RULES

PUBLICATION 80/P

NON-DESTRUCTIVE TESTING

July
2021

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

GDAŃSK

Publication 80/P – Non-destructive Testing – July 2021, is an extension of the requirements contained in *Part I – Classification Regulations* and *Part IX – Materials and Welding* of the *Rules for the Classification and Construction of Sea-going Ships*.

The present *Publication* was approved by the PRS Board on 28 June 2021 and enters into force on 1 July 2021.

Publication 80/P – Non-destructive Testing – July 2021 replaces *Publication 80/P – Non-destructive Testing – 2017.*

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1 GENERAL

1.1 General Provisions

1.1.1 This Publication gives minimum requirements on the methods and quality levels that are to be adopted for the non-destructive testing (NDT) of ship hull structure steel welds during new building and minimum requirements on the methods and quality levels that are to be adopted for the advanced non-destructive testing (ANDT) of materials and welds during new building and ship repair.

1.1.2 Referenced documents are necessary for use of this *Publication*. In the case of dated references only the quoted issue applies. For non-dated references, the last issue of referenced document including amendments applies.

1.1.3 The laboratory performing non-destructive tests by the following method:
- Visual (VT),
- Penetrant (PT),
- Magnetic-particle (MT),
- Radiographic (RT),
- Ultrasonic (UT)

shall be approved by PRS in accordance with the principles set forth in *Publication No. 51/P – Procedural Requirements for Service Suppliers*.

1.1.4 The scope of non-destructive testing, applied non-destructive testing methods and required level of acceptance or quality shall be specified in the product technical documentation, e.g. Non-destructive Testing Plan, which is subject to agreeing with PRS.

1.1.5 Detected imperfections which are not acceptable shall be repaired as agreed with PRS and the repaired areas shall be re-tested. The extent of testing shall cover the repair area and minimum 100 mm beyond the repair boundaries. Reports on the tests performed after the repair, together with documents relating to the tests performed before the repair, shall be submitted to PRS' Surveyor.

1.1.6 Test reports shall be maintained by the laboratory for at least 5 years from the date of the product or welded structure delivery. Reports may be prepared in paper or electronic format.

1.2 Terms and Definitions

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

Test segment – segment of a weld where non-destructive testing is performed; for penetrant testing, magnetic-particle testing and ultrasonic testing, a minimum test length of 500 mm shall be taken; for radiographic testing, a standard radiograph length of 480 mm shall be taken (the minimum RT test length should be 300 mm).

Non-destructive Testing Plan – a document containing at least the following information: location of testing areas or test segments, the method of testing, acceptance level, an explicit system of marking particular testing areas or test segments, the system of marking testing areas or test segments after repair, as well as the quality level of the product or welded structure.

Automated Ultrasonic Examinations – a technique of ultrasonic examination performed with equipment and search units that are mechanically mounted and guided, remotely operated, and motor-controlled (driven) without adjustments by the technician. The equipment used to perform the examinations is capable of recording the ultrasonic response data, including the scanning positions, by means of integral encoding devices such that imaging of the acquired data can be performed.

Semi-Automated Ultrasonic Examinations – a technique of ultrasonic examination performed with equipment and search units that are mechanically mounted and guided, manually assisted (driven), and which may be manually adjusted by the technician. The equipment used to perform the examinations is capable of recording the ultrasonic response data, including the scanning positions, by means of integral encoding devices such that imaging of the acquired data can be performed

Other definitions are contained in the series of standards related to non-destructive testing.

1.3 Abbreviations

NDT – Non-Destructive Testing
ANDT – Advanced Non-Destructive Testing
RT – Radiographic Testing
RT-D – Digital Radiography
RT-S – Radioscopic testing with digital image acquisition (dynamic ≥ 12 bit)
RT-CR – Testing with computed radiography using storage phosphor imaging plates
UT – Ultrasonic Testing
AUT – Automated Ultrasonic Examinations
SAUT – Semi-Automated Ultrasonic Examinations
PAUT – Phased Array Ultrasonic Testing
TOFD – Time of Flight Diffraction
MT – Magnetic Particle Testing
PT – Dye or Liquid Penetrant Testing
VT – Visual Testing
PWHT – Post Weld Heat Treatment

1.4 Qualification of personnel involved in NDT

1.4.1 The Shipbuilder or its subcontractors is responsible for the qualification and preferably 3rd party certification of its supervisors and operators to a recognised certification scheme based on ISO 9712:2012.

Personnel qualification to an employer based qualification scheme as e.g. SNT-TC-1A, 2016 or ANSI/ASNT CP-189, 2016 may be accepted if the Shipbuilder or its subcontractors written practice is reviewed and found acceptable by PRS. The Shipbuilder or its subcontractors written practice shall as a minimum, except for the impartiality requirements of a certification body and/or authorised body, comply with ISO 9712:2012.

The supervisors' and operators' certificates and competence shall comprise all industrial sectors and techniques being applied by the Shipbuilder or its subcontractors. Level 3 personnel shall be certified by an accredited certification body.

1.4.2 The Shipbuilder or its subcontractors shall have a supervisor or supervisors, responsible for the appropriate execution of NDT operations and for the professional standard of the operators and their equipment, including the professional administration of the working procedures. The Shipbuilder or its subcontractors shall employ, on a full-time basis, at least one

supervisor independently certified to Level 3 in the method(s) concerned as per the requirements of item 2.3.1. It is not permissible to appoint Level 3 personnel; they must be certified by an accredited certification body. It is recognised that a Shipbuilder or its subcontractors may not directly employ a Level 3 in all the stated methods practiced. In such cases, it is permissible to employ an external, independently certified, Level 3 in those methods not held by the full-time Level 3(s) of the Shipbuilder or its subcontractors.

The supervisor shall be directly involved in review and acceptance of NDT Procedures, NDT reports, calibration of NDT equipment and tools. The supervisor shall on behalf of the Shipbuilder or its subcontractors re-evaluate the qualification of the operators annually.

1.4.3 The operator carrying out the NDT and interpreting indications, shall as a minimum, be qualified and certified to Level 2 in the NDT method(s) concerned and as described in item 2.3.1.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at level 1.

The operator shall have adequate knowledge of materials, welding, structures or components, NDT equipment and limitations that are sufficient to apply the relevant NDT method for each application appropriately.

2 NON-DESTRUCTIVE TESTING OF SHIP HULL STEEL WELDS

2.1 General

2.1.1 This document gives minimum requirements on the methods and quality levels that are to be adopted for the non-destructive testing (NDT) of ship hull structure steel welds during new building.

2.1.2 The non-destructive testing of ships using gas fuel or other low flash-point fuels shall be carried out in accordance with IGF Code.

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

2.1.4 The NDT is normally to be performed by the Shipbuilder or its subcontractors in accordance with these requirements. The PRS surveyor may require witnessing of the testing.

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

2.1.6 The extent of testing and the number of checkpoints are to be agreed between the Shipbuilder and PRS. For criticality of structure reference is to be made to relevant structural members categories according to the requirements of the *Part II of the Rules – Hull*, the *Common Structural Rules for Bulk Carriers and Oil Tankers* or *Publication No. 48/P.*

2.1.7 This chapter covers conventional NDT methods. Advanced non-destructive testing (ANDT) methods such as phased array ultrasonic testing (PAUT), time of flight diffraction (TOFD), digital radiography (RT-D), radioscopic testing (RT-S), and computed radiography (RT-CR) are covered by Chapter 3.

