RULES FOR
CLASSIFICATION OF

SHIPS / HIGH SPEED, LIGHT CRAFT AND NAVAL SURFACE CRAFT

NEWBUILDING

MATERIALS AND WELDING

PART 2 CHAPTER 3

FABRICATION AND TESTING OF STRUCTURES

JANUARY 2005

This booklet includes the relevant amendments and corrections shown in the July 2008 version of Pt.0 Ch.1 Sec.3.

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CHANGES IN THE RULES

General

The present edition of the rules includes additions and amendments decided by the Board on 29 November 2004, and supersedes the January 2003 edition of the same chapter.

The rule changes come into force as indicated below.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

Significant editorial changes adopted July 2008

Taking effect immediately

- **Sec.8 Structural and Tightness Testing**

— Under B301, the minimum test pressure specified in Table B1 for tanks containing liquids has been reduced for FRP tanks.
— In Table B1, tablenote 2) has been amended to align the requirement to structural testing of subsequent vessels with other IACS members.

Main changes adopted July 2006

Coming into force 1 July 2006

- **Sec.8 Structural and Tightness Testing**

— The first sentence of item B302 has been replaced.

Main changes adopted January 2006

Coming into force 1 January 2006

- **Sec.8 Structural and Tightness Testing**

— In Table B1, the footnote 2) has been replaced.

Main changes adopted January 2004

Coming into force 1 July 2005

- **General**

Until now, rules for fabrication of ship structures have been found in different parts of the rules (e.g. Pt.2, Pt.3 and Pt.5). Further, benchmarking has uncovered a need to align the rules with the latest development and with industry standards. With this in mind, this booklet is issued as a new and consolidated version under the title “Fabrication and Testing of Ship Structures”. The main goals of the upgrading are:

— Include, as far possible, all requirements for fabrication and fabrication testing in one booklet.
— Update the requirements to align with other international standards for welding, assembly and testing of steel structures.
— Provide a rule structure suited for optimising quantitative requirements based on FSA (Formal Safety Assessment).

Among others, important changes are:

- **Sec.1 General Requirements**

— Project specific NDT procedures and test plan is required submitted for approval.

- **Sec.2 Requirements for Builders of Ship Structures**

— Requirements for builder and subcontractor have been clearly defined.

- **Sec.5 Welding Procedures**

— Different alternatives for approval of welding procedures have been included. Validity of a welding procedure has been adjusted and the range of qualification has been updated to align with common international standards.

- **Sec.7 Non Destructive Testing of Welds**

— Extent of NDT has been given as a percentage of total welded length and importance of the welded structure. It should be noted that this section replaces the old text in Pt.3 Ch.1 Sec.11 "All weld crossings in the bottom and deck plating within 0.4 L amidships are to be examined".

Corrections and Clarifications

In addition to the above stated rule requirements, a number of corrections and clarifications have been made in the existing rule text.

Comments to the rules may be sent by e-mail to *rules@dnv.com*
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SECTION 1
GENERAL REQUIREMENTS

A. General

A 100 Application

101 This section provides general requirements for fabrication of welded structures involving parts and units described in Pt.3.

102 Basic requirements are given in Pt.1 Ch.1 Sec.1 B300 (ship rules).

103 Additional fabrication requirements for ship hull structures relating to special service and type are given in Pt.5.

104 Fabrication and welding of piping and boilers/pressure vessels are dealt with in Pt.4 Ch.6 Sec.7 (ship rules) and Pt.4 Ch.7 Sec.8, respectively.

A 200 Basic requirements

201 Welding of important structures like:

— hull, superstructure taking part in the overall strength
— hull equipment, stern frames, rudders, rudder stocks and rudder horn

shall be carried out by certified welders, with approved welding procedures and welding consumables, and at builders and subcontractors recognized by the Society.

202 Welders and welding procedures approved for the type of connection and parent material in question as given in Sec.3 and Sec.5, respectively, shall be used.

203 Welding consumables shall be type approved. Sec.4 specifies basic groups and grades, application of the various grades and grouping of shielding gases.

A 300 Builders and subcontractors

301 Builders and subcontractors will have to prove their abilities for the welding operations in question.

302 It is assumed that the builders and subcontractors make use of the necessary equipment for carrying out inspection of the welding operations in a satisfactory manner.

303 Important welding operations shall be carried out under daily supervision of an inspector, who has the experience and qualifications which enable him to judge this type of work. The work of each welder shall be regularly examined.

304 Builders and subcontractors shall keep a card index or register of all certified welders. The register shall give information on training of the welders and date and results of qualification tests. Information about the base metal, type of welding consumable, joint design and welding positions shall be stated in the event of re-qualification tests. The surveyor shall be allowed to examine the register at any time.

B. Definitions

B 100 Terms

101 The following terms are used in connection with fabrication of ship structures:

Builder	Yard involved in fabrication planning, building, assembly and testing of ship structures for purpose of classification.
Subcontractor	Independent unit performing work under supervision by the builder. The subcontractor may be required to be approved by the Society.
Quality Management System	Quality Management System worked out in accordance with a reputable quality standard, such as ISO 9001:2000 or equivalent. The Quality Management System may be required to be certified by an accredited certification body, see Pt.1 Ch.1 Sec.4 B500.
New Building Survey Arrangement (NSA)	Agreement between the builder and the Society defining responsibility and authority of personnel and items to be controlled with acceptance criteria, quality control functions. The activities through this agreement are complementary to the Society's own inspection scheme.
pWPS	Preliminary welding procedure specification: A tentative welding procedure specification, which is assumed adequate by the builder as basis for approval by the Society.
WPS	Welding procedure specification: A specification of material, detailed methods, practices and parameters employed in the welding of a particular joint, and which have been approved by the Society.
WPQR	Welding procedure qualification record: The record of the actual parameters employed during welding of the qualification test piece, and results from non-destructive testing and mechanical testing.
WPQT	Welding procedure qualification test: A test carried out in order to demonstrate that the weld carried out according to the pWPS meets the specified requirements.
WPT	Weld production test: A test carried out to demonstrate that actual production welding meets the specified requirements.
NDT	Non-destructive testing: Visual inspection, radiographic testing, ultrasonic testing, magnetic particle testing, penetrant testing and other non-destructive methods for revealing defects and irregularities.
Manual welding	Welding where the electrode holder, welding hand gun, torch or blowpipe are manipulated by hand.
Partly mechanised welding	Manual welding where the wire feed is mechanized.
Fully mechanised welding	Welding where all main operations (excluding the handling of the workpiece) are mechanized.
Fully automatic processes	Welding where all operations are mechanized.

C. Documentation

C 100 Plans and particulars

101 The following documentation shall be submitted for approval:

— WPS, including WPQR, if applicable
— project specific NDT procedures
— NDT test plan.

102 The following documentation to be sent for information:

— erection and inspection plan
— tank testing plan.

103 For builders, unknown to the Society, documentation describing the following activities shall be submitted for information:

— qualification and acceptance of fabrication procedures and personnel
— correct identification and documentation and use of materials
— inspection of preparatory work (assembly, fit-up form work, reinforcements, preheating, etc.)
— erection sequence
— inspection of fabrication work for compliance with specifications and procedures
— witnessing NDT, control and testing
— repairs and inspection of repairs
— welding inspection
— ensure functionality of examination, testing equipment and of recording and/or measuring devices vital for correct functioning of equipment and machinery used in fabrication.

SECTION 2
REQUIREMENTS FOR BUILDERS OF SHIP STRUCTURES

A. General

A 100 Application

101 This section specifies general requirements to builders of ship structures, hereafter called "builders", involved in building activities of structures intended for classification by the Society.

A 200 Basic requirements

201 Prior to commencement, builders unknown to the Society shall demonstrate their capability to carry out fabrication in line with the overall requirements of this section.

Guidance note:

Upon successful conformity with this section, the Society may grant a Newbuilding Survey Arrangement (NSA), which entitles builders to carry out fabrication within an actual scope of work, and further, indicates that the builder's quality management system has been adopted as complementary to the Society's classification surveys.

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B. Survey Arrangement

B 100 Quality management system

101 Unless otherwise agreed with the Society, builders of hull structures shall possess a documented and implemented quality management system. The extent of the quality management system shall be dependent on the size and type of the organisation, complexity and interaction of the processes and competence of personnel.

102 This section shall also apply to subcontractors of builders, when performing fabrication work defined under the Society's classification scope for the project.

C. Workmanship and Supervision

C 100 General

101 Builders shall ensure that works are skilfully and competently executed in accordance with fabrication procedures and work instructions, inspection and test plans

102 Builders shall ensure that all works are effectively and systematically controlled at all stages.

Guidance note:

Quality requirements for welding may be based on EN 729-series.

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103 Builders shall be in control of work performed at the location of subcontractors and/or of subcontractors performing work at the builder.

SECTION 3
QUALIFICATION OF WELDERS

A. General

A 100 Application

101 These requirements shall apply to the Society's acceptance of welders for fusion welding of steel and non-ferrous metals.

A 200 Requirements

201 Welding operators using fully mechanized or fully automatic processes shall be required to have records of proficiency, which provide evidence that the operators are receiving adequate regularly training in setting, programming and operating the equipment.

B. Qualification testing and certification

B 100 General

101 Welders shall be qualified to a standard recognised by the Society, e.g. EN 287, ISO 9606, ASME Section IX, ANSI/AWS D1.1.

102 Recognition of other standards is subject to acceptance by the Society.

B 200 Certification

201 Welding and testing of weld assemblies shall be performed in the presence of the Society's representative. Upon successful completion, and on client's request, the Society will certify that the welder has passed the approval testing.

202 Where certification is performed by other IACS members or independent organisations e.g. accredited or nationally approved certification bodies, recognition of such certification will be evaluated on a case by case basis. The Society reserves the right, however, to require verification of welders' qualifications when deemed necessary. Such verification may include testing prior to production, extra NDT and/or welding production tests.

SECTION 4
WELDING CONSUMABLES

A. General

A 100 Application

101 This section specifies basic groups and grades for type approved welding consumables, application of the various grades and grouping of the shielding gases.

A 200 Basic groups and grades

201 Welding consumables are divided into groups, depending on the strength of the filler metal and further divided into grades depending on the impact test temperature and the chemical composition of the filler metal.

The grades of welding consumables are specified in Table A1.

Table A1 Grades of welding consumables

	Normal strength steels	*High strength steels*	*Extra high strength steels*	*Austenitic stainless steels*
Grade of welding consumables	1 2 3 5 I II III V	2 Y 3 Y 4 Y 5 Y 2/3/4 Y40 I Y II Y III Y IV Y V Y II/III/IV Y40	3/4/5 Y42 3/4/5 Y46 3/4/5 Y50 3/4/5 Y55 3/4/5 Y62 3/4/5 Y69	308 /308Mo/ 308L 309 /309L/ 309Nb/ 309 Mo/309Mo L 310/310 Nb/310Mo 312 316/ 316 L 317/317 L 318 330 347 349

202 Welding consumables which have satisfied the requirements for a higher toughness grade, are also considered as complying with the requirements for a lower toughness grade of the same group.

203 The following tables (Table A2 - Table A7) show which welding consumables that can be applied for various steel grades.

When two different steel grades shall be joined, the welding consumable shall have a yield strength not below that of the lower strength steel.

When welding high strength steels of grade E, it is recommended that the applied welding consumable have been tested at -40°C (grade 4 or IV).

204 Where applicable, the composition of the shielding gas shall be reported. The approval of a wire ion combination with any particular gas can be applied to or transferred to any combination of the same wire and any gas in the same numbered group as defined in Table A8.

