be prepared by the Builder and are to be made available to the Society.

4.1.2 Reports of NDT are to include the following generic items:

- date of testing
- hull number, location and length of weld inspected
- names, qualification level and signature of personnel that have performed the testing
- identification of the component examined
- identification of the welds examined
- steel grade, type of joint, thickness of parent material, welding process
- acceptance criteria
- testing standards used
- testing equipment and arrangement used
- any test limitations, viewing conditions and temperature
- results of testing with reference to acceptance criteria, location and size of reportable indications
- statement of acceptance / non-acceptance, evaluation date, name and signature of evaluator
- number of repairs if specific area repaired more than twice.

4.1.3 In addition to generic items, reports of PT are to include the following specific items:

- type of penetrant, cleaner and developer used
- penetration time and development time.

4.1.4 In addition to generic items, reports of MT are to include the following specific items:

- type of magnetization
- magnetic field strength
- detection media
- viewing conditions
- demagnetization, if required.

4.1.5 In addition to generic items, reports of RT are to include the following specific items:

- type and size of radiation source (width of radiation source), X-ray voltage
- type of film/designation and number of film in each film holder/cassette
- number of radiographs (exposures)
- type of intensifying screens
- exposure technique, time of exposure and source-to-film distance as per below:
- distance from radiation source to weld
- distance from source side of the weld to radiographic film
- angle of radiation beam through the weld (from normal)
- sensitivity, type and position of IQI (source side or film side)
- density
- geometric un-sharpness
- specific acceptance class criteria for RT.

Examinations used for acceptance or rejection of welds are to be recorded in an acceptable medium. A written record providing following information: identification and description of welds, procedures and equipment used, location within recorded medium and results are to be included. The control of documentation unprocessed original images and digitally processes images is to be to the satisfaction of the Surveyor.

4.1.6 In addition to generic items, reports of UT are to include the following specific items:

- type and identification of ultrasonic equipment used (instrument maker, model, series number), probes (instrument maker, serial number), transducer type (angle, serial number and frequency) and type of couplant (brand)
- sensitivity levels calibrated and applied for each probe
- transfer loss correction applied Type of reference blocks
- signal response used for defect detection
- reflections interpreted as failing to meet acceptance criteria.

The method for review and evaluation of UT reports is required for adequate quality control and is to be to the satisfaction of the Surveyor.

4.1.7 The yard is to keep the inspection records specified in [4.1.2] [4.1.6] for at least for 5 years.

5 Unacceptable indications and repairs

5.1 General

5.1.1 General guidance to repair work is given IACS Recommendation 47, “Shipbuilding and Repair Quality Standard”.

5.1.2 Unacceptable indications are to be eliminated and repaired where necessary. The repair welds are to be examined on their full length using at least the same NDT method(s) as specified for the original weld.

5.1.3 When unacceptable indications are found, additional areas of the same weld length are to be examined unless it is agreed with the Surveyor and fabricator that the indication is isolated without any doubt. In case of automatic welded joints, additional NDT are to be extended to all areas of the same weld length.

5.1.4 All radiographs exhibiting non-conforming indications are to be brought to the attention of the Surveyor. Such welds are to be repaired and inspected as required by the Surveyor. When non-conforming indications are observed at the end of a radiograph, additional RT is generally required to determine their extent. As an alternative, the extent of non-conforming welds may be ascertained by excavation, when approved by the Surveyor.

The inspection records specified in Article [4] are to include the records of repaired welds.

5.1.5 The extent of testing may be extended at the Surveyor’s discretion when repeated non-acceptable discontinuities are found.

5.1.6 The inspection records specified in Article [4] are to include the records of repaired welds.

5.1.7 The Builder is to take appropriate actions to monitor and improve the quality of welds to the required level. The repair rate is to be recorded by the yard and any necessary corrective actions are to be identified in the builder’s Quality Assurance system.

5.1.8 For steels with yield stress of 300 MPa and above, and for special and first structural categories, a welding repair procedure qualification is to be carried out.

5.1.9 Welding repairs at same location is to be limited to three times. Further repairs may be agreed with the Society.

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

© **2025 BUREAU VERITAS** - All rights reserved

BUREAU VERITAS
1828
BUREAU
VERITAS

Shaping a World of Trust