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RULES

PUBLICATION No. 74/P

PRINCIPLES FOR WELDING PROCEDURE QUALIFICATION TESTS

2018

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Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków
complete or extend the Rules and are mandatory where applicable.

GDAŃSK

Publication No. 74/P – Principles for Welding Procedure Qualification Tests – March 2018 is an extension of the requirements contained in *Part IX – Materials and Welding* of the *Rules for Classification and Construction of Sea-going Ships*.

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CONTENTS

Page

1 General 5
1.1 Application 5
1.2 Definitions 5
1.3 Symbols and Abbreviations 6

2 General Requirements 7

3 Welding Procedure Specifications 7

4 Making of Test Assemblies 7
4.1 General Requirements 7
4.2 Preparation of Test Assemblies 7
4.3 Welding of Test Assemblies 8

5 Testing of Test Assemblies 8
5.1 General Requirements 8
5.2 Non-destructive Tests 9
5.3 Destructive Tests 10
5.4 Test Results Assessment 14
5.5 Re-tests 14
5.6 Re-test of Welding Procedure Qualification 15

6 Records 15

7 Range of Qualification 15
7.1 General 15
7.2 Welding Processes 16
7.3 Weld Type 16
7.4 Parent Material 16
7.5 Thickness 18
7.6 Welding Positions 19
7.7 Welding Consumables 20
7.8 Heat Input 20
7.9 Preheat and Interpass Temperature 21
7.10 Type of Current 21
7.11 Post-weld Heat Treatment 21
7.12 Weld Details 21

Annex 1 23

Annex 2 26

1 GENERAL

1.1 Application

1.1.1 The present *Publication* specifies the principles for qualification tests of welding procedures used for weldable steels and aluminium alloys intended for hull construction and other marine structures. The requirements of the present *Publication* apply to qualification tests of welding procedures used for normal and higher strength hull structural steel, high strength steel intended for welded structures, weldable steel forgings and castings, as well as wrought aluminium alloys complying with the requirements of the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*.

1.1.2 The present *Publication* does not cover the requirements concerning the welding procedure qualification tests for materials used in the construction of liquefied gas tankers – these requirements are given in *Publication No. 48/P – Requirements Concerning Gas Tankers.*

1.1.3 Qualification tests of welding procedures used for materials and products not covered by the present *Publication* shall be performed in accordance with test programme agreed with PRS. This test programme shall include specific properties of these materials and products, as well as the requirements of the applicable current standards, such as PN-EN ISO 15614 or AWS.

1.1.4 All welding procedure qualification tests carried out after 1 July 2007 shall comply with the requirements of the present *Publication.*

1.1.5 The present *Publication* does not invalidate welding procedure qualification tests carried out and accepted by PRS before 1 July 2007, provided the welding procedure qualification tests are considered to meet the technical intent of the present *Publication* or have been qualified in accordance with the applicable standards, such as EN, ISO standards or AWS.

1.2 Definitions

Capping run – in multi-run welding, the run visible on the weld face after completion of welding.

Ceramic backing (temporary) – individually shaped ceramic material, for the purpose of supporting molten weld metal and forming a face root run.

Filling run – in multi-run welding, the run deposited after the root run.

Heat affected zone (HAZ) – metal area in the welded joint adjacent to the weld, undergoing changes of structural, physical, mechanical and other properties under the effect of welding heat.

Heat input (linear energy) – the amount of heat energy introduced into the welded material per unit length of the weld run.

Manufacturer – shipyard or other works manufacturing welded structures.

Metal backing (permanent) – a plate made of metal having a melting point equal or almost equal to the melting point of the welded material, placed at the reverse side of the joint to be welded for supporting molten weld metal; the plate undergoes partial melting.

Metal backing (temporary) – a plate made of metal having a melting point significantly different from the melting point of the welded material, placed at the reverse side of the joint to be welded for supporting molten weld metal; the plate does not undergo partial melting.

Multi-run weld – the weld made by depositing more than one run.

One-side weld – the weld made using one-side welding process.

One-side welding – the welding process during which the whole weld is made from one side of the welded joint.

Parent material – material from which the element to be welded is made.

Preliminary welding procedure specification (pWPS) – welding procedure specification prepared by the manufacturer, which will constitute the basis for the welding procedure qualification tests.

Root run – in multi-run welding, the run of the first layer deposited in the root.

Sample – a piece of welded test assembly from which test specimens are taken.

Single-run weld – the weld made by depositing a single run only.

Specimen – a section of a welded joint taken from the sample, with specified shape and dimensions, to be subjected to the required destructive tests.

Test assembly – welded joint made for the purpose of examining the correctness of the welding process used or for the purpose of examining the properties of welding consumables.

Weld – part of a welded joint made of the material melted during the welding process.

Weld layer – one or several weld runs deposited side by side on one level.

Weld run – metal melted or deposited under one heat source run.

Weld thickness – thickness of the weld without reinforcement; for butt welds it is equal to the welded material thickness, for fillet welds it is equal to the minimum height of the triangle inscribed into the weld cross-section.

Welding consumable – material constituting the weld or which allows to make the weld; it may be, e.g. covered electrode, welding rod, wire, flux, gas.

Welding imperfection – a weld metal discontinuity or a deviation from the assumed weld geometry.

Welding procedure qualification tests – checking the correctness of the welding procedure stated in a preliminary welding procedure specification (pWPS) by subjecting the welded joint made in accordance with the pWPS to the required tests.

Welding Procedure Specification (WPS) – a document stating details of variable parameters required for a specified welding process and ensuring that welded joints made in accordance with this document satisfy quality uniformity criteria.

Welding procedure qualification record (WPQR) – a record including all required particulars of the test assembly welding, as well as the results of all tests of the welded test assembly carried out during the welding procedure qualification.

1.3 Symbols and Abbreviations

pWPS – a preliminary welding procedure specification
HAZ – heat affected zone
WPQR – welding procedure qualification record
WPS – welding procedure specification.

2 GENERAL REQUIREMENTS

2.1 The purpose of the welding procedure qualification tests is to verify that a manufacturer is adequately qualified to perform welding operations according to established welding procedure specifications and that the welded joints made using these specifications comply with PRS requirements.

2.2 The manufacturer intending to carry out the welding procedure qualification tests shall apply to PRS for direct supervision of the tests.

2.3 The welding procedure qualification tests shall reflect fabrication conditions in respect of welding equipment, inside or outside fabrication, edge preparation, cleaning the material to be welded, preheating and post-weld treatment. The manufacturer shall demonstrate and document that the tested welding procedures are suitable for the particular application.

2.4 For the welding procedure qualification, by PRS, satisfactory welding procedure qualification tests shall be carried out. Welding procedure specifications (WPSs) shall refer to the test results achieved during welding procedure qualification tests.

2.5 The welding procedure qualification remains valid, provided that fabrication and organization conditions, applied during the welding procedure qualification tests, are maintained. Welding procedures qualified at a manufacturer are valid for welding in workshops under the same technical and quality management.

3 WELDING PROCEDURE SPECIFICATIONS

3.1 The manufacturer intending to perform the welding procedure qualification tests shall prepare test assemblies welding procedure specifications. These documents are regarded as preliminary welding procedure specifications (pWPS). The manufacturer shall agree the pWPS with PRS prior to the tests.

3.2 Welding procedure specification (WPS) used by the manufacturer for the production welds may be approved by PRS as a final WPS upon the welding procedure satisfactory tests, based on this WPS, regarded as a pWPS for the purpose of the tests. The range of qualification shall be in compliance with the requirements specified in Chapter 7 of the present *Publication.*

3.3 Where necessary, a pWPS can be modified and amended during the welding procedure qualification tests within the scope of relevant variables given in PN-EN ISO 15614 or other recognized standards.

3.4 A welding procedure specification (WPS) used as a basis for the production welds shall include, all parameters characterizing the welding process, i.e. type of the welding process and appropriate equipment; type of joint, edge preparation; backing material, if applicable; parent metal and its thickness range; welding consumable; welding positions; minimum preheat temperature; maximum interpass temperature; shielding gas; welding parameters; post-weld treatment, if applicable, as well as other information relevant to the welding procedure used.