Table A2

Hull Structural steel grade	*Grade of welding consumables*									
	1 (DP)	2	2 Y [1]	2 Y40 [1]	3	3 Y [1]	3 Y40 [1]	4 Y [1]	4 Y40 [1]	5 Y [1]
NV A	X	X	X	(X)	X	X	(X)	X	(X)	X
NV B		X	X	(X)	X	X	(X)	X	(X)	X
NV D		X	X	(X)	X	X	(X)	X	(X)	X
NV E					X	X	(X)	X	(X)	X
NV A27S			X	X		X	X	X	X	X
NV D27S			X	X		X	X	X	X	X
NV E27S						X	X	X	X	X
NV A32/36			X	X		X	X	X	X	X
NV D32/36			X	X		X	X	X	X	X
NV E32/36						X	X	X	X	X
NV F32/36								X	X	X
NV A40				X			X		X	
NV D40				X			X		X	
NV E40							X		X	
NV F40									X	

1) To have Hydrogen mark H15, H10 or H5, (x) may be used, but should preferably be avoided.

Table A3

Hull Structural steel grade	*Grade of welding consumables*										
	1	I Y	II	II Y	II Y40	III	III Y	III Y40	IV Y	IV Y40	V Y
NV A	X	X	X	X	(X)	X	X	(X)	X	(X)	X
NV B			X	X	(X)	X	X	(X)	X	(X)	X
NV D			X	X	(X)	X	X	(X)	X	(X)	X
NV E						X	X	(X)	X	(X)	X
NV A27S		X		X	X		X	X	X	X	X
NV D27S				X	X		X	X	X	X	X
NV E27S							X	X	X	X	X
NV A32/36		X		X	X		X	X	X	X	X
NV D32/36				X	X		X	X	X	X	X
NV E32/36							X	X	X	X	X
NV F32/36									X	X	X
NV A40					X			X		X	
NV D40					X			X		X	
NV E40								X		X	
NV F40										X	

(X) May be used, but should preferably be avoided.

Table A4

For welding of steel grade	*Grade of welding consumables*										
	1(DP)	2	2Y [1]	2Y 40 [1]	3	3Y [1]	3Y40 [1]	4Y [1]	4Y40 [1]	5	5Y [1]
NV 360-ON	X	X	X	(X)	X	X	(X)	X	(X)	X	X
NV 360-1FN		X	X	(X)	X	X	(X)	X	(X)	X	X
NV 360-2FN				(X)	X	X	(X)	X	(X)	X	X
NV 410-ON			X	X		X	(X)	X	(X)		X
NV 410-1FN			X	X		X	X	X	X		X
NV 460-ON			X	X		X	X	X	X		X
NV 460-1FN			X	X		X	X	X	X		
NV 490-ON			X	X		X	X	X	X		X
NV 490-1FN			X	X		X	X	X	X		X
NV 510-1FN				X			X		X		X
NV 2-2					X	X	X	X	X	X	X
NV 2-3								X	X	X	X
NV 2-4 (L)										X [2]	X [2]
NV 4-2						X	X	X	X		X
NV 4-3								X	X		X
NV 4-4 (L)											X [2]

1) To have Hydrogen mark H15, H10 or H5, (x) may be used, but should preferably be avoided.

2) To be specially approved for low temperature application.

Table A5

For welding of steel grade	*Grade of welding consumables*										
	1	I Y	II	II Y	II Y40	III	III Y	III Y40	IV Y	IV Y40	V Y
NV 360.ON	X	X	X	X	(X)	X	X	(X)	X	(X)	X
NV 360-1FN			X	X	(X)	X	X	(X)	X	(X)	X
NV 360-2FN					(X)	X	X	(X)	X	(X)	X
NV 410-ON		X		X	X		X	(X)	X	(X)	X
NV 410-1FN				X	X		X	X	X	X	X
NV 460-ON		X		X	X		X	X	X	X	X
NV 460-1FN				X	X		X	X	X	X	
NV 490-ON		X		X	X		X	X	X	X	X
NV 490-1FN				X	X		X	X	X	X	X
NV 510-1FN					X			X		X	X
NV 2-2						X	X	X	X	X	X
NV 2-3									X	X	X
NV 2-4 (L)											X [1]
NV 4-2							X	X	X	X	X
NV 4-3									X	X	X
NV 4-4 (L)											X [1]

1) To be specially approved for low temperature application.

Table A6

For welding of steel grade	*Grade of welding consumable*					
	Y42H10 [1]	Y46H10 [1]	Y50H10 [1]	Y55H5	Y62H5	Y69H5
NV D420 NV E420 NV F420	3/III, 4/IV, 5/V 4/IV, 5/V 5/V	3/III, 4/IV, 5/V 4/IV, 5/V 5/V	3/III, 4/IV, 5/V 4/IV, 5/V 5/V			
NV D460 NV E460 NV F460		3/III, 4/IV, 5/V 4/IV, 5/V 5/V	3/III, 4/IV, 5/V 4/IV, 5/V 5/V			
NV D500 NV E500 NV F500			3/III, 4/IV, 5/V 4/IV, 5/V 5/V	3/III, 4/IV, 5/V 4/IV, 5/V 5/V		
NV D550 NV E550 NV F550				3/III, 4/IV, 5/V 4/IV, 5/V 5/V	3/III, 4/IV, 5/V 4/IV, 5/V 5/V	
NV D620 NV E620 NV F620					3/III, 4/IV, 5/V 4/IV, 5/V 5/V	3/III, 4/IV, 5/V 4/IV, 5/V 5/V
NV D690 NV E690 NV F690						3/III, 4/IV, 5/V 4/IV, 5/V 5/V

1) May have hydrogen mark H5

Table A7 Selection of suitable consumables for combinations of aluminium alloys

Base metal alloy	NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	NV-5083 NV-5383 NV-5059	NV-6060, NV-6061 NV-6063, NV-6005A NV-6082
NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183
NV-5083, NV-5383 NV-5059	5356, 5556, 5183	5183 [1]	5356, 5556, 5183
NV-6060, NV6061 NV-6063, NV-6005A NV-6082	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183

Note: All consumables are covered by the AWS specification. The prefix "ER" is committed.

1) Other consumables may be use if allowable stresses are reduced.

Table A8 Grouping of shielding gases, [1]

Group	*Gas composition (Vol.%)*				
	CO_2	*O_2*	*H_2*	*He*	*Ar*
I 1					100
I 2				100	
I 3				> 0-95	Rest
M 11	> 0 - 5		> 0 - 5		Rest [2]
M 12	> 0 - 5				Rest [2]
M 13		> 0 - 3			Rest [2]
M 14	> 0 - 5	> 0 - 3			Rest [2]
M 21	> 5 - 25				Rest [2]
M 22		> 3 - 10			Rest [2]
M 23	> 5 - 25	> 0 - 8			Rest [2]
M 31	> 25 - 50				Rest [2]
M 32		> 10 - 15			Rest [2]
M 33	> 5 - 50	> 8 - 15			Rest [2]
C 1	100				
C 2	Rest	> 0 - 30			

1) The compositions of shielding gasses in group I are in accordance with EN 439, while group M and C gasses are in accordance with IACS W17:1993.

2) Argon may be partly substituted by Helium up to 95% of the Argon content.

SECTION 5
WELDING PROCEDURES

A. General

A 100 Application

101 This section specifies requirements for welding procedure specifications and welding procedure qualification tests for C-Mn and low alloy steels, aluminium, austenitic stainless steel and feritic-austenic (duplex) stainless steels. C-Mn and low alloy steels are in this context referred to as "steels".

A 200 Welding processes

201 Welding may be performed with the following processes unless otherwise specified:

- manual metal arc welding (metal arc welding with covered electrode)
- self-shielded tubular-cored arc welding
- submerged arc welding with one wire electrode (SAW)
- submerged arc welding with strip electrode
- metal inert gas welding, (MIG) welding
- metal active gas welding, (MAG) welding
- tubular-cored metal arc welding with active gas shield
- tubular-cored metal arc welding with inert gas shield
- tungsten inert gas arc welding, (TIG) welding
- plasma arc welding.

202 Other processes shall be specially approved.

B. Welding Procedure Specification

B 100 General

101 A welding procedure specification shall as a minimum contain the following information as relevant for the welding operation:

- material: standard, grade and modification
- nominal thickness or diameter range (dimensions)
- welding process
- joint or groove design with tolerances
- welding position(s) and direction of progression
- welding consumables: trade name, electrode or wire diameter, shielding gas, flux and recognised classification
- welding sequence: number and order of passes or layers
- electrical parameters: voltage range, current range, polarity
- travel speed- and heat input ranges
- preheat and interpass temperatures
- post weld heat treatment parameters
- details on cleaning processes employed and restrictions if any.

B 200 Approved welding procedure specification

201 Welding procedure specifications shall be approved by the Society prior to welding.

202 A welding procedure specification may be approved based on one of the following alternatives:

a) Review of a welding procedure qualification test record (WPQR) corresponding to the welding procedure specification in question. The welding procedure test on which the WPQR is based shall be witnessed by the Society or by a party recognised by the Society.

b) Review and verification of documentation showing successful application of the welding procedure specification over a prolonged period of time.

c) The welding procedure specification is compiled on basis of other approved welding procedures.

203 For the following type of services the approval of welding procedure specifications shall be based on alternative 202 a):

- butt welds used in cargo tanks, process pressure vessels and/or piping systems for liquefied gases
- all welds in aluminium
- butt welds and essential fillet welds used in cargo tanks, hull structure, process pressure vessels and/or piping systems in ferritic-austenitic stainless steels
- butt welds in plate thickness above 50 mm
- butt welds of material grade E and F single-side buttwelds with and without backing in the vertical down positions, welded connections between castings/forgings and rolled material, such as e.g. stern frames, rudder, rudder horns and struts. welding of highly stressed butt welds and cruciform joints located at large hatch openings
- when welding consumables are not type approved.

204 When a welding procedure qualification test (WPQT) is required, the tests must be performed in the environment applicable to the actual production and meet the specified minimum requirements.

C. Welding Procedure Test Assembly and Sampling of Test Pieces

C 100 Butt welds in plates

101 The test assembly consists of two plates welded together. As far as possible the plates shall have a size which can simulate the heat transfer during the production welding. For manual or semiautomatic welding, a test assembly according to Fig.1 shall be carried out with:

l_{min} = 300 mm
L_{min} = 350 mm

For automatic welding, the dimensions shall be:

l_{min} = 400 mm
L_{min} = 1 000 mm

Edge preparation and fit-up shall be as detailed in the pWPS. The plates shall be joined and held by tack welds to provide the correct gap for the edge preparation used. 50 mm of each end of the test piece shall be discarded. The test assemblies shall normally be so prepared that the principal direction of rolling is parallel to the direction of welding.

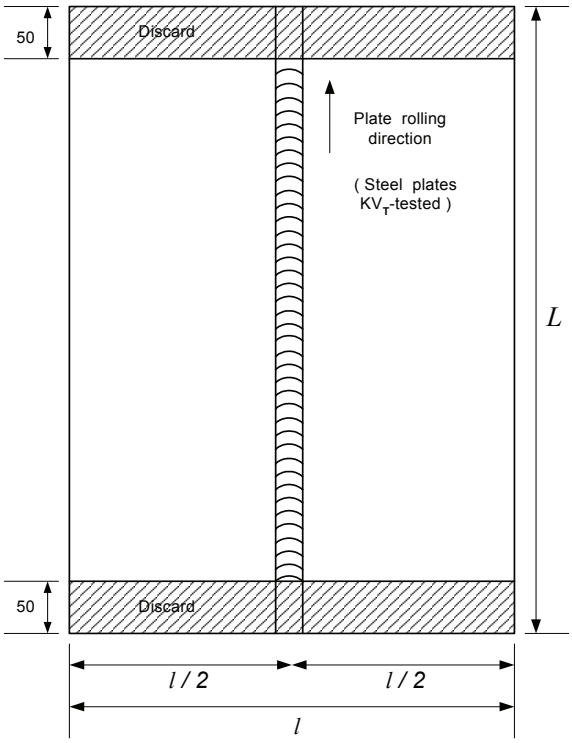


Fig. 1
Test assembly for butt welds in plates

102 The following mechanical tests are required from each assembly (see Fig.2):

— 2 tensile test (flat specimen transverse to the weld)
— 1 root and 1 face bend tests when t ≤ 20 mm and 2 side bend tests when t > 20 mm
— when the welding consumable is not approved, 1 extra tensile test (round specimen from the weld metal)
— 12 Charpy V-notch tests with the notch location as given in 107
— 1 macrosection test (metallographic examination + hardness measurements).