2.2 Application

2.2.1 Base metals

This document applies to fusion welds made in normal and higher strength hull structural steels, high strength steels for welded structures and connections welds with hull steel forgings and hull steel castings in accordance with the *Rules Part IX – Materials and Welding*. Base metal other than the above may be applied upon prior agreement with PRS.

2.2.2 Welding processes

This chapter applies to fusion welds made using manual metal arc welding (shielded metal arc welding, 111), gas-shielded metal arc welding (gas metal arc welding, including flux cored arc welding, 13x), gas-shielded arc welding with non-consumable tungsten electrode (gas tungsten arc welding, 14x), submerged arc welding (12x), electro-slag welding (72x) and electro-gas welding processes (73). Terms and numbers according to ISO 4063:2009 ("x" indicates that relevant subgroups are included). This chapter may also be applied to welding processes other than the above at the discretion of PRS.

2.2.3 Weld joints

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

2.2.4 Timing of NDT

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

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

At the discretion of the surveyor, a longer interval and/or additional random inspection at a later period may be required, (for example in case of high thickness welds).

At the discretion of the surveyor, the 72 hour interval may be reduced to 48 hours for RT or UT inspection, provided there is no indication of delayed cracking, and a complete visual and random MT or PT inspection to the satisfaction of the surveyor is conducted 72 hours after welds have been completed and cooled to ambient temperature.

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

2.2.5 Applicable methods for testing of weld joints

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

2.2.5.2 Applicable methods for testing of the different types of weld joints are given in Table 2.2.5.2

Table 2.2.5.2
Applicable methods for testing of weld joints

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

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

2.3 Qualification of personnel involved in NDT

Qualification of personnel carrying out activities covered by this Chapter shall meet requirements of 1.4.

2.4 Surface condition

2.4.1 Areas to be examined shall be free from scale, slag, loose rust, weld spatter, oil, grease, dirt or paint that might affect the sensitivity of the testing method.

Preparation and cleaning of welds for subsequent NDT are to be in accordance with the accepted NDT procedures, and are to be to the satisfaction of the surveyor. Surface conditions that prevent proper interpretation may be cause for rejection of the weld area of interest.

2.5 General plan of testing: NDT method selection

2.5.1 The extent of testing and the associated quality levels are to be planned by the Shipbuilder according to the ship design, ship type and welding processes used. For new construction survey reference is to be made to the NDT requirements of *Publication No. 81/P* and the applicable parts of the *Publication No. 81/P* Table I and Appendices.

2.5.2 For each construction, the Shipbuilder shall submit a plan for approval by PRS, specifying the areas to be examined and the extent of testing and the quality levels, with reference to the NDT procedures to be used. Particular attention is to be paid to inspecting welds in highly stressed areas and welds in primary and special structure indicated in the *Part II of the Rules – Hull* or the *Common Structural Rules for Bulk Carriers and Oil Tankers*. The NDT procedure(s) shall meet the requirement stated in section 6 of this UR and the specific PRS requirements. The plan shall only be released to the personnel in charge of the NDT and its supervision.

In selecting checkpoints, emphasis shall be given to the following inspection locations:
– Welds in high stressed areas
– Fatigue sensitive areas
– Other important structural elements
– Welds which are inaccessible or very difficult to inspect in service
– Field erected welds,
– Suspected problem areas.

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

For other marine and offshore structures the extent is to be agreed by PRS.

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

2.5.3 The identification system shall identify the exact locations of the lengths of weld examined.

2.5.4 All welds over their full length are to be subject to VT by personnel designated by the Shipbuilder, who may be exempted from the qualification requirements defined in 1.4.

2.5.5 As far as practicable, PT or MT shall be used when investigating the outer surface of welds, checking the intermediate weld passes and back-gouged joints prior to subsequent passes deposition. MT shall be performed in ferromagnetic materials welds unless otherwise agreed with PRS. Surface inspection of important tee or corner joints, using an approved MT or PT method, shall be conducted to the satisfaction of the surveyor.

2.5.6 Welded connections of large cast or forged components (e.g. stern frame, stern boss, rudder parts, shaft brackets) are to be tested over their full length using MT (MT is the preferred method) or PT, (PT is to be applied for non-ferrous metals) and at agreed locations using RT or UT.

2.5.7 As given in Table 2.2.5.2, UT or RT or a combination of UT and RT may be used for testing of butt welds with full penetration of 8 mm or greater. Methods to be used shall be agreed with PRS. The method used shall be suited for the detection of particular types and orientations of discontinuities. RT and UT are used for detection of internal discontinuities, and in essence they supplement and complement each other. RT is generally most effective in detecting volumetric discontinuities (e.g. porosity and slag) whilst UT is more effective for detecting planar discontinuities (e.g. laminations, lack of fusion and cracks). Although one method may not be directly relatable to the other, either one would indicate conditions of inadequate control of the welding process.

2.5.8 In general start/stop points in welds made using automatic or fully mechanized welding processes are to be examined using RT or UT, except for internal members where the extent of testing is to be agreed with the attending surveyor.

2.5.9 Where the surveyor becomes aware that an NDT location has been repaired without a record of the original defect, the shipyard is to carry out additional examinations on adjacent areas to the repaired area to the satisfaction of the attending surveyor. Reference is to be made to *Publication No. 81/P*.

2.5.10 Welds in thick steels (>50mm) used in container carrier, deck and hatch coaming areas are to be inspected in accordance with the additional requirements in 2.10.

2.5.11 The non-destructive testing of ships using gas fuel or other low flash-point fuels shall be carried out in accordance with IGF Code.

2.6 Testing

2.6.1 General

2.6.1.1 The testing method, equipment and conditions shall comply with recognized national or international standards, or other documents to the satisfaction of PRS.

2.6.1.2 Sufficient details shall be given in a written procedure for each NDT technique submitted to PRS for acceptance.

2.6.1.3 The testing volume shall be the zone which include the weld and parent material for at least 10 mm each side of the weld, or the width of the heat affected zone (HAZ), whichever is greater. In all cases inspection shall cover the whole testing volume.

2.6.1.4 Provision is to be made for the surveyor to verify the inspection, reports and records (e.g. radiographs) on request.

2.6.2 Visual testing (VT)

2.6.2.1 The personnel in charge of VT is to confirm that the surface condition is acceptable prior to carrying out the inspection. VT shall be carried out in accordance with standards agreed between the Shipbuilder and PRS.

2.6.3 Liquid penetrant testing (PT)

2.6.3.1 PT shall be carried out in accordance to ISO 3452-1:2013 or a recognized accepted standard and the specific requirement of PRS.

2.6.3.2 The extent of PT shall be in accordance to the plans agreed with the attending surveyor and to the satisfaction of the surveyor.

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

2.6.3.4 The temperature of parts examined shall be typically between 5°C and 50°C, outside this temperature range special low/high temperature penetrant and reference comparator blocks shall be used.