3.5 Where the test assemblies welded according to the pWPS show unacceptable results, the manufacturer shall prepare a new pWPS and submit it to the PRS Head Office for acceptance. The new test assemblies shall be welded in accordance with the new pWPS.

4 MAKING OF TEST ASSEMBLIES

4.1 General Requirements

4.1.1 The preparation and welding of test assemblies shall be in accordance with the pWPS and under the conditions of production welding which the pWPS represents.

4.1.2 Each test assembly shall be durably marked, e.g. in the upper right corner to enable its proper identification.

4.2 Preparation of Test Assemblies

4.2.1 The test assemblies shall be prepared from the parent materials and welding consumables specified in pWPS; the grade and quality of the materials and welding consumables shall be confirmed by certificate. Welding consumables shall have valid PRS' approval granted for the appropriate grade in accordance with the requirements of the *Rules for Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*.

4.2.2 Where welding consumables, not approved by PRS, are used for welding procedure qualification tests, additional tests on deposited weld metal, specified in the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*, shall be performed.

4.2.3 The test assembly shall be of a size sufficient to ensure proper heat distribution. The minimum dimensions of test assemblies depend on the mechanization level of the tested welding procedure. For manual or semi-automatic welding, the length of the test assembly is 350 mm; the minimum width of the test assembly – 300 mm for butt weld and 150 mm for fillet weld. For automatic welding, the length of the test assembly is 1000 mm, the minimum width of the test assembly – 400 mm for butt weld and 150 mm

for fillet weld. The dimensions of typical butt weld test assemblies and fillet weld test assemblies are given in *Annex 1*.

4.2.4 For butt weld test assemblies, identification of the rolling direction of the used plates shall be provided.

4.2.5 For normal or higher strength hull structural steel plates impact tested in the longitudinal direction, the butt weld of the test assembly shall be perpendicular to the rolling direction of the two plates.

4.2.6 For high strength hull structural steel plates impact tested in the transverse direction, as well as for Al alloy plates, the butt weld of the test assembly shall be parallel to the rolling direction of the two plates.

4.3 Welding of Test Assemblies

4.3.1 PRS Surveyor checks the prepared test assembly for compliance with pWPS and stamps it with PRS seal.

4.3.2 The test assembly welding shall be witnessed by PRS Surveyor supervising the welding procedure qualification tests.

4.3.3 During the welding procedure tests, the welding parameters used shall be recorded.

4.3.4 The test assemblies shall be welded in accordance with pWPS agreed with PRS. Where necessary, the welding parameters specified in the pWPS can be modified and amended. In that case, the welding procedure specification (WPS) prepared on the basis of satisfactory welding procedure qualification tests shall include the welding parameters amended during the tests.

4.3.5 Fillet welding steel test assemblies shall be performed on one side only. Fillet welding aluminum alloy test assemblies shall be welded on one or both sides – as specified in the pWPS agreed with PRS.

4.3.6 If tack welds and start and stop points are a condition of the weld process, they shall be fused into the joint and shall be included in the test assemblies.

4.3.7 For single-run fillet welds, a stop/restart points shall be included in the test length. Location of these points on the test assembly shall be clearly marked.

5 TESTING OF TEST ASSEMBLIES

5.1 General Requirements

5.1.1 The programme of tests assemblies examinations shall be agreed with the PRS Head Office.

5.1.2 In the case of welding procedure qualification tests of structures surveyed in accordance with the requirements other than those specified in PRS *Rules*, additional tests may be required.

5.1.3 Each test assembly shall be clearly marked to allow its identification.

5.1.4 Test assemblies examinations shall be carried out by a laboratory holding valid PRS *Approval Certificate*, authorizing to perform such tests.

5.1.5 The results of all test assemblies examinations shall be documented. Test assembly report shall contain identification sign of the test assembly.

5.1.6 Prior to the examination, each test assembly shall be thoroughly cleaned from slag and chips and the weld shape and dimensions checked. The weld face and root surface shall be free from any grinding traces. Stop and restart points of single-run fillet welds shall be clearly marked.

5.1.7 All non-destructive tests of the test assemblies shall be performed prior to cutting the test samples. Where post-weld heat treatment of the test assemblies is required, non-destructive tests shall be performed after the heat treatment.

5.1.8 For high strength steel with yield strength $R_{eH} \geq 420$ MPa, non-destructive tests shall be delayed for a minimum of 48 hours, unless heat treatment has been performed.

5.1.9 After satisfactory non-destructive examinations of the test assemblies, test samples, from which specimens for destructive tests will be prepared, shall be taken. The sequence of taking test samples is given in *Annex 1*. The cutting of test samples and the test specimens treatment shall be such as not to affect the test results.

5.1.10 The test methods to be used for examination of the test assemblies, as well as the extent of the examinations depending on the weld type are given in Table 5.1.10.

Table 5.1.10
Testing of test assemblies

Test methods	Butt weld BW	Fillet weld FW
Visual testing (VT) in accordance with PN-EN ISO 17637	100% of weld length	100% of weld length
Penetrant testing (PT) in accordance with PN-EN ISO 3452-1 or magnetic-particle testing (MT) in accordance with PN-EN ISO 17638	100% of weld length	100% of weld length
Radiographic testing (RT) [1)] in accordance with PN-EN ISO 17636-1	100% of weld length	not required
Transverse tensile test in accordance with PN-EN ISO 4136	2 specimens	not required
Deposited metal longitudinal tensile test in accordance with PN-EN ISO 5178	1 specimen[2)]	not required
Bend test in accordance with PN-EN ISO 5173	transverse bend test[3)] 4 specimens	not required
Charpy V-notch impact test[4)] in accordance with PN-EN ISO 148-1	3 or 5 sets of 3 specimens [5)] 6 or 10 sets of 3 specimens [6) 7)]	not required
Fracture test in accordance with PN-EN ISO 9017	not required	required
Macroscopic examination in accordance with PN-EN ISO 17639 and Vickers hardness test [8)] in accordance with PN-EN ISO 9015-1	1 specimen	2 specimens

1) For material thickness $t \geq 8$ mm, the radiographic testing may be replaced by ultrasonic testing in accordance with PN-EN ISO 17640.
2) Required only when the welding consumable, not approved by PRS, has been used for the tests.
3) In each case the same number of specimens for root bend test and face bend test. For material thickness $t \geq 12$ mm, the transverse bend test may be replaced by the side bend test.
4) Impact test is required for steel test assemblies.
5) If the heat input does not exceed 50 kJ/cm – 3 sets; if the heat input is above 50 kJ/cm, the test shall be performed on 5 sets.
6) The double number of sets is required for the material thickness $t > 50$ mm. In this case, the same number of test specimen sets shall be taken from the side of the weld face and from the side of the weld root.
7) For one-side welding, the number of additional sets of test specimens taken from the side of the root and location of the notch shall be in accordance with *Annex 2*.
8) Hardness test is required only for test assemblies made of steel with $R_{eH} \geq 355$MPa.

5.2 Non-destructive Tests

5.2.1 Visual Testing

5.2.1.1 Each test assembly shall be subjected to visual testing (VT).

5.2.1.2 Visual testing and test reports shall be in accordance with PN-EN 970.

5.2.1.3 The quality level of test assemblies shall be assessed in accordance with PN-EN ISO 5817 – for steel plates and with PN-EN ISO 10042 – for Al alloy plates.

5.2.1.4 Surface imperfections of the test assembly shall be within quality level B. The quality level C is permitted only for such imperfections as:
– excess butt weld metal (502),
– excessive convexity fillet weld metal (503),
– excess throat thickness of the fillet weld (5214),
– excessive penetration (504).
The reference numbers in brackets are in accordance with PN-EN ISO 6520-1.

5.2.2 Penetrant and Magnetic-particle Testing

5.2.2.1 Each test assembly shall be subjected to penetrant tests (PT) or magnetic-particle tests (MT) for surface crack detection.