103 Specimens for transverse tensile testing shall be in accordance with K200, type B.

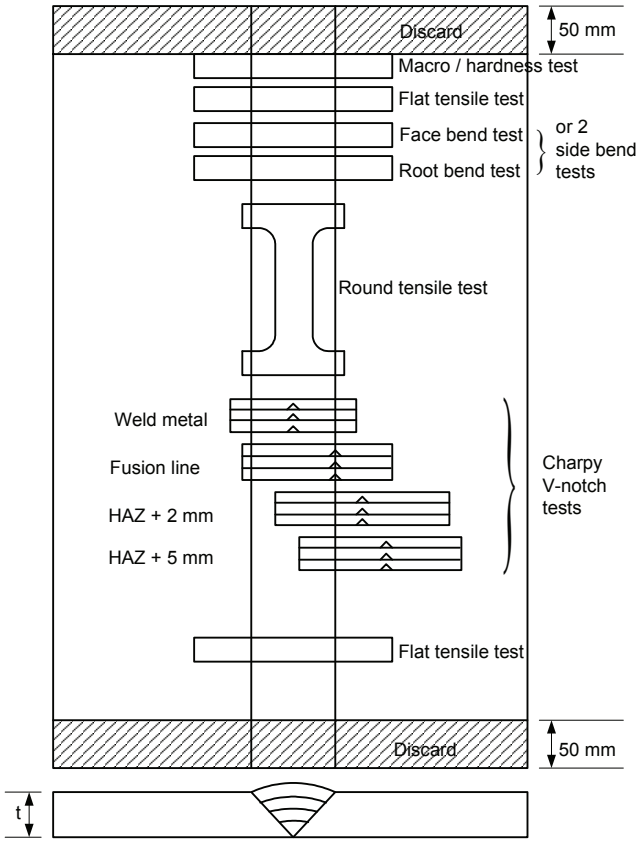


Fig. 2
Sampling of test specimens in plates

104 When required the round tensile specimen shall be machined to the dimensions shown in K200, type A, care being taken that the longitudinal axis coincides with the intersection between the midplane of the weld, and the midplane of the plates. If the section area of the weld metal is too small to allow sampling of the round specimen, an all-weld-metal tensile test shall be carried out.

105 Transverse side bend, root bend and face bend specimens shall be machined to the dimensions shown in K300. For a mixed or heterogeneous butt joint, longitudinal bend test specimens may replace transverse bend test specimens.

106 The macrosection shall include about 10 mm of unaffected base material and shall be prepared and etched on one side to clearly reveal the fusion line and the HAZ

107 The Charpy V-notch specimens shall be machined in accordance with the requirements given in Ch.1 Sec.2 (ISO148). The specimens shall be sampled 2 mm below the surface of the parent material and transverse to the weld.

12 Charpy V-notch specimens shall be localized in the welded joint as follows:

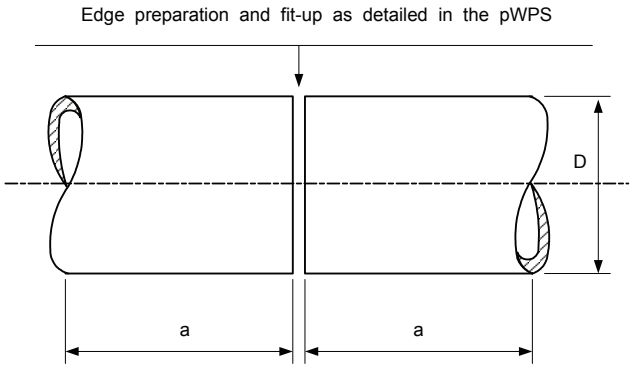
— 3 specimens with the notch along the weld metal centreline
— 3 specimens with the notch in the fusion line
— 3 specimens with the notch in the HAZ, 2 mm from the fusion line
— 3 specimens with the notch in the HAZ, 5 mm from the fusion line.

108 HAZ impact test specimens are normally not required for grade NVA steels, aluminium and austenitic stainless steels with service temperature above -105 degrees Celsius. For material thicknesses below 6 mm impact testing is not required unless specifically required by the Society. The V-notch shall

be perpendicular to the plate surface. For plate thicknesses >50 mm, two additional sets of specimens shall be taken from the root area: one with the notch in the centre of the weld and one with the notch in the fusion line.

C 200 Butt welds in pipes

201 The test assembly shall be in accordance with Fig.3.



a = minimum value 150 mm
D = outside diameter.

Fig. 3
Test assembly for butt welds in pipes

202 The following mechanical tests are required from each assembly (see Fig.4):

- 2 tensile test (flat specimen transverse to the weld)
- 1 root and 1 face bend tests when t ≤ 20 mm and 2 side bend tests when t > 20 mm
- 12 Charpy V-notch tests with the notch location as given in 107
- 1 macrosection test (metallographic examination + hardness measurements).

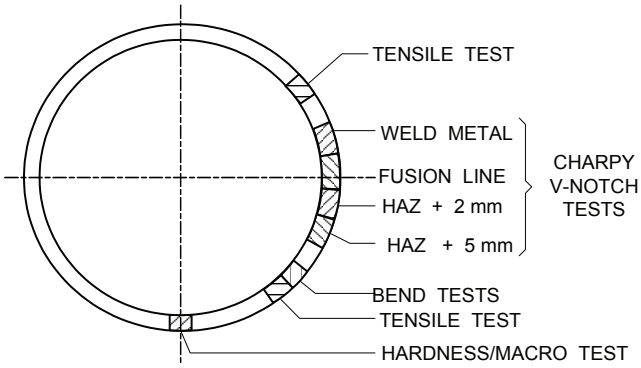
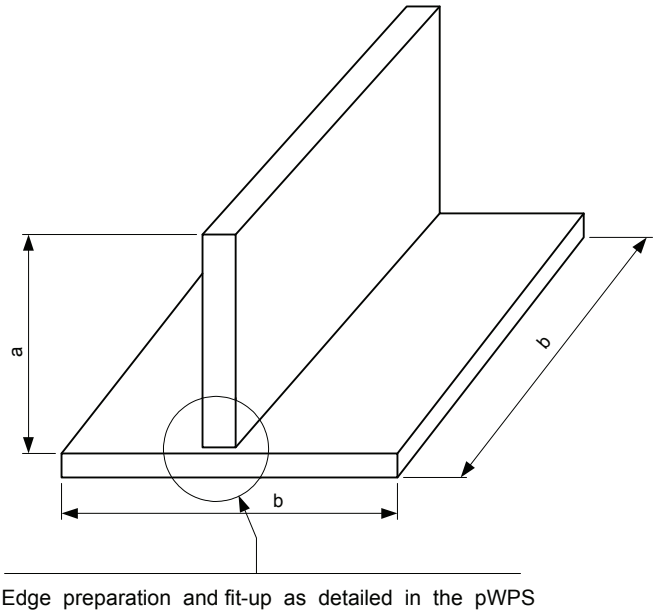


Fig. 4
Sampling of test specimens in pipes

C 300 Full penetration T-, Y-, and K- joints

301 WPQT's for full penetration groove welds between plates at right angles or inclined, i.e. T- or Y- and K- configurations, shall cover a weld length of minimum 350 mm (see Fig.5).



a = 3 t; minimum value 150 mm
b = 6 t; minimum value 350 mm

Fig. 5
Test assembly for full penetration T-joints

302 The following mechanical tests are required from each assembly (see Fig.6):

- 12 Charpy V-notch tests with the notch location as given in 107
- 1 macrosection test (metallographic examination + hardness measurements).

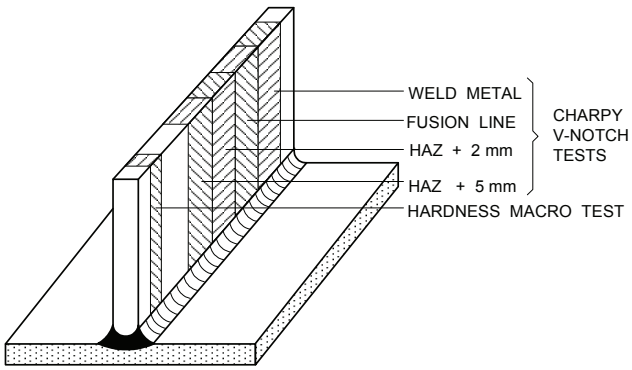
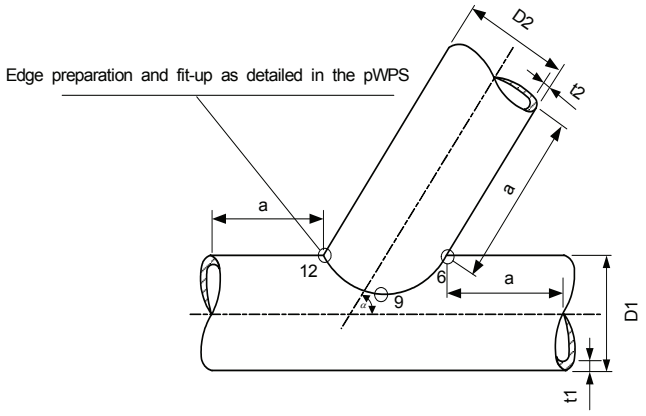


Fig. 6
Sampling of test specimens in full penetration T-joints

C 400 Branch connection

401 The following mechanical tests are required from each assembly (see Fig.7):

- 12 Charpy V-notch tests sampled at 9 o'clock in the branch pipe and with the notch location as given in 107
- two macrosection tests (metallographic examination + hardness measurements) at 12 and 6 o'clock.



a = minimum value 150 mm
D1 = outside diameter of the main pipe
t1 = wall thickness of the main pipe
D2 = outside diameter of the branch pipe
t2 = wall thickness of the branch pipe.

Fig. 7
Test assembly for branch connections

C 500 Fillet welds

501 The two plates are assembled and positioned edgewise so as to constitute a tee-assembly with no clearance. As far as possible the plates shall be of a sufficient size to ensure a reasonable heat distribution. For fillet welds the test assembly shall be as defined in Fig.8.

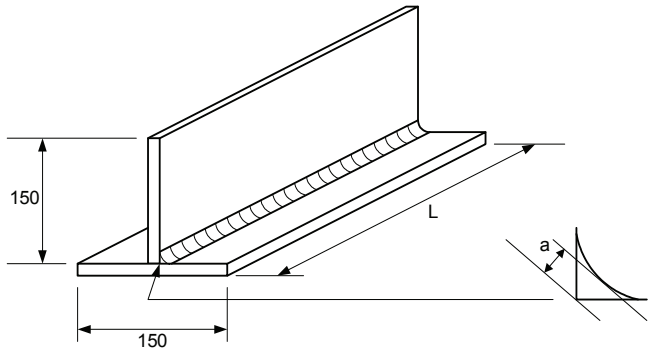


Fig. 8
Test assembly for fillet welds

For manual and semi-automatic welding the length of the test piece shall be:

L_{min} = 350 mm.

For automatic welding the length shall be:

L_{min} = 1 000 mm.

Weld and fit-up shall be as detailed in the pWPS. The test assembly shall be welded on one side only. For manual and semi-automatic welding, the stop/restart position is normally to be included in the test length and shall be clearly marked for subsequent examination. The ends of the specimen are exempted from examination over a length of 50 mm.

502 The following tests shall be performed:

— two macrosection tests (metallographic examination, hardness measurements). One of the macrosections shall be taken at the marked position of the stop/restart (for more details see 106). For hardness testing, see E302.

D. Non Destructive Testing of Test Assemblies

D 100 Butt welds and full penetration T-joints

101 The extent of the testing shall be as follows:

— 100% visual inspection
— 100% radiographic or ultrasonic testing
— 100% surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld shall comply, unless otherwise specified, with ISO 5817 level B for ferrous materials or ISO 10042 level B for aluminium.