2.6.4 Magnetic particle testing (MT)

2.6.4.1 MT shall be carried out in accordance to ISO 17638:2016 or a recognized accepted standard and the specific requirement of PRS.

2.6.4.2 The extent of MT shall be in accordance to the plans agreed with the attending surveyor and to the satisfaction of the surveyor.

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

2.6.5 Radiographic testing (RT)

2.6.5.1 RT shall be carried out in accordance to ISO 17636-1:2013 or an accepted recognized standard and any specific requirement of PRS.

2.6.5.2 The minimum inspected weld length for each checkpoint is to be specified in the approved NDT plan (see 2.5.2) and shall follow the PRS requirements. For hull welds the minimum length inspected by RT is typically 300mm.

The extent of RT shall be in accordance to the approved plans and to the satisfaction of the surveyor.

Consideration may be given for reduction of inspection frequency for automated or fully mechanized welds where quality assurance techniques indicate consistent satisfactory quality.

The number of checkpoints is to be increased if the proportion of non-conforming indications is abnormally high.

2.6.5.3 The inside and outside surfaces of the welds to be radiographed are to be sufficiently free from irregularities that may mask or interfere with interpretation. Surface conditions that prevent proper interpretation of radiographs may be cause for rejection of the weld area of interest.

2.6.6 Ultrasonic testing (UT)

2.6.6.1 UT shall be carried out according to procedure based on ISO 17640:2018 (testing procedure), ISO 23279:2017 (characterization) and ISO 11666:2018 (acceptance levels) or accepted standards and the specific requirements of PRS.

2.6.6.2 The minimum inspected weld length for each checkpoint is to be specified in the approved NDT plan (see 2.5.2) and shall follow the requirements of PRS.

The extent of UT shall be in accordance to the approved plans and to the satisfaction of the surveyor.

A checkpoint shall consist of the entire weld length or a length agreed with the Classification Society.

2.7 Acceptance levels (criteria)

2.7.1 General

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

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

2.7.1.3 The assessment of indications not covered by this document shall be made in accordance with a standard agreed with PRS. Alternative acceptance criteria can be agreed with PRS, provided equivalency is established.

The general accepted methods for testing of welds are provided in Table 2.7.1.3-1 and Table 2.7.1.3-2 for surface and embedded discontinuities respectively. Refer to ISO 17635:2016.

Table 2.7.1.3-1
Methods for detection of surface discontinuities
(all type of welds including fillet welds)

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

Table 2.7.1.3-2
Methods for detection of embedded discontinuities
(for butt and T-joints with full penetration)

Materials and type of joint	Nominal thickness t of the parent material to be welded [mm]		
	$t < 8$	$8 \le t \le 40$	t > 40
Ferritic butt joint	RT or UT 1)	RT or UT	UT or RT 2)
Ferritic T-joints	UT 1) or RT 2)	UT or RT 2)	UT or RT 2)

Notes:
1) Below 8 mm PRS may consider application of an appropriate advanced UT method.
2) RT may be applied however there will be limitations.

2.7.2 Quality levels

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

In general Quality level C is to be applied for hull structure.

Quality level B corresponds to the highest requirement on the finished weld, and may be applied on critical welds.

This standard applies to steel materials with thickness above 0.5 mm. ISO 5817:2014 Table 1 provides the requirements on the limits of imperfections for each quality level. ISO 5817:2014 Annex A also provides examples for the determination of percentage of imperfections (number of pores in surface percent).

All levels (B,C and D) refer to production quality and not to the fitness-for-purpose (ability of product, process or service to serve a defined purpose under specific conditions). The correlation between the quality levels defined in ISO 5817:2014, testing levels/ techniques and acceptance levels (for each NDT technique) will serve to define the purpose under specific conditions. The acceptance level required for examination shall be agreed with PRS. This will determine the quality level required in accordance with the non-destructive technique selected. Refer to tables 2.7.5, 2.7.6, 2.7.7, 2.7.8, 2.7.9.1-1 and 2.7.9.1-2.

2.7.3 Testing levels

2.7.3.1 The testing coverage and thus the probability of detection increases from testing level A to testing level C. The testing level shall be agreed with PRS. Testing level D is intended for special applications, this can only be used when defined by specification. ISO 17640:2018 Annex A tables A.1 to A.7 provide guidance on the selection of testing levels for all type of joints in relation to the thickness of parent material and inspection requirements.

2.7.3.2 The testing technique used for the assessment of indications shall also be specified.

2.7.4 Acceptance levels

2.7.4.1 The acceptance levels are specified for each testing technique used for performing the inspection. The criteria applied is to comply with each standard identified in tables tables 2.7.5, 2.7.6, 2.7.7, 2.7.8, 2.7.9.1-1 and 2.7.9.1-2 (or any recognized acceptable standard agreed with PRS).

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

2.7.5 Visual testing (VT)

The acceptance levels and required quality levels for VT are provided in Publication 107/P and Table 2.7.5.

Table 2.7.5
Quality and acceptance levels for visual testing

Quality levels acc. to ISO 5817:2014 a)	Testing techniques/levels acc. to ISO 17636:2016 a)	Acceptance levels b)
B	Level not specified	B
C		C
D		D
a) or any recognized standard agreed with PRS and demonstrated to be acceptable b) The acceptance levels for VT are the same to the quality level requirements of ISO 5817:2014		

2.7.6 Penetrant testing (PT)

The acceptance levels and required quality levels for PT are provided in Table 2.7.6.

Table 2.7.6
Quality and acceptance levels for penetrant testing

Quality levels acc. to ISO 5817:2014 a)	Testing techniques/levels acc. to ISO 3452-1:2013 a)	Acceptance levels acc. to ISO 23277:2015 a)
B	Level not specified	2X
C		2X
D		3X
a) or any recognized standard agreed with PRS and demonstrated to be acceptable		

2.7.7 Magnetic particle testing (MT)

The acceptance levels and required quality levels for MT are provided in Table 2.7.7.

Table 2.7.7
Quality and acceptance levels for magnetic particle testing

Quality levels acc. to ISO 5817:2014 a)	Testing techniques/levels acc. to ISO 17638:2016 a)	Acceptance levels acc. to ISO 23278:2015 a)
B	Level not specified	2X
C		2X
D		3X
a) or any recognized standard agreed with PRS and demonstrated to be acceptable		

2.7.8 Radiographic testing (RT)

The acceptance levels and required quality levels for RT are provided in Table 2.7.8. Reference radiographs for the assessment of weld imperfections shall be provided in accordance to ISO 5817:2014 or acceptable recognized standard agreed with PRS.