5.2.2.2 Penetrant tests and the test reports shall be in accordance with PN-EN ISO 3452-1.

5.2.2.3 Magnetic-particle tests and the test reports shall be in accordance with PN-EN ISO 17638.

5.2.2.4 Test assemblies tested shall not reveal any cracks.

5.2.3 Radiographic and Ultrasonic Tests

5.2.3.1 The butt weld test assemblies, satisfactorily examined by visual testing (VT) and penetrant testing (PT) or magnetic-particle testing (MT), shall be subjected to radiographic testing (RT). Radiographic testing may be replaced by ultrasonic testing (UT) for test assemblies whose base material is minimum 8 mm in thickness.

5.2.3.2 Radiographic tests shall be performed in accordance with PN-EN ISO 17636-1. The acceptance level of imperfections detected in the test assemblies shall correspond to acceptance level 1 in accordance with PN-EN ISO 10675.

5.2.3.3 Ultrasonic tests shall be performed in accordance with PN-EN ISO 17640. The acceptance level of imperfections detected in the test assemblies shall correspond to acceptance level 2 in accordance with PN-EN ISO 11666.

5.2.3.4 Radiographic or ultrasonic test reports shall include acceptance levels of imperfections detected using these tests methods.

5.2.3.5 The correlation between the acceptance levels of imperfections detected in the test assemblies using particular non-destructive methods and the quality levels for imperfections is given in PN-EN ISO 17635.

5.2.3.6 The test result is considered satisfactory if internal imperfections of the test assembly are within quality level B in accordance with PN-EN ISO 5817 – for steel test assemblies and PN-EN ISO 10042 – for Al alloy test assemblies. The quality level C is permitted only for such imperfections as:
– excess butt weld metal (502),
– excessive penetration (504).
The reference numbers in brackets are in accordance with PN-EN ISO 6520-1.

5.3 Destructive Tests

5.3.1 Tensile Test

5.3.1.1 From steel and aluminium alloy butt weld test assemblies, satisfactorily examined by non-destructive tests, test specimens shall be taken as follows: for steel test assembly – two transverse tensile test specimens; for Al alloy test assembly – one transverse test specimen. The specimens shall be taken perpendicular to the weld so that the centre of the weld will lie in the centre of the specimen gauge length.

5.3.1.2 The preparation of transverse test specimens, tensile test and test reports shall be in accordance with PN-EN ISO 4136.

5.3.1.3 The tensile strength of steel or cast steel welded joint for each specimen shall be not less than the required minimum tensile strength of the parent material.

5.3.1.4 The tensile strength of Al alloy welded joint shall be not less than the minimum tensile strength specified in Table 5.3.1.4.

Table 5.3.1.4
Minimum tensile strength of Al alloy welded joint

Test assembly parent material designation	Welded joint tensile strength R_m [MPa] min.
5754	190
5086	240
5083	275
5383	290
5456	290
5059	330
6005A	170
6061	170
6082	170

5.3.1.5 Where the butt weld test assembly has been prepared from two different parent materials, the tensile strength of the joint shall comply with the requirements for the parent material with the lower tensile strength.

5.3.1.6 Where welding consumable, not approved by PRS, has been used for welding steel or cast steel butt weld test assembly, an additional round test specimen shall be taken for deposited metal tensile test.

5.3.1.7 Where more than one welding process or different types of welding consumables have been used for the test assembly preparation, longitudinal test specimens shall be taken from different areas of the weld. This requirement does not apply to different welding processes or welding consumables used for the root only.

5.3.1.8 The preparation of longitudinal test specimens, tensile test and the test reports shall be in accordance with PN-EN ISO 5178.

5.3.1.9 The mechanical properties determined for each longitudinal tensile test specimen shall be not less than the required minimum mechanical properties of the deposited metal for the particular grade of welding consumable.

5.3.2 Bend Test

5.3.2.1 From butt weld test assembly, satisfactorily examined by non-destructive tests, four transverse bend test specimens shall be taken: two specimens for root bend test and two specimens for face bend test.

5.3.2.2 For test assemblies prepared from two different parent materials, transverse test specimens may be replaced by four longitudinal test specimens: two specimens for longitudinal root bend test and two specimens for longitudinal face bend test.

5.3.2.3 Before bend test, the weld shape and location shall be determined. For that purpose, the specimens surface shall be slightly etched.

5.3.2.4 For a test assembly made from material with thickness $t > 12$ mm, the transverse bend test may be replaced by the side bend test on four test specimens.

5.3.2.5 The preparation of all test specimens and the test reports shall be in accordance with PN-EN ISO 5173.

5.3.2.6 Diameter, *d*, of the mandrel used for the bend test of normal and higher strength steel test assemblies shall be 4 *t*.

5.3.2.7 Diameter, *d*, of the mandrel used for test pieces taken from test assemblies of high strength steel with yield strength R_{eH}: 420, 460 and 500 MPa shall be 5*t*. For test specimens prepared from high strength steel with yield strength R_{eH}: 550, 620 and 690 MPa, the mandrel diameter, *d*, shall be 6*t*.

5.3.2.8 Diameter, *d*, of the mandrel used for the bend test of test pieces taken from Al alloy test assemblies depends on the relative elongation *A* of the test assembly parent material and the bend test piece thickness t_s. For the test assembly prepared from two different Al alloys, to calculate the mandrel diameter, the lower value of *A* shall be used. The bending mandrel diameter shall be determined from the following formula:

$$d = \frac{100 \times t_s}{A} - t_s$$

5.3.2.9 The bending angle for all specimens shall be 180º. The bend test result is considered satisfactory if no cracks of the length ≥ 3 mm are found on the stretched side after bending the specimen by 180 º. The cracks appearing at the corners of the test specimen shall be investigated case by case. The cracks appearing at the corners of the test specimen may be disregarded unless there is evidence that they are due to the welded joint defect.

5.3.3 Impact Test

5.3.3.1 The dimensions and testing of the test specimens shall be in accordance with PN-EN ISO 148-1.

5.3.3.2 The method of the test specimens preparation is given in *Annex 1*. Impact test shall be made on Charpy-V-notch test specimens sampled from 1 to 2 mm below the surface of the parent material, transverse to the weld.

5.3.3.3 The V–notch shall be cut perpendicular to the surface of the test assembly. The notch for sets consisting of 3 specimens shall be cut at the weld centerline, in the fusion line, in the heat affected zone 2 mm from the fusion line; where 5 sets are required, the notch shall be additionally cut in the heat affected zone at 5 mm and 10 mm from the fusion line. The positions of test specimens, including additional specimen sets and location of the notch for particular specimen sets are given in *Annex 2*.

5.3.3.4 Where butt weld test assembly is made from different steel grades or steel with different yield strength level, the test specimens shall be taken from the side of the joint with lower toughness of steel. Test temperature and absorbed energy results shall be in accordance with the requirements for the lower toughness steel.

5.3.3.5 Where more than one welding process or welding consumables have been used for the test weld, impact test specimens shall be taken from the respective areas of the weld. This does not apply to the process or consumables used solely to make the first weld run or the root run.

5.3.3.6 Where the testing of sub-size specimens is required, the specimens dimensions and testing shall be in accordance with PN-EN ISO 148-1.

5.3.3.7 Test temperature and the minimum value of the absorbed energy for normal and higher strength test assemblies are given in Table 5.3.3.7.

Table 5.3.3.7
Impact test for butt test assemblies of normal and higher strength steel with $t \leq 50$ mm [1), 2)]

Test assembly steel grade	Test temperature [°C]	Minimum average energy value from three specimens [J]		
		For manually or semi-automatic welded joints		For joints welded using automatic welding
		Welding position		
		Flat PA Horizontal PC Overhead PE	Vertical upward PF and vertical downward PG	
A [3)]	20	47	34	34
B [3)], D	0			
E	–20			
AH32, AH36	20			
DH32, DH36	0			
EH32, EH36	–20			
FH32, FH36	–40			
AH40	20		39	39
DH40	0			
EH40	–20			
FH40	–40			

Notes:
1) For thickness above 50 mm, impact test requirements shall be agreed with PRS.
2) These requirements are applicable to test assemblies with butt weld perpendicular to the rolling direction of the parent material.
3) For Grade A and B steels, the minimum average absorbed energy on fusion line and in heat affected zone shall be 27 J.