D 200 Fillet welds and partial penetration welds

201 The extent of the testing shall be as follows:

— 100% visual inspection
— 100% surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld shall comply, unless otherwise specified, with ISO 5817 level B for ferrous materials or ISO 10042 level B for aluminium. If the stop/restart spot is included in the test length, special attention shall be paid to this position with respect to profile, proper fusion and absence of crater defects.

E. Destructive Testing

E 100 Transverse tensile test

101 The tensile strength shall not be below the specified minimum tensile strength for the steel grade in question.

E 200 Bend test

201 The test specimens shall be bent on a mandrel with diameter 4xt, where t is the thickness of the specimen, except for extra high strength steels grades 550, 620, and 690 where the diameter shall be 5xt. The bending angle shall be at least 180°. After bending, the test specimens shall not reveal any open defects in any direction greater than 3 mm. Defects appearing at the corners of a test specimen during testing shall be ignored in the evaluation.

E 300 Macrosection and hardness testing

301 Cracks and lack of fusion are not accepted. The welded joints shall have a regular profile with smooth transitions to the base materials and without significant or excessive reinforcement.

302 The hardness testing shall be in accordance with ISO 6507/1 or equivalent, and is only required for grades NV27S and higher. Normally, the Vickers method (HV10) is used. Indentations shall be made along traverses in the weld, HAZ and the parent metal approximately 1 mm below the surface. For each traverse a minimum of 3 indentations shall be made in the weld, HAZ (both sides) and parent metal (both sides). For HAZ the first indentation shall be placed as close to the fusion line as possible.

303 For material grades up to NV 460 a maximum hardness limit of 350 HV10 shall normally be met. For single run fillet welds a maximum hardness limit of 380 HV10 shall be met.

E 400 Impact testing

401 *Hull construction*

The test temperature and absorbed energy shall be in accordance with the following requirements:

Impact test temperatures:	For grades:
+20°C	B, A27S, A32, A36 and A40
0°C	D, D27S, D32, D36 and D40
-20°C	E, E27S, E32, E36 and E40
-40°C	F32, F36 and F40

Guidance note:

If tested, the average value for absorbed energy in weld metal, fusion line and HAZ shall not be less than 27 J at 20°C for NVA.

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The average value for absorbed energy in weld metal, fusion line and HAZ shall not be less than:

- for manual and semi-automatic welding in all welding positions except vertical: 47 J
- for automatic welding: 34 J (NV 40 grades 41 J)
- for manual and semi-automatic welding in vertical position: 34 J (NV 40 grades 41 J).

For extra high strength structural steels the Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ shall be the same as required for the base material.

402 For pressure vessels and production/drilling plants related equipment, structures and systems the Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ shall be the same as required for the base material.

403 The average impact requirements shall be satisfied for each notch location, but one single value of three values from specimens from the same notch location may be below the average requirements, but not below 70% of minimum average.

404 In the case of reduced Charpy V-notch test specimens (10 x 7.5 mm and 10 x 5 mm), the impact energy values to be obtained shall satisfy Table E1:

Table E1 Impact energy requirement for subsize specimens

Dimensions of Charpy V-notch test specimen	*Impact energy*
10 x 10 mm	KV
10 x 7.5 mm	5/6 KV
10 x 5 mm	2/3 KV

405 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken. The results obtained shall be combined with the original results to form a new average which, for acceptance, shall be not less than the required value. Additionally, for these combined results not more than two individual values shall be less than the required average value, and of these, not more than one shall be less than 70% of the average value. Further re-tests may be made at the surveyor's discretion, but these shall be made on a new welded assembly (revised WPS) and shall include all tests required for the original assembly, even those which were previously satisfactory.

E 500 Welds between different material grades

501 When a butt weld is made between two plates of different grades, the test temperature and achieved impact energy shall comply with the minimum specified requirements for the lower steel grade (see E401 and E402). In the same way, the tensile strength to be obtained on the welded assembly shall be in agreement with the requirements relating to the plate steel having the lower strength. As an example the test temperature, impact energy and tensile strength for the butt welded joints given in Fig.9 are those required for the plate of grade D in the left assembly and for the plate of grade E in the right assembly.

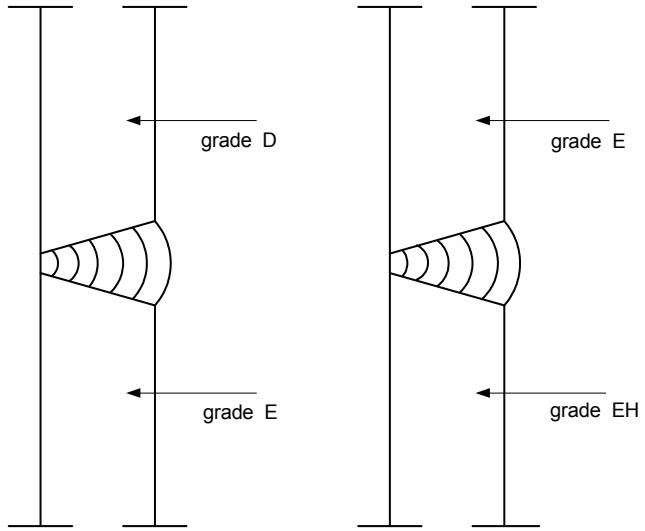

Fig. 9
Butt welded plate joints of different grades

502 Impact testing may be required from both sides of the weld.

Guidance note:

Welds between cast or forged material and rolled plate should be impact tested from both sides of the weld.

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E 600 Retesting

601 If the WPQT fails to comply with any of the requirements for NDT one extra WPQT shall be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPS shall be considered as not qualified and a re-specification of the WPS shall be made prior to a new qualification test.

F. Validity of Approved Welding Procedures

F 100 General

101 The validity of an approved WPS shall be restricted to the builder or subcontractor performing the qualification or receiving the approval. It is a prerequisite that the workshops/ yards belonging to the builder and/or subcontractor are under the same technical management and working in accordance with the same QA – program and – procedures.

102 Qualification of a welding procedure remains valid provided the parameters are kept within the qualified ranges during production welding. The qualified ranges are given in F 200. When one or more variations outside the qualification ranges occur, the welding procedure qualification shall be considered invalid, and the welding procedure is therefore to be re-specified and re-qualified.

Guidance note:

Note that a qualified procedure is always based on a welding procedure test (WPQT) and that approval of a WPS based on a welding procedure test is only required for the type of services listed in B203.

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F 200 Range of qualification

201 A qualified welding procedure shall be used within the

ranges of the parameters below.

Base material

The following changes shall lead to a new qualification:

a) In general, significant change of material properties which will obviously affect the weldability and mechanical properties.

b) More specifically, structural steels are grouped in three categories:

   i) Normal strength steel, grades A, B, D and E or equivalent structural steels with tensile strength 400–520 N/mm^2.

   ii) High strength steel, grades A27S, D27S, E27S, A32, D32, E32, F32, A36, D36, E36, F36, A40, D40, E40, F40 or equivalent structural steels with minimum specified yield strength 265–390 N/mm^2.

   iii) Extra high strength steels, grades A-F 420, A-F 460, A-F 500, A-F 550, A-F 620, A-F 690 or equivalent structural steels with minimum specified yield strength 420-690 N/mm^2.

The qualification on steel grades of higher toughness requirements will qualify the grades of lower toughness but not vice versa.

Thickness

Thickness, t, is defined as follows:

a) For a butt weld:
The base metal thickness, which for welds between dissimilar thicknesses is that of the thinner material.

b) For a fillet weld:
The base metal thickness, which for welds between dissimilar thicknesses is that of the thicker material.

c) For a set-on branch connection:
The thickness of the branch pipe.

d) For a set-in or set-through branch connection:
The thickness of the main pipe.

e) For a T-joint in plate:
The thickness of the prepared plate.

The requirements to qualified thickness range for butt welds shall be as given in Table F1.

Table F1 Qualified thickness range

Thickness t (mm) of test piece	*Qualification range* [1]	
	Single run or single run from both sides	*Multi-run*
t < 12	0.5 t to 1.3 t	Up to 2 t
12 ≤ t ≤ 100	0.5 t to 1.1 t	0.5 t to 2 t (max. 150)
t > 100	Not applicable	50 to 2 t

1) The qualification range for vertical downward position is 0.5 t to 1.1 t

Range of qualification for material thickness and throat thickness of fillet welds shall be as given in Table F2.

Table F2 Range of qualification for material thickness and throat thickness of fillet welds

Thickness t (mm) of test piece	*Range of qualification*		
	Material thickness	*Throat thickness*	
		Single run	*Multi-run*
t < 30	0.5 t to 1.2 t	0.75 a to 1.5 a [1]	No restriction
t ≥ 30	≥ 5	a [2]	No restriction

1) a is the throat as used for the test piece

2) for special applications only. Each throat thickness has to be proofed separately by a welding procedure test.

Note: Where a fillet weld is qualified by means of a butt weld test, the throat thickness range qualified shall be based on the thickness of the deposit material.

Diameter of pipes and branch connections

The qualification of a welding procedure test on diameter D shall include qualification for diameters in the following ranges as given in Table F3.

Table F3 Qualified range for pipe and branch connection diameters

Diameter of the test piece D (mm) [1] [2]	*Qualification range*
D ≤ 25	0.5 D to 2 D
D > 25	≥ 0.5 D and plates

1) D is the outside diameter of the pipe or outside diameter of the branch pipe.

2) Qualification given for plates also covers pipes when the outside diameter is greater than 500 mm.

Angle of branch connections

A WPQT carried out on a branch connection with angle α shall qualify all branch connection angles in the range of α to 90°.

Welding consumables

The following changes shall lead to a new qualification:

— any change in consumable classification
— change of consumable brand when impact testing is required at temperatures below -20°C
— any significant change of mixture/composition (e.g. change from argon/mixed gas to CO_2 gas, see Sec.4 Table A8), flow rate, filling time and filling volume for shielding and purging gases.

Welding positions

The following changes shall lead to a new qualification.

Change from one principal welding position (see Figs. 10, 11, 12) to another, unless complying with Table F4.

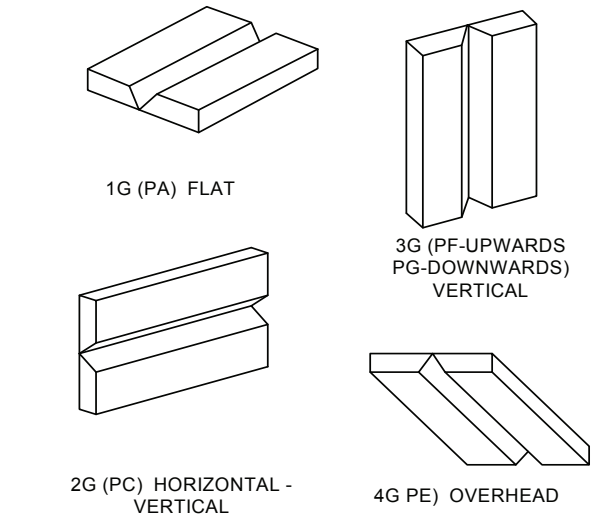

Fig. 10
Plate test positions

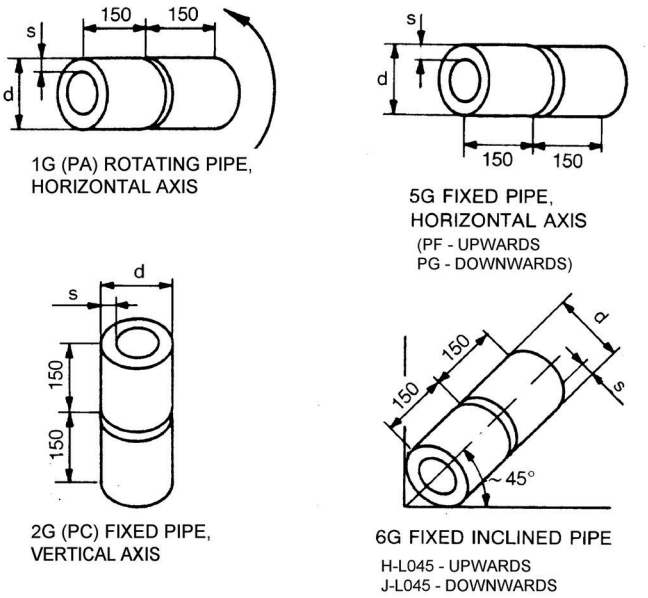

Fig. 11
Pipe test positions

Type of joint

The following changes shall lead to a new qualification:

— change from fillet weld to butt weld
— change from two sided welding to one side, but not vice versa
— deletion of back gouging
— addition or deletion of ceramic backing
— change from butt joint in plates to butt joints in pipes with outside diameter less than 500 mm.
— any change of groove dimensions specified in the WPS.