Table 2.7.8
Quality and acceptance levels for radiographic testing

Quality levels acc. to ISO 5817:2014 a)	Testing techniques/levels acc. to ISO 17636-1:2013 a)	Acceptance levels acc. to ISO 10675-1:2016 a)
B	B (class)	1
C	B b) (class)	2
D	At least A (class)	3

a) or any recognized standard agreed with PRS and demonstrated to be acceptable
b) For circumferential weld testing, the minimum number of exposures may correspond to the requirements of ISO 17636-1:2013, class A

2.7.9 Ultrasonic testing (UT)

2.7.9.1 The acceptance levels and required quality levels for UT are provided in Tables 2.7.9.1-1 and 2.7.9.1-2.

Table 2.7.9.1-1
Quality and acceptance levels for ultrasonic testing

Quality levels acc. to ISO 5817:2014 a) b)	Testing techniques/levels acc. to ISO 17640:2018 a) b)	Acceptance levels acc. to ISO 11666:2018 a) b)
B	At least B	2
C	At least A	3
D		3 c)

a) or any recognized standard agreed with PRS and demonstrated to be acceptable.
b) When characterization of indications is required, ISO 23279:2017 is to be applied.
c) UT is not recommended but can be defined in a specification with same requirement as Quality Level C.

Table 2.7.9.1-2
Recommended testing and quality levels acc. to ISO 17640:2018

Testing level a) b) c) acc. to ISO 17640:2018	Quality level acc. to ISO 5817:2014
A	C, D
B	B
C	By agreement
D	Special application

a) POD increases from testing level A to C as testing coverage increases
b) Testing level D for special application shall be agreed with PRS.
c) Specific requirements for testing levels A to C are provided for various types of joints in ISO 17640:2018 Annex A

2.7.9.2 UT acceptance levels apply to the examination of full penetration ferritic steel welds, with thickness from 8 mm to 100 mm. The nominal frequency of probes used shall be between 2 MHz and 5 MHz. Examination procedures for other type of welds, material, thicknesses above 100 mm and examination conditions shall be submitted to the consideration of PRS.

2.7.9.3 The acceptance levels for UT of welds are to be defined in accordance to ISO 11666:2018 requirements or any recognized acceptable standard agreed with PRS. The standard specifies acceptance level 2 and 3 for full penetration welded joints in ferritic steels, corresponding to quality levels B and C (Refer to table 2.7.9.1-1).

2.7.9.4 Sensitivity settings and levels. The sensitivity levels are set by the following techniques:
- Technique 1: based on 3 mm diameter side-drilled holes
- Technique 2: based on distance gain size (DGS) curves for flat bottom holes (disk-shaped reflectors)
- Technique 3: using a distance-amplitude-corrected (DAC) curve of a rectangular notch of 1 mm depth and 1 mm width
- Technique 4: using the tandem technique with reference to a 6 mm diameter flat-bottom hole (disc-shaped reflector)

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

2.8 Reporting

2.8.1 Reports of NDT required shall be prepared by the Shipbuilder and shall be made available to PRS.

2.8.2 Reports of NDT shall include the following generic items:
- Date of testing
- Hull number, location and length of weld inspected
- Names, qualification level and signature of personnel that have performed the testing
- Identification of the component examined
- Identification of the welds examined
- Steel grade, type of joint, thickness of parent material, welding process
- Acceptance criteria
- Testing standards used
- Testing equipment and arrangement used
- Any test limitations, viewing conditions and temperature
- Results of testing with reference to acceptance criteria, location and size of reportable indications
- Statement of acceptance / non-acceptance, evaluation date, name and signature of evaluator
- Number of repairs if specific area repaired more than twice

2.8.3 In addition to generic items, reports of PT shall include the following specific items:
- Type of penetrant, cleaner and developer used
- Penetration time and development time

2.8.4 In addition to generic items, reports of MT shall include the following specific items:
- Type of magnetization
- Magnetic field strength
- Detection media
- Viewing conditions
- Demagnetization, if required

2.8.5 In addition to generic items, reports of RT shall include the following specific items:
- Type and size of radiation source (width of radiation source), X-ray voltage
- Type of film/designation and number of film in each film holder/cassette
- Number of radiographs (exposures)
- Type of intensifying screens
- Exposure technique, time of exposure and source-to-film distance as per below:
- Distance from radiation source to weld
- Distance from source side of the weld to radiographic film
- Angle of radiation beam through the weld (from normal)

– Sensitivity, type and position of IQI (source side or film side)
– Density
– Geometric un-sharpness
– Specific acceptance class criteria for RT

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

2.8.6 In addition to generic items, reports of UT shall include the following specific items:
– Type and identification of ultrasonic equipment used (instrument maker, model, series number), probes (instrument maker, serial number), transducer type (angle, serial number and frequency) and type of couplant (brand).
– Sensitivity levels calibrated and applied for each probe
– Transfer loss correction applied
– Type of reference blocks
– Signal response used for defect detection
– Reflections interpreted as failing to meet acceptance criteria

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

2.8.7 The shipyard is to keep the inspection records specified in 2.8.2 to 2.8.6 of this document for at least for 5 years.

2.9 Unacceptable indications and repairs

2.9.1 Unacceptable indications shall be eliminated and repaired where necessary. The repair welds are to be examined on their full length using appropriate NDT method at the discretion of the Surveyor.

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

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

2.9.3 The extent of testing can be extended at the surveyor's discretion when repeated non-acceptable discontinuities are found.

2.9.4 The inspection records specified in section 2.8 are to include the records of repaired welds.

2.9.5 The Shipbuilder shall take appropriate actions to monitor and improve the quality of welds to the required level. The repair rate is to be recorded by the shipyard and any necessary corrective actions are to be identified in the builder's QA system.

2.10 Requirements for testing of welded joints on container ships

2.10.1 Non-Destructive Testing during construction

2.10.1.1 Where NDT during construction is required in UR S33 Annex I, the NDT is to be in accordance with 2.10.1.2 ÷ 2.10.1.4. Enhanced NDT as specified in the PRS Rules for sea-going ships, Part II – Hull, para. 18.6.3.3 shall be carried out in accordance with an appropriate standard.

2.10.1.2 On container ships, ultrasonic testing is to be carried out on all block-to-block butt joints of all upper flange longitudinal structural members in the cargo hold region. Upper flange longitudinal structural members include the topmost strakes of the inner hull/bulkhead, the sheer strake, main deck, coaming plate, coaming top plate and all attached longitudinal stiffeners defined in Fig. 2.10.1.1.

2.10.1.3 Acceptance criteria of UT are to be accordance with 2.7.9.

2.10.1.4 The acceptance criteria may be adjusted under consideration of the appertaining brittle crack initiation prevention procedure and where this is more severe than required in 2.7.9, the UT procedure shall be amended accordingly to a more severe sensitivity.