5.3.3.8 Test temperature and the minimum average absorbed energy value for test assemblies prepared from particular grades of high strength steel shall comply with the requirements for the parent material specified in the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding.*

5.3.4 Macroscopic Examination

5.3.4.1 For macroscopic examination, one test specimen shall be taken from each butt weld test assembly and two test specimens shall be prepared from each fillet weld test assembly.

5.3.4.2 The test specimens shall be prepared and etched on one side to clearly reveal the weld metal, the fusion line, heat affected zone and parent material. The macroscopic examination test specimens shall include also about 10 mm unaffected parent material on both sides of the weld.

5.3.4.3 The preparation of test specimens and the test reports shall be in accordance with PN-EN ISO 1739.

5.3.4.4 The macroscopic examination result is considered satisfactory if the examinations reveal a regular weld profile, thorough fusion between adjacent layers of the weld and parent material and the absence of defects such as cracks, lack of fusion, etc. The internal imperfections in the test assembly shall be within the limits of quality level B in accordance with PN-EN ISO 5817 – for steel test assemblies and PN-EN ISO 10042 – for Al alloy test assemblies.

5.3.5 Hardness Test

5.3.5.1 Hardness test is required for test assemblies of steel with specified minimum yield strength $R_{eH} \geq 355$ MPa.

5.3.5.2 The Vickers method HV10 shall be used.

5.3.5.3 Position of indentation rows and particular indentations, as well as recording the measurements shall be in accordance with PN-EN ISO 9015-1. Hardness measurements shall be made in accordance with PN-EN ISO 6507-1.

5.3.5.4 The indentations shall be made in the weld metal, the heat affected zone and the parent material. At least two rows of indentations shall be made. For each row of indentation, there are to be at least 3 individual indentations in the weld, the heat affected zone (on both sides) and the parent material (on both sides).

5.3.5.5 The results from the hardness test shall not exceed the following: 350 HV10 for steel with specified minimum yield strength $R_{eH} \leq 420$ MPa and 420 HV10 for steel with specified minimum yield strength 420 MPa < $R_{eH} \leq 690$ MPa.

5.3.6 Fracture Test

5.3.6.1 Each fillet weld test assembly shall be subjected to fracture test. The purpose of the test is to detect the weld internal imperfections, such as cracks, porosity and pores, inclusions, lack of fusion and incomplete penetration.

5.3.6.2 Testing and the test reports shall be in accordance with PN-EN ISO 9017. Fracture in the test assembly weld shall be visually tested.

5.3.6.3 The results of the test are considered satisfactory if internal imperfections at the fraction of the test assembly are within the limits of quality level B in accordance with PN-EN ISO 5817 – for steel test assemblies and PN-EN ISO 10042 – for Al alloy test assemblies.

5.4 Test Results Assessment

5.4.1 The overall result of the tests is considered satisfactory if the results of all tests performed on the test assemblies are satisfactory.

5.4.2 Welding procedure qualification test results shall be recorded in the welding procedure qualification record (WPQR).

5.5 Re-Tests

5.5.1 If the test assembly fails to comply with the requirements for visual or non–destructive testing, one further test assembly shall be welded and subjected to the same tests. If the additional test assembly does not comply with the requirements, the pWPS shall be regarded as not capable of complying with the requirements without modifications. A new pWPS shall be prepared.

5.5.2 The additional test specimens for re-tests shall be taken from the same test assembly if there is sufficient material available or from a new test assembly prepared in accordance with the same pWPS.

5.5.3 If the test assembly fails to comply with the requirements for destructive testing due to weld imperfections, two further test specimens shall be tested for each one that failed. The additional test specimens shall be taken from the same test assembly if there is sufficient material available or from a new test assembly. If the additional test assembly does not comply with the requirements, the pWPS shall be regarded as not capable of complying with the requirements without modifications. A new pWPS shall be prepared.

5.5.4 If a tensile test specimen fails to meet the requirements, two further test specimens shall be prepared and tested. The test results are considered satisfactory if both test specimens satisfy the tensile test requirements.

5.5.5 For Charpy impact test, where the results from a set of three test specimens do not comply with the requirements or the average value for two specimens is lower than the required value or the average value for one specimen is lower than 70% of the required value, three additional test specimens shall be

taken. The average value of three specimens together with the initial results shall be not be lower than the required average. The impact test result is considered satisfactory if the new average value complies with the requirements and when the new average value for not more than two specimens is lower than the average value and only one value is lower than 70% of the required value.

5.5.6 If there is a single hardness value above the maximum values allowed, additional hardness tests shall be carried out on the reverse of the specimen or after sufficient grinding of the tested surface. The re-test result is considered satisfactory if none of the additional hardness value exceeds the maximum hardness value required.

5.6 Re-Test of Welding Procedure Qualification

5.6.1 If the test assembly prepared in accordance with the pWPS fails the tests, the manufacturer shall prepare a new pWPS and submit it to PRS for acceptance. A new test assembly shall be welded in accordance with the new pWPS.

6 RECORDS

6.1 Welding conditions for test assemblies and the test results shall be recorded in the welding procedure qualification record (WPQR), prepared by the manufacturer carrying out the welding procedure qualification tests. WPQR shall include all details of the tested welding procedure relevant to the WPS preparation. It is recommended that the welding procedure qualification record should have a form specified by PRS or as given in the relevant standard.

6.2 WPQR prepared from each welding procedure qualification shall contain a statement of all results from the tests performed on each test specimen, including re-tests, if any. In the case of re-tests, the reasons of failure to comply with the requirements set forth in Chapter 5 of the present *Publication* shall be given.

6.3 Welding procedure qualification test documentation shall include:
- a preliminary welding procedure specification (pWPS) for a test assembly,
- copies of certificates issued for parent materials and welding consumables used for the test assemblies preparation,
- records of test assembly welding parameters,
- reports on all tests performed on the test assemblies,
- welding procedure qualification record (WPQR).

6.4 PRS Surveyor directly supervising the welding procedure qualification tests verifies all documents relating to the tested procedure. If there are no rejectable features or unacceptable test results found, WPQR is qualified and shall be signed, dated and stamped with identification number by the Surveyor.

6.5 Welding procedure qualification record (WPQR) signed by PRS Surveyor constitutes the basis for the preparation, by the manufacturer, the welding procedure specification (WPS), based on the pWPS verified by the welding procedure tests, within the scope corresponding to the qualification range specified in accordance with Chapter 7 of the present *Publication*.

7 RANGE OF QUALIFICATION

7.1 General

7.1.1 Qualification of the welding procedure used by the manufacturer constitutes the basis for determining the range of qualification. If, additionally, all other requirements necessary to obtain approval for welding structures surveyed by PRS are satisfied, the manufacturer may be granted PRS' approval for using the qualified welding procedure within the scope corresponding to the qualification range.

7.1.2 All conditions, given below, for particular items of the qualification range are equally important and shall be met independently.

7.1.3 Changes which would affect the qualification range, determined in accordance with the below principles, require a new welding procedure qualification.

7.1.4 Shop primers may have influence on the quality of fillet welds and this shall be considered when conducting the welding procedure test. The welding procedure qualification of fillet welds of materials with shop primer will qualify the fillet welds without shop primer but not vice versa.