Welding condition

The following changes shall lead to a new qualification:

— any change of welding process
— change from spray arc to short arc or pulsed arc or vice versa
— change in heat input beyond ±25%
— any decrease in preheat temperature
— change of interpass temperature beyond 25°C
— addition or deletion of post weld heat treatment; the temperature range validated is the holding temperature used in the welding procedure test ±20ºC.

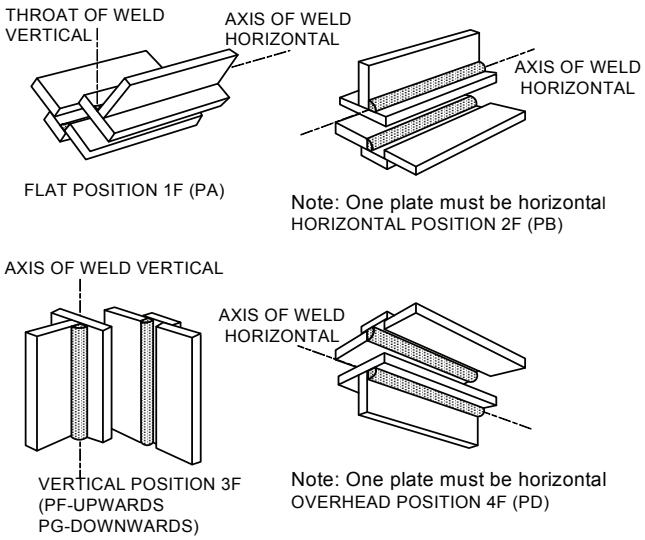

Fig. 12
Positions of test plate for fillet welds

Table F4 Qualified principal positions for butt welds and fillet welds, steel

Test weld *Joint configuration* [1)2)]	*Principal positions*	*Qualified positions* [3)]		
		Butt welds		*Fillet welds plates or pipes*
		Plates	*Pipes*	
Butt welds in plates	2G + 3G 1G 2G 3G 4G	All 1G 1G, 2G, 4G 3G 1G, 4G		All 1F 1F, 2F, 4F 3F 1F, 4F
Butt welds in pipes	2G + 5G = 6G 1G 2G 5G	All 1G 1G, 2G, 4G All	All 1G 1G, 2G 1G, 5G	All 1F 1F, 2F, 4F All
Fillet welds	2F + 3F 1F 2F 3F 4F 5F			All 1F 1F, 2F, 4F 3F 1F, 2F, 4F All

1) Pipes with D > 500 mm are considered equivalent to plates (apply only to the main pipe in branch connections.

2) Branch connections shall be qualified separately.

3) The vertical downwards position shall be qualified separately.

G. Additional Requirements WPQT for Liquefied Gas Systems

G 100 Welds in plates and pipes

101 Test assembly shall be as described in C101 or C201.

102 From each test assembly for plates the following additional test specimens shall be taken:

— one set of Charpy V test specimens (each set consists of 3 specimens) with the notch 1 mm from the fusion line.

For austenitic stainless steels, only one set of Charpy V test specimens with the notch in the centre of the welds are required for design temperature below -105°C.

G 200 Test requirements

201 The butt weld tensile test shall comply with the following requirements:

Generally, the tensile strength shall not be less than the specified minimum tensile strength for the parent material. In cases where the Society has approved the use of welding consumables which give lower tensile strength in the weld metal than that required for the parent material, the approved value for the welding consumable in question applies. The position of fracture shall be reported.

202 Charpy V testing shall be conducted at the temperature prescribed for the base material (ref. Pt.5 Ch.5 Sec.2 of the Rules for Classifcation of Ships). When specimens of 10 x 10 mm cross-section are used, the average value from 3 tests shall not be less than 27 J for weld metal. One single test may give a value below the required average but not lower than 19 J.

For fusion line and heat affected zone the requirement for minimum average value is the same as for the base material.

G 300 Weld production test requirements

301 In general the tests requirements shall comply with G100.

302 Impact testing is for carbon-manganese steels, austenitic chromium-nickel steels and nickel steels to be conducted at the temperature prescribed for the base material. For austenitic chromium-nickel steels, testing is only required for design temperature below -105°C. For welding of plates the following apply when pieces of 10 x 10 mm cross section are used:

1) If the impact test pieces from plate materials are taken with their longitudinal axes transverse to the main direction of rolling, the average value from 3 tests shall not be less than 27 J for weld metal, fusion line, heat affected zone and parent material. One single test may give a value below the required average, but not lower than 19 J.

2) If the impact test pieces from plate materials are taken with their longitudinal axes parallel with the main direction of rolling the average value from 3 tests is for the fusion line and the heat affected zone not to be less than 41 J, and for the weld metal not to less than 27 J. One single test may give a value below the required average but not lower than 29 J and 19 J respectively. For testing of thin materials where it is impossible to use a standard test piece 10 x 10 mm, the larger of the following pieces shall be used:

   — 10 x 7.5 mm, 10 x 5 mm, 10 x 2.5 mm.

The impact values are then reduced to respectively 5/6, 2/3 and 1/2 of the required values of the standard test pieces.

303 If the impact test (3 specimens) fails to meet the requirements, 3 additional impact test specimens may be prepared and tested provided that only one of the below mentioned three cases occurred in the first test:

1) The average value was below the requirement, one value being below the average requirement but not below the minimum requirement for a single value.

2) The average value met the requirement. Two values were below the average requirement but not below the requirement for a single value.

3) The average met the requirement. Two values were above or equal to the average requirement and one value was below the requirement for a single value. The initial 3 impact values and the additional 3 values shall form a new average of six values. If this new average complies with the requirement and no more than two individual results of all six specimens are lower than the required average and no more than one result is lower than the required value for a single specimen, the test may be accepted.

304 If the impact values do not comply with the requirements in 302 and 303, the results may be submitted for consideration. The production weld test may be accepted subject to acceptable results from additional test prescribed by the Soci-

ety.

H. Additional Requirements WPQT for Ferritic-Austenitic Stainless Steel

H 100 Welds in plates and pipes

101 Test assembly shall be as described in C101 or C201.

102 From each test assembly the following additional test specimens shall be taken:

— one corrosion test according to ASTM G48-76 Method A
— one microsection test specimen.

H 200 Test requirements

201 Corrosion test according to ASTM G48-76 Method A. The test specimen shall be in the as welded state after normal weld cleaning operation. The test specimens shall be exposed to the solution at a constant temperature of 20°C for 24 hours.

Test requirements :

— no pitting attack shall be visible on the test face(s)
— general weight loss shall not exceed 20 mg.

Guidance note:

Welds between Ferritic-Austenitic steels and other grades of stainless, C/Mn steels or for welds in "non corrosive " area may not need to be corrosion tested.

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202 Impact testing shall be as described in C107 using an impact test temperature of -20°C. The average value for absorbed energy shall not be less than 27 J.

203 Concerning the micro structural examination, the test samples shall comprise the weld metal, heat affected zone and base metal. The microstructure shall be suitably etched and examined at 400X magnification and shall be free from grain boundary carbides and precipitates. The ferrite content in the weld metal root and un-reheated weld cap shall be determined in accordance with ASTM E 562 and be in the range of 25-70%.

H 300 Validity of a qualified welding procedure

301 Reference is made to D200 and any change in the following additional essential variables which shall lead to a new qualification:

— variation in the heat input greater than ±15%.

I. Additional Requirements WPQT for Austenitic Stainless Steel

I 100 Welds in plates and pipes

101 Test assembly shall be as described in C101 or C201.

102 Impact testing is not required for design temperatures above -105°C.

I 200 Test requirements

201 If impact testing is required, the testing shall be conducted at -196°C meeting an average impact energy level of 34 J.

J. Welding procedures for aluminium

J 100 General

101 Basic requirements are given in A General and B Welding procedures.

102 Welding consumables shall be one of those recommended in Table J1.

Table J1 Selection of suitable consumables for combinations of aluminium alloys

Base metal alloy	*NV-5052, NV-5754* *NV-5154, NV-5454* *NV-5086*	*NV-5083* *NV-5383* *NV-5059*	*NV-6060, NV-6061* *NV-6063, NV-6005A* *NV-6082*
NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183
NV-5083, NV-5383 NV-5059	5356, 5556, 5183	5183 [1] 5556	5356, 5556, 5183
NV-6060, NV-6061 NV-6063, NV-6005A NV-6082	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183

Note: All consumables are covered by the AWS specification. The prefix «ER» is omitted.

1) Other consumables may be used if allowable stresses are reduced, see Table J2.

J 200 Butt welds in plates

201 Test assembly shall be as described in C101.

202 The following mechanical tests are required from each assembly:

— 1 tensile test specimen
— 1 root and 1 face or 2 side bend specimens
— 1 macro test specimen.

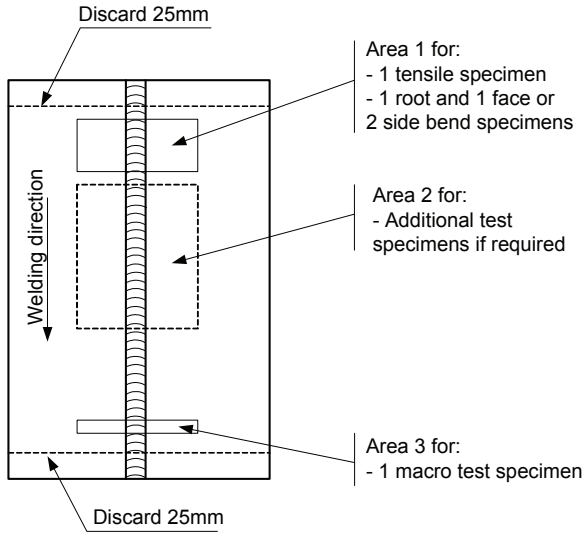

Fig. 13
Location of test specimens for a butt weld on plate

203 One tensile specimen shall be taken from each of the welded assemblies. The test specimen, 25 mm wide and with full plate thickness and orientated transverse to the weld, is shown in Fig.14.

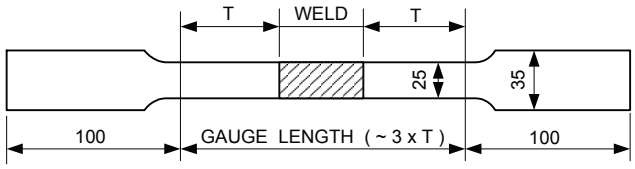

Fig. 14
Tensile test specimen

204 Side-bend tests shall be carried out for thickness equal to and above 10 mm. Two bend specimens shall be taken from each of the welded assemblies. The bend test specimens shall be machined to the dimensions given in K300.

205 For thickness below 10 mm one face bend and one root bend test specimens shall be taken. The diameter of the bending mandrel shall be as given in J702.

206 One macrosection shall be prepared from the test assembly to reveal the weldment macro structure. The macrosection shall be visually inspected using a magnification of 5 to 10X.

J 300 Butt welds in pipes

301 Test assembly shall be as described in C201.

302 The following mechanical tests are required from each assembly:

— 1 tensile test specimen
— 1 root and 1 face or 2 side bend specimens
— 1 macro test specimen.