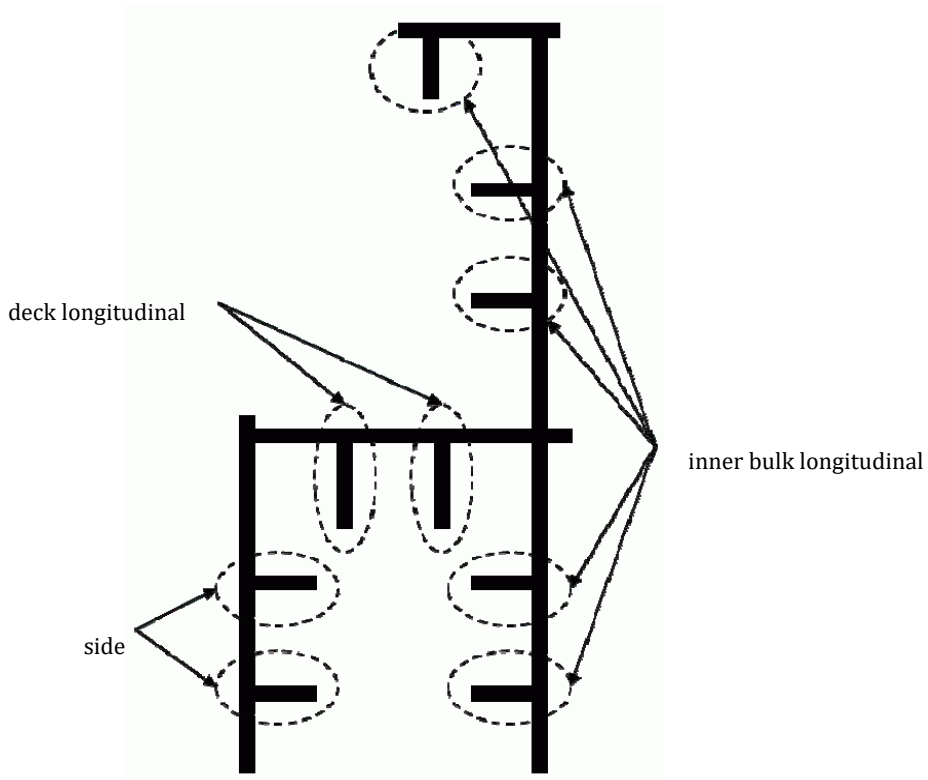

Fig. 2.10.1.1 Upper flange longitudinal structural members

2.10.2 Periodic NDT after delivery

2.10.2.1 Where periodic NDT after delivery is required, the NDT is to be in accordance with PRS requirements.

2.10.2.2 The procedure of the NDT shall be in accordance with 2.6.6 irrespective of the applicability clause for new building in 2.1.1.

2.10.2.3 Where UT is carried out, the frequency of survey shall be in accordance with PRS requirements.

2.10.2.4 Where UT is carried out, acceptance of UT are to be in accordance with 2.7.9, irrespective of the applicability clause for new building in 2.1.1.

3 ADVANCED NON-DESTRUCTIVE TESTING OF MATERIALS AND WELDS

3.1 General

3.1.1 This Chapter gives minimum requirements on the methods and quality levels that are to be adopted for the advanced non-destructive testing (ANDT) of materials and welds during new building and ship repair. The advanced methods intended for use under this Chapter are listed in 3.2.5.

3.1.2 The ANDT is to be performed by the shipbuilder, manufacturer or its subcontractors in accordance with the requirements of this Chapter. PRS surveyor may require witnessing testing.

3.1.3 It is the shipbuilder's or manufacturer's responsibility to ensure that testing specifications and procedures are adhered to during the construction, and the report is to be made available to PRS on the findings made by the ANDT.

3.1.4 The extent and method of testing, and the number of checkpoints are normally agreed between the shipyard and PRS.

3.2 Applicability

3.2.1 Materials

This Chapter applies to the following materials and products manufactured in accordance with *Rules Part IX – Materials and Welding*:
- Material and welding for gas tankers,
- Normal and higher strength hull structural steels,
- High strength quenched and tempered steels for welded structures,
- Connection welds with hull steel forgings,
- Hull steel castings,
- Extremely Thick Steel Plates in Container Ships
- Offshore mooring chain
- Cast Copper Alloy propellers
- Aluminium alloys for hull construction
- Cast Steel Propellers
- YP47 Steels and Brittle Crack Arrest Steels
- Hull and machinery steel forgings
- Marine steel castings

3.2.2 Welding processes

This Chapter applies to welding processes specified in Table 3.2.2. ANDT of welding process unspecified in Table 1 is to be to the satisfaction of PRS.

Table 3.2.2
Applicable welding processes

Welding process		Process number acc. to ISO 4063:2009
Manual welding	Shield Metal Arc Welding (SMAW)	111
Resistance welding	Flash welding (FW)	24
Semi-automatic welding	(1) Metal Inert Gas Welding (MIG) (2) Metal Active Gas Welding (MAG) (3) Flux-Cored Arc Welding (FCAW)	131 135, 138 136
TIG welding	Gas Tungsten Arc Welding (GTAW)	141
Automatic welding	(1) Submerged Arc Welding (SAW) (2) Electro-gas Welding (EGW) (3) Electro-slag Welding (ESW)	12 73 72

3.2.3 Weld joints

This Chapter applies to butt welds with full penetration. Variations of joint design, for example, tee, corner and cruciform joints (with or without full penetration) can be tested using PAUT. The constraints of joint design with respect to testing are to be recognized, documented, and agreed with PRS before application.

3.2.4 Timing of ANDT

3.2.4.1 ANDT shall be conducted after welds have cooled to ambient temperature and after post weld heat treatment where applicable.

3.2.4.2 The timing of ANDT shall be in accordance with appropriate PRS requirements. Timing of ANDT on ship hull welds on steels with specified minimum yield stress in the range of 420 MPa to 690 MPa shall be in accordance with 2.2.4.2.

3.2.5 Testing methods

3.2.5.1 The methods mentioned in this Chapter for detection of imperfections are PAUT (only automated / semi-automated PAUT), TOFD, RT-D.

3.2.5.2 Applicable methods for testing of the different types of materials and weld joints are given in Table 3.2.5.2.

Table 3.2.5.2
Applicable methods for testing of materials and weld joints

Materials and weld joints	Parent material thickness, t [mm]	Applicable methods
Ferritic butt welds with full penetration	$t < 6$	RT-D
	$6 \le t < 40$	PAUT, TOFD, RT-D
	$t > 40$	PAUT, TOFD, RT-D [1)]
Ferritic T-joints and corner joints with full penetration	$t \ge 6$	PAUT, RT-D [1)]
Ferritic cruciform joints with full penetration	$t \ge 6$	PAUT [1)]
Austenitic stainless steel butt welds with full penetration1	$t < 6$	RT-D
	$6 \le t \le 40$	RT-D, PAUT [1)]
	$t > 40$	PAUT [1)], RT-D [1)]

Materials and weld joints	Parent material thickness, t [mm]	Applicable methods
Austenitic stainless steel tee joints, corner joints with full penetration [2]	$t \geq 6$	PAUT [1], RT-D [1]
Aluminium tee joints and corner joints with full penetration	$t \geq 6$	PAUT [1], RT-D [1]
Aluminium cruciform joints with full penetration	$t \geq 6$	PAUT [1]
Aluminium butt welds with full penetration	$t < 6$	RT-D
	$6 \leq t \leq 40$	RT-D, TOFD, PAUT
	$t > 40$	TOFD, PAUT, RT-D [1]
Cast Copper Alloy	All	PAUT, RT-D [1]
Steel forgings	All	PAUT, RT-D [1]
Steel castings	All	PAUT, RT-D [1]
Base materials/Rolled steels, Wrought Aluminium Alloys	$t < 6$	RT-D
	$6 \leq t \leq 40$	PAUT, TOFD, RT-D
	$t > 40$	PAUT, TOFD, RT-D [1]

[1] Only applicable with limitations, needs special qualification subject to PRS acceptance.
[2] The ultrasonic testing of anisotropic material using advanced methods will require specific procedures and techniques. Additionally, the use of complementary techniques and equipment may also be required, e.g. using angle compression waves, and/or creep wave probes for detecting defects close to the surface.