7.2 Welding Processes

7.2.1 The range of qualification is only valid for the welding process used in the test assembly welding procedure.

7.2.2 The designation of the most common welding processes is given in Table 7.2.2.

Table 7.2.2
Welding Processes

Welding process	Welding process designation acc. to PN-EN ISO 4063
Metal arc welding with covered electrode	111
Self-shielded tubular-cored arc welding	114
Submerged arc welding with solid wire electrode	121
Submerged arc welding with tubular cored electrode	125
MIG welding with solid wire electrode	131
MAG welding with solid wire electrode	135
MAG welding with flux cored electrode	136
MAG welding with metal cored electrode	138
TIG welding with solid filler material (wire/rod)	141
Plasma arc welding	15

7.2.3 Multi-run welding procedure qualification is not valid for the test aseembly single-run welding. A change to the welding process requires a new welding procedure qualification.

7.2.4 For multi-process procedures, the welding procedure approval may be performed with separate welding procedure test for each welding process. It is also possible to make the welding procedure test with a welded test assembly made following a multi-process procedure. The approval of such test is only valid for the processes sequence performed during the multi-process procedure test.

7.3 Weld Type

7.3.1 In general, butt welds used in the welding qualification procedure test assemblies qualify butt welds only; fillet welds used in the test assemblies qualify fillet welds only.

7.3.2 In exceptional cases, where butt weld is the predominant form of production welding, the butt weld test assembly will also qualify fillet welds within the scope specified in sub-chapter 7.5.

7.4 Parent Material

7.4.1 The welding procedure qualification tests performed for normal strength hull structural steel qualify only for welding normal strength hull structural steel of the same grade as that used in welding the test assemblies and of the lower grades.

7.4.2 For higher strength hull structural steel with specified yield strength level, the tested procedure qualifies only for welding hull structural steel of the same and two lower yield strength levels but of the same grade as that used in welding the test assemblies and of the lower grades.

7.4.3 The range of qualification for normal and higher strength hull structural parent material used for the test assemblies for welding processes with heat input not exceeding 50 kJ/cm is given in Table 7.4.3.

Table 7.4.3
Range of qualification for normal and higher strength steel parent material used for test assemblies

Test assembly hull structural steel	Range of qualification for welding hull structural steel															
	A	B	D	E	AH 32	DH 32	EH 32	FH 32	AH 36	DH 36	EH 36	FH 36	AH 40	DH 40	EH 40	FH 40
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
D	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–
E	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–
AH 32	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–
DH 32	X	X	X	–	X	X	–	–	–	–	–	–	–	–	–	–
EH 32	X	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–
FH 32	X	X	X	X	X	X	X	X	–	–	–	–	–	–	–	–
AH 36	X	–	–	–	X	X	X	X	X	–	–	–	–	–	–	–
DH 36	X	X	X	–	X	X	–	–	X	X	–	–	–	–	–	–
EH 36	X	X	X	X	X	X	X	–	X	X	X	–	–	–	–	–
FH 36	X	X	X	X	X	X	X	X	X	X	X	X	–	–	–	–
AH 40	–	–	–	–	X	–	–	–	X	–	–	–	X	–	–	–
DH 40	–	–	–	–	X	X	–	–	X	X	–	–	X	X	–	–
EH 40	–	–	–	–	X	X	X	–	X	X	X	–	X	X	X	–
FH 40	–	–	–	–	X	X	X	X	X	X	X	X	X	X	X	X

Key
X qualified
– not qualified.

7.4.4 For normal and higher strength hull structural steel for heat input processes above 50 kJ/cm, e.g. the two-run technique with either submerged arc or gas shielded metal arc welding, electro slag and electro gas welding, the welding procedure qualifies for welding steel of the same strength and one lower yield strength level but of the same grade as that used in welding the test assemblies tested and one grade below.

7.4.5 For high strength quenched and tempered steels with specified yield strength level, the welding procedure qualifies only for welding steel of the same and one lower yield strength level but of the same grade as that used in welding the test assemblies tested and of the lower grades.

7.4.6 The approval of high strength quenched and tempered steel does not qualify thermo-mechanically rolled steels and vice versa.

7.4.7 For weldable unalloyed or alloy steel forgings, the welding procedure qualifies for welding forgings of the same or lower minimum mechanical properties specified in the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*, as that used in welding the test assemblies.

7.4.8 For weldable carbon steel castings, the welding procedure qualifies for welding castings of the same or lower minimum mechanical properties specified in the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*, as that used in welding the test assemblies.

7.4.9 The approval of quenched and tempered hull steel castings does not qualify other delivery conditions and vice versa.

7.4.10 The range of qualification for particular aluminium alloys depends on the test assembly alloy used in the welding procedure qualification tests. The range of qualification is given in Table 7.4.10.

Table 7.4.10
Range of qualification for test assembly aluminium alloy

Test assembly Al group	Test assembly alloy designation	Range of qualification								
		5754	5086	5083	5383	5456	5059	6005A	6061	6082
Mg ≤ 3,5%	5754	X	–	–	–	–	–	–	–	–
4% ≤ Mg ≤ 5,6%	5086	X	X	–	–	–	–	–	–	–
	5083	X	X	X	–	–	–	–	–	–
	5383	X	X	X	X	X	–	–	–	–
	5456	X	X	X	X	X	–	–	–	–
	5059	X	X	X	X	X	X	–	–	–
Al-Mg-Si	6005A	–	–	–	–	–	–	X	X	X
	6061	–	–	–	–	–	–	X	X	X
	6082	–	–	–	–	–	–	X	X	X
Key X qualified, – not qualified.										

7.5 Thickness

7.5.1 The qualification of a welding procedure performed on steel or cast steel test assembly of thickness *t* qualifies the thickness range given in Table 7.5.1.

Table 7.5.1
Range of qualification of test assembly parent material thickness for butt weld or fillet weld

Test assembly parent material thickness *t* [1] [mm]	Range of qualification [mm]	
	Two-run butt weld or single-run fillet weld	Multi–run butt weld or fillet weld [2]
3 < *t* ≤ 12	0.7 *t* to 1.1 *t*	3 to 2 *t*
12 < *t* ≤ 100	0.7 *t* to 1.1 *t* [3]	0.5 *t* to 2 *t* (max.150)

Notes:
1) For multi-process welding, the recorded thickness contribution of each process shall be used as a basis for the range of approval for the individual welding processes.
2) For fillet welds, the range of approval is applicable to both parent materials.
3) For high heat input processes above 50 kJ/cm, the upper limit of approval is 1.0*t*.

7.5.2 The range of qualification for material thickness, *t*, of multi-run butt welds or fillet welds, stated in Table 7.5.1, qualifies multi-run butt welds or fillet welds of the parent material thickness $a = t$.

7.5.3 For single-run fillet welds, the range of qualification depends on the tests weld throat thickness, *a*, and is as follows: 0.75*a* to 1.5*a*.

7.5.4 For the vertical-downward welding, the steel test assembly thickness *t* shall be always taken as the upper limit of the range of qualification.

7.5.5 Notwithstanding the above, the approval of maximum thickness of the parent material shall be restricted to the test assembly thickness *t* if three of the hardness values in the heat affected zone are found to be within 25 HV10 of the maximum permitted, as stated in 5.3.5.5.

7.5.6 For butt weld test assembly made from different thickness parent materials, the range of qualification is always determined on the lesser thickness material; for fillet weld test assembly – on the thicker material.

7.5.7 The qualification of a welding procedure performed on Al alloy butt weld test assemblies of thickness *t* qualifies the thickness range given in Table 7.5.7.

Table 7.5.7
Range of qualification of aluminium alloy test assembly parent material thickness or weld thickness for butt weld

Parent material or weld thickness t [mm]	Range of qualification [mm]
$t \leq 3$	$0.5t$ to $2t$
$3 < t \leq 20$	3 to $2t$
$t > 20$	$\geq 0.8t$

7.5.8 For Al alloy test assemblies with fillet welds, the range of qualification of the throat thickness, a, qualifies the thickness range stated in Table 7.5.8.

Table 7.5.8
Range of qualification of throat thickness for Al alloy test assembly with fillet welds

Throat thickness of test assembly with fillet weld a [mm]	Range of qualification [mm]
$a \leq 10$	$0.75a$ to $1{,}5a$
$a > 10$	≥ 7.5

7.5.9 Where a fillet weld is qualified on the basis of satisfactory results of Al alloy test assemblies with butt welds, the butt weld thickness shall be taken as a. In that case the range of qualification of throat thickness for fillet welds shall be also determined in accordance with Table 7.5.8.