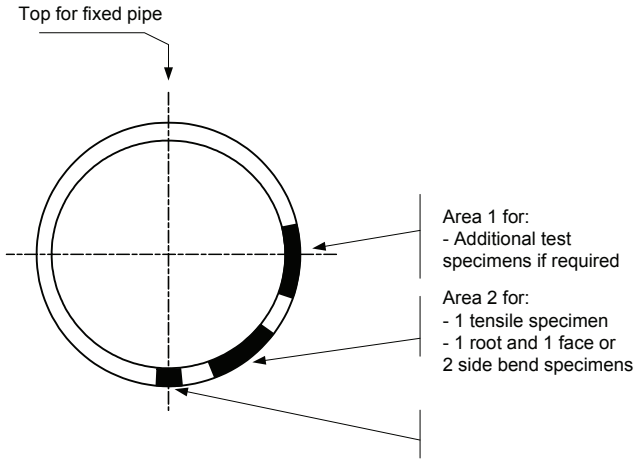

Fig. 15
Location of test specimens for a butt weld in pipe

303 One tensile specimen shall be taken from each of the welded assemblies. The test specimen, 25 mm wide and with full plate thickness and orientated transverse to the weld, is shown in Fig.14.

304 Side-bend tests shall be carried out for thickness equal to and above 10 mm. Two bend specimens shall be taken from each of the welded assemblies. The bend test specimens shall be machined to the dimensions given in K300.

305 For thickness below 10 mm one face bend and one root bend test specimens shall be taken. The diameter of the bending mandrel shall be as given in J702.

306 One macrosection shall be prepared from the test assembly to reveal the weldment macro structure. The macrosection shall be visually inspected using a magnification of 5 to 10X.

J 400 Branch connections

401 The following mechanical tests are required from each assembly (see Fig.7):

— two macrosection tests at 12 and 6 o'clock.

J 500 Fillet welds

501 Test assembly shall be as described in C501.

502 The following tests shall be performed:

— two macrosection tests. One of the macrosections shall be taken at the marked position of the stop/restart. The macrosection shall include about 10 mm of unaffected base material and shall be prepared and etched on one side to clearly reveal the fusion line and the HAZ.

J 600 Non destructive testing of test assemblies

601 Non destructive testing shall be according to D100 for butt welds and D200 for fillet welds and partial penetration welds.

J 700 Destructive testing

701 The tensile strength of the test specimens shall not be less than specified for the parent alloy in Table J2.

Table J2 Mechanical properties in the welded condition

Alloy	*Temper*	*Filler*	*Tensile strength R_m minimum (N/mm^2)*	*Yield strength in HAZ, $R_{p0.2}$ minimum (N/mm^2)*
NV-5052	0, H111, H32, H34	5356	170	65
NV-5754	0, H111, H24	5356-5183	190	80
NV-5154A	0, H111 H32, H34	5356-5183	215	85
NV-5454	0, H111, H32, H34,	5356-5183	215	85
NV-5086	0, H111, H112 H116, H321, H34	5356-5183	240	100
NV-5083	0, H111, H112 t < 6 mm 0, H111, H112 t > 6mm H116, H321 H116, H321	5183 5356-5183 5356 5183	270 270 270 270	125 115 115 125
NV-5383	0, H111, H116, H321	5183	290	145
NV-5059	0, H111, H116, H321	5183	330	160
NV-6060	T4, T5, T6	5356-5183	95	65
NV-6061	T4 T5 or T6	5356-5183	165 165	115 115
NV-6063	T4, T5 T6	5356-5183	100 100	65 65
NV-6005A	T4, T5 or T6	5356-5183	165	115
NV-6082	T4 T5 or T6	5356-5183	170 170	110 115

702 The bend test specimens shall be bent on a mandrel with maximum diameter as given in the formula below. The bending angle shall be at least 180°. After bending, the test specimens shall not reveal any open defects in any direction greater than 3 mm. Smaller cracks developing from the edges of the specimens shall not normally be considered as significant, unless there is definite evidence that they result from inclusions or other defects.«Wrap around» bending as shown in K300 is the preferred bending method.

$$d = \frac{(100xt_s)}{A} - t_s$$

where

d = maximum former diameter
t_s = thickness of the bend test specimen (this includes side bends)
A = minimum tensile elongation required by the material specification (for combination between different alloys, the lowest individual value shall be used).

703 The macrosections shall show a regular weld profile with smooth transitions to the base materials and without significant or excessive reinforcement. Cracks and lack of fusion are not acceptable.

704 When a butt weld is made between two plates of different alloys the tensile strength to be obtained on the welded assembly shall be in agreement with the requirements relating to the alloy having the lower strength.

705 If the WPQT fails to comply with any of the requirements for NDT one extra WPQT shall be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPS shall be considered as not qualified and a re-specification of the WPS shall be made prior to a new qualification test.

J 800 Range of qualification

801 The validity of approved welding procedure shall be as given in F100.

802 A qualified welding procedure shall be used within the ranges of the parameters below.

Base material

The following changes shall lead to a new qualification:

a) In general, significant change of material properties which will obviously affect the weldability and mechanical properties.

b) More specifically, aluminium alloys are grouped in the following categories:

   i) NV-5052, NV-5754A, NV-5154, NV-5454

   ii) NV-5086, NV-5083, NV-5383, NV-5059

   iii) NV-6060, NV-6061, NV6063, NV-6005A, NV-6082

The qualification on aluminium alloys in category iii) will qualify for the alloys in category ii) and category i) but not vice versa. The qualification on aluminium alloys in category ii) will qualify for the alloys in category i) but not vice versa.

Thickness

Thickness, t, is defined as follows:

a) For a butt weld: The base metal thickness, which for welds between dissimilar thicknesses is that of the thinner material.

b) For a fillet weld: The base metal thickness, which for welds between dissimilar thicknesses is that of the thicker material. However, for each thickness range qualified, as in Table B2 there is an associated range of qualified throat thickness as given below.

c) For a set-on branch connection: The thickness of the branch pipe.

d) For a set-in or set-through branch connection: The thickness of the main pipe.

e) For a T-butt joint in plate: The thickness of the prepared plate.

The requirements to qualified thickness range for butt welds shall be as given in Table J3.

Table J3 Qualified thickness range

Thickness t (mm) of test piece	*Qualification range*
t < 3	0.5 t to 2 t
3 ≤ t ≤ 20	3 to 2 t
t > 20	≥ 0.8 t

In addition to the requirements of Table J3, the range of qualification of the throat thickness "a" of fillet welds is given in Table J4.

Table J4 Range of qualification for the throat thickness for plates and pipes

Throat thickness of the test piece a	*Range of qualification*
a < 10	0.75 a to 1.5 a
a ≥ 10	≥ 7.5

Where a fillet weld is qualified by means of a butt weld test, the throat thickness range qualified shall be based on the thickness of the deposited weld metal.

Diameter of pipes and branch connections

The qualification of a welding procedure test on diameter D shall include qualification for diameters in the following ranges as given in Table J5.

Table J5 Qualified range for pipe and branch connection diameters

Diameter of the test piece D (mm) 1)	*Qualification range*
D ≤ 25	0.5 D to 2 D
D > 25	≥ 0.5 D and plates

1) D is the outside diameter of the pipe or outside diameter of the branch pipe.

Angle of branch connections

A WPQT carried out on a branch connection with angle α shall qualify all branch connection angles in the range of α to 90°.

Welding consumables

The following changes shall lead to a new qualification:

— any change in consumable classification
— any significant change of shielding gas mixture.

Welding positions

The following changes shall lead to a new qualification:

— change from one principal welding position (see figures in F200) to another, unless complying with Table J6.

Type of joint

The following changes shall lead to a new qualification:

— change from fillet weld to butt weld
— change from two sided welding to one side, but not vice versa
— deletion of back gouging
— addition or deletion of ceramic backing
— change from butt joint in plates to butt joints in pipes with outside diameter less than 500mm.
— any change of groove dimensions specified in the WPS.

Welding condition

The following changes shall lead to a new qualification:

— any change of welding process
— change from spray arc to short arc or pulsed arc or vice versa
— change in heat input beyond ±25%
— any decrease in preheat temperature
— change of interpass temperature greater than 25°C
— change of post weld heat treatment parameters.

Table J6 Qualified principal positions for butt welds and fillet welds, aluminium

Test weld Joint configuration 1)2)	*Principal positions*	*Qualified positions 3)*		
		Butt welds		*Fillet welds plates or pipes*
		Plates	*Pipes*	
Butt welds in plates	1G 2G 3G 4G	1G 1G, 2G, 3G 1G, 2G, 3G All	1G	1F 1F, 2F, 3F 1F, 2F, 3F All
Butt welds in pipes	1G 2G 5G	1G 1G, 2G, 3G All	1G 2G 1G, 5G	1F 1F, 2F, 4F All
Fillet welds	1F 2F 3F 4F 5F			1F 1F, 2F, 3F 1F, 2F, 3F All All

1) Pipes with D > 500 mm are considered equivalent to plates (apply only to the main pipe in branch connections).
2) Branch connections shall be qualified separately.
3) The vertical downwards position shall be qualified separately.

J 900 Retesting

901 If the WPQT fails to comply with any of the requirements for NDT one extra WPQT shall be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPS shall be considered as not qualified and a re-specification of the WPS shall be made prior to a new qualification test.

K. Testing

K 100 General

101 Testing of welds shall be carried out as specified in 200 to 300. Reference is also made to relevant paragraphs in Ch.1 Sec.2.

K 200 Tensile testing at ambient temperature

201 For tensile testing of all-weld-metal and butt welds two different types of test specimens may be used, round test specimens or flat test specimens (see Fig.16) as described below.

a) Deposited metal tensile test

Normally, round test specimens with the following dimensions shall be used:

d = 10 mm
L_o = 50 mm
L_c = 60 mm
R ≥ 5 mm

b) Butt weld tensile test

Flat test specimens with the weld machined flush with the surface of the plate, shall be used. The dimensions shall be as follows:

a = thickness of plate, t
b = 25 mm
L_0 = L_c = 3t or 2t + width of weld, whichever is the greatest

R = 25 mm.

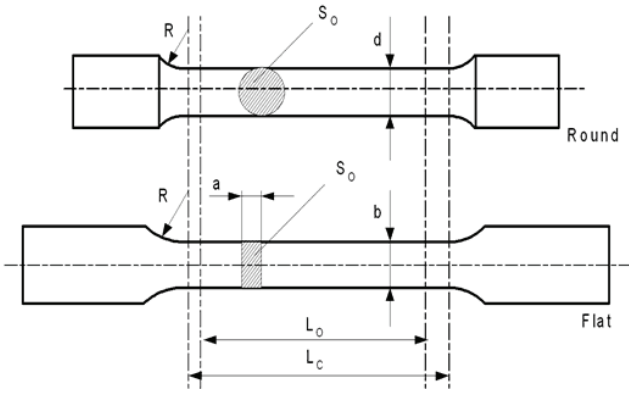

Fig. 16
Tensile test specimen.

K 300 Bend testing

301 Flat bend test specimens, as given in Fig.17 shall be used. Edges on tension side to be rounded to a radius of 1 to 2mm.

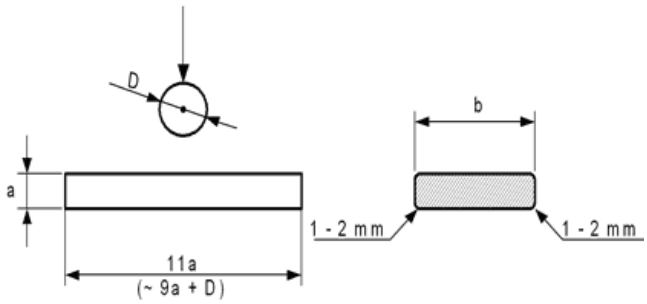

Fig. 17
Bend test specimen.