3.3 Qualification of personnel involved in ANDT

Qualification of personnel carrying out activities covered by this Chapter shall meet requirements of 1.4.

3.4 Technique and procedure qualification

3.4.1 General

The shipbuilder or manufacturer shall submit to PRS the following documentation for review:
– The technical documentation of the ANDT.
– The operating methodology and procedure of the ANDT according to 3.7.
– Result of software simulation, when applicable.

3.4.2 Software simulation

Software simulation may be required by PRS, when applicable for PAUT or TOFD techniques. The simulation may include initial test set-up, scan plan, volume coverage, result image of artificial flaw etc. In some circumstances, artificial defect modeling/simulation may be needed or required by the project.

3.4.3 Procedure qualification test

The procedure qualification for ANDT system shall include the following steps:
– Review of available performance data for the inspection system (detection abilities and defect sizing accuracy).
– Identification and evaluation of significant parameters and their variability.
– Planning and execution of a repeatability and reliability test programme [1] which including onsite demonstration.
– Documentation of results from the repeatability and reliability test programs.

Note: 1) The data from the repeatability and reliability test program shall be analyzed with respect to comparative qualification block test report and onsite demonstration. The qualification block shall be in accordance with ASME V Article 14 Mandatory Appendix II UT Performance Demonstration Criteria or agreed by PRS, and at least the intermediate level qualification blocks shall be used. The high level qualification blocks shall be used when sizing error distributions and an accurate POD need to be evaluated. The demonstration process onsite shall be witnessed by the PRS surveyor.

3.4.4 Procedure approval

The testing procedure shall be evaluated based upon the qualification results, if satisfactory the procedure can be considered approved.

3.4.5 Onsite review

For the test welds, supplementary NDT shall be performed on an agreed proportion of welds to be cross checked with other methods. Alternatively, other documented reference techniques may be applied to compare with ANDT results.

Data analyses shall be performed in accordance with the above activities. Probability of Detection (PoD) and sizing accuracy shall be established when applicable.

When the result of inspection review does not conform to the approved procedure, the inspection shall be suspended immediately. Additional procedure review qualification and demonstration shall be undertaken to account for any nonconformity.

When a significant nonconformity is found, PRS has the right to reject the results of such activities.

3.5 Surface condition

3.5.1 Area to be examined shall be free from scale, loose rust, weld spatter, oil, grease, dirt or paint that might affect the sensitivity of the testing method.

3.5.2 Where there is a requirement to carry out PAUT or TOFD through paint, the suitability and sensitivity of the test shall be confirmed through an appropriate transfer correction method defined in the procedure. In all cases, if transfer losses exceed 12 dB, the reason shall be considered and further preparation of the scanning surfaces shall be carried out, if applicable. If testing is done through paint, then the procedure shall be qualified on a painted surface.

3.5.3 The requirement for acceptable test surface finish shall ensure accurate and reliable detection of defects. For the testing of welds, where the test surface is irregular or has other features likely to interfere with the interpretation of NDT results, the weld shall be ground or machined.

3.6 General plan of testing: NDT method selection

The extent of testing shall be planned by the shipbuilder or manufacturer according to the ship design, ship or equipment type and welding processes used. Particular attention shall be paid to highly stressed areas. The extent of testing shall be in accordance with the *Rules* applicable with material of weld examined.

3.7 Testing requirements

3.7.1 General

3.7.1.1 The shipyard or manufacturer shall ensure that personnel carrying out NDT or interpreting the results of NDT are qualified to the appropriate level as detailed in 1.4.

3.7.1.2 Procedures

.1 All NDT are to be carried out to a procedure that is representative of the item under inspection.
.2 Procedures shall identify the component to be examined, the NDT method, equipment to be used and the full extent of the examinations including any test restrictions.
.3 Procedures shall include the requirement for components to be positively identified and for a datum system or marking system to be applied to ensure repeatability of inspections.
.4 Procedures shall include the method and requirements for equipment calibrations and functional checks, together with specific technique sheets / scan plans, for the component under test.
.5 Procedures shall be approved by personnel qualified to Level III in the appropriate technique in accordance with a recognised standard.
.6 Procedures shall be reviewed by PRS Surveyor.

3.7.1.3 The methods considered within the application of this Chapter are defined in 3.2.5.1.

3.7.1.4 PAUT techniques shall conform as a minimum to 3.7.2. Depending on the complexity of the item under test and the access to surfaces, there may be a requirement for additional scans and/or complementary NDT techniques to ensure that full coverage of the item is achieved.

PAUT of welds shall include a linear scan of the fusion face, together with other scans as defined in the specific test technique. Refer to linear scan requirements in section 3.7.2.2.4.

3.7.1.5 TOFD techniques shall conform as a minimum to 3.7.3. Depending on the complexity of the item under test and the access to surfaces, there may be a requirement for additional scans and/or complementary NDT techniques to ensure that full coverage of the item is achieved.

3.7.1.6 RT-D techniques shall conform as a minimum to 3.7.4. For the purpose of this UR, RT-D comprises of two main RT methods; RT-S and RT-CR. Other methods may be included (e.g. radioscopy systems), however, then must conform to this UR as applicable, and any specific requirements shall demonstrate equivalence to these requirements.

In all RT-D methods, in addition to specific requirements, detector output quality control methods shall be described within the procedure.

The procedure shall define the level of magnification, post-processing tools, image/data security and storage, for final evaluation and reporting.

3.7.2 Phased array ultrasonic testing

PAUT shall be carried out according to procedures based on ISO 13588:2019, ISO 18563-1:2015, ISO 18563-2:2017, ISO 18563-3:2015 and ISO 19285:2017 or recognized standards and the specific requirements of PRS.

3.7.2.1 Information required prior to testing

A procedure shall be written and include the following information as in minimum shown in Table 3.7.2.1. When an essential variable in Table 3.7.2.1 is to change from the specified value, or range of values, the written procedure shall require requalification. When a nonessential variable is to change from the specified value, or range of values, requalification of the written procedure is not required. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.