7.6 Welding Positions

7.6.1 The designation of the most common welding positions for test assemblies with butt welds BW or fillet welds FW for plates is given in Table 7.6.1.

Table 7.6.1
Test assembly welding positions

Test assembly		Welding position acc. to PN-EN ISO 6947	
Product type	Weld type	Welding position	Designation
Plate welding P	Butt weld BW	Flat	PA
		Horizontal	PC
		Vertical upward	PF
		Vertical downward	PG
		Overhead	PE
	Fillet weld FW	Horizontal vertical	PB
		Vertical upward	PF
		Vertical downward	PG
		Horizontal overhead	PD

7.6.2 Qualification is generally valid only for the welding position (in accordance with PN-EN ISO 6947) used for welding steel test assembly in the welding procedure qualification tests.

7.6.3 To qualify a range of welding positions for steel and cast steel, one test assembly shall be welded in position for the highest heat input position and the other for the lowest heat input position. For example, for butt welds, the highest heat input is normally in the vertical upward position PF and the lowest – in the horizontal position PC. Both test assemblies shall be subjected to all tests required.

7.6.4 The welding of Al alloy test assembly in any one position qualifies for welding in all positions, except for PG position (vertical downward), provided that comparable welding parameters are used.

7.6.5 To qualify PG (vertical downward) welding position, separate welding procedure tests shall be performed.

7.7 Welding Consumables

7.7.1 For welding processes with heat input not exceeding 50 kJ/cm, the welding consumable used in the welding procedure tests qualifies only approved welding consumables of the same grade as the consumable used in welding the test assemblies. Grade notations of welding consumables, including all suffixes shall be in accordance with the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*. For tubular cored electrode, the welding procedure qualifies only tubular cored electrode of the same type of core as those used in welding the test assemblies.

7.7.2 The welding consumables used in Al alloy welding procedure qualification tests qualify welding consumables, approved by PRS, of the same or higher tensile strength as the consumables used in welding the test assemblies.

7.7.3 The designation of shielding gas is given in Table 7.7.3.

Table 7.7.3
Shielding gas composition in accordance with PN-EN ISO 14175

Welding process	Gas designation	Composition, volume percentage				
		CO_2	O_2	H_2	Ar	He
135, 136	C1	100	–	–	–	–
	C2	The remainder	> 0 to 30	–	–	–
	M11	> 0 to 5	–	> 0 to 5	The remainder	–
	M12	> 0 to 5	–	–	The remainder	–
	M13	–	> 0 to 3	–	The remainder	–
	M14	> 0 to 5	> 0 to 3	–	The remainder	–
	M21	> 5 to 25	–	–	The remainder	–
	M22	–	> 3 to 10	–	The remainder	–
	M23	>5 to 25	> 0 to 8	–	The remainder	–
	M31	> 25 to 50	–	–	The remainder	–
	M32	–	> 10 to 15	–	The remainder	–
	M33	> 5 to 50	> 8 to 15	–	The remainder	–
131, 137,141	I1	–	–	–	100	–
	I2	–	–	–	–	100
	I3	–	–	–	The remainder	> 0 to 95

7.7.4 The welding procedure qualification test performed using combination wire/shielding gas qualifies only the shielding gas (gas or gas mixture) including backing gas as that used in welding the test assemblies.

7.8 Heat Input

7.8.1 The upper limit of heat input qualified is 25% greater than that used in welding the test assembly or 55 kJ/cm, whichever is lesser. If, however, for specific parent materials, other limits of heat input have been established, such limits shall be taken into account in determining the upper limit of heat input.

7.8.2 For high heat input welding process over 50 kJ/cm, the upper limit qualified is 10% greater than that used in welding the test assembly.

7.8.3 The lower limit of heat input qualified is 25% lower than that used in welding the test assembly.

7.9 Preheat and Interpass Temperature

7.9.1 The minimum preheat temperature shall not be less than the nominal preheat temperature applied at the start of the welding procedure qualification test.

7.9.2 The maximum interpass temperature shall not be higher than the highest temperature used in welding the test assembly within the procedure qualification tests.

7.10 Type of Current

7.10.1 For arc welding, the welding procedure tests qualify only for the type of current and polarity used in welding the test assemblies.

7.10.2 Changes in the type of current (AC, DC, pulsed) and polarity require new welding procedure qualification tests.

7.11 Post-weld Heat Treatment

7.11.1 The post-weld heat treatment used in the welding procedure qualification tests shall be maintained during manufacture. The approved holding temperature shall not differ by more than 20°C from that used in the welding procedure tests. Heating rates, cooling rates and holding time shall be adjusted as a function of the thickness.

7.11.2 For aluminium alloys, addition or deletion of post-weld treatment is not permitted, except that artificial ageing for Al-Mg-Si (6005A, 6061, 6082) group of aluminium qualifies for prolonged natural ageing.

7.12 Weld Details

7.12.1 A test assembly welding procedure test performed on a single-run weld qualifies for single-run welds only. A test assembly welding procedure test performed on multi-run weld qualifies for multi-run welds only. The same principle applies to the test assembly welding procedure qualification tests performed on two-run butt joints, welded from both sides (single run on each side).

7.12.2 The qualification of the manufacturer for one-side or both-sides welding with ceramic backing requires the welding procedure qualification tests with the use of ceramic backing.

7.12.3 The range of qualification for test assembly butt weld details is given in Table 7.12.3.

Table 7.12.3
Range of qualification for test assembly butt weld details

Test assembly butt weld details	Range of qualification for butt weld (BW) details					
	one-side welding with no backing	one-side welding with backing		both sides welding		
		ceramic	metal	with ceramic backing	with weld root removed	without removing weld root
one-side welding with no backing	X	–	X	–	X	X
one-side welding with ceramic backing	–	X	X	X	X	–
both sides welding with ceramic backing	–	–	X	X	X	–
welding with metal backing	–	–	X	–	X	–
both sides welding with weld root removed	–	–	X	–	X	–
both sides welding without removing weld root	–	–	X	–	X	X
Key X qualified, – not qualified.						