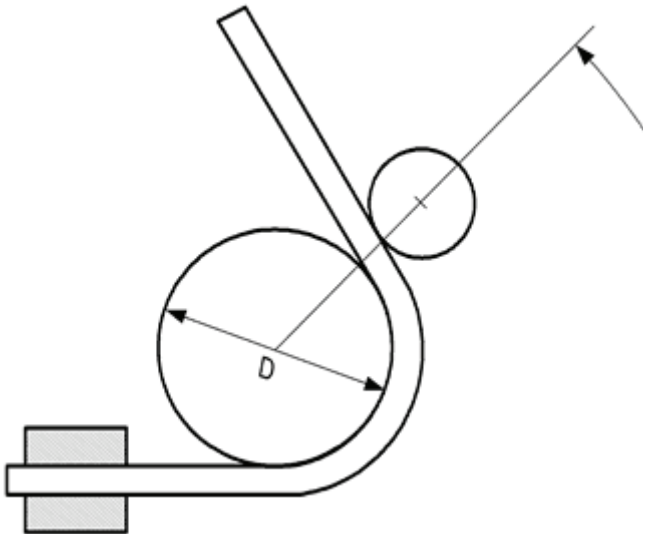

Fig. 18
Wrap around bend test.

302 When the wrap around bend test, exemplified in Fig.18 is used, e.g. for the side bend test of a weld, the length of the test specimen has to be greater than the length 11a shown in Fig.17.

303 For butt weld bend test specimens, the weld shall be machined flush with the surface of the plate.

304 For transverse face-bend and root-bend test specimens for butt weld test the dimensions shall be as follows:

a = as rolled thickness t of the plate
b = 30 mm.

If the as rolled thickness t is greater than 25 mm, it may be reduced to 25 mm by machining on the compression side of the test specimen.

305 For transverse side-bend test specimens for butt weld test the dimensions shall be as follows:

a = 10 mm
b = as rolled thickness t of the plate.

If $t \geq 40$ mm, the side-bend test specimen may be subdivided, each part being at least 20 mm wide.

306 When a longitudinal face-bend or root-bend weld test is required, a test specimen according to an appropriate standard will be accepted.

SECTION 6
FABRICATION AND TOLERANCES

A. General

A 100 Application

101 This section specifies general requirements for steel fabrication processes, including essential variables, which shall be maintained and controlled by the builders.

B. Material Identification

B 100 General

101 A material identification system which ensures correct installation and documentation of the material grades shall be established.

C. Approval of Shop Primers

C 100 General

101 Shop primer applied over areas, which will subsequently be welded, shall be of approved type as having no detrimental effect on the finished weld.

Guidance note:

Type approved shop primers are listed under "Non-Metallic Materials(K)" in the DNV register of approved products and manufacturers, available on the DNV Internet site.

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102 Approved shop primers or thin coatings of linseed oil may be applied to welds subject to tightness test in agreement with the manufacturer's recommendation. In general the applied film thickness on welds shall not exceed 50 microns.

D. Welding Environment

D 100 General

101 Welding work shall not be carried out in environmental conditions that may have a detrimental effect such as wind, damp and cold.

102 Welding processes sensitive to draughts shall be adequately protected.

103 The grooves shall by dry at all time of welding.

104 Preheating temperature, whenever required, shall in any case be within the limit of essential variables, see E306.

105 The welding interpass temperature shall not drop below the minimum required preheating temperature.

E. Cutting, Forming, Assembly and Welding

E 100 Cutting

101 Cut edges are to be accurate and uniform in order to provide a shape compatible with the weld joint design.

102 Deviation of cut edges shall generally be within the standard specified by IACS Shipbuilding and Repair Standard Part A.

103 Attention shall be paid to avoid excessive local hardening and carbon contaminations by thermal cutting.

104 The effect of work hardening and risk of cracked edges shall be considered if shearing is used for cutting of material.

105 Correction by welding as compensation for improper cutting shall be in accordance with procedures for repairs.

E 200 Forming

201 Forming and straightening of materials shall be performed according to procedures which outline the succession of the controlled steps.

202 The degree of cold forming for steels in structural members shall be carried out within the deformation range recommended by the manufacturer. Should however such documentation not be available, the deformation rate for carbon manganese steels shall be less than 10 %, respectively 20% for austenitic and ferritic-austenitic steels. If the deformation exceeds 10%, respectively 20% either heat treatment or strain ageing test shall be carried out in accordance with an agreed procedure as stipulated in Pt.3 Ch.1 Sec.3 C1100 (Rules for Classification of Ships).

Guidance note:

The plastic deformation e may be calculated by the following simplified formulae:

Single-curvature deformation

Cold rolling or pressing of plates to cylindrical forms:

$e = (t/D) \times 100\%$

Cold bending of straight pipes to bends:

$e = (D/2Rc) \times 100\%$

Double curvature deformation

Forming of plates to spheres:

$e = (t(1 + \nu)/2Rc) \times 100\%$

t = material thickness
D = outside diameter of pipe of vessel
Rc = forming radius
N = Poisson's ratio (0.5 for plastic condition).

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203 Forming of steels at high temperatures shall be effectuated with due regard to adverse effects of the material's properties. Forming of steels above 650ºC shall be subject to agreement with the Society.

E 300 Assembly and Welding

301 Members to be welded shall be brought into correct alignment and held in position by clamps, tack welds, or other suitable devices, until welding has been completed or progressed to a stage where in control of the process. Such arrangement shall be suitably arranged to minimise distortion and built-in stresses.

302 Fit-up shall be checked for dimensional accuracy before welding. Special attention shall be drawn to assure correct fit-up of areas, of which direct visual inspection is impossible.

303 Surfaces to be welded shall be free from mill scale, slag, rust, paint or other contaminating substances.

304 Grooves shall be within the groove profile particulars given by the welding procedure specification (WPS). Grooves shall be slag free.

305 All welding, including tack welding, seal welding, welding of lifting lugs and repair welding, shall be performed within the limits of essential variables of the welding procedure specification (WPS).

306 Preheating, when required, shall be applied in accord-

ance with agreed procedures. Special attention shall be paid to temperature control during the welding process such that the preheat temperature is kept uniformly in affected part of the welded object.

Guidance note:

Normal strength steels may require preheating depending on the combined plate thicknesses and the degree of joint restraint.

Preheating is normally required for welding of high and extra high strength steels depending on chemical composition, rolling process, joint restraint and combined plate thickness. Post heating may additionally be required for extra high strength steels.

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307 The welding sequence shall be such that the amount of shrinkage, distortions and residual stresses are minimised.

308 Welds shall be terminated in a manner such that all welds are sound and without end craters. Run-off plates shall be used, where practicable, and be removed upon completion and cooling of the weld. Cut welds shall be made smooth and flush with the edges of the abutting parts.

309 Tack welding shall be carried out in accordance with approved welding procedure specifications (WPS), specifying the applied minimum welding length.

310 Tack welds used for assembly shall be removed before welding leaving the effected area free from defects.

311 Tack welds, if retained as part of the welding process, shall be free from defects and provide adequate conditions for pass welding.

312 Storage and handling of welding consumables shall be in accordance with the manufacturer's recommendations, and in accordance with procedures giving details regarding conditions in storage rooms, temperature in storage ovens and quivers, length of exposure and conditions, as applicable.

313 Consumables which have been contaminated by moisture, rust, oil, grease, dirt or other deleterious matters, shall be discarded unless properly reconditioned.

314 Recycling of fluxes for submerged arc welding (SAW) shall be performed in a manner that ensures a mixture of new and used flux with continually homogenous properties.

F. Repairs

F 100 General

101 Guidance to general welding repair work is given in IACS Shipbuilding and Repair Quality Standard Part A.

102 Defects in welds may be repaired by grinding, machining and/or welding. In order to verify complete removal of defects, effected areas shall be examined with suitable NDT methods.

F 200 Repair welding

201 Repairs by welding shall be carried out in accordance with approved welding procedure specifications (WPS). Mechanical properties shall satisfy the minimum specified properties of the material in question.

202 Defects shall be completely removed before necessary repairs are carried out. Repairs with arc-air gouging shall be followed by grinding.

203 Repair welding in the same area may be carried out twice. Further repairs shall be subject to agreement with the Society.

204 All weld repairs shall at least be re-inspected with the same NDT methods as originally applied.

F 300 Flame straightening

301 Members distorted by welding may be straightened by mechanical means or by a limited amount of localised heat.

302 Corrective measures relating to flame straightening shall be carried out with due regard to possible degradation of the material properties.

G. Inspection and Tolerances

G 100 General

101 Inspection shall be carried out in accordance with inspection and test plans to confirm that work is carried out in accordance with established project procedures and plans such that all project requirements are complied with to the satisfaction of the Society.

102 Due consideration shall be given to the access and the time required for adequate inspection during fabrication.

103 High non-conformance rates in execution of the work or in the product itself shall call for special considerations in agreement with the Society. Such special considerations may include, but not be limited to, increased inspection, re-qualification of personnel or other agreed remedial actions.

G 200 Alignment and straightness

201 Allowable acceptable alignment shall be established on the criticality of the design. Special requirements relating to special type and service are given in Pt.5.

202 In general fabrication tolerances shall be in compliance with IACS Shipbuilding and Repair Quality Standard, Part A.

G 300 Special building tolerances

301 Special building tolerances and/or weld finish as a result of operations in harsh environment and/or vessels with increased target design life, relating to Class Notations **PLUS-1** and **PLUS-2**, ref Pt.3 Ch.1 Sec.15 and Sec.16 (Rules for Classification of Ships), shall be readily included in the fabrication instructions and procedures, see Sec.1.

G 400 Weld production test requirements

401 The Society may require weld production tests to be carried out. The extent and type of testing shall be agreed with the Society.

402 When production weld tests are required the test assembly and test requirements shall comply with the relevant requirements of Sec.5.

403 If the achieved test results do not comply with the requirements of Sec.5, the results may be submitted for consideration. The production weld test may be accepted subject to acceptable results from additional test prescribed by the Society.

SECTION 7
NON DESTRUCTIVE TESTING OF WELDS

A. General

A 100 Application

101 This section provides requirements for quality control of ship hull welds during newbuilding. The section contains requirements for the application of non-destructive testing (NDT) - methods, extent of testing and required quality level for satisfactory workmanship.

102 Additional requirements to extent of testing are given in Pt.5 for the relevant ship types.

A 200 Basic requirements

201 The rules are based on the following conditions mentioned below.

Weld joint types

The following main weld joints are covered (see figures in Sec.5):

— butt joints
— T-joints (with and without full penetration)
— fillet welds.

Types of imperfections

The main types of imperfections in fusion welding are given in EN ISO 6520-1 "Welding and Allied Processes – Classification of Geometric Imperfections in Metallic materials, Part 1: Fusion Welding".

Testing methods

— For detection of surface imperfections the following methods applies: Visual testing (VT), Magnetic particle testing (MT) and Penetrant testing (PT).
— For detection of sub-surface imperfections the following methods applies: Ultrasonic testing (UT) and Radiographic testing (RT).

The choice of test methods to be applied in each case depends on the component- or weld shape, the material and the defects to be detected.

202 For NV 420 grades and higher, final inspection and NDT shall not be carried out before 48 hours after completion.

B. NDT Procedures

B 100 General

101 Welds shall be subjected to visual survey and inspection, as fabrication proceeds. NDT shall be performed according to approved procedures and if required, qualified for the work. The approved procedures shall be in accordance with DNV Classification Note No.7 or other recognised standard for the test method.

102 Unless otherwise agreed, the surface to be tested shall be presented clean and smooth, i.e. free from dirt, scale, rust, welding spatter, etc. which may influence the results of the testing.

B 200 Visual testing

201 If necessary mechanical aids (gauges and rulers) should be used to assess and size the discontinuities. Unless otherwise agreed, visual testing shall be completed before other NDT methods are applied.

B 300 Magnetic particle testing

301 Magnetic particle testing shall be carried out as specified in the approved written procedures. Where possible, both sides of the welds shall be tested. Magnetic particle testing shall be applied for welds in ferro-magnetic materials if not otherwise agreed.

B 400 Radiographic testing

401 Radiographic testing shall be carried out as specified in the approved written procedures established in accordance with a recognized standard.

402 For radiographic inspection, X-ray source shall be used whenever possible. Gamma-ray sources may be used as outlined in Classification Note No.7.

403 Processing and storage shall be such that the radiographs maintain their quality throughout the agreed storage time. The radiographs shall be free from imperfections due to development processing.