Table 3.7.2.1
Requirements of a PAUT procedure

Requirement	Essential variable	Nonessential variable
Material types or weld configurations to be examined, including thickness dimensions and material product form (castings, forgings, pipe, plate, etc.)	X	–
The surfaces from which the examination shall be performed	X	–
Technique(s) (straight beam, angle beam, contact, and/or immersion)	X	–
Angle(s) and mode(s) of wave propagation in the material	X	–
Search unit type, frequency, element size and number, pitch and gap dimensions, and shape	X	–
Focal range (identify plane, depth, or sound path)	X	–
Virtual aperture size (i.e., number of elements, effective height [1)], and element width)	X	–
Focal laws for E-scan and S-scan (i.e., range of element numbers used, angular range used, element or angle increment change)	X	–
Special search units, wedges, shoes, or saddles, when used	X	–
Ultrasonic instrument(s)	X	–
Calibration [calibration block(s) and technique(s)]	X	–
Directions and extent of scanning	X	–
Scanning (manual vs. automatic)	X	–
Method for sizing indications and discriminating geometric from flaw indications	X	–
Computer enhanced data acquisition, when used	X	–
Scan overlap (decrease only)	X	–
Personnel performance requirements, when required	X	–
testing levels, acceptance levels and/or recording levels	X	–
Personnel qualification requirements	–	X
Surface condition (examination surface, calibration block)	–	X
Couplant (brand name or type)	–	X
Post-examination cleaning technique	–	X
Automatic alarm and/or recording equipment, when applicable	–	X
Records, including minimum calibration data to be recorded (e.g., instrument settings)	–	X
Environmental and safety issues	–	X
[1)] Effective height is the distance from the outside edge of the first to the last element used in the focal law.		

3.7.2.2 Testing

3.7.2.2.1 Testing levels

The testing levels specified in the testing procedure shall be in accordance with recognized standards accepted by the Classification Society. Four testing levels are specified in ISO 13588:2019, each corresponding to a different probability of detection of imperfections.

3.7.2.2.2 Weld Examinations

The weld examinations shall in accordance with ISO 13588:2019 and the additional special requirements of this Chapter.

3.7.2.2.3 Material Examinations

Material examinations shall conform to 3.2.1 as a minimum.

3.7.2.2.4 Volume to be inspected

The purpose of the testing shall be defined by the testing procedure. Based on this, the volume to be inspected shall be determined.

A scan plan shall be provided. The scan plan shall show the beam coverage, the weld thickness and the weld geometry.

If the evaluation of the indications is based on amplitude only, it is a requirement that an 'E' scan (or linear scan) shall be utilized to scan the fusion faces of welds, so that the sound beam is perpendicular to the fusion face ± 5º. This requirement may be omitted if an 'S' (or sectorial) scan can be demonstrated to verify that discontinuities at the fusion face can be detected and sized, using the stated procedure (note, this demonstration shall utilize reference blocks containing suitable reflectors in location of fusion zone).

3.7.2.2.5 Reference blocks

Depending on the testing level, a reference block shall be used to determine the adequacy of the testing (e.g. coverage, sensitivity setting). The design and manufacture of reference blocks shall be in accordance with ISO 13588:2019 or recognized equivalent standards and the specific requirements of PRS.

3.7.2.2.6 Indication assessment

Indications detected when applying testing procedure shall be evaluated either by length and height or by length and maximum amplitude. Indication assessment shall be in accordance with ISO 19285:2017 or recognized standards and the specific requirements of PRS. The sizing techniques include reference levels, Time Corrected Gain (TCG), Distance Gain Size (DGS) and 6 dB drop. 6 dB drop method shall only be used for measuring the indications larger than the beam width.

3.7.3 Time of flight diffraction

TOFD shall be carried out according to procedure based on ISO 10863:2011, and ISO 15626:2018 or recognized standards and the specific requirements of PRS.

3.7.3.1 Information required prior to testing

A procedure shall be written and include the following information as shown in Table 3.7.3.1. When an essential variable in Table 3.7.3.1 is to change from the specified value, or range of values, the written procedure shall require requalification. When a nonessential variable is to change from the specified value, or range of values, requalification of the written procedure is not required. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.

Table 3.7.3.1
Requirements of a TOFD procedure

Requirement	Essential variable	Nonessential variable
Weld configurations to be examined, including thickness dimensions and material product form (castings, forgings, pipe, plate, etc.)	X	–
The surfaces from which the examination shall be performed	X	–
Angle(s) of wave propagation in the material	X	–
Search unit type(s), frequency(ies), and element size(s)/shape(s)	X	–
Special search units, wedges, shoes, or saddles, when used	X	–
Ultrasonic instrument(s) and software(s)	X	–
Calibration [calibration block(s) and technique(s)]	X	–
Directions and extent of scanning	X	–
Scanning (manual vs. automatic)	X	–
Data sampling spacing (increase only)	X	–
Method for sizing indications and discriminating geometric from flaw indications	X	–
Computer enhanced data acquisition, when used	X	–
Scan overlap (decrease only)	X	–
Personnel performance requirements, when required	X	–
testing levels, acceptance levels and/or recording levels	X	–
Personnel qualification requirements	–	X
Surface condition (examination surface, calibration block)	–	X
Couplant (brand name or type)	–	X
Post-examination cleaning technique	–	X
Automatic alarm and/or recording equipment, when applicable	–	X
Records, including minimum calibration data to be recorded (e.g., instrument settings)	–	X
Environmental and safety issues	–	X

3.7.3.2 Testing

3.7.3.2.1 Testing levels

The testing levels specified in the testing procedure shall be in accordance with recognized standards accepted by PRS. Four testing levels are specified in ISO 10863:2011, each corresponding to a different probability of detection of imperfections.

3.7.3.2.2 Volume to be inspected

The purpose of the testing shall be defined by the testing procedure. Based on this, the volume to be inspected shall be determined.

A scan plan shall be provided. The scan plan shall show the locations of the probes, beam coverage, the weld thickness and the weld geometry.

3.7.3.2.3 Due to the nature of the TOFD method, there is a possibility that the scan plan may reveal weld volume zones that will not receive full TOFD coverage (commonly known as dead zones, either in the lateral wave, back wall, or both). If the scan plan reveals that these dead zones are not adequately inspected, then further TOFD scans and/or complementary NDT methods shall be applied to ensure full inspection coverage.

3.7.4 Digital radiography

Digital radiography shall be performed per procedure(s) based on ISO 17636-2:2013 and standards referenced therein, or recognized standards and additional specific requirements of PRS.

Any variation to applying the standard (e.g. IQI placement) shall be agreed with PRS.

A procedure shall be written and include the following information as shown in table 3.7.4.

Table 3.7.4
Requirements of a TOFD procedure

Requirement
Material types or weld configurations to be examined, including thickness dimensions and material product form (castings, forgings, pipe, plate, etc.)
Digitizing System Description:
Manufacturer and model no. of digitizing system
Physical size of the usable area of the image monitor
Film size capacity of the scanning device
Spot size(s) of the film scanning system
Image display pixel size as defined by the vertical/horizontal resolution limit of the monitor
Illuminance of the video display
Data storage medium
Digitizing Technique:
Digitizer spot size (in microns) to be used
Loss-less data compression technique, if used
Method of image capture verification
Image processing operations
Time period for system verification
Spatial resolution used:
Contrast sensitivity (density range obtained)
Dynamic range used
Spatial linearity of the system
Material type and thickness range
Source type or maximum X-ray voltage used
Detector type
Detector calibration
Minimum source-to-object distance
Distance between the test object and the detector
Source size
Test object scan plan (if applicable)
Image Quality Measurement Tools
Image Quality Indicator (IQI)
Wire Image Quality Indicator
Duplex Image Quality Indicator
Image Identification Indicator
Testing levels, acceptance levels and/or recording levels
Personnel qualification requirements
Surface condition
Records, including minimum calibration data to be recorded
Environmental and Safety issues

3.7.4.1 Testing levels

Regarding choice of testing level per ISO 17636-2:2013 this is referred to in section 8.4.