ANNEX 1

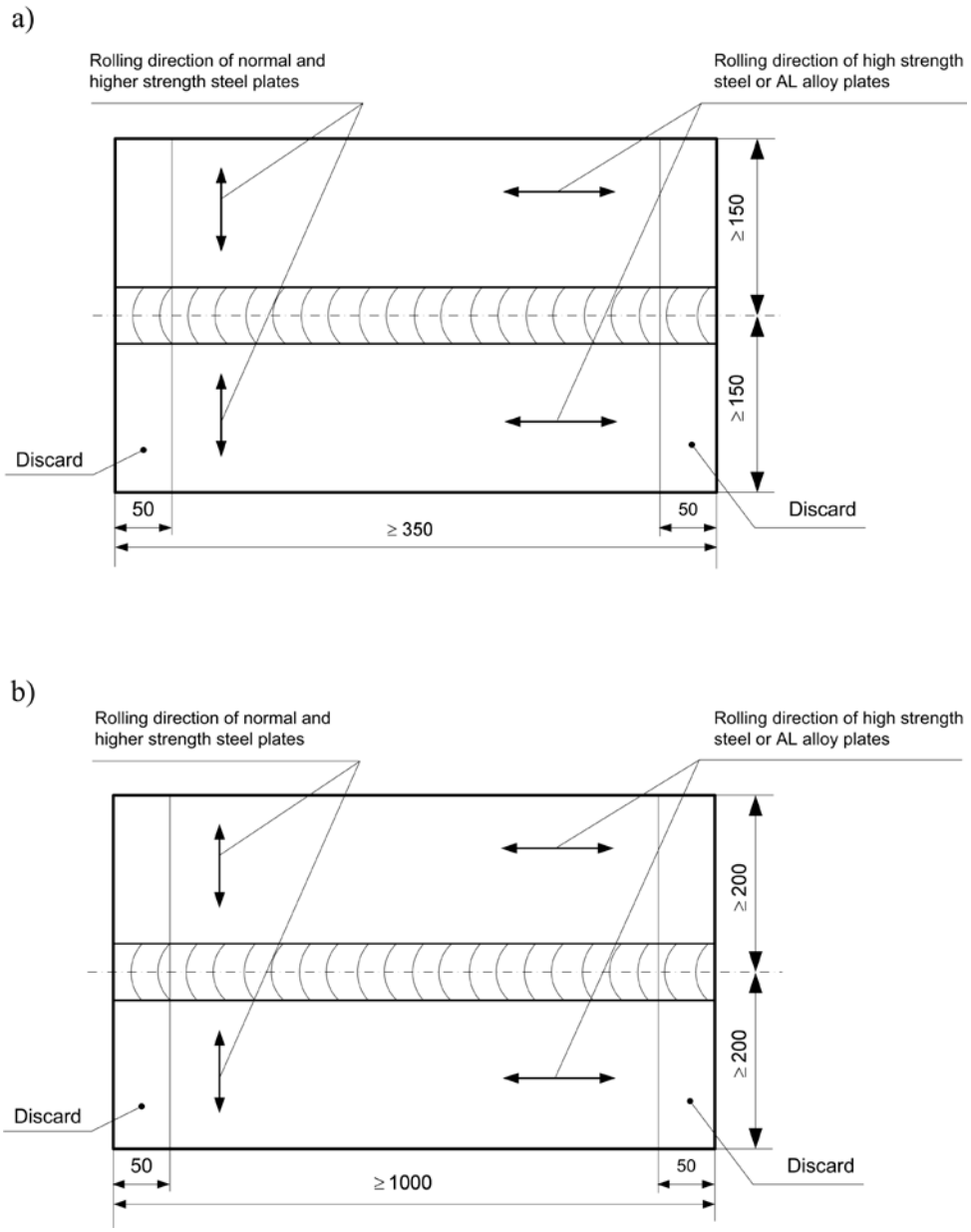


Fig. 1. Dimensions of test assembly for butt weld

a) manual or semi-automatic welding
b) automatic welding

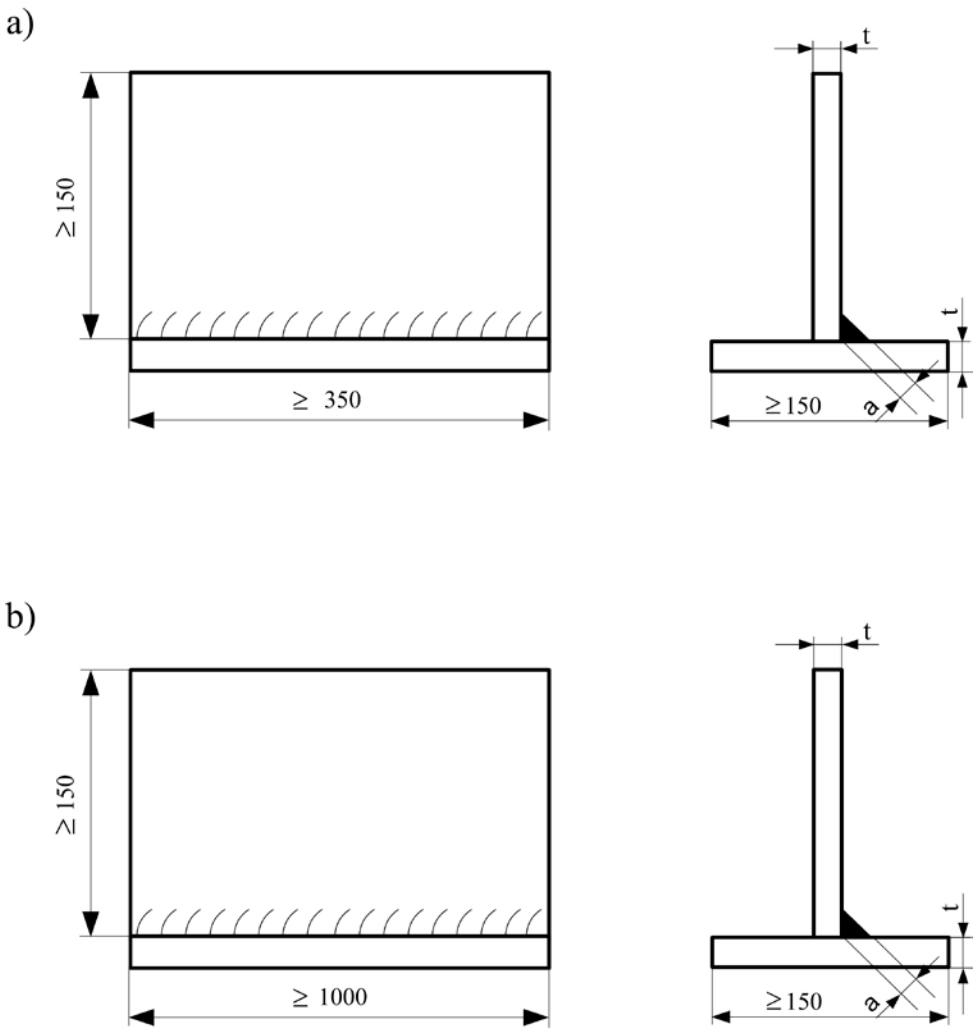


Fig.2. Dimensions of test assembly for fillet weld

a) manual or semi-automatic welding
b) automatic welding

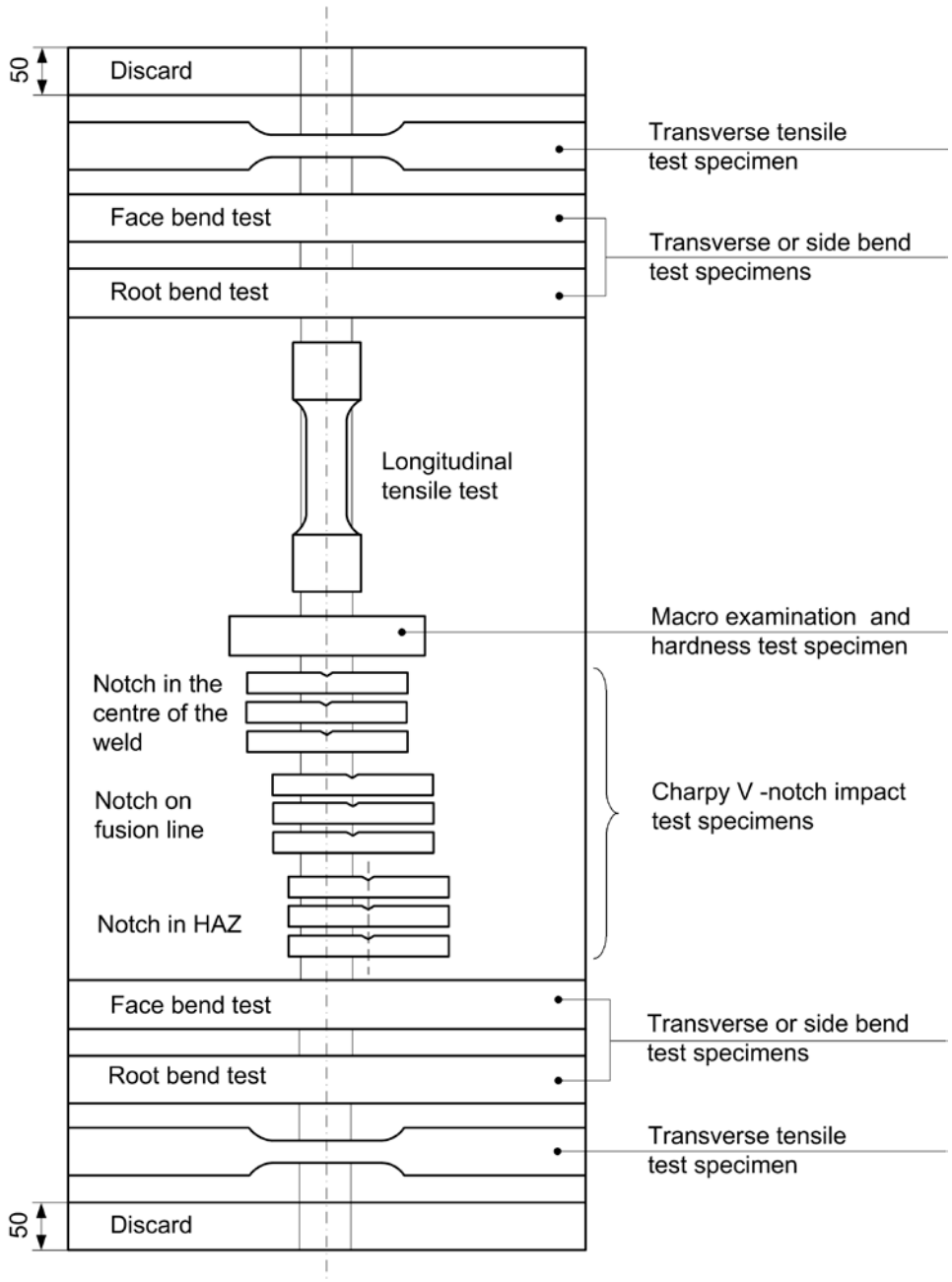


Fig.3. Arrangement of butt weld test assembly for destructive testing

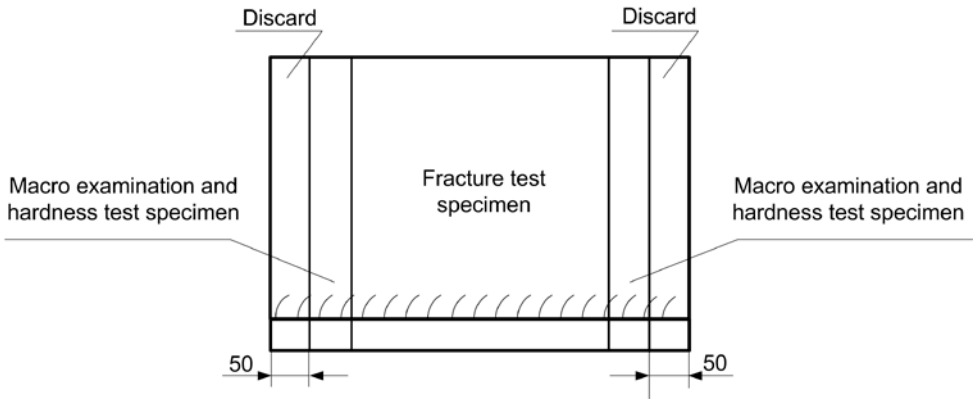
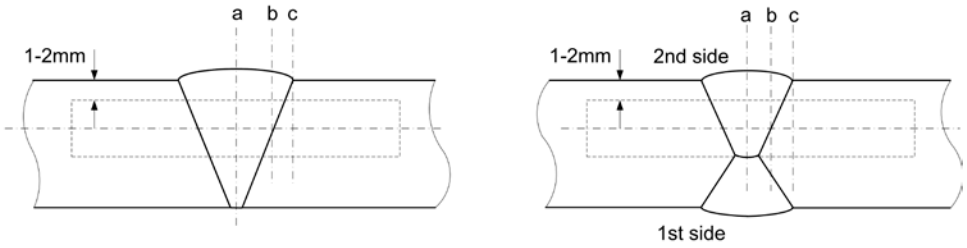


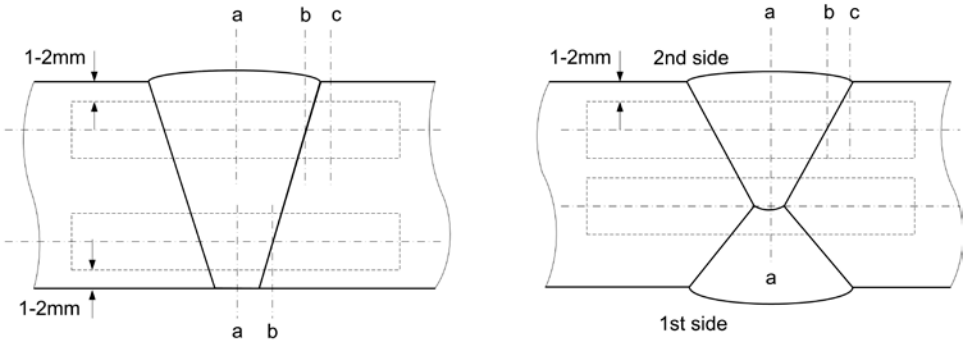
Fig. 4. Arrangement of fillet weld test assembly for destructive testing

a) $t \leq 50$ mm



For one-side welding with thickness over 20 mm, addditional notch specimens shall be cut on root side a – notch location

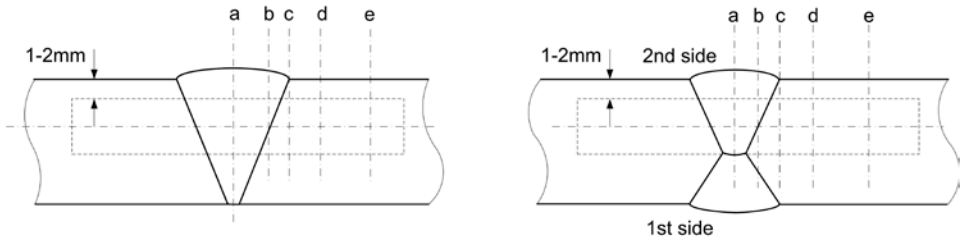
b) $t > 50$ mm



Notch location:
a: centre of weld
b: fusion line
c: HAZ, 2 mm from fusion line

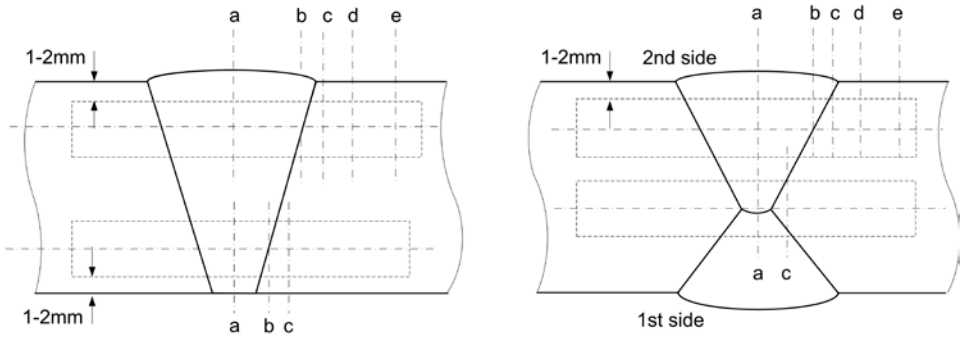
Fig. 1. Location of Charpy V-notch for butt weld test assembly with heat input not exceeding 50 kJ/cm.

a) t ≤ 50 mm



For one-side welding with thickness over 20 mm, additional 3 sets of specimens shall be cut on root side
a, b, c - notch location

b) t > 50 mm



Notch location:
a: centre of weld
b: fusion line
c: HAZ, 2 mm from fusion line
d: HAZ, 5 mm from fusion line
e: HAZ, 10 mm from fusion line in the case of heat input > 200 kJ/cm

Fig. 2. Location of CharpyV-notch for butt weld test assembly with heat input exceeding 50kJ/cm.

List of amendments effective as of 1 January 2015

Item	*Title/Subject*	*Source*
1.1.3	New standard for welding qualification procedures	PN-EN ISO 15614
Numerous paragraphs	Edition update for PN EN ISO standards	UUP
Numerous paragraphs	Glossary amendment to the Polish version	UUP
1.3	Paragraphs from 1.3.1 to 1.3.3 have been deleted	UUP
5.1.3	The following second sentence has been deleted.	UUP