404 Suspect planar indications discovered by radiographic testing that is left un-repaired shall be type determined, located and sized by ultrasonic testing.

B 500 Ultrasonic testing

501 Ultrasonic testing shall be carried out as specified in the approved written procedures. Ultrasonic test procedures shall contain sketches for each type of joint and dimensional range of joints which clearly show scanning pattern and probes to be used. Ultrasonic testing shall not be used for thickness less than 10 mm. Ultrasonic testing of welds shall include testing of the area adjacent to the weld for laminations and scanning for transverse defects in the weld and base material.

502 The testing records shall include the imperfection position, the echo height, the dimensions (length), and the depth below the surface and, if possible, the defect type.

B 600 Penetrant testing

601 **P**enetrant testing shall be carried out as specified in the approved written procedures. Where possible, both sides of the welds shall be tested. Penetrant testing shall only be applied for welds in non-ferro magnetic materials if not otherwise agreed.

C. Personnel Qualifications

C 100 General

101 All testing shall be carried out by qualified and certified personnel. The NDT operators shall be certified according to a recognized certification scheme accepted by the Society, e.g. EN 473, ISO 9712. The certificate shall clearly state the qualifications as to which testing method and within which category the operator is certified.

D. Extent of NDT

D 100 General

101 The extent of testing is defined as the percentage of the length of welds which shall be tested by a specific method. The extent of testing will depend on the type of ship and the location of the joints.

102 The basic requirements for all ship types are that all

welds are subject to 100% visual testing. In addition, welds shall be subjected to testing with other test methods as given in the table below.

Table D1 Minimum extent (in%) of NDT for structural welds

Area	*Type of connection*	*Testing method*	
		MT/PT[1)]	*RT/UT[2)]*
General	Butt- and T-Joints, full penetration T-joints, partly penetration Fillet welds	2% 2% -	2% - -
Deck/bottom plating within 0.4 L amidship	Butt- and T-Joints, full penetration T-joints, partly penetration Fillet welds	5% 5% -	5% - -
Critical areas	Butt- and T-Joints, full penetration T-joints, partly penetration Fillet welds	20% 20% 20%	20% - -

1) Magnetic particle testing shall be applied for ferro-magnetic materials.

2) Radiographic testing shall not be applied for T-joints.

103 The different areas in Table D1 are defined as follow:

Critical areas

Areas in way of critical load transfer points and large stress concentrations where a failure will endanger the safety of the ship, such as:

- stress concentrations in rudders or intersection between rudder structure and hull
- for twin hull vessels stress concentrations in way of connections between hull and wet deck
- deck beams in open hatch container ships
- strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configuration
- other areas where the likelihood of occurrence of detrimental defects is considered to be extra high.

Guidance note:

Areas to be considered for classification under this item are:

- welds produced by welding methods which the yard has little or no user experience
- welds produced by high heat input (>5 kJ/mm) welding methods
- welds in large thickness (>50mm).

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Deck and bottom plating within 0.4L amidship

- Sheer strake at strength deck.
- Stringer plate in strength deck.
- Deck strake at longitudinal bulkhead.
- Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch opening configuration.
- Bilge strake.
- Longitudinal hatch coamings of length greater than 0.15 L.
- End brackets and deck house transition of longitudinal cargo hatch coamings.
- All watertight bulkheads independent of location.

Guidance note:

For ships with no clearly defined strength deck e.g. cruise ships, the above extents shall be applied to the decks contributing most to the hull strength

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General

Areas not mentioned above.

104 NDT shall cover start and stop points of automatically welded seams.

E. Acceptance Criteria for NDT

E 100 General

101 All welds shall show evidence of good workmanship. For visual inspection "IACS Rec. No.47 "Shipbuilding and Repair Quality standard part A" may be applied. Acceptance criteria for NDT shall normally comply with ISO 5817 quality level C, intermediate. For critical areas more stringent requirements such as ISO 5817 level B, may be applied.

E 200 Non-conforming weldments

201 If a non-conforming discontinuity is detected the lengths welded immediately before and after the section containing the discontinuity shall be examined by the same method. If systematically repeated discontinuities are revealed, the extent of testing shall be increased at the Surveyors discretion for welds manufactured under same conditions and where similar defects may be expected.

202 If non-conforming discontinuities are found to occur regularly, the welding procedures shall be reassessed before continuation of the welding, and necessary actions shall be taken to bring the production to the required quality level.

203 Detected non-conforming discontinuities shall be repaired unless they are found acceptable by the Society. Removal of weld discontinuities and repair shall be performed in accordance with a procedure approved by the Society.

204 After repair welding has been performed, the complete weld, (i.e. the repaired area plus at least 100 mm on each side) shall be subjected to at least to the same NDT method(s) as specified for the original weld.

SECTION 8
STRUCTURAL AND TIGHTNESS TESTING

A. General

A 100 Application

101 This section specifies general requirements to structural and tightness testing of tanks and holds.

102 For Tanker for Liquefied Gas additional requirements are given in Pt.5 Ch.5 (Rules for Classification of Ships).

B. Testing

B 100 Definitions

101 The following terms are used in B:

Structural testing is a hydrostatic test, carried out in order to demonstrate the tightness of the tanks and the structural adequacy of the design. Where hydrostatic testing is not practically feasible, hydropneumatic testing may be carried out instead under provision that the test is simulating, as far as practicable, the actual loading of the tank. Apart from compulsory structural tests to Tanker for Chemicals ESP, structural tests do not need to be repeated for subsequent vessels in a series of identical newbuildings, unless considered necessary by the Society.

Leak testing is an air or other medium test, carried out in order to demonstrate the tightness of the structure.

Hydropneumatic testing is a combination of hydrostatic and air testing, carried out in order to demonstrate the tightness of the tanks and the structural adequacy of the design.

Hose testing is a water test carried out to demonstrate tightness of structural items.

Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

Protective coating is a final coating protecting the structure from corrosion.

Watertight means capable of preventing the passage of water through the structure under a head of water for which the surrounding structure is designed.

Weathertight means that in any sea conditions water will not penetrate into the ship.

B 200 General requirements

201 Structural testing may be carried out after a protective coating has been applied, provided a leak test is carried out before application of the protective coating. All pipe connections to tanks shall be fitted before structural testing.

When structural testing at the building berth is undesirable or impossible, structural testing afloat may be accepted. The structural testing shall be carried out by filling each tank separately to the test head. Examination of bottom and lower side structures shall be made in empty tanks at the maximum practical attainable draught.

202 Leak testing shall be carried out prior to the protective coating being applied to the welds. Shop primer may be applied to welds.

An efficient indicating liquid shall be applied, when air is used as the test medium. The air pressure shall be kept at a maximum pressure of 20 kN/m^2 for 1 hr. and shall be reduced to 15 kN/m^2 before inspection. In addition to an effective means of reading the air pressure, a safety valve, or a reliable equivalent alternative, shall be connected to the compartment being tested.

Guidance note:

Silicate based shop primer may be applied to welds before leak testing. The layer of the primer should be maximum 50 microns. Other primers of uncertain chemical composition shall be maximum 30 microns.

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203 For hose testing, the hose pressure shall be at least 200 kN/m^2 and applied at a maximum distance of 1.5 m. The nozzle inside diameter shall be at least 12.0 mm.

B 300 Specific requirements for extent and type of testing

301 The requirements in 302 and 303 give conditions for testing for:

— gravity tanks included independent tanks of 5 m^3 or more in capacity
— watertight or weathertight structures.

302 Leak testing shall be carried out on all weld connections of tank boundaries, pipe penetrations and erection joints on tank boundaries, except for automatic weld joints and FCAW semi automatic full penetration butt welds of erection joints.

Selected locations of automatic erection welds and pre-erection manual or automatic welds may be required to be similarly tested at the discretion of the surveyor taking account of the quality control procedures operating in the shipyard.

303 Extent of testing is given in Table B1.

Table B1 Extent of testing

Item to be tested	*Type of testing*	*Structural test pressure*	*Extent of structural testing*
All ship types			
Tanks containing liquid and the structures forming boundaries of tanks containing liquid	Structural testing	The greater of the following: — head of water up to top of overflow — 2.4 m head of water above highest point of tank. For FRP tanks: 1.0 m above highest point of tank — pressure valve opening pressure	Tank boundary tested from at least one side [1), 2)] Test of aft peak tank to be carried out after the stern tube has been fitted
Fore peak not used as tank	See SOLAS Ch. II-1/ 14		
After peak not used as tank	Leak testing		
Chain locker (if aft of collision bulkhead)	Structural testing	Head of water up to top	
Double plate rudders	Leak testing		

Table B1 Extent of testing (Continued)			
Item to be tested	*Type of testing*	*Structural test pressure*	*Extent of structural testing*
Watertight doors below freeboard or bulkhead deck and watertight hatch covers	See SOLAS Ch. II-1/18		Each door and hatch cover [7]
Weathertight doors, hatch covers, and closing appliances	Hose testing		
Watertight bulkheads and decks	See SOLAS Ch. II-1/14.3 and II-1/19.5		[3], [5], [6]
Ballast ducts	Structural testing	Ballast pump maximum pressure	
Trunks, tunnels and ventilators	Hose test. See SOLAS Ch. II-1/19.5		[6]
Cofferdams	Structural testing	The greater of the following: — head of water up to top of overflow — 2.4 m head of water above highest point of tank	[4]
Independent tanks	Structural testing	The greater of the following: — head of water up to top of overflow — 0.9 m head of water above highest point of tank — pressure valve opening pressure	
Dry bulk cargo carrier			
Ballast holds	Structural testing	The greater of the following: — head of water up to top of overflow — 0.9 m head of water above highest point of tank	[1], [2] In the structural testing, a minor amount of water leakage from hatch cover sealing may be allowed
Combination carriers (OBOs)			
Watertight hatch covers of cargo tanks	Structural testing	The greater of the following: — head of water up to top of overflow — 2.4 m head of water above hatch coaming — pressure valve opening pressure	At least every second hatch cover, provided that leak testing is carried out for all hatch covers
Chemical carriers			
Integral and independent cargo tanks	Structural testing	1) Integral and independent tanks with a design pressure of less than 0.7 bar, the greater of the following: — 2.4 m head of water above the highest point of the tank — pressure valve opening pressure. 2) Independent tanks with a design pressure exceeding 0.7 bar shall be tested to 1.5 times the pressure valve opening pressure	Tank boundary tested from at least one side [1], [2]

1) Except for cargo space boundaries of **Tanker for Chemical ESP**, leak or hydropneumatic testing may replace structural testing, provided that at least one tank of each type is structurally tested.

2) Structural testing need not be repeated for subsequent vessels in a series of idential newbuildings, unless surveyors deem the repetition necessary. This relaxation does not apply to cargo space boudaries for vessels with the class notation **Tanker for Chemical ESP**.

3) When a hose test cannot be performed without possible damage to outfitting (machinery, cables, switchboards, insulation, etc.) already installed, it may be replaced, at the Society's discretion, by a careful visual inspection of all the crossings and welded joints; where necessary, dye penetrant test, leak test or an ultrasonic leak test may be required.

4) Leak or hydropneumatic testing may be accepted under the conditions specified under 301 when, at the Society's discretion, the latter is considered significant in relation to the construction techniques and the welding procedures adopted.

5) Testing main compartments (not tanks for liquids) by filling them with water is not compulsory. When such testing is not carried out, a hose test is compulsory. This test shall be carried out in the most advanced stage of the fitting out of the ship. In any case, a thorough inspection of the watertight bulkheads shall be carried out.
(SOLAS Ch. II-1/14.3)

6) After completion, a hose or flooding test shall be applied to watertight decks and a hose test to watertight trunks, tunnels and ventilators.
(SOLAS Ch. II-1/19.5)

7) Before installation (i.e. normally at the manufacturers) the watertight access doors/hatches shall be hydraulically tested from that side which is most prone to leakage. Test pressure = design pressure. Acceptance criteria:

— doors or hatches with gaskets: no leakage
— doors or hatches with metallic sealing: maximum water leakage 1 litre per minute.