3.8 Acceptance Levels

3.8.1 General

3.8.1.1 This section details the acceptance levels followed for the assessment of the NDT results. Methods include but are not limited to: Phased array ultrasonic testing (PAUT), Time of flight diffraction (TOFD), Digital radiography (RT-D).

3.8.1.2 It may be necessary to combine testing methods to facilitate the assessment of indications against the acceptance criteria.

3.8.1.3 Acceptance criteria for each material and weld joint shall be in accordance with respective *PRS Rules*.

3.8.2 Phased array ultrasonic testing

3.8.2.1 Weld Examinations

The relationship between acceptance levels, testing levels and quality levels is given in Table 3.8.2.1.

Quality levels and acceptance levels for PAUT of welds shall be in accordance with ISO 19285:2017 or recognized standard agreed with PRS.

Table 3.8.2.1
Acceptance levels for PAUT

Quality levels acc. to ISO 5817:2014	Testing levels acc. to ISO 13588:2019	Acceptance levels acc. to ISO 19285:2017
C, D	A	3
B	B	2
By agreement	C	1
Special application	D	By agreement

3.8.2.2 Material Examinations

Quality levels and acceptance levels for PAUT of material testing shall be in accordance to recognized standard agreed with PRS.

The acceptance levels for material examinations shall conform as a minimum to the appropriate PRS Rules.

3.8.3 Time of flight diffraction

The relationship between acceptance levels, testing levels and quality levels is given in Table 3.8.3.

Quality levels and acceptance levels for TOFD of welds shall be in accordance to ISO 15626:2018 or recognized standard agreed with PRS.

Table 3.8.3
Acceptance levels for TOFD

Quality levels acc. to ISO 5817:2014	Testing levels acc. to ISO 10863:2011	Acceptance levels acc. to ISO 15626:2018
B (Stringent)	C	1
C (Intermediate)	At least B	2
D (Moderate)	At least A	3

3.8.4 Digital radiography

The relationship between acceptance levels, testing levels and quality levels is given in Table 3.8.4.

Quality levels and acceptance levels for Digital Radiography of welds shall be in accordance with ISO 10675 or standard agreed with PRS.

Table 3.8.4
Acceptance levels for Digital Radiography

Quality levels accc to ISO 5817:2014 or ISO 10042:2018	Testing techniques/level(class) acc. to ISO 17636-2:2013	Acceptance level acc. ISO 10675-1:2016 and ISO 10675-2:2017
B (Stringent)	B (class)	1
C (Intermediate)	B* (class)	2
D (Moderate)	A (class)	3
*For circumferential weld testing, the minimum number of exposures may correspond to the requirements of ISO 17636-2:2013, class A		

3.9 Reporting

3.9.1 The test report shall include at least the following information:

.1 a reference to standards of compliance;
.2 information relating to the object under test:
- identification of the object under test,
- dimensions including wall thickness,
- material type and product form,
- geometrical configuration,
- location of welded joint(s) examined,
- reference to welding process and heat treatment,
- surface condition and temperature,
- stage of manufacture;

.3 information relating to equipment, acc. to Table 3.9.1
.4 information relating to test technology, acc. to Table 3.9.1
.5 information relating to test results, acc. to Table 3.9.1

Table 3.9.1
Information required in test report

Method	Information relating to equipment	Information relating to test technology	Information relating to test results
All	manufacturer and type of instrument, including with identification numbers if required.	1) testing level and reference to a written test procedure, 2) purpose and extent of test, 3) details of datum and coordinate systems, 4) method and values used for range and sensitivity settings, 5) details of signal processing and scan increment setting, 6) access limitations and deviations from standards, if any.	1) acceptance criteria applied, 2) tabulated data recording the classification, location and size of relevant indications and results of evaluation, 3) results of examination including data on software used, 4) date of test, 5) reference to the raw data file(s), 6) date(s) of scan or exposure and test report, 7) names, signatures and certification of personnel.

Method	Information relating to equipment	Information relating to test technology	Information relating to test results
PAUT	1) manufacturer, type, frequency of phased array probes including number and size of elements, material and angle(s) of wedges with identification numbers if required, 2) details of reference block(s) with identification numbers if required, 3) type of couplant used.	1) increment (E-scans) or angular increment (S-scans), 2) element pitch and gap dimensions, 3) focus (calibration should be the same as scanning), 4) virtual aperture size, i.e. number of elements and element width, 5) element numbers used for focal laws, 6) documentation on permitted wedge angular range from manufacturer, 7) documented calibration, TCG and angle gain compensation, 8) scan plan.	1) phased array images of at least those locations where relevant indications have been detected on hard copy, all images or data available in soft format, 2) reference points and details of the coordinate system.
TOFD	1) manufacturer, type, frequency, element size and beam angle(s) of probes with identification numbers if required, 2) details of reference block(s) with identification numbers if required, 3) type of couplant used.	1) details of TOFD setups, 2) details of offset scans, if required.	TOFD images of at least those locations where relevant TOFD indications have been detected.
RT-D	1) system of marking used, 2) radiation source, type and size of focal spot and identification of equipment used, 3) detector, screens and filters and detector basic spatial resolution.	1) detector position plan, 2) tube voltage used and current or source type and activity, 3) time of exposure and source-to-detector distance, 4) type and position of image quality indicators, 5) achieved and required SNRN for RT-S or achieved and required grey values and/or SNRN for RT-CR, 6) for RT-S: type and parameters such as gain, frame time, frame number, pixel size, calibration procedure, 7) for RT-CR: scanner type and parameters such as pixel size, scan speed, gain, laser intensity, laser spot size, 8) image-processing parameters used, e.g. of the digital filters.	N/A

3.9.2 Results of NDT shall be recorded and evaluated by the shipbuilder or manufacturer on a continual basis. These records shall be available to the Surveyor.

3.9.3 The shipbuilder or manufacturer shall be responsible for the review, interpretation, evaluation and acceptance of the results of NDT. Reports stating compliance or otherwise with the criteria established in the inspection procedure shall be issued.

3.9.4 In addition to the above general reporting requirements, all specified NDT methods will have particular requirements and details that shall be listed in the report. Refer to the applicable method standards for specific requirements.

3.9.5 The shipbuilder or manufacturer shall keep the inspection records for minimum of 5 years.

3.10 Unacceptable indications and repairs

All indications (discontinuities) exceeding the applicable acceptance criteria shall be classed as defects, and shall be eliminated and repaired as per applicable PRS requirements.

List of amendments effective as of 1 July 2021

Item	Title/Subject	Source
Chapter 1	General Requirements	UR W33 Rev 1 May 2020, UR W34 New Dec 2019
Chapter 2	Non-destructive testing of hull welds	UR W33 Rev 1 May 2020
2.10	Non-destructive testing on container ships	UR S33 Rev. 3 section 2, 3
Chapter 3	Advanced non-destructive testing of materials and welds	UR W34 New Dec 2019
2.5.8 2.6.5.2 2.9.2	Corrigenda – “or” added	UR W33 Rev1 Corr1 Aug